A HOUSEHOLD SOLID WASTE SORTING AND RECOGNITION RECYCLING SYSTEM

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Bachelor of Computer Science (Computer System and Networking) With Honours

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TITLE A HOUSEHOLD SOLID WASTE SORTING AND RECOGNITION
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ABSTRAK

Kitar semula rendah dan kadar penyortiran rendah adalah masalah jangka panjang bukan sahaja di Malaysia tetapi semua negara membangun seperti Vietnam dan Thailand. Walau bagaimanapun, projek ini hanya tertumpu pada masalah kitar semula dan penyortiran di Malaysia sahaja. Aplikasi yang dicadangkan direka khas untuk rakyat Malaysia. Dengan populasi 32 juta, Malaysia menghasilkan lebih daripada 28000 tan metrik sisa pepejal setiap hari. Anehnya, hanya 10% daripadanya dikumpulkan untuk tujuan kitar semula. Lebih-lebih lagi, sistem kitar semula aliran tunggal yang diamalkan di kalangan Malaysia mengakibatkan lebih banyak pencemaran dan kualiti sisa pepejal yang boleh dikitar semula. Oleh itu, aplikasi yang dicadangkan dikembangkan untuk menghentikan kedua-dua masalah ini. Objektif projek ini adalah untuk mengenal pasti batasan semasa penggunaan sistem kitar semula yang ada, mengembangkan aplikasi mudah alih yang membantu memberikan maklumat mengenai menyusun sisa pepejal kitar semula ke dalam kategori berdasarkan pengecaman gambar menggunakan rangkaian saraf dan menilai fungsi sistem yang dicadangkan. Setelah penyelidikan dilakukan pada tiga aplikasi yang ada, dapat didapati bahawa aplikasi yang ada hanya akan lebih fokus dalam menyusun sisa pepejal isi rumah. Namun, untuk aplikasi yang dicadangkan ini, Places API dilaksanakan sehingga lokasi kitar semula yang berdekatan diberikan kepada pengguna dan mereka dapat mengetahui di mana hendak menghantar sampah yang dapat dikitar semula. Bagi sampah yang boleh dikitar semula yang tidak dapat dihantar oleh pengguna sendiri, mereka boleh menempah koleksi depan pintu dari pusat kitar semula. Metodologi tangkas yang terdiri dari fasa keperluan, fasa reka bentuk, fasa pengembangan, fasa ujian, dan fase penyebaran akan dilaksanakan untuk pengembangan aplikasi yang dicadangkan. Terakhir, Ujian Penerimaan Pengguna dilakukan untuk mengesan sebarang kecacatan aplikasi yang dicadangkan. Pasaran semasa di Malaysia masih kekurangan aplikasi mudah alih kitar semula dan penyortiran seperti ini yang membantu memajukan pencapaian kitar semula dan penyortiran. Itulah sebabnya saya berada di sini untuk menyumbang usaha saya untuk melakukannya. Hasil yang diharapkan dari permohonan tersebut adalah untuk menyaksikan peningkatan jumlah orang yang mengambil bahagian dalam aktiviti kitar semula. Mungkin ini dapat mengurangkan sisa pepejal isi rumah yang dihasilkan oleh rakyat Malaysia dan secara tidak langsung menyumbang kepada persekitaran yang bersih dan selamat. Hasil yang diharapkan kedua adalah kepada orang ramai yang terlibat dalam sistem kitar semula

dwi-aliran dan membantu mengumpulkan lebih banyak bahan tulen dan pemulihan sisa kitar semula yang lebih tinggi. Kerja masa depan yang perlu dilakukan termasuk meningkatkan set data model latihan pembelajaran mesin sisa pepejal isi rumah dari 30 hingga 100 sehingga sisa pepejal isi rumah dapat diimbas oleh pengguna. Peningkatan kedua dapat membiarkan manual pengguna menyesuaikan kawasan pencarian (radius) dari lokasi kitar semula berdekatan.

ABSTRACT

Low recycling and low sorting rate are the long-term problems not only in Malaysia but all the developing country like Vietnam and Thailand. However, this project was focused on the recycling and sorting problem in Malaysia only. The proposed application is specially designed for Malaysian. With a population of 32 million, Malaysia generates more than 28000 metric tonnes of solid waste everyday. Surprisingly, only 10% of it are collected for recycling purpose. What is more, the single-stream recycling system practiced among Malaysia results in more contamination and low quality of recyclable solid waste. Hence, the proposed application is developed to stop these two problems. The objectives of this project are to identify the current limitation of the existing application of the recycling system, develop a mobile application that helps provide information regarding sorting recycled solid waste into categories based on image recognition using a neural network and evaluate the functionalities of the proposed system. After research done on three existing applications, it can be found that the existing applications will only focus more in sorting the household solid waste. However, for this proposed application, the Places API is implemented so that nearby recycling location are provided to the users and they can know where to send their recyclable waste. For those recyclable waste that cannot send by the user themselves, they can book a doorstep collection from the recycling center. Agile methodology consisting of requirements phase, design phase, develop phase, test phase, and deploy phase will be implemented for the development of the proposed application. Lastly, a User Acceptance Test were conducted in order to detect any defects of the proposed application. Current market in Malaysia still lack of this kind of recycling and sorting mobile application that helps push forward the milestones of recycling and sorting. That why I am here to contribute my effort to do so. The proposed application's expected outcome is to witness an increase in the number of persons participating in recycling activities. Perhaps these can reduce the household solid waste generated by Malaysian and indirectly contribute to a clean and safe environment. The second expected outcome is to public involved in the dual-stream recycling system and help collect more pure material and higher recycled waste recovery. Future work that needs to be done includes increasing dataset of machine learning training model of household solid waste from 30 to 100 so that diverse household solid waste can be scanned by the user. The second improvement can be let the user manual adjust the searching area (radius) of nearby recycling location.

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LIST OF SYMBOLS

CNN	Convolutional Neural Network
ERD	Entity Relationship Diagram
FYP	Final Year Project
SV	Supervisor
UAT	User Acceptance Test

CHAPTER 1

INTRODUCTION

1.1   Introduction

Solid waste is defined as the useless and unwanted waste in the solid-state that is created by human activities and discarded by society. The Eleventh Malaysia Plan (2015-2020) has stated that solid waste is one of Malaysia's three major environmental challenges. It certainly reduces the environment's capacity to sustain life (Sreenivasan et al., 2012). Malaysia's solid waste stream usually starts from households, industries, commercial and institutional entities and ends up at landfills, which is the primary mode of disposal (Abdel-Shafy & Mansour, 2018). There are approximately 40-60% of possibly recyclable solid wastes like paper, cardboard plastic, glass, and metals in the stream are being disposed of at landfills (Yatim et al., 2019). These recyclable solid wastes will contaminate the landfill environment and contribute to groundwater pollution, air pollution, sanitary issues, and degradation of environmental quality.

Solid waste management is a critical component of public and environmental health in society. Accumulation of solid waste that clogs drains is one of the factors contributing to the KL flash floods on 18 December 2021 says by the Department of Irrigation and Drainage Kuala Lumpur (JPSKL). They also urged Malaysians to maintain a clean environment and rivers, warning that if they do not do so, the frequency of flash floods may grow in the future. That was not all. Others issues like climate change, global warming, and deforestation should be a concern too.

In general, each person is estimated to generate 0.85 kg of solid waste daily (Zainu et al., 2017). With a population of 32 million, we can conclude that Malaysia generates more than 28000 metric tonnes of domestic solid waste per day. 18000 out of 28000 metric tonnes of solid waste are from households, which is approximately take up to 70%

(Jereme et al., 2015). What surprised us is the recyclable materials collected from households are just 1800 metric tonnes with a recycling rate of 10 percent (Kesejahteraan Bandar et al., n.d.).

Single stream recycling refers to a system in which all recyclable solid wastes are mixed in a single bin throughout the collection process. These recyclable solid wastes are collected by a single trunk and sent to the Material Recovery Facility (MRF) or any recycling center to be sorted through a variety of automated sorting equipment and hand-picking. Under the dual-stream system, residents normally will sort the recyclable solid waste before they are picked up. Malaysia is still lagging behind significantly in solid waste management practices compared to other developed countries. The most common way of recycling in Malaysia is the traditional method, otherwise known as mechanical recycling, which is only feasible for single-stream (Ministry of Environment & Water (KASA) Malaysia, n.d.).

It is critical to transforming the current system of solid waste disposal that get used by Malaysians for a long time (Ipsos, 2016). To cope with solid waste problems that burden Malaysia, we need to evolve that system although everyone is already familiar with it and it has become a habit. In January 2019, China's State Council published a "zero waste" plan and a standard for solid waste classification (Lee et al., 2020). The standard divides solid waste into four categories, each distinguished by a different colour: green for food waste, blue for recyclable trash, red for hazardous waste, and black for residual garbage. "Zero Waste" plan has forced all the citizens in China to sort their solid waste before processing it. In the same year, there were 280 applications that sort solid waste using artificial intelligence launched on WeChat (SQLI Digital Experience, 2020).

Currently, Malaysia's market still lacks this kind of recycling and sorting mobile application that helps push forward the milestones of recycling. Hence, we develop this sorting and recycling system for household solid waste based on image recognition. Extracting effective features of images is important to achieve a more accurate classification and detection of solid waste (Chen, 2021). The deep learning algorithm is implemented in the mobile application because it performs well in multiple target recognition and localization. Besides sorting, this mobile application also features the

function to search the nearby recycling center via Google Places API. Last but not least, users can also use the mobile application to book a slot for the doorstep collection of their large household items like furniture, television, refrigerators and sofa.

1.2   Problem Statement

Weak and fragile supply chain has become the largest challenge faced by current and past local recyclers (Chen et al., 2021). To meet the demand, local recyclers have imported 850000 metric tons of solid waste from China in 2018 (Muslim, 2021). Most Malaysians are still unaware of the importance of recycling which can reduce the solid waste we produce every day. This ignorance is reflected in the nation's recycling rate, which is recorded at 31.52 percent in 2021, despite government campaigns encouraging citizens to practice 3R – reduce, reuse and recycle since 1993(Bernama, 2022). Besides low awareness of the importance of recycling, many people also do not have the concept of recycling. "Why is it so hard to recycle? " is a question often asked by people. Some of them have the will to do so but they do not know how to get started in the journey of recycling. Thus, a recycling system is developed to encourage more people to engage in recycling activities.

Local recyclers complain that the single-stream recycling system that is practiced among Malaysians has troubled them a lot (Hofford, 2019). This is because although single-stream recycling is more convenient with just one recycling bin is needed, it results in more contamination and low quality recyclable solid waste. For example, the juices, sauces, or liquid in the bottle will contaminate the high-grade paper into low-grade paper. Things go worse when glass tends to shatter during the collection process. Besides that, local recyclers also complain that they need to spend extra money on buying and maintaining the automated sorting equipment due to the practice of a single-stream recycling system. Single-stream recycling system inherent difficulty for those start-up local recyclers that do not have funds to invest in additional sorting technology. On average, single-stream recycling is 28.5% more expensive than dual-stream recycling (Lakhan, 2015). For long-held assumptions, local recyclers who seek to cut costs at the expense of overall recycling advised the public to practice a dual-stream recycling system. That is not all. Household items are diverse and this certainly increases the difficulties to sort them based on their physical and chemical characteristics before undergoing any treatment process (Abdel-Shafy & Mansour, 2018). By saying all of this,

this mobile application will provide information regarding how to sort household solid waste to the user to encourage them to be involved in the dual-stream recycling system.

When the user tends to sort the household solid waste in a mobile application, generally they will enter the name of the household solid waste on the search bar. Based on the input he or she enters, a group of information will be shown to the users. A very common situation faced by the users is they are not sure about the name of the household solid waste. So, sorting the household solid waste using the traditional way can be horrible because nowadays users can only search based on the name of the household solid waste. When they are not sure about the name of household solid waste, they must try and error and keep on searching it. This consumes a lot of time. Gradually, they will lose patience which results in a bad user experience and dissatisfaction. In addition, their enthusiasm for recycling will be diminished soon and lower the national recycling rate. Hence, the implementation of image recognition in the recycling system enhances the user experience by allowing the users to take a picture of the household solid waste to search it. This certainly also speeds up the sorting process.

After sorting, users have to send the household solid wastes to the recycling center by themselves. In this process, they may notice there are some household solid wastes that are out of their ability and cannot be sent by themselves. Furniture like sofa and electronics and electrical appliances like washing machines, and refrigerators are examples that cannot fit in the car. Thus, users have to search for a lorry pick up service from a reliable third party for these bulky household solid wastes. This is why we should create a booking system for our users. We wish to create a one-stop recycling mobile application for the users and minimize their inconvenience. "karung guni" aunties and uncles only collect things they can sell (Jay, 2021). If the users require service from a transport company like Lalamove, they have to pay for that and increase their financial burden. Therefore, a norm that can be seen in Malaysia is these bulky household solid wastes are being thrown along the roadside. In conclusion, a booking system must exist in our project to minimize this situation and users' inconvenience.

1.3   Objective

The objectives of this project are as the following:

   i.   To identify the current limitation of the existing application of the recycling system.

  ii.   To develop a mobile application that helps provide information regarding sorting recycled solid waste into categories based on image recognition using a neural network.

 iii.   To evaluate the functionalities of the proposed system.

1.4   Scope

The scopes of this project are as the following:

   i.   The mobile application is developed only for Android-based smartphones with an internet connection.

  ii.   It is free to install without any in-app purchases.

 iii.   This mobile application is targeted at Malaysians.

1.5　Significance

i.　Malaysia residents

Before recycling, Malaysians can easily sort their household items into categories by capturing a photo using the mobile application. Besides that, they can also search and filter the nearby recycling location by using this mobile application. If the household solid waste is too big like furniture and unable to send by themselves, they can book a slot for doorstep collection.

ii.　Staff of Recovery Facility/Recycle center

Recovery Facility or Recycle center acts as a player that processes all the household solid waste after collecting it. The staff of the recovery facility need to approve or reject the booking from users.

1.6 Thesis Organization

This report contains five chapters.

Chapter 1 explain the project's overview including the introduction, problem statements, objective of the project, scope, significance, and thesis organization.

Chapter 2 briefly explain the literature review on existing systems of sorting and recycling system for household solid waste.

Chapter 3 explains the methodology used in this project. The stages that are used in this project are Requirements, Design, Develop, Test and Deploy. Besides that, the interface design of the mobile application will be drafted. The hardware and software requirements are listed.

Chapter 4 explains about results and discussion based on the development and testing of this project. In this chapter, all the results and output of the project were briefly discussed. These include software development, application testing, collecting data and the result of the project.

Chapter 5 will conclude and summarize the final result of this project.

.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many things that need to take into account before developing the sorting and recognition recycling system. In this chapter, three relevant existing systems will be chosen and compared with the proposed mobile application. The three existing mobile applications will be reviewed, explained, discussed and compared. The advantages, disadvantages and comparisons of the existing applications and the proposed mobile application will also be discussed based on their features, function, platform and other relevant aspects. The result of the comparison will be taken as guidelines in developing this mobile application to enhance users' experience and system performance. This chapter aims to give a better view and understanding of what the proposed mobile application should be able to develop.

2.2 Existing Systems

The three existing systems which are similar to the proposed mobile application are MyEwaste, Recycle Smart and Recycle Coach. The existing applications will be explained, analysed and discussed in this section. The discussion aims to have better enhancement and avoid any possible bugs in the proposed application by comparing the advantages and disadvantages of these applications.

2.2.1 MyEwaste

E-SISA is a web-based recycling system developed by the Department of Environment (DOE). The website link of the E-SISA web-based system is https://ewaste.doe.gov.my/. It is an official website developed by the government of Malaysia to specially deal with e-waste. E-waste is electrical and electronic appliances that are broken, non-functional,

old, or obsolete. Printers, lamps, rice cookers, microwave ovens, and computer monitors are examples of e-waste.

In 11 March 2021, MyEwaste, a mobile application for e-waste management is launched by the Department of Environment (DOE). MyEwaste mobile application function is quite similar to E-SISA web-based system. Both of them aim to facilitate the public in providing information, assist in sending their e-waste and identify the nearest collection centers. This application is available in Android Play Store and iOS App Store. Users can download the mobile application by scanning the qr code as shown in Figure 2.1.

Figure 2.1 QR code to download MyEwaste mobile application

In detail, MyEwaste/E-SISA mobile application system collects 6 types of E-waste: air conditioners, computers and laptops, mobile phones, refrigerators, television, and washing machine only. The user can see the type of E-Waste collected once they login to the homepage. The interface of Home Page can refer to Figure 2.2.
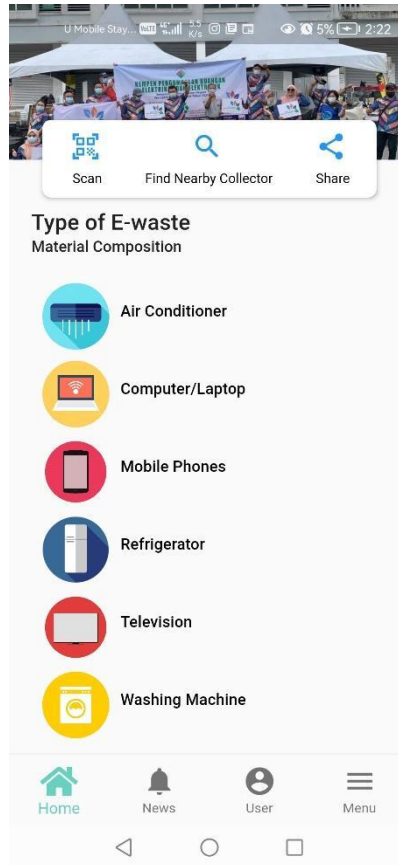
Figure 2.2 Home page in the in MyEwaste mobile application

The only special feature that can be found in MyEwaste mobile application is users can preview the material composition of E-waste after clicking the e-waste icon in the Home Page. For instance, Figure 2.3 show the design of the material composition of air conditioner.
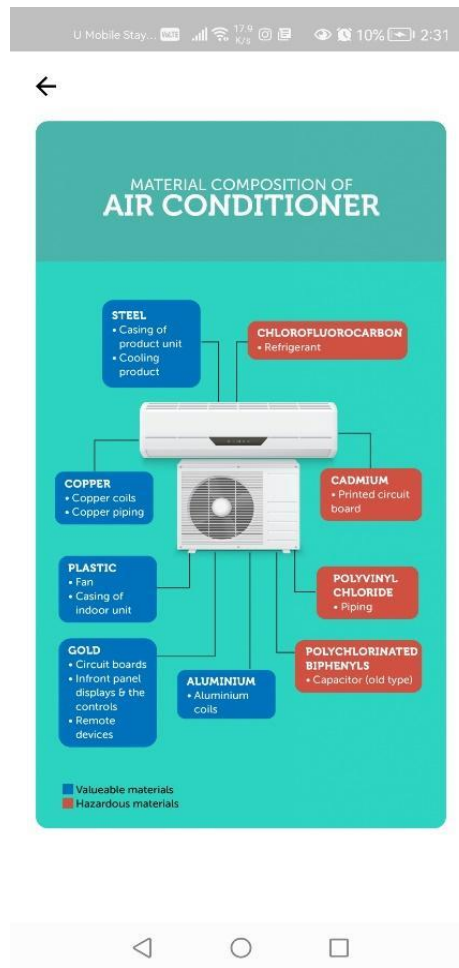
Figure 2.3 Material composition of e-waste in MyEwaste mobile application

Figure 2.4 show that MyEwaste/E-SISA system allows the users to search the nearby collection center and recovery facilities via Google Maps. Collection center here refers to the players that collect the E-waste like NGOs, school institutions, recyclable buyers, and charity organizations while recovery facility refers to a facility that has been licenced by the Department of Environment (DOE) to process household E-wastes. Figure 2.4 also show that users can search based on the category of E-waste in MyEwaste mobile application. For example, if the users select computer/laptop, the mobile application will list out the nearby recovery facilities or collection center that collect computer/laptop. The mobile application will provide information like name, address, phone number, and distance between the user and the recycling center. For example, Figure 2.5 show that nearby recycling center is Kampung Jaya Recycling Centre that located 41.5 km away from the user.
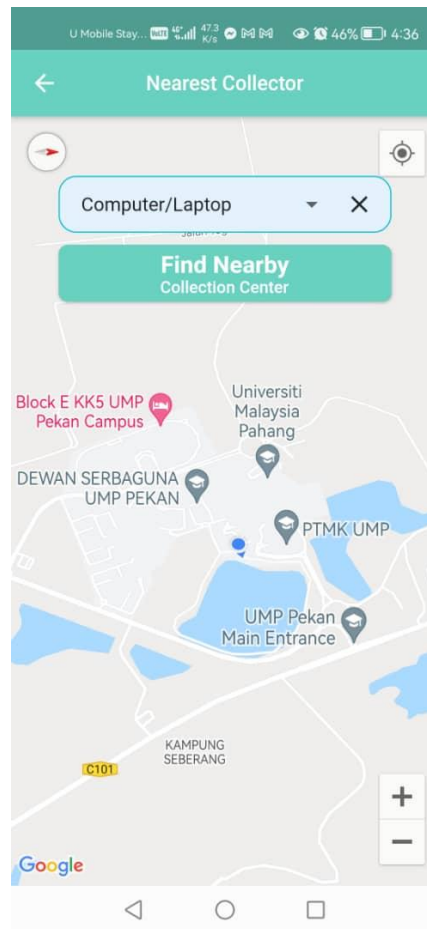
Figure 2.4 Search function that find nearby collection center and recovery facility in
MyEwaste mobile application

Figure 2.5 List of collection center and recovery facility in in MyEwaste mobile
application

Besides that, MyEwaste/E-SISA users can also read the latest news regarding e-waste. After clicking the news button, MyEwaste will list out the news like notification interface as shown in Figure 2.6. User just need to click into the news they interested to read it.

Figure 2.6 Newspaper clip in MyEwaste mobile application

Figure 2.7 show that E-SISA system users can view the latest updates on programs and activities organized by the government. Infographics and videos can also be watched by the E-SISA system users from time to time. More details about the infographics and videos is show in Figure 2.8 and Figure 2.9. Frequently Asked Questions that are available in the E-SISA web-based system can also solve the user's query. Until this cut-off point, these features are still unavailable in MyEwaste mobile application. MyEwaste is available on Google Play Store and Apple App Store. Users need to register through email to unlock more features. It is totally free of charge.
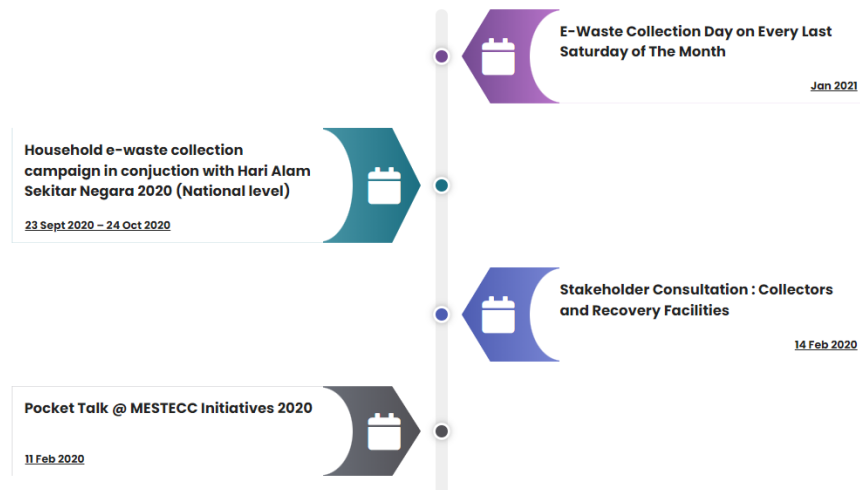
Figure 2.7 Infographic timeline of governments' programs and activities in E-SISA web-based system

Figure 2.8 Infographic in E-SISA web-based system

Figure 2.9 Video in E-SISA web-based system

2.2.2 Recycle Smart

Recycle Smart is an innovative waste management company founded by Giorgio Baracchi on 29 august 2019. Its mission is to make household solid waste recycling as easy as ordering a grab through Recycle Smart mobile application.

The idea is simple. Recycle Smart mobile application users book a pickup and left their household solid waste outside. Then, the drivers will come to their house to collect it. What makes Recycle Smart different from others is they will plant a tree for each bag collected.

Figure 2.10 show that Recycle Smart picks up four categories: soft plastic, clothes, e-waste and problem waste. Basically, Recycle Smart focuses its business in Australia only. The service is currently available to Hunters Hill Council, Willoughby City Council, Inner West Council, City of Canada Bay Council, City of Sydney Council, etc.

Figure 2.10 Pickup page in Recycle Smart mobile application

There are 12 categories of solid waste in Recycle Smart mobile application. These include household, plastic, food, electronics, batteries, paper and cardboard, glass, chemical, metals, garden, automotive and construction. Recycle smart mobile application will provide information to users when they search for an item in the search bar. By referring Figure 2.11, we can know that the search bar is located on the top of the Home Page.

Figure 2.11 Home Page of Recycle Smart mobile application

When the users search for "plastic container with food", it will show the users information like "rinse the container before disposing container in the yellow bin". For more information, please refer to Figure 2.12.
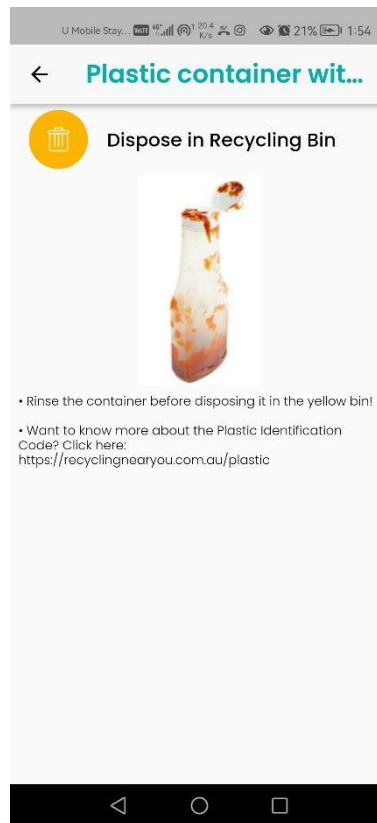
Figure 2.12 Example of information provided by Recycle Smart mobile application

Recycle Smart mobile application is available on Google Play Store and Apple App Store. Users need to register to unlock more features. Email is needed during registration. Besides that, users can choose to sign in with Facebook or Google account. Figure 2.13 show the subscribe plan in Recycle Smart mobile application. Currently, they offer two plans which are "Yellow Fish" and "Teal Turtle". "Yellow Fish" plan allows users to book a pick up at any time based on their convenience but each bag will be charged $2. "Teal Turtle" plan allows users to have a free pickup once a month and up to two bags every pickup. An additional bag will be charged $2. Maximum 10 bags per pickup. Payment can be made via Master Card and Visa card. Pickup time for "Teal Turtle" is fixed once the users have decided it. Before subscribing, the user will be given to choosing one day from the month to pick up the bags. For example, if the users select 27th April, then the next pick up will be on 27th May. Payment can be made via Master Card and Visa card.
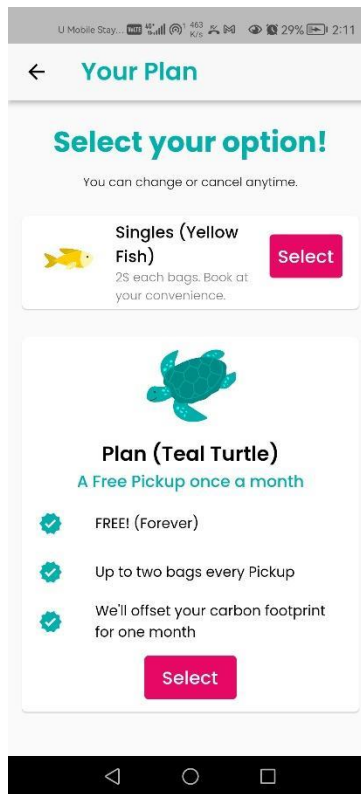
Figure 2.13 Subscribe plan page in Recycle Smart mobile application

2.2.3 Recycle Coach

Recycle Coach is a recycling calendar company founded by Creighton Hooper in 2001. Recycle Coach mobile application is a recycling education platform that spread knowledge about recycling to help communities work together to waste less and recycle more. Currently, Recycle Coach's service is only available in North America and Europe.

Figure 2.14 show the main highlight of Recycle Coach mobile application which is calendar features. It includes a personalized collection, event schedule, and pick-up reminders. Users can customize collection calendars based on the address they enter. On the collection day, a pick-up reminder will send to the users.

The second feature offered by Recycle Coach mobile application is the "Where Goes Where Search Tool". This search tool is linked with a comprehensive database of various household solid wastes. By using the search tool, users can get the pick-up and drop-off details of the household solid wastes.

Third, report a problem. Users can report issues such as missed collections or a broken cart that needs to be replaced in the community via Recycle Coach mobile application. Figure 2.14 show that name, email, address and issue is required to fill in when reporting a problem.
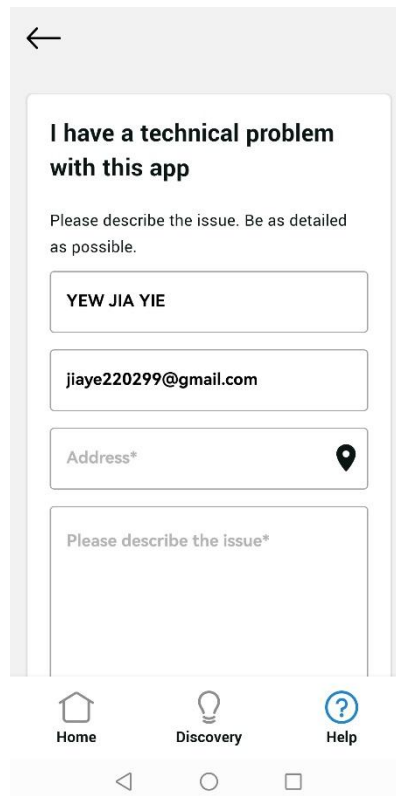
Figure 2.14 Report Page of Recycle Coach mobile application

Lastly, launch assistance is one of the features offered by Recycle Coach. After downloading Recycle Coach, users can know everything about recycling. Latest waste management programs, events, and news will be updated from time to time. All these is available in the discovery zone as shown in Figure 2.15.
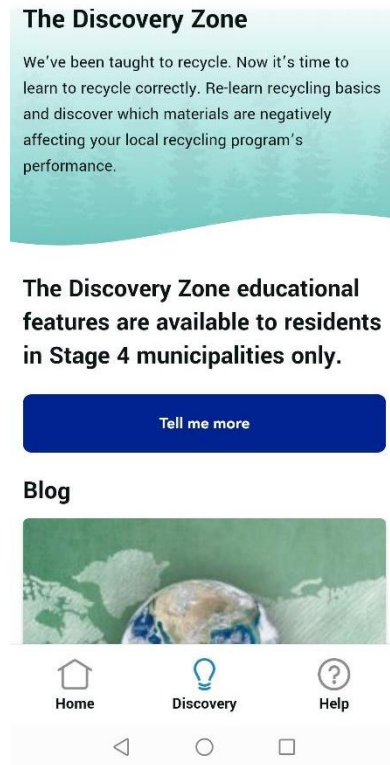
Figure 2.15 Discovery zone of Recycle Coach mobile application

Recycle Coach mobile application is available on Google Play Store and Apple App Store. You may download the mobile application by scanning the QR code as shown in Figure 2.16.

Figure 2.16 QR code to download Recycle Coach mobile application

2.3   Comparative Analysis

In this section, a comparison table will be built based on different aspects to compare the existing applications with the proposed application in Table 2.1. The advantages and disadvantages of the existing application will be discussed in Table 2.2.

Table 2.1 Comparison of the three existing applications and the proposed application

Specification	MyEwaste	Recycle Smart	Recycle Coach	Proposed Application
Application Type	Mobile	Mobile	Mobile	Mobile
Platform	iOS and android	iOS and android	iOS and android	Android
Application Size	66.8 MB in iOS 39MB in android	72.4 MB in iOS 54MB in android	56.5 MB in iOS 32MB in android	Expected to be 40-50 MB
Application Compatibility	Requires iOS 11.0 or later	Requires iOS 14.0 or later	Requires iOS 12.0 or later.	Requires Android 5.0 and above

	Requires Android 5.0 and above	Requires Android 5.0 and above	Requires Android 4.1 and above	
Application Category	Lifestyle	Education	Education	Education
Version	1.0.4	7.4.2	15.5.0	1.0.0
Search function for sorting	×	√	√	√
Image recognition	×	×	×	√
Information on how to deal with the household solid waste	×	√	√	√
Search and filter nearby recycling location	√	√	√	√
Booking system	×	√	×	√

Collection tracking	×	×	×	√
Hardware requirement	Devices running iOS and Android with camera	Devices running iOS and Android	Devices running iOS and Android with camera	Devices running Android with camera
Access permission	Wi-FI connection information, location, phone, photo gallery, storage, camera, microphone	Wi-FI connection information, location	Wi-FI connection information, location, phone, photo gallery, storage, camera, Device ID & call information,	Wi-FI connection information, location, photo gallery, storage, camera,
Language	English and Bahasa Melayu	English	English	English
Service area	Malaysia	Australia	Europe and North American countries	Malaysia

Table 2.2 Comparison table of the advantages and the disadvantages of the three existing applications and the proposed application

Existing Application	Advantages	Disadvantages
MyEwaste	Price ● Free to use Special features ● Users can view the material composition of the e-waste ● Users can share on social media ● Include QR code scanner integration Ease of use ● Net and clean interface ● Easy to use ● More language of availability ● Allow users to browse in dark mode	● Only recycle for e-waste

	Others ● Information and news regarding e-waste can be found in the mobile application	
Recycle Smart	Price ● Each bag collected will be charged $2 Special features ● Detailed sorting by categorising the household solid wastes into 12 category Ease of use ● Attractive interface	● Only English language is available ● Only serve for Australia country
Recycle Coach	Price ● Free to use Special features	● Only English language is available ● Only serve North American and Europe countries

	● Has a personalized collection calendar, event schedule and pick-up reminder ● Users can report issues that happen in the community ● Has help desk system Ease of use ● Overcomplicate the icon designs ● Difficult to recognize the function of icons Others ● Allow push notifications	
Proposed Application	Price ● Free to use Special features ● Implement image recognition for sorting household solid wastes	● Only English language is available ● Only for Android

	● Has collection tracking system Ease of use ● Clean, neat, and attractive interface ● Design a walkthrough screen for beginner's user	

2.4   Chapter Summary

In conclusion, each application has its unique feature and some may have a lot of improvement to move on. Overall, the three existing applications are good and perform well in each service area. The main function of the three existing applications is to recycle and sort household solid wastes. From the studies done, the proposed application stands out from others by implementing image recognition for sorting household solid wastes in the application. Another superiority of the proposed application is it has collection tracking features. Lastly, just this quick line to remind you that the proposed application service area is Malaysia.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the methodology used to develop the sorting and recognition recycling system. The methodology that going to be discussed includes design, interface, framework architecture as well as project requirements. In addition, the system flow of the main module of the system is drawn in the flowchart in order to brief the process.

3.2 Project Management Framework

The project management framework is a structured and systematic approach to software development. In other words, it is a methodology for structuring, planning, and controlling the process of developing a system. The common software development methodologies are waterfall development, agile development, spiral development, DevOps development and rapid application development (RAD). Each of these development methodologies is associated with different advantages and disadvantages.

After deep consideration of the team structure, experience, project requirement, goals and budget, the agile model methodology is chosen to develop the sorting and recognition recycling system. Agile development is a combination of iterative and incremental model of software development. Agile development methodology is chosen because this approach is well-suited to the development of the sorting and recognition recycling system as it can appropriately meet the specific requirements of the context within 2 semesters of the final year project (FYP). On the other hand, agile methodology focuses on users' needs and reduces the risk of defects when implementing new requirements or functionalities. Agile methodology has 5 stages which are Requirement,

Design, Develop, Test and Deploy. This cycle will continue to run as many times as possible to adapt to feedback from the user to ensure users' satisfaction. Through Agile development, it allows the users to validate the outcome of whether the system meets their needs. The agile development methodology can be represented in Figure 3.1.
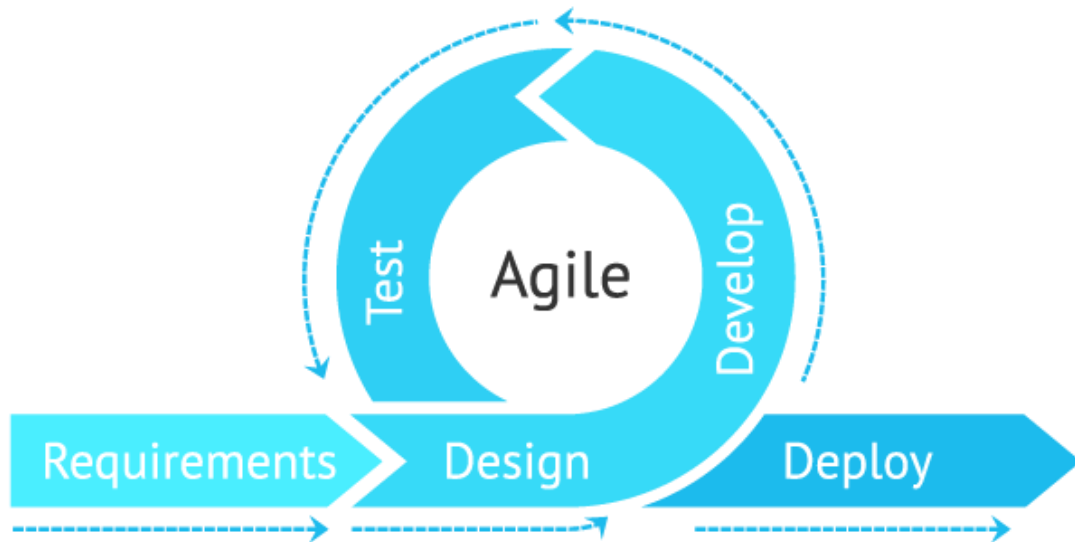
Figure 3.1 Agile methodology

3.2.1 Requirements Phase

Requirements is the first phase of Agile development and this phase is also known as define phase. It is mainly focusing on gathering and analyzing the requirements of the proposed system. Before that, the problems of the current existing application system have determined through a literature review. After that, I define the requirements of the proposed system based on the problems I figured out. For example, I notice it is difficult to understand the purpose of the icons in the Recycle Coach mobile application. Based on Figure 3.2, there are a money and building symbol in the top navigation bar of the Recycle Coach home page. It is confusing the user. Thus, the design of the icon in the proposed system should be simple. This certainly will improve the user experience and the performance of the proposed systems.
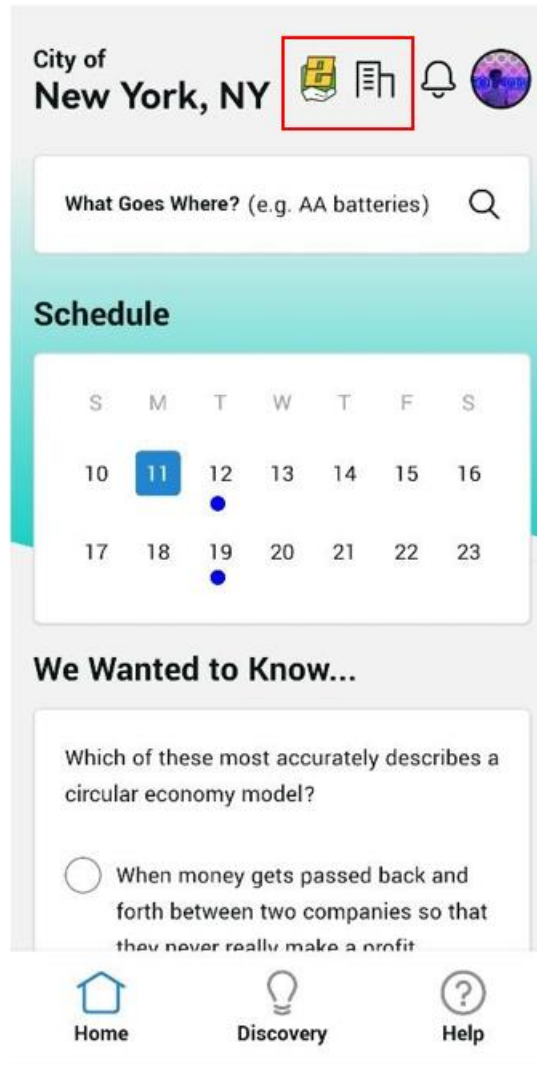
Figure 3.2 Home Page of the Recycle Coach mobile application

Actually, requirements are categorized into types which are functional requirements and non-functional requirements. Functional requirement is what a system must do and what functions and features it must offers (Cleland-Huang, 2007). For instance, the system must allow users to reset their password by clicking on "forgot password" and receiving a link to their verified email address. Non-functional requirement describes the general properties of a system. They are also known as quality attributes (Paech & Kerkow, n.d.). Quality attributes here can refer to security, reliability, performance, maintainability, scalability and usability. For instance, when the "forget password" button is clicked, a link must be sent to the user's verified email address within 3 seconds. Further details of the requirements of the proposed system will be list in chapter 3.3 project requirements.

3.2.2 Design Phase

Design is the second phase of agile development. It mainly focuses on designing the system architecture and flow of the proposed system. Parts of it will be present as UML diagram. For example, context diagram, use case diagram, activity diagram, and entity relationship diagram (ERD). On the other hand, data dictionary, hardware and software requirements will be present in table form. In this phase, programming language and machine learning which will be implemented in the proposed system are determined. After a discussion with supervisor, I decide implement machine learning model which is Convolutional Neural Network (CNN) in my FYP for the image recognition of the sorting of the household solid waste. In addition, with the agreement from supervisor, Google Places API is also implemented for the purpose of searching nearby recycling location. All these documents are drafted and reviewed by the supervisor before starting development phase.

3.2.3 Develop Phase

Develop is the third phase of agile development. This is the phase that implements source code to develop the proposed system based on the flows designed according to the defined requirements. However, this phase will consume a lot of time because this phase will convert all the documentation made into an actual product.

3.2.4 Test Phase

The application developed in the previous phase is tested through a variety of tests. Tests like testing the image recognition with different sources, successfully booking for the collection tracking system and the system should be able to load the home page within 5 seconds when opening the mobile application are carried out. A complete test plan are drafted to test the system to ensure that the proposed system is working as stated in the document and error-free. This phase is crucial because it will help to confirm the proposed system meets the goal and users' needs. If any bugs, defects, or critical issues were noticed, it is solved in this phase too. After that, final testing known as User Acceptance Testing (UAT) are carried out by the users. Feedback from the users are collected by using Google Form.

3.2.5   Deploy Phase

Deployment is the last phase of Agile development. An error-free and complete mobile application is released to end users. After deploying, the system is ready for the final year project evaluation.

3.3   **Project Requirement**

        Well-defined project requirements will lead to a successful project. According to the statistics from the editor's choice, 70% of projects fail globally. That is not all. Unclear requirements will increase the project timeline and budget up to 60%.

        In the requirement phase, a survey form was conducted and send out to UMP students. The total sample is 40 persons. The purpose of the survey form is to collect the demographic background and the requirements of the proposed recycling and sorting application in order to have the detailed definition of the system requirements.

Category A: Demographic Background

The question in this category were to get the demographic background of the users of this type recycling and sorting application. The question in this survey aims to investigate the popularity of the recycling and sorting application among Malaysian. Besides that, this survey target to figure out is the proposed application able to achieve its objective.

Question 1

Based on the result in question 1, we can conclude that most of the respondents have practice recycling activity in their daily life. From the analysis, 72.5% of them chose the "Yes" option and 27.5% of the respondents chose the "No" option which represented 29 respondents and 11 respondents respectively. This result tells us that most of the undergraduate have the awareness about the importance of recycling. They have the concept of recycling. This statistic is in contrast with the nation's recycling rate which just recorded at 31.52% in 2021.

Are you participating in any recycling activity?
40 responses
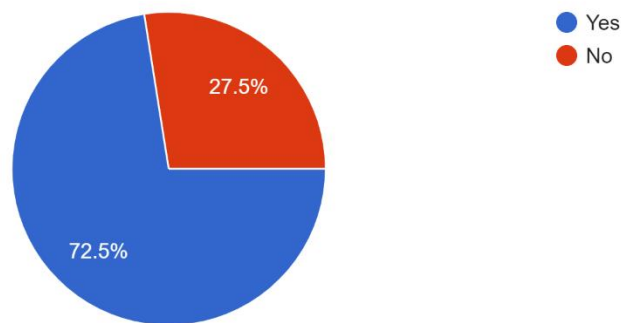
Figure 3.3 Are you participating in any recycling activity

Question 2

Based on the result in question two, we can conclude that most of the respondents do not use the recycling and sorting application before. From the analysis, 62.5% of them chose the "No" option and 37.5% of the respondents chose the "Yes' option which represented 25 respondents and 15 respondents respectively. This result show that the use of recycling and sorting application still not popular and common for the public. Hence, there is a need for the proposed application to exist so that it may help and providing information about the recycling for the public.

Have you used any recycling and sorting application before?
40 responses
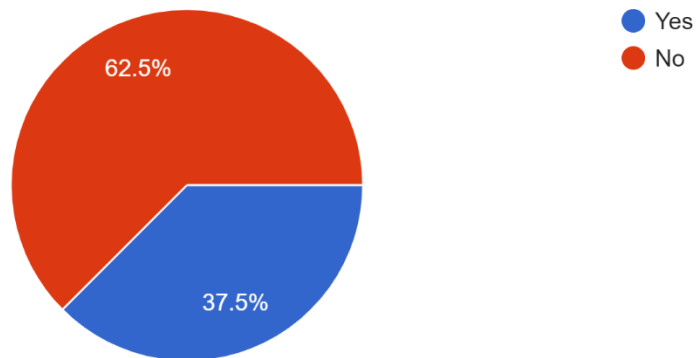
Figure 3.4 Have you used any recycling and sorting application before

Question 3

Based on the result in question three, we can conclude that all the respondents aware that the environment is contaminated by rubbish. 40 respondents have selected the "Yes" option. This result show that our environment is severely contaminated and lower down the quality of our daily life. That why all the respondents already notice it.

Do you aware the environment is contaminated by rubbish?
40 responses
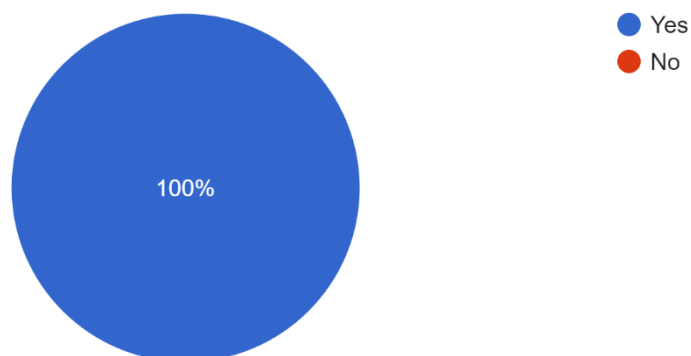
Figure 3.5 Do you aware the environment is contaminated by rubbish

Question 4

Based on the result in question four, we can conclude that most of the respondents think that recycling and sorting application can help in increasing awareness of the importance of recycling. From the analysis, 82.5% of them chose the "Yes" option and 17.5% of the respondents chose the "NO" option which represented 33 respondents and 7 respondents respectively. The reason of this result probably is because they think that the proposed application can act as a medium to share information and let more people know about the recycling. Indirectly, it may increase the awareness of the importance of recycling.

Do you think recycling and sorting application can help in increasing awareness of the importance of recycling?
40 responses

Yes
No

17.5%

82.5%
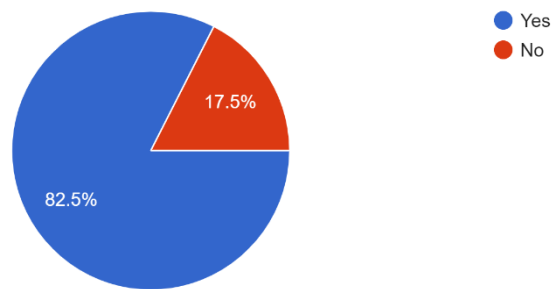
Figure 3.6 Do you think recycling and sorting application can help in increasing awareness of the importance of recycling

Question 5

Based on the result in question five, we can conclude that most of the respondents think that recycling and sorting application can help in increasing the number of the people participating recycling activity. From the analysis, 90% of them chose the "Yes" option and 10% of the respondents chose the "NO" option which represented 36 respondents and 4 respondents respectively. The reason of this result probably is because they think that by using the proposed application can encourage more people to participating the recycling activity. This is because the proposed application had a search function that filter the nearby recycling center for the users. It makes the users more convenience.

Do you think recycling and sorting application can help in increasing the number of people participating in recycling activity?
40 responses
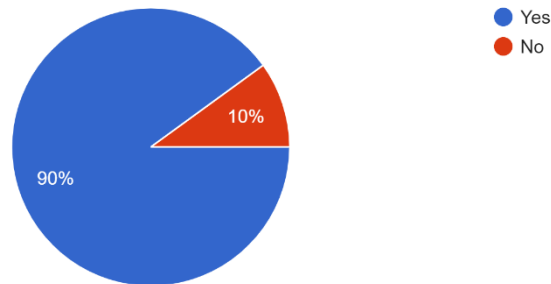
Figure 3.7 Do you think recycling and sorting application can help in increasing the number of people participating in recycling activity

Category B: Feature Requirement

In this section, the questions asked in the survey is to collect the requirements for the proposed application.

Question 6

Based on the result in question six, we can conclude that most of the respondents prefer the proposed application designed with colourful layout. From the analysis, 55% of them chose the "No" option and 45% of the respondents chose the "Yes" option which represented 22 respondents and 18 respondents respectively. The reason of this result probably is because colourful design is more attractive. User may not easily get

aesthetically tired. Although black and white colour is simple, but in long term use the user will feel boring for this design.

Will it be good if the application is designed with black and white colour?
40 responses
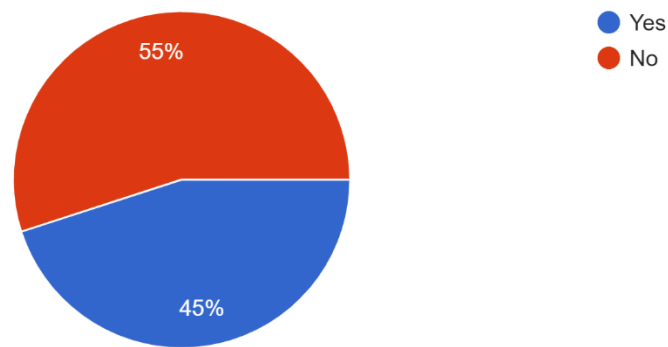
Figure 3.8 Will it be good if the application is designed with black and white colour

Question 7

Based on the result in question seven, we can conclude that most of the respondents prefer the bottom navigation as the home page layout. From the analysis, 70% of them chose the "Bottom Navigation" option and 30% of the respondents chose the "Side Navigation" option which represented 28 respondents and 12 respondents respectively. The reason of this result probably is because most of the application in the market applied bottom navigation bar. Hence, user already get used to it.

Which home page layout design you prefer?

40 responses
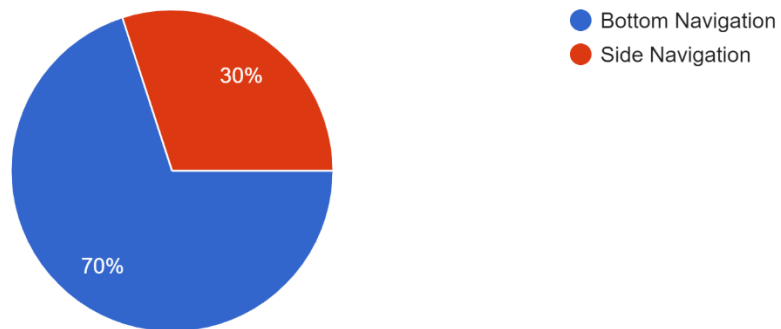
Figure 3.9 Which home page layout design you prefer

Question 8

Based on the result in question eight, we can conclude that most of the respondents think that it will be helpful if the application can search the location of the nearby recycling center based on the GPS sensor. From the analysis, 97.5% of them chose the "Yes" option and 2.5% of the respondents chose the "No" option which represented 39 respondents and 1 respondent respectively. By referring to the pie chart, generally, the respondents were glad to see the proposed application to have the feature of searching the location of the nearby recycling center. With this feature, user who wants to send the recyclable waste to recycling center can search the location more faster with just clicking a few buttons in the proposed application.

Will it be helpful if the application can search the location of the nearby recycling center based on GPS?

40 responses
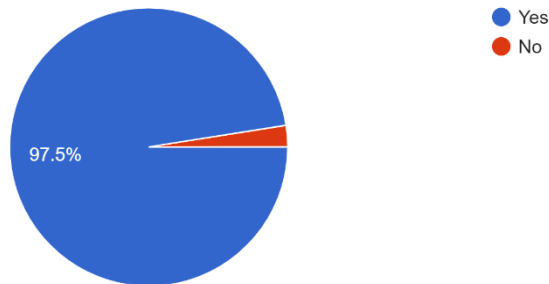
Figure 3.10 Will it be helpful if the application can search the location of the nearby recycling center based on GPS

Question 9

Based on the result in question nine, we can conclude that most of the respondents think with the implementation of image recognition can let the user search a waste with less effort. From the analysis, 80.0% of them chose the "Yes" option and 20.0% of the respondents chose the "No" option which represented 32 respondents and 8 respondents respectively. By referring to the pie chart, generally, the respondents were glad to see the proposed application to have the feature of searching the waste by using image recognition. With this feature, user who not sure with the waste keyword can easily search it by capturing the image of the waste.

Do you think with the implementation of image recognition can let the user search a waste with less effort.
40 responses

● Yes
● No

20%
80%
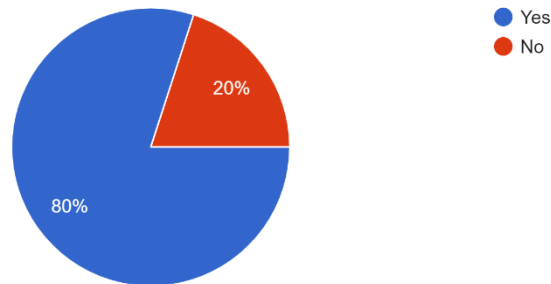
Figure 3.11 Do you think with the implementation of image recognition can let the user search a waste with less effort

Question 10

Based on the result in question tenth, we can conclude that most of the respondents think that it will be more convenience if the proposed application has a booking system to collect the bulky household solid waste. From the analysis, 87.5% of them chose the "Yes" option and 12.5% of the respondents chose the "No" option which represented 35 respondents and 5 respondents respectively. By referring to the pie chart, generally, the respondents were glad to see the proposed application to has the booking system. With this feature, user can deal the bulky household solid waste by using the service provided in the proposed application. They no need request a service from the third party anymore.

Will it be more convenience if the application has a booking system to collect the bulky household solid waste?

40 responses
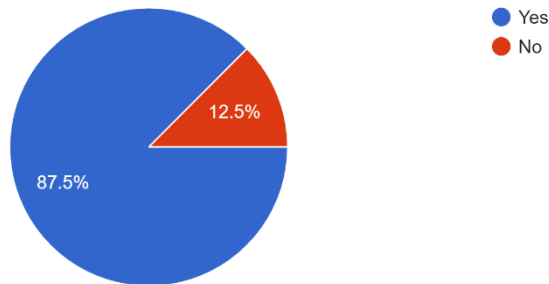
Figure 3.12 Will it be more convenience if the application has a booking system to collect the bulky household solid waste

Question 11

Based on the result in question eleventh, we can conclude that most of the respondents think it is necessary to have a collection tracking system. From the analysis, 75.0% of them chose the "Yes" option and 25.0% of the respondents chose the "No" option which represented 30 respondents and 10 respondents respectively. By referring to the pie chart, generally, the respondents were glad to see the proposed application to has the collection tacking system. With this feature, user can check the status of the booking from time to time and get ready for the doorstep collection.

Do you think is it necessary to have a collection tracking system?
40 responses

Yes
No

25%

75%
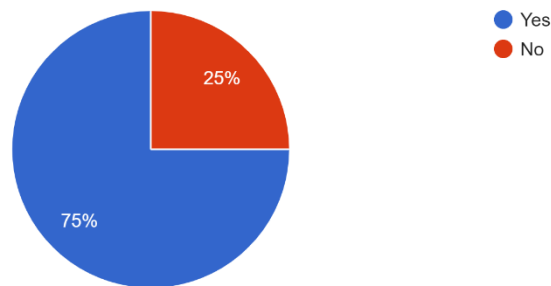
Figure 3.13 Do you think is it necessary to have a collection tracking system

Question 12

Based on the result in question twelve, we can conclude that most of the respondents want to know more tips in handling the household solid waste. From the analysis, 85.0% of them chose the "Yes" option and 15.0% of the respondents chose the "No" option which represented 34 respondents and 6 respondents respectively. The feature of providing tips in handling the household solid waste is subjective as those respondents who do not want the tips may because they think they are expert in this fields. Different from the respondents who do not want this feature, those respondents who want this feature may be because they want to have a better knowledge in handling the household solid waste.

Do you want to know more tips in handling the household solid waste?

40 responses
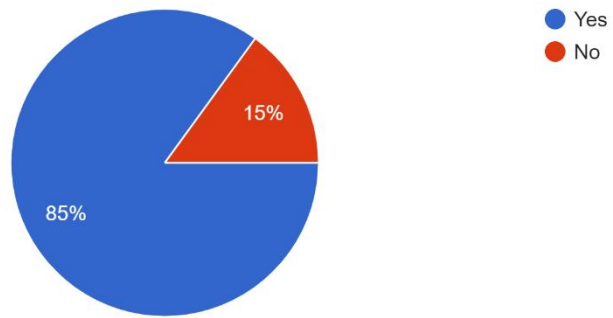
Figure 3.14 Do you want to know more tips in handling the household solid waste

3.3.1 Functional and Non-Functional Requirements

Functional Requirements:

    i.   The system shall integrate with Google Places API to search and filter the location of nearby recycling center.

   ii.   The system shall authenticate a user when he or she tries to log into the system.

  iii.   The system shall update the profile information once the user clicks the update button

  iv.   The system shall allow users to search and filter specific recycling location

   v.   The system shall allow users to search and filter nearby recycling locations.

  vi.   The system shall allow users to book a doorstep collection.

 vii.   The system shall allow users to view the pickup status.

viii.   The system shall allow users to search for sorting.

  ix.   The system shall display the information on how to deal with the household solid waste items when users search for sorting.

   x.   The system shall allow users to use image recognition to search for sorting.

Non-Functional Requirements:

    i.   The system shall design with a colourful layout.

   ii.   The system shall design bottom navigation bar in the home page.

  iii.   The system shall meet or exceed 99% uptime.

  iv.   The system shall process each request within 10 seconds.

   v.   The system shall not exceed 3 hours when there is a downtime after a failure.

  vi.   The system shall allow users to view a page within 3 seconds.

 vii.   The system shall be able to support average traffic loads of up to 1000 simultaneous users without impacting performance.

viii.   The system shall transmit data in encrypted form.

  ix.   The system shall be able to accommodate new functions without major reengineering.

   x.   The system defect rate shall be less than 1 failure per 1000 hours of operation.

  xi.   The system shall leave all database contents and all personal settings unchanged when there is an installation of a new version.

 xii.   The application CPU utilization for the agreed workload and user concurrency should be no more than 50% at peak.

3.3.2 Constraint

Project constraints are defined as the general limitation factors which need to account for throughout the project life cycle. The most common constraint is the "Iron Triangle". The idea of the Iron Triangle is presented in Figure 3.3. The Iron Triangle is a framework that helps in balancing the competing demands of cost, time and scope (Atkinson, 1991). These three constraints are mutually dependent on each other (Ebbesen & Hope, 2013). For example, the increase in project scope will increase the amount of time taken to complete the project which also contributes to the increase in budget.

Figure 3.15 Iron Triangle

Scope:

Understanding the content and boundaries of the project scope is a must before writing the first project requirement statement. Application behaviour is defined by project requirements. They reveal what users expect from the proposed application. The project scope describes the activities that must be completed in order to meet the requirements.

The scope of this project is a mobile application system that provides a collection tracking system as well as image recognition for sorting household solid wastes for Malaysians. In addition, a search engine and filter function of nearby recycling locations are implemented in the proposed application system too. Lastly, information on how to

deal with household solid waste is also available. Advertising of products and account billing are not parts of this project. Issues of security are also not our main concern. Be aware that this project is not about finding technical solutions to recycling but is implementing the existing and accumulated knowledge about recycling in the proposed application system.

Cost:

Cost is simply the amount of money that can be used for developing the proposed application system for the Final Year Project (FYP). Sadly to say that there is no budget for it. Hence, an effort is well spent in finding an open-source software and API as well as free version resources.

Time:

Gantt chart for PSM1 and PSM2 will be attached in Appendix A.

3.3.3   Limitations

The limitations of the proposed application are that this application can only be installed on Android devices. The proposed application can only work in Android devices with Android 5.0 and above operating system as well as API level 30. The proposed application can only recognise 30 household solid waste items. The user needs to key in specific and accurate words to be able to search for sorting and nearby recycling locations.

3.4 Use Case Diagram

Use case diagram is a UML diagram that visualizes the relationships between use cases, actors, and systems. This application contains 5 actors. The actors are general users, collectors, staff of recovery facilities, convolutional neural network (CNN) and Google Map API. In this application, there are six modules which are Manage Sign Up, Manage image recognition, Manage sorting, Manage nearby recycling location search, Manage booking system and Manage collection tracking.
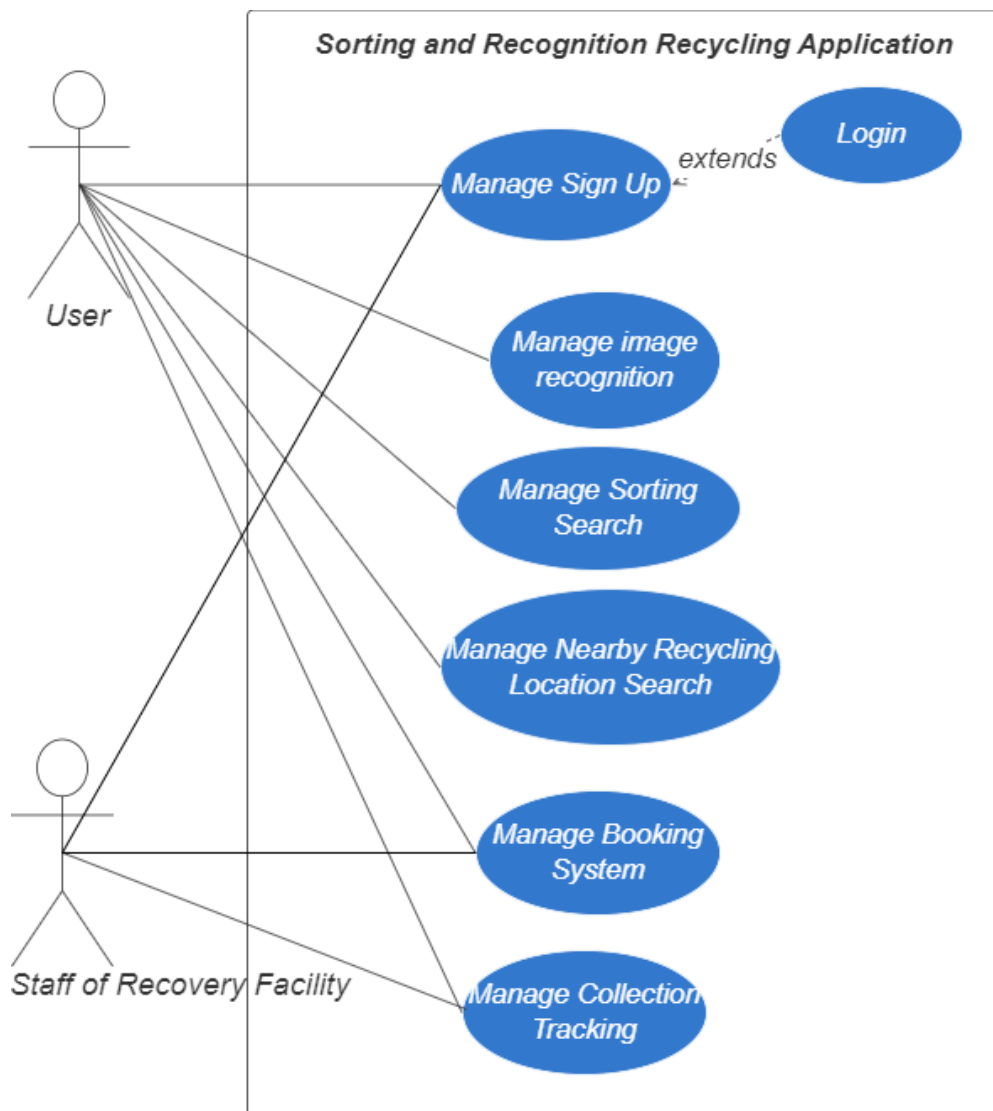
Figure 3.16 Use case diagram of Sorting and Recognition Recycling Application

The following table are the list of the use case description:

Table 3.1 Use Case Description

Modules	Functions	Actors
Manage Sign Up	This use case allows user to sign up and log into the Sorting and Recognition Recycling Application	General user, Staff
Manage Image Recognition	This use case allows the user to capture or select an image of the household solid waste from the user's phone to sort the waste.	General user
Manage Sorting Search	This use case allows the user to sort the household solid waste by just inserting the keyword of waste. In this use case, staff can upload the information of household solid waste.	General user, Staff of recovery facility
Manage Nearby Recycling Location Search	This use case allows the user to search the nearby recycling location.	General user
Manage Booking System	This use case allows the user to book a doorstep collection service for their huge size household solid waste.	General user
Manage Collection Tracking	This use case allows the user to check and update their booking status.	General user, Staff of recovery facility

3.4.1 Manage Sign Up

Use Case Diagram
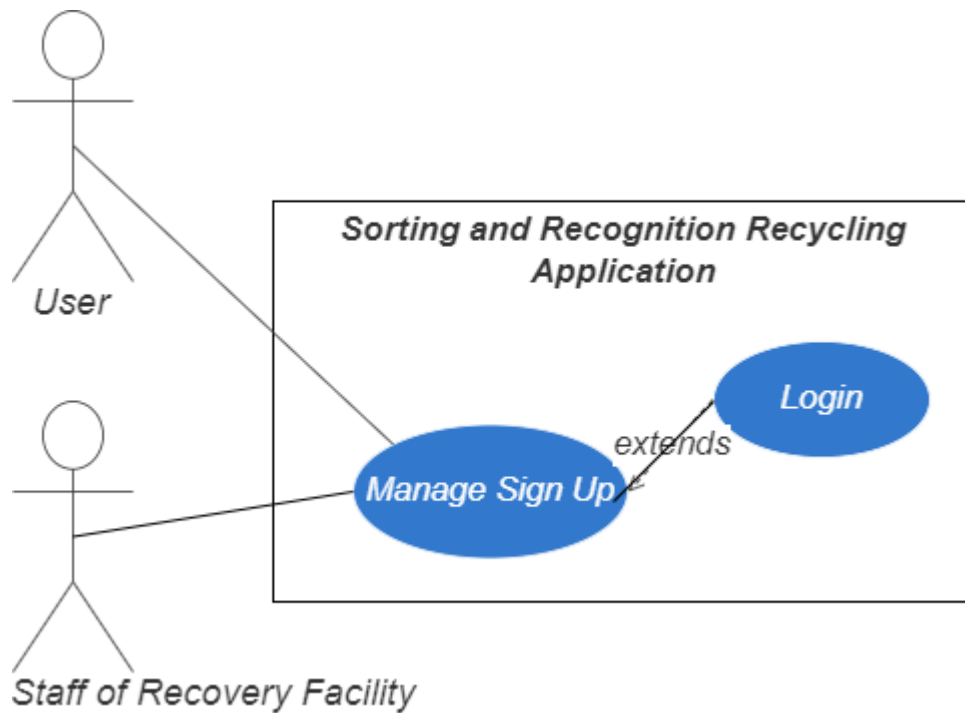
Figure 3.17 Use Case Diagram of Manage Sign Up

Use Case Description

Table 3.2 Manage Sign Up Use Case Description

Use case ID	SRRA_UC_100
Brief Description	This use case allows user to sign up and log into the Sorting and Recognition Recycling Application
Actor	User and staff of recovery facility
Pre-condition	1. The user connected to the internet. 2. The user must download and open the Sorting and Recognition Recycling Application.

	3. The user must have an email address.
Basic Flow	1. The user case starts when user enter login interface.
	2. User click the "Sign Up" button.
	3. System receives the sign up request.
	4. User will be directed to sign up interface.
	5. User fills in the email address, username, password, password confirmation and profile picture into the registration page.
	6. User clicks the "Submit" button.
	7. System validates the registered information. **[A1: User insert incomplete information]** **[A2: Password confirmation does not match]** **[A3: Password format invalid]**
	8. System will store the data in the firebase and display login interface.
	9. Use case ends.
Alternative Flow	**A1: User insert incomplete information** 1. System displays "Please fill out this field" message. 2. Use case continues to step 5 in the basic flow of manage Sign Up. **A2: Password confirmation does not match** 1. System displays "The password confirmation does not match". 2. Use case continues to step 5 in the basic flow of manage Sign up.

	A3: Password format invalid 1. System displays "The password format is invalid" message. 2. Use case continues to step 5 in the basic flow of manage Sign Up.
Exceptional Flow	-
Post-Condition	1. User can login to the system after successfully sign up. 2. The registered information are saved into the database.
Rules	-
Constraints	1. Email must be a valid. 2. Every information is required.

3.4.2 Manage Image Recognition

Use Case Diagram
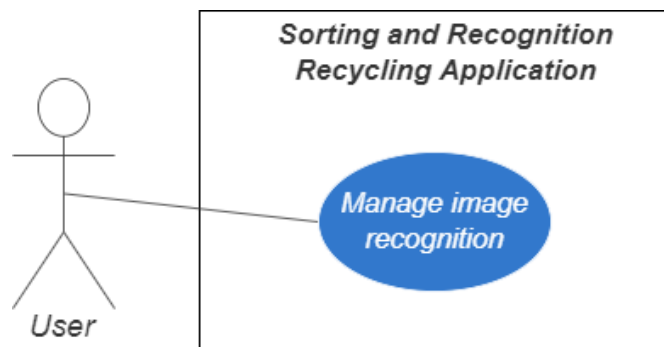
Figure 3.18 Use Case Diagram of Manage Image Recognition

Use Case Description

Table 3.3 Manage Image Recognition Use Case Description

Use case ID	SRRA_UC_200
Brief Description	This use case allows the user to capture or select an image of the household solid waste from the user's phone to sort the waste.
Actor	User
Pre-condition	1. The user must have a built-in camera smartphone.
Basic Flow	1. The user case starts when user clicks the "Capture" button. **[A1-The user select "Gallery"]** 2. User click the shutter button to capture the household solid waste. 3. The system send image to the CNN model. 4. CNN model will process and classify the image. 5. The system will display the results.

	6. Use case ends.
Alternative Flow	**A1: The user select "Gallery"** 1. User selects an image in the album. 2. Use case continues to step 3 in the basic flow of manage image recognition.
Exceptional Flow	-
Post-Condition	The system will display the sorting result.
Rules	-
Constraints	-

3.4.3   Manage Sorting Search

Use Case Diagram

Figure 3.19 Use Case Diagram of Manage Sorting Search

Use Case Description

Table 3.4 Manage Sorting Search Use Case Description

Use case ID	SRRA_UC_300
Brief Description	This use case allows the user to sort the household solid waste by just inserting the keyword of waste.
Actor	User
Pre-condition	-
Basic Flow	1. The user case starts when user clicks the search bar in the home page of the application.
	2. User key in keywords of the household solid waste. **[A1: Inaccurate keyword]**
	3. System display a drop-down menu of household solid waste
	4. User select an item from the list
	5. System sends the inputs to the Firebase.
	6. System retrieves the data of household solid waste from Firebase.

	7. System displays the result of searching a household solid waste. 8. Use case ends.
Alternative Flow	**A1: Inaccurate keyword** 1. System not responding and drop-down menu is not displayed 2. Use case continues to step 2 in the basic flow of manage sorting search.
Exceptional Flow	-
Post-Condition	The system will display the searching result.
Rules	-
Constraints	-

3.4.4 Manage Nearby Recycling Location Search

Use Case Diagram
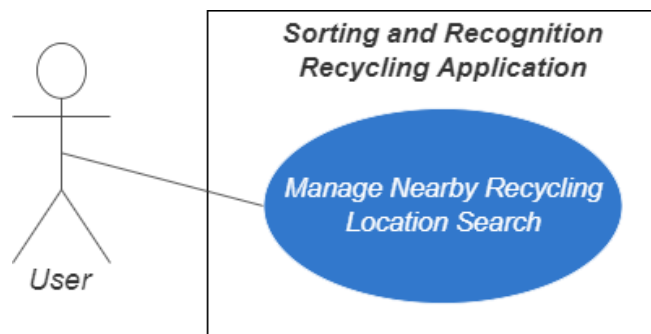
Figure 3.20 Use Case Diagram of Manage Nearby Recycling Location Search

Use Case Description

Table 3.5 Manage Nearby Recycling Location Search Sorting Search Use Case
Description

Use case ID	SRRA_UC_400
Brief Description	This use case allows the user to search the nearby recycling location.
Actor	User
Pre-condition	-
Basic Flow	1. The user case starts when user clicks the maps icon in the home page of the application. 2. User enter specific location. **[A1-The user select "Recycling center" button] [A2-The user select "E-waste" button] [A3-The user select "Cloth" button]** 3. System display a drop-down menu. 4. User select a location based on the drop-down menu. 5. System sends the specific location request to the Google Map via Google Places API.

	6. Google Map retrieve the location of the address.
	7. Google Map send the location to the system.
	8. System will display the location by using marker.
	9. Use case ends.
Alternative Flow	**A1-The user select "Recycling center" button**
	1. System sends the recycling center nearby location request to the Google Map via Google Places API.
	2. Use case continues to step in the basic flow of manage nearby recycling location search.
	A2-The user select "E-waste" button
	1. System sends the e-waste nearby location request to the Google Map via Google Places API.
	2. Use case continues to step 6 in the basic flow of manage nearby recycling location search.
	A3-The user select "Cloth" button
	1. System sends the cloth bin nearby location request to the Google Map via Google Places API.
	2. Use case continues to step 6 in the basic flow of manage nearby recycling location search.
Exceptional Flow	-
Post-Condition	The system will display the searching result.

Rules	-
Constraints	-

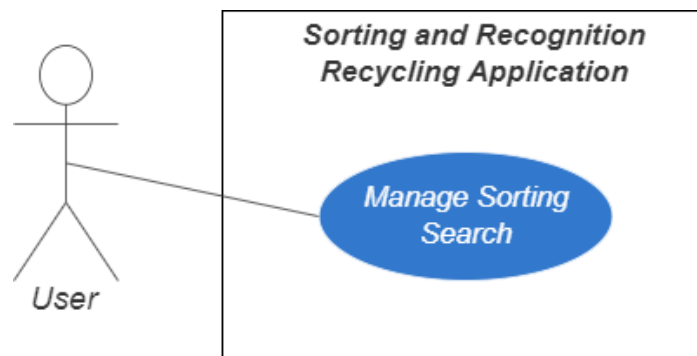### 3.4.5 Manage Booking System

Use Case Diagram
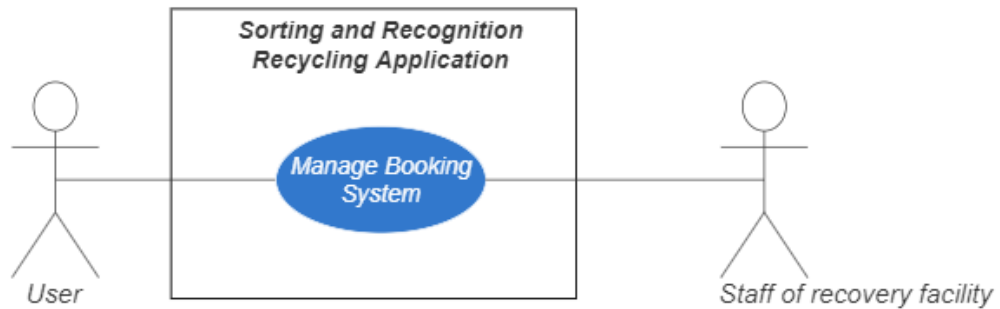
Figure 3.21 Use Case Diagram of Manage Booking System

Use Case Description

Table 3.6 Manage Booking System Use Case Description

Use case ID	SRRA_UC_600
Brief Description	This use case allows the user to book a doorstep collection service for their huge size household solid waste.
Actor	User and staff of recovery facility
Pre-condition	-
Basic Flow	1. The user case starts when user select the booking icon in the navigation bar in the application. 2. System will display a form to fill by the users. 3. User key in all the necessary information like address, number of waste and type of waste into the booking form. 4. User clicks the "Submit" button. 5. System sent the booking details to the staff of recovery facility. 6. Staff of recovery facility accept the booking.

	7. Use case ends.
Alternative Flow	-
Exceptional Flow	-
Post-Condition	1. The booking information are saved into the firebase. 2. The booking information are sent to the collector.
Rules	-
Constraints	-

3.4.6 Manage Collection Tracking

Use Case Diagram
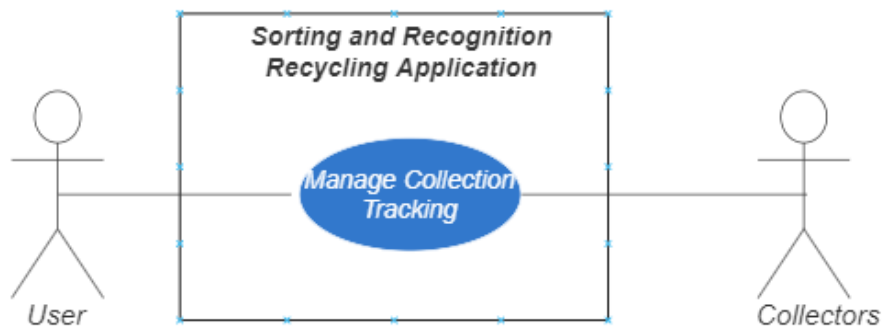
Figure 3.22 Use Case Diagram of Manage Collection Tracking

Use Case Description

Table 3.7 Manage Collection Tracking Use Case Description

Use case ID	SRRA_UC_700
Brief Description	This use case allows the user to check their booking status.
Actor	User and staff of recovery facility
Pre-condition	-
Basic Flow	1. The user case starts after staff of recovery facility receive the booking information in their Home Page. 2. Staff of recovery facility update the booking status. 3. System save the booking status to Firebase. 4. System display the booking status to the user. 5. User view the booking status. 6. Use case ends.
Alternative Flow	-

Exceptional Flow	-
Post-Condition	-
Rules	-
Constraints	-

3.5   Context Diagram

The context diagram is the top level of the data flow diagram that shows the information transmitted between all the external entities and the system. It is well known as level 0 DFD. The entire system will be presented by a single process in a context diagram. The context diagram also helps in defining the system boundary (Grgec & Mužar, n.d.).
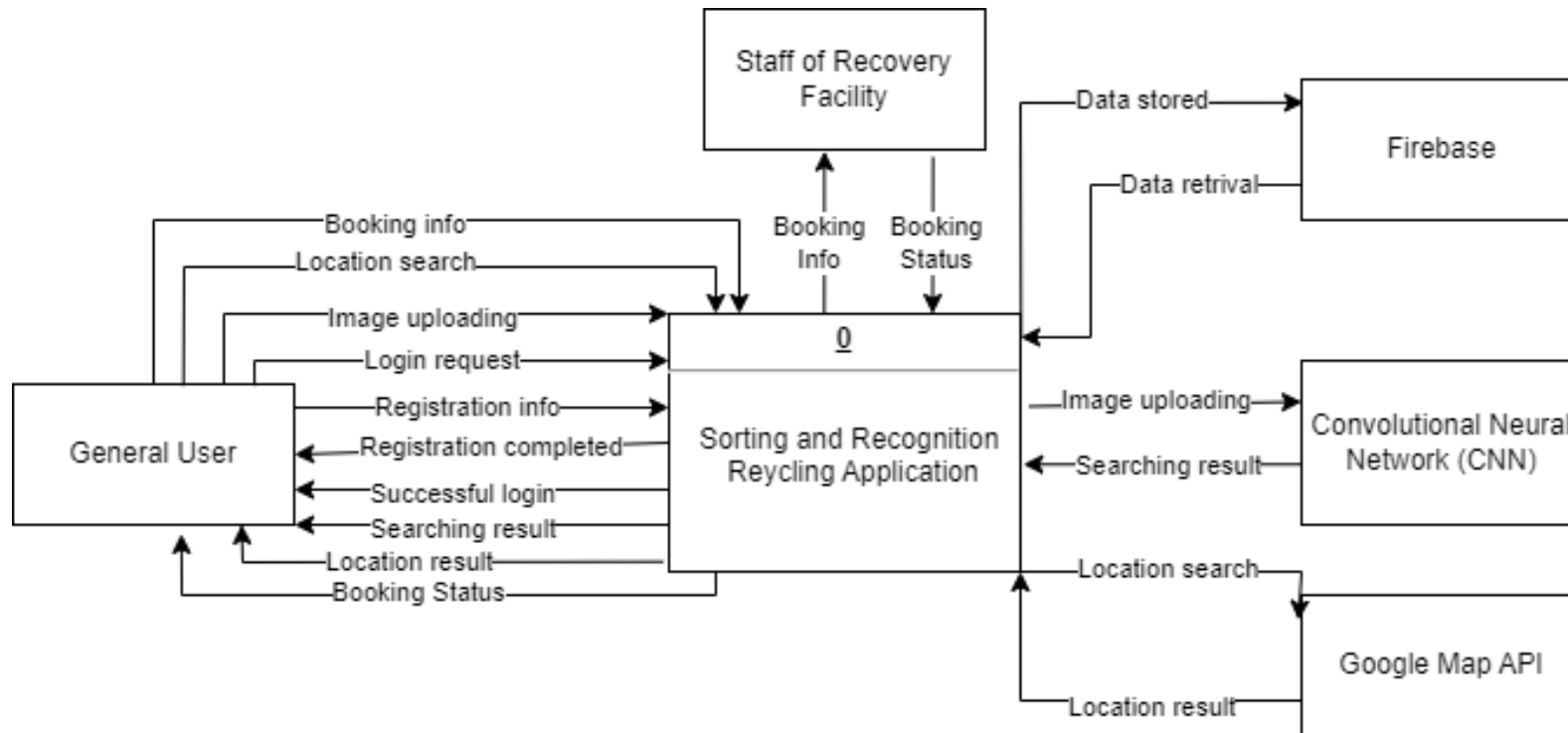
Figure 3.23 Context diagram of Sorting and Recognition Recycling Application

3.6   Activity Diagram

The activity diagram is considered another basic behavior diagram in the UML diagram. It visualizes a series of actions or flow control in a system. It can be modelled either in concurrent or vice versa sequential. Typically, the activity diagram is the advanced version of the flowchart.

Figure 3.24 shows the activity diagram of the Sorting and Recognition Recycling Application. It presents the entire activity in the proposed application from the beginning until the end. Firstly, the user will be direct to the home page after they successfully login. For those users does not have an account yet, they have to sign up an account in the application using their email. In the application, users can capture or upload the image then the application will process the image and come out with a sorting result. Second, the users can search for nearby recovery facility after they turn on the GPS function. Thirdly, users can also book a doorstep collection for the huge household solid waste. During this process, they have to select the recovery facility and household solid waste type they wish to recycle. Then, the recovery facility has the rights to accept or reject the booking. If the booking is accepted, the collector will receive a notification about the booking. The collector has also been given the option to decide whether they want to collect the household solid waste or not. If one rejects, it will pass to another collector. Lastly, the collector has to update the collection status after they accept the booking
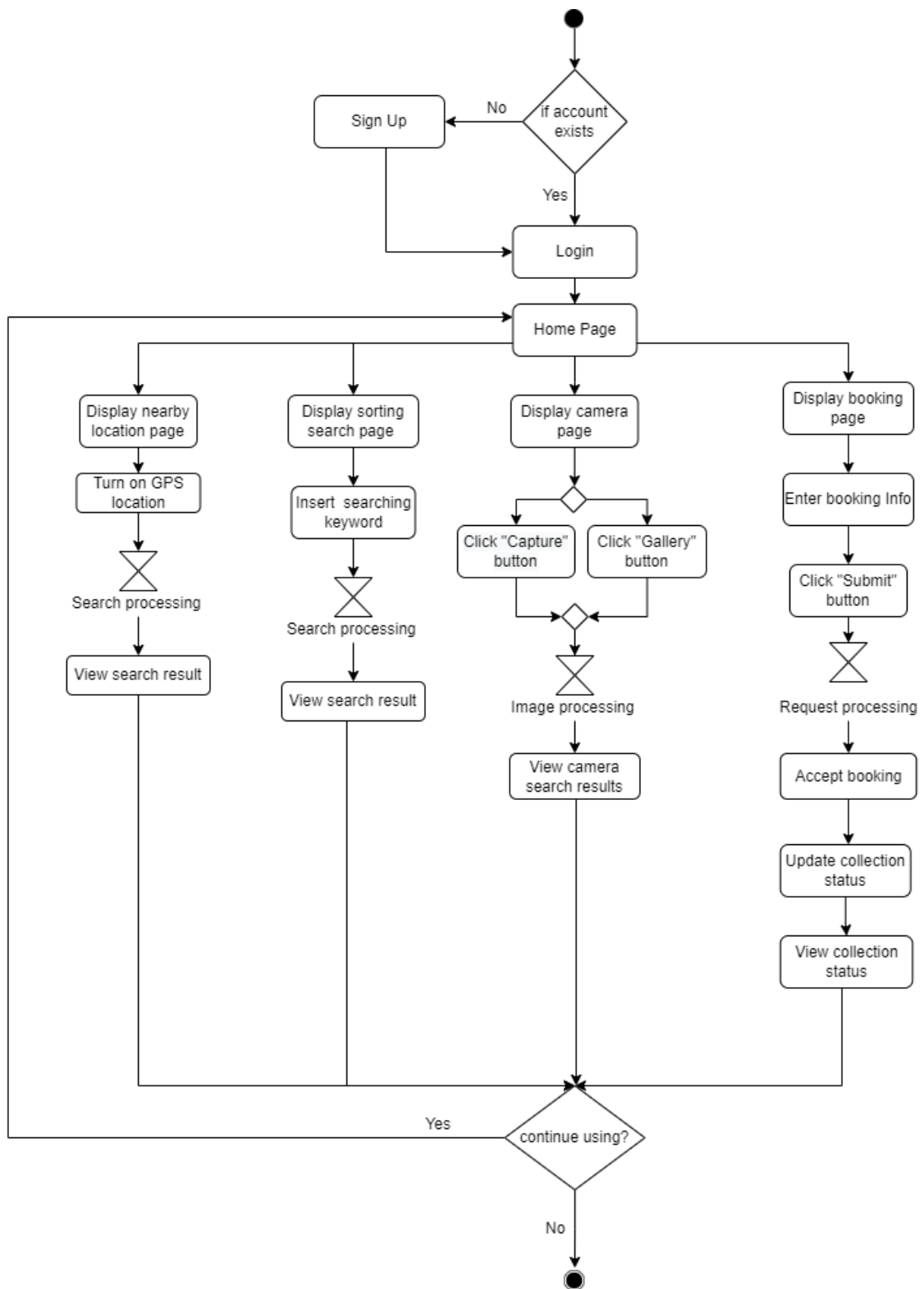
Figure 3.24 Activity diagram of the Sorting and Recognition Recycling Application

3.6.1 Manage Sign Up

Figure 3.13 shows the registration of the application. The user shall fill in the username, email address, password, confirm password and profile picture in order to register. User can login into their account after successful register and continue using the application. The application will direct users to the home page after login.
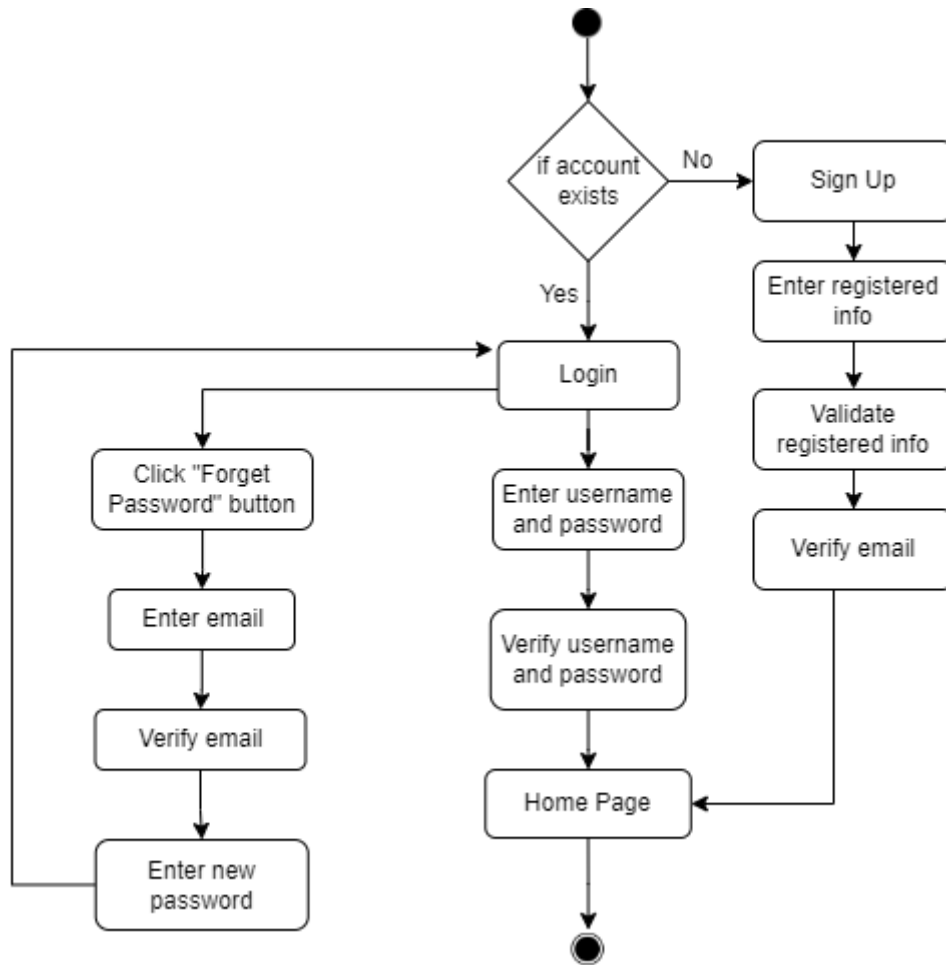
Figure 3.25 Activity diagram of Manage Sign Up module

3.6.2   Manage Image Recognition

The user is given the option either capture the image of household solid waste or select the image in their gallery. Once the image is received by the application, it will being send to CNN algorithm for image processing. Then, the application will display the sorting information.
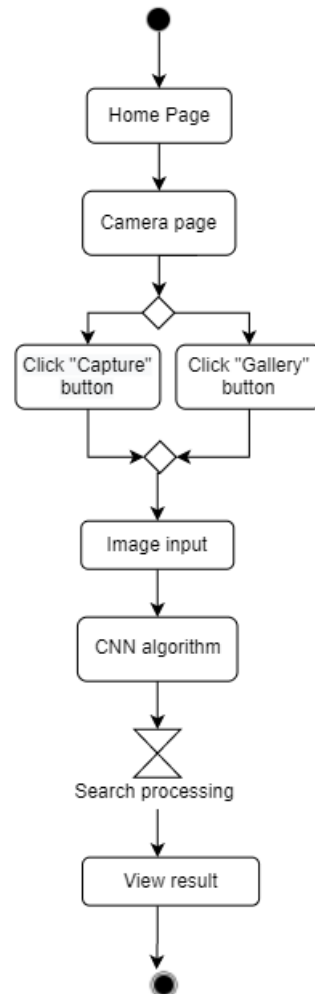
Figure 3.26 Activity diagram of Manage image recognition module

3.6.3   Manage Sorting Search

The user can enter the household solid waste name into the application to search for the information and category of the household solid waste. They just need to key in the correct keyword in the search bar, then the sorting result will be displayed.
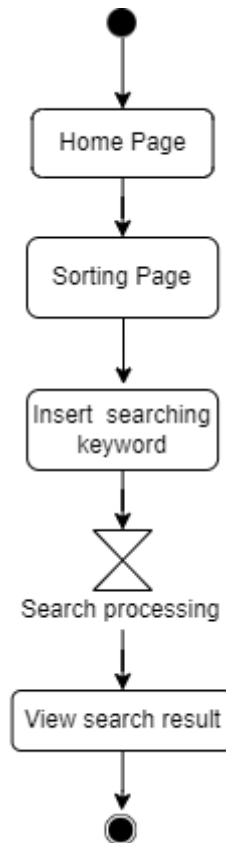
Figure 3.27 Activity diagram of Manage Sorting Search module

3.6.4 Manage Nearby Recycling Location Search

The nearby recovery facility or recycling center will be displayed after the users turn on GPS location. The location will be obtained from Google Map via Google Places API.

Figure 3.28 Activity diagram of Manage Nearby Recycling Location Search module

3.6.5 Manage Booking System

User can book a doorstep collection for the huge size household solid waste. During booking, they have to select the recovery facility and household solid waste type they wish to recycle. After that, just waiting for the approved from the recovery facility they selected.
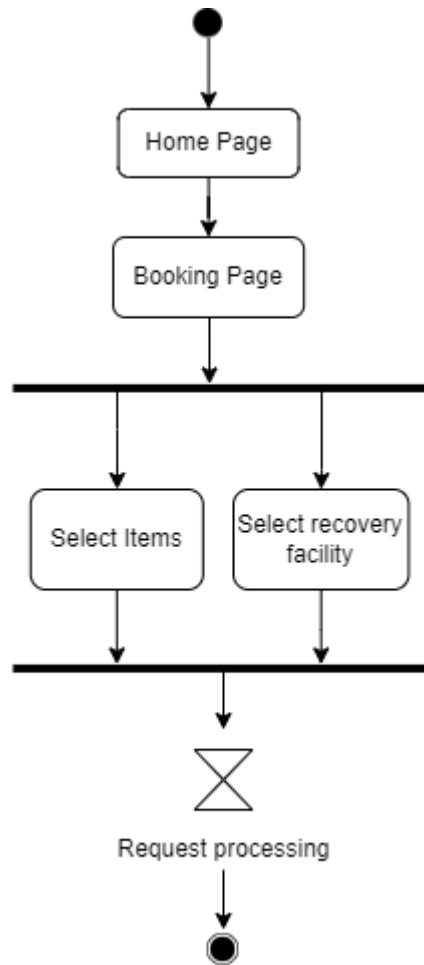
Figure 3.29 Activity diagram of Manage Booking System module

3.6.6   Manage Collection Tracking

After the user book a doorstep collection, the staff of recovery facility will receive the booking details in their Home Page. After they accepting the booking, the staff of recovery facility has to update the pickup status from time to time.
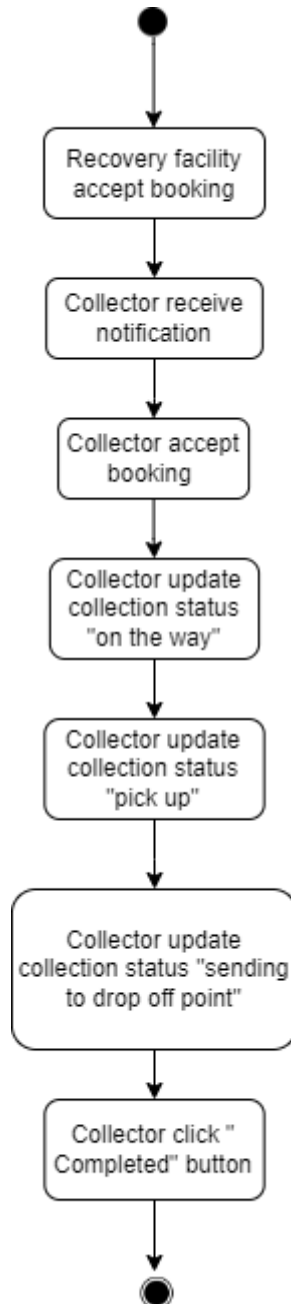
Figure 3.30 Activity diagram of Manage Collection Tracking module

3.6.7 Activity diagram of Convolutional Neural Network

When an image is uploaded to the machine learning model, the CNN will be initialised. Next, the convolution process will take place where all the computational parts are involved. After convolution, the pooling process where spatial dimensions of activation map are reduced.
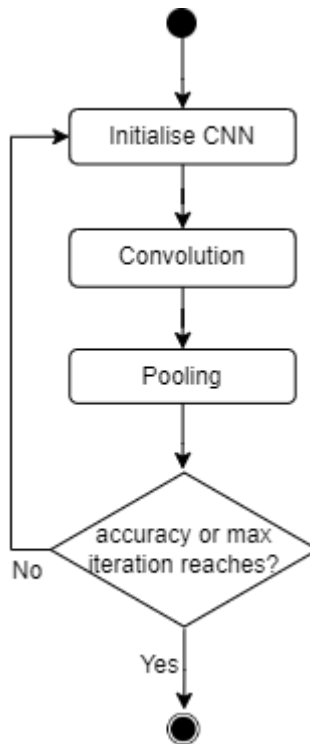
Figure 3.31 Activity diagram of Convolutional Neural Network

3.7   ERD Diagram
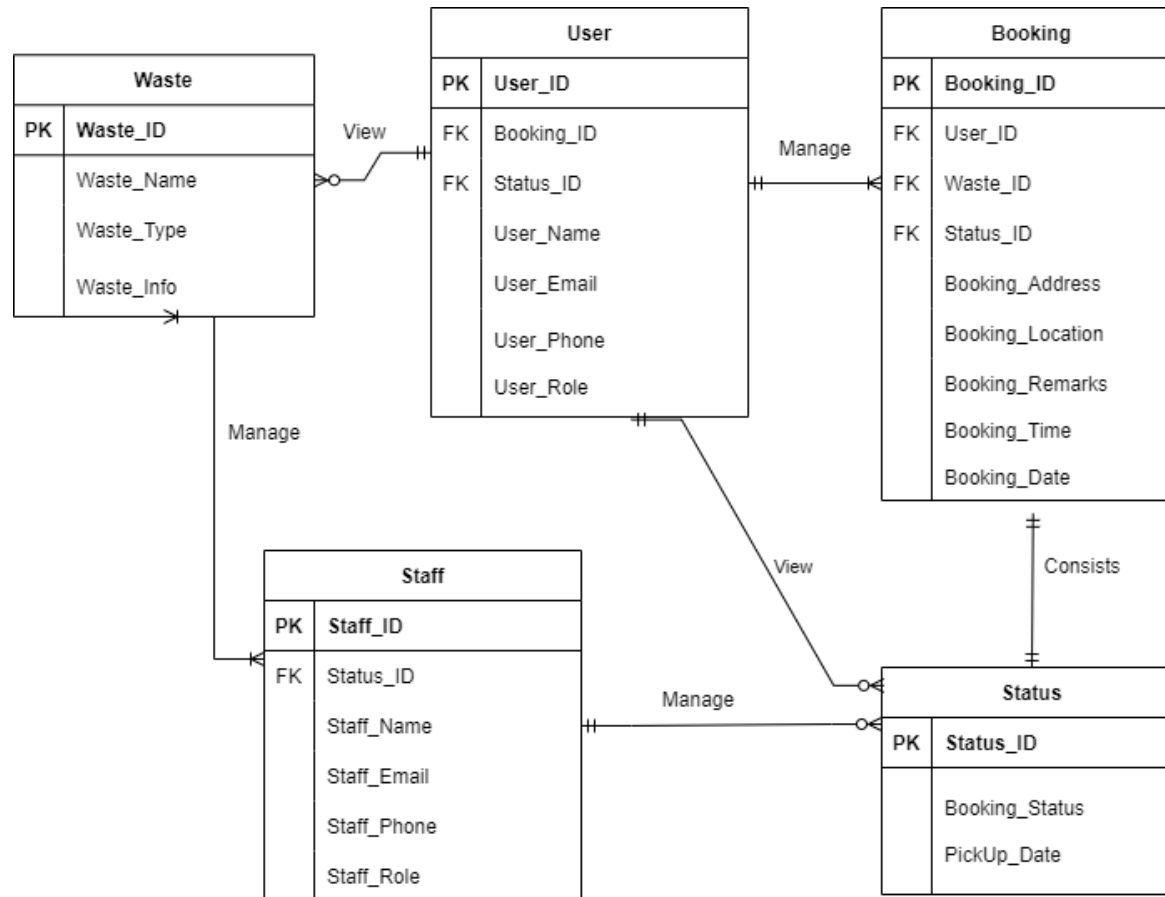
Figure 3.32 ERD Diagram

3.8   Data Dictionary

Table 3.8 Data Dictionary of Users

Field Name	Description	Data Type	Constraint
User_ID	User ID	Varchar (255)	PK
Booking_ID	Booking ID	Varchar (255)	FK
Status_ID	Booking status ID	Varchar (255)	FK
User_Name	Username	Varchar (255)	
User_Email	User email address	Varchar (255)	
User_Phone	User phone no	Varchar (255)	
User_Role	User role	Varchar(255)	

Table 3.9 Data Dictionary of Waste

Field Name	Description	Data Type	Constraint
Waste_ID	Household solid waste ID	Varchar (255)	PK
Waste_Name	Household solid waste name	Varchar (255)	
Waste_Type	Household solid waste category	Varchar (255)	
Waste_Info	Information on how to deal with the household solid waste	Varchar (255)	

Table 3.10 Data Dictionary of Booking

Field Name	Description	Data Type	Constraint
Booking_ID	Booking ID	Varchar (255)	PK
User_ID	User ID	Varchar (255)	FK
Waste_ID	Household solid waste ID	Varchar (255)	FK
Status_ID	Booking status ID	Varchar (255)	FK
Booking_Address	Doorstep collection address	Varchar (255)	
Booking_Location	Recovery facility address	Varchar (255)	
Booking_Remarks	Remark of household solid waste send to recovery facility	Varchar (255)	

Booking_Date	The date when user booking the service	Varchar (255)	
Booking_Time	The time when user booking the service		

Table 3.11 Data Dictionary of Staff

Field Name	Description	Data Type	Constraint
Staff_ID	Staff of recovery facility ID	Varchar (255)	PK
Status_ID	Status ID	Varchar (255)	FK
Staff_Name	Staff of recovery facility name	Varchar (255)	
Staff_Email	Staff of recovery facility email address	Varchar (255)	
Staff_Phone	User phone no	Varchar (255)	
Staff_Role	Staff role	Varchar(255)	

Table 3.12 Data Dictionary of Status

Field Name	Description	Data Type	Constraint
Status_ID	Booking status ID	Varchar (255)	PK
Booking_Status	Booking status	Varchar (255)	
PickUp_Date	The estimated pickup date for the door step collection of household solid waste	Varchar (255)	

3.9   Storyboard

Figure 3.33 Storyboard

3.10 Hardware and Software Specification

Table 3.12 Hardware specification

Hardware	Specification	Function
Laptop	HP Pavilion Gaming - 15t-dk0000 Intel® Core™ i5-9300H (2.4 GHz base frequency, up to 4.1 GHz with Intel® Turbo Boost Technology, 8 MB L3 cache, 4 cores) 8 GB DDR4-2666 SDRAM (1 x 8 GB)	To run Android Studio and develop the Sorting and Recognition Recycling Application
Android Smartphone	Honor 70 Built-in camera	To recognize the category of household solid waste

Table 3.13 Software specification

Software	Specification	Function
Microsoft Office Word 2016	Version 2016	To prepare documentation
Draw.io	Version 18.1.2	To design and draw all the diagrams
Android Studio	Version 4.2	To develop the mobile application
Firebase		To store database
Mendeley	Version 1.19.8	To cite the references in APA 7th edition
Windows	Version 11	Operating system that run all the other software required

3.11   Machine Learning

Machine learning is a subset of Artificial Intelligence. The demand of machine learning is increasing dramatically currently since it allows the machines to learn and improve based on the previous data and experience. In theoretically, computer algorithm is implemented to analyse and interpret patterns and structures in data set to enable learning process and involve a decision making without human interaction. In the proposed application, image recognition which is the subset of machine learning is implemented to identify and classify a household solid waste into different category for recycling purpose.

3.11.1 Teachable Machine (TM)

Teachable Machine is an AI experiment by Google Creative Lab. It is a web-based tool to train machine learning model quick, simple, and easy for everyone. No coding is needed. After creating the project, we need to import the dataset and group them into classes. We can either upload image or directly capture live with a webcam. Next, train the model using tensorflow.js. Now, the model is ready for testing. We need to check the accuracy of the model. An output result is display when a household solid waste is scan. The result is not so satisfied since the accuracy is low. More dataset is imported to improve the accuracy of output. Lastly, the model is export in TensorFlow Lite to deploy in Android Studio.

For your information, TensorFlow is an open source machine learning framework built in C++ . It is serve as the core platform and library for training AI model. TensorFlow.js is a JavaScript framework that used to build and train machine learning model in the browser while TensorFlow Lite contain APIs to generate and deploy TensorFlow models on mobile, embedded and IoT devices.

3.11.2 Data Collection

Data collection is an important step in training image recognition models. The data collected is used to train the model to recognize and classify the bin of household solid wate should throw at. The process of data collection involves the following steps:

1. Define the problem: Determine the type of images you want the model to recognize. In my model, the image is made up of battery, calendar, caps and lids, cardboard, cartons, Christmas tree, computer, computer monitor, container, egg shell, glass bottle, kitchen sponges, leaves, LED light bulb, mask, mobile phone, mouthwash bottle, newspaper, paper, paper cup, perfume bottle, plastic bags, printer, spectacles, toothbrush, toothpaste tube, tyre, wet wipes, window and yoga matt.

2. Collect images: 500 images of household solid waste that mention above is collected. Some of them is captured by myself while some of them is download form google websites.

3. Label the images: Assign labels to the images to specify what the image represents.

4. Preprocess the data: Perform operations such as resizing, cropping, and normalizing the images.

5. Store the data: Store the processed data in a format that can be used by the image recognition model.

The quality and quantity of data collected can greatly impact the accuracy of the image recognition model, so it is important to ensure that the data is diverse and representative of the real-world scenarios the model will encounter.

3.11.3 Convolutional Neural Network

Convolutional Neural Networks is a neural architecture that specially designed for image recognition and pixel data processing. It consists of three main layers which namely convolutional layers, pooling layers, and fully connected layers.

In convolutional layers, the features of the input data will be extracted. Lines, corners, and edges are low-level features that are extracted by the first convolution layer. The successive convolution layer then combine this simple features to build a more complex features as shown in Figure x.xx and Figure x.xx.
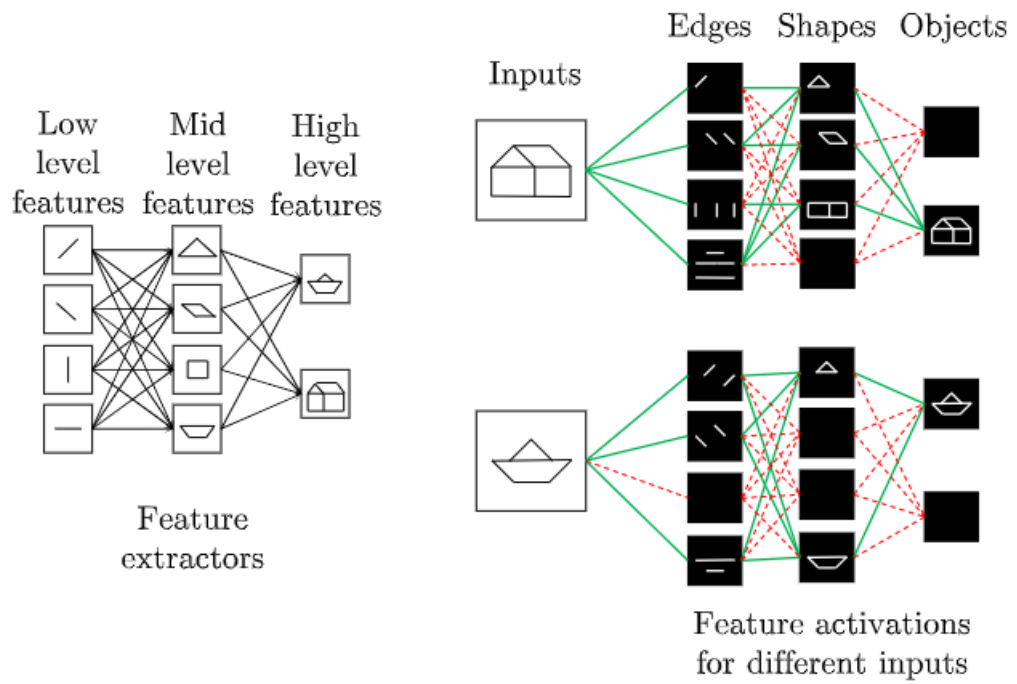
Figure 3.34 Learning strategy of CNNs

Figure 3.35 Feature maps obtained from different layers of a CNN

In pooling layers, the resolution of the features is being reduced. Pooling layer are important to reduce the computational time and overfitting issues in the Convolutional Neural Network. The most common ways to do pooling is max pooling and average pooling. Figure x.xx describes the pooling procedure in more detail. The input is 4x4 in size. A 4x4 image is split into four non-overlapping 2x2 matrices for 2x2 subsampling. When using max pooling, the output is the highest value among the four values in the 2x2 matrix. When using average pooling, the output is the average of the four values. Please take note that the averaged result for the output with index (2,2) is a fraction that has been rounded to the nearest integer.
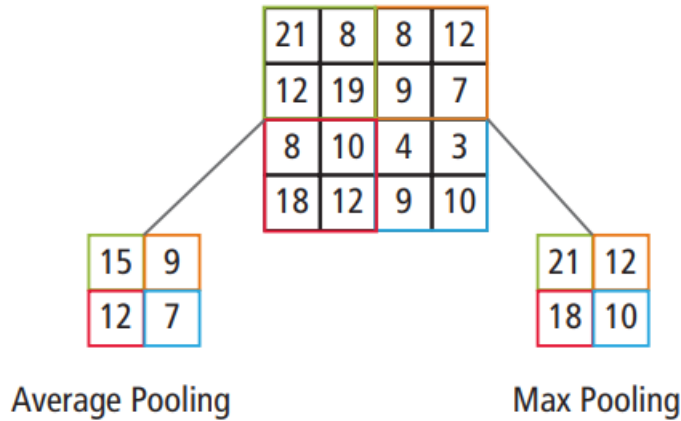
Figure 3.36 Pictorial representation of max pooling and average pooling

As the definition implies, all neurons in a fully connected layer connect to all the neurons in the previous layer. A fully connected layer multiplies the input by a weight matrix W and then adds a bias vector b. In this layer, the feature vector of the input data is produced and can be used for machine learning tasks like classification. Training from scratch and performing transfer learning by use of pre-trained models such as AlexNet, GoogleNet, SqueezNet and ResNet are the two methods to apply Convolutional Neural Network models. Training for scratch is time-consuming as the number of layers is needed and a massive amount of data is used compared to performing transfer learning by use of pre-trained model method.
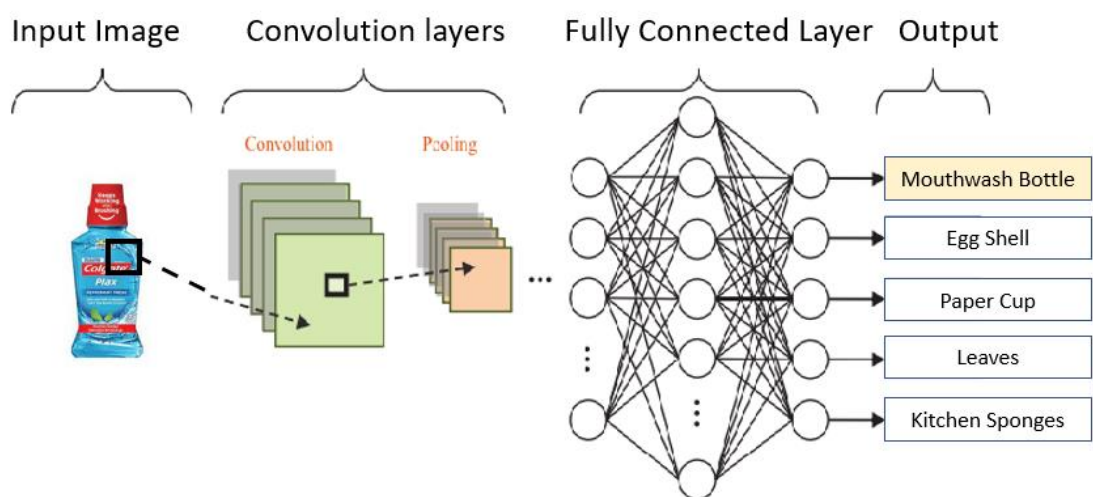
Figure 3.37 Simplified Convolutional Neural Network Architecture for household solid waste sorting

3.12   Dataset

The dataset in the proposed application consists of 30 household solid waste as shown below:

- Battery

- Calendar

- Caps and Lids

- Cardboard

- Cartons

- Christmas Tree

- Computer

- Computer Monitor

- Container

- Egg Shell

- Glass Bottle

- Kitchen Sponges

- Leaves

- LED Light Bulb

- Mask

- Mobile Phone

- Mouthwash Bottle

- Newspaper

- Paper

- Paper Cup

- Perfume Bottle

- Plastic Bags

- Printer

- Spectacles

- Toothbrush

- Toothpaste Tube

- Tyre

- Wet Wipes

- Window

- Yoga Matt

Some images of the dataset

Table 3.14 Examples of dataset

Battery	Glass Bottle
Calendar	Kitchen Sponges
Cardboard	Plastic Bags
Egg Shell	Mouthwash Bottle

3.13 Testing Plan

This is the sample of User Acceptance Test (UAT) of sorting and recognition recycling android mobile application. The functionalities of the application are tested. Failed test will discuss and fix later. The testers will send the feedback using Google Form.

Table 3.15 User Acceptance Test

No	Module	Activities	Status	Comments
		User sign up with blank input	Pass/Fail	
		Sign up using wrong username format (at least 1 digit+ at least 1 letter + not less than 6 characters)	Pass/Fail	
		Use wrong email address format	Pass/Fail	
		Password less than 6 character	Pass/Fail	
1	Sign Up	Confirmation password not the same	Pass/Fail	
		Login without sign up	Pass/Fail	
		Login with wrong user type	Pass/Fail	
		Login with wrong username or password	Pass/Fail	
		Able to sign up when "Sign Up" button is clicked	Pass/Fail	

		Able to login when "Log In" button is clicked	Pass/Fail	
2	Image recognition	Camera function	Pass/Fail	
		Display captured image	Pass/Fail	
		Choose image gallery	Pass/Fail	
		Able to recognise household solid waste when an image is inserted	Pass/Fail	
3	Sorting search	Able to display list of household solid waste	Pass/Fail	
		Able to search from the list	Pass/Fail	
4	Nearby recycling location search	Able to search nearby recycling center	Pass/Fail	
		Able to search nearby E-waste collection point	Pass/Fail	
		Able to search nearby cloth bin	Pass/Fail	
		Able to search specific location of nearby recycling center	Pass/Fail	

		Able to turn on GPS location	Pass/Fail	
		Able to return to current location after searching for nearby recycling center	Pass/Fail	
		Able to create route in google map after clicking the location marker	Pass/Fail	
5	Booking system	Able to select item	Pass/Fail	
		Submit the booking form with blank address input	Pass/Fail	
		Able to submit the booking form	Pass/Fail	
6	Collection tracking	Able to view the booking details and pickup details	Pass/Fail	
		Able to update the pickup status	Pass/Fail	

This test has been performed by:

Name   : _____

Signature : _____

Date   : _____

3.14 Potential use of proposed solution

Current market in Malaysia still lacking this kind of recycling and sorting mobile application that helps push forward the milestones of recycling and sorting. That why I am here to contribute my effort to do so.

Most Malaysia are still unaware the importance of recycling which can reduce the solid waste we produce every day. This ignorance is reflected in nation's recycling rate, which is recorded at 31.52 percent in 2021. Hence, the proposed application's expected outcome is to witness an increase in the number of persons participating in recycling activities. Perhaps these can reduce the household solid waste generated by Malaysian and indirectly contribute to a clean and safe environment.

Besides that, single steam recycling that is practiced among Malaysia has trouble local recyclers a lot. This is because single-stream recycling contaminates the recyclable household solid waste and burden the local recyclers in term of financial. They need to buy extra automated sorting equipment for sorting. Thus, image recognition is implemented via CNN framework to provide information regarding how to sort household solid waste to the users. The desired result of the proposed application is to encourage public involved in the dual-stream recycling system. Dual-stream recycling system will lower the contamination levels of the recyclable waste and reduce recycling errors. In short, dual-stream recycling system helps collect more pure material and higher quality recycled waste recovery.

CHAPTER 4

RESULT AND DISCUSSION

4.1   Introduction

This chapter will discuss on the implementation and development of the proposed mobile application. A detailed and accurate information of the proposed mobile application will be provided as the solution to the problem stated in Chapter 1. The functionalities of the proposed mobile application will be discussed too.

4.2   Development Environment

This chapter can be divided into two parts which are artificial intelligence implementation and Integrated Development Environment (IDE). The proposed mobile application requires a mobile device running at least Android 4.1 (Jelly Bean) with camera and internet connection so that the mobile application can perform based on the functionality designed.

4.3   System Output and Results

User interface is an important part of a system or an application. User interface play a role as the communication and interaction between human and computer. A well-designed user interface can effectively support the functionality of application. The user interface in the proposed mobile application is designed based on two criteria which is clean design and green colour theme. Green colour theme is used because it gives user eco-friendly impression.

Figure 4.1 show the splash screen interface of Household Solid Waste Management Application. It will pop out for 3 seconds when the user run the proposed mobile application. There is a sentence "Recycling takes little effort on your part, for a big difference to our world." in the middle center of the screen. The message that desires to deliver is caring our earth is our responsibility. We must take care of the planet we are living now.
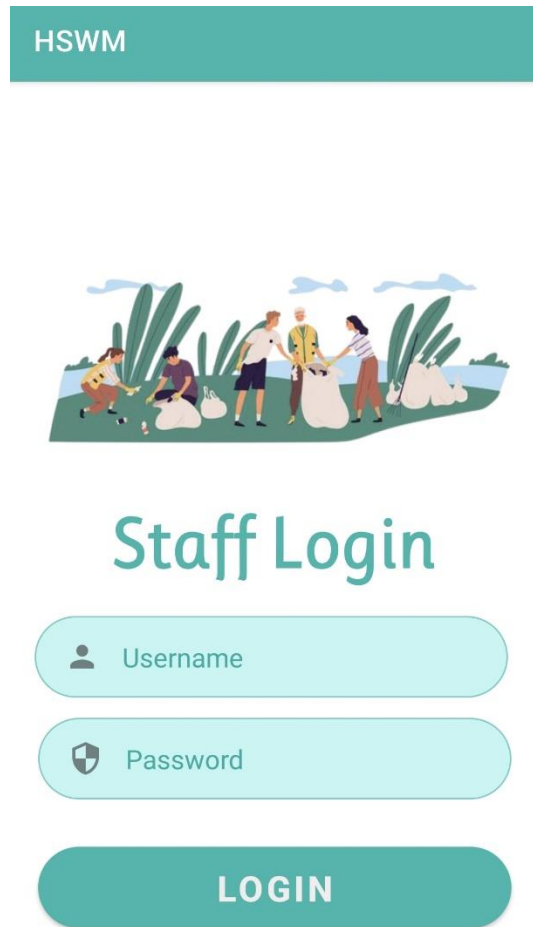
Figure 4.1 Splash screen Interface

Figure 4.2 show the main activity of Household Solid Waste Management Application. It will be displayed after the splash screen. There are two pictures in this interface. Once the staff click the picture in the left with a caption "I am recycling center staff", the staff will be direct to the staff login interface. If the users click the picture on the right with the caption "I am recycling hero", the users will be direct to the user login interface. A sentence "Don't have an account yet?" is located at the bottom of the main page of the proposed mobile application. It will direct the new user to the registration page.

Figure 4.2 Main page of the proposed mobile application
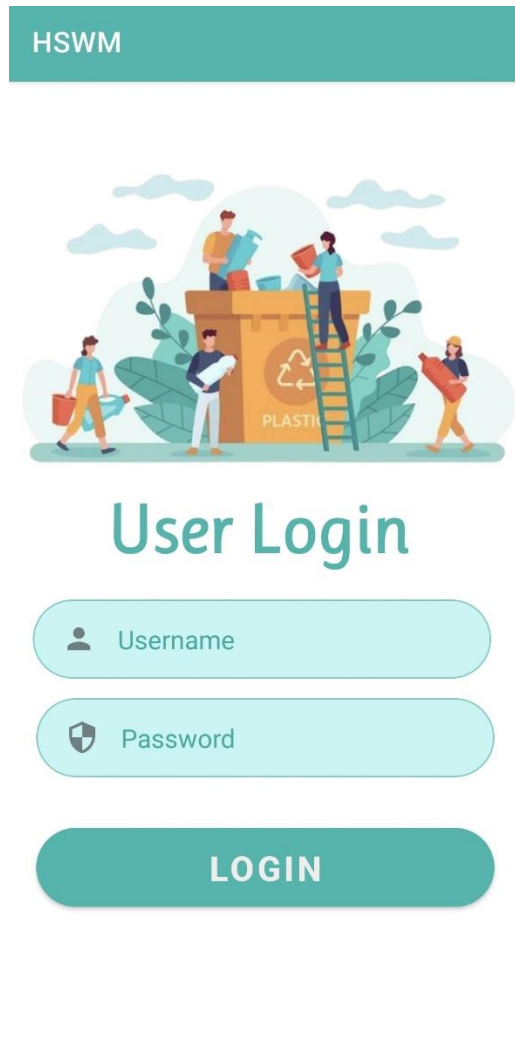
Figure 4.3 below show the staff login interface of Household Solid Waste Management Application. The staff is required to fill in the username and password in the text field provided to login. Once the "Login" button is clicked, the system will undergo authentication and authorization process to verify the identity. If the username and password is match and correct, the system will display and direct user to Staff Home page.

Figure 4.3 Staff login interface

Figure below show the user login interface of Household Solid Waste Management Application. The user is required to fill in the username and password in the text field provided to login. Once the "Login" button is clicked, the system will undergo authentication and authorization process to verify the identity. If the username and password is match and correct, the system will display and direct user to Staff Home page.

Figure 4.4 User Login Interface

Figure 4.5 below show the sign up interface of Household Solid Waste Management Application. The user needs to insert username, email address, phone and password. There are some validations being set so that the user can enter a correct format information. A red warming error will appear just like Figure 4.6 if the user inserts an incorrect format personal data. The requirement for the inserted data includes:

Username:

i.   The username length should not more than 15 characters.

ii.   The username length should not less than 6 characters.

iii.   The username must contain at least 1 digit and 1 alphabet.

Email:

i.   The email must be in the correct format which mean it must contain the symbol "@".

Password:

i.   The username length should not more than 15 characters.

ii.   The username length should not less than 6 characters.

Confirm Password:

i.   The confirm password should be same as the password.

Figure 4.5 Sign Up Interface

Figure 4.6 Sign Up Interface Error

Coding:

```
String emailRegex = "^[a-zA-Z0-9_+&*-]+(?:\\." +
        "[a-zA-Z0-9_+&*-]+)*@" +
        "(?:[a-zA-Z0-9-]+\\.)+[a-z" +
        "A-Z]{2,7}$";
Pattern pat = Pattern.compile(emailRegex);


String usernameVal = "^" +
        "(?=.*[0-9])" +          //at least 1 digit
        "(?=.*[a-zA-Z])" +       //any letter
        "(?=\\S+$)" +            //no white spaces
        ".{5,}" ;                //at least 6 characters



private boolean validateUsername(){
    String val = regName.getText().toString();

    if (val.isEmpty()) {
        regName.setError("Field cannot be empty");
        regName.requestFocus();
    } else if (val.length() >= 15) {
        regName.setError("Username too long");
        regName.requestFocus();
    }  else if (val.length() <= 6) {
        regName.setError("Username too short");
        regName.requestFocus();
    }else if (!val.matches(usernameVal)) {
        regName.setError("Username is too simple (at least 1 digit +
any letter)");
        regName.requestFocus();
    } else {
        regName.setError(null);
        return true;
    }
    return false;
}

private boolean validatePass() {
    String val = regPassword.getText().toString();

    if (val.isEmpty()) {
        regPassword.setError("Field cannot be empty");
        regPassword.requestFocus();
    } else if (regPassword.length() <= 5) {
        regPassword.setError("Password Should at least 6 character");
        regPassword.requestFocus();
    } else if (regPassword.length() >= 16) {
        regPassword.setError("Password Should not more than 15
character");
        regPassword.requestFocus();
    } else {
        regPassword.setError(null);
        return true;
    }
    return false;
}
```

```java
private boolean validatePhone() {
    String val = regPhone.getText().toString();

    if (val.isEmpty()) {
        regPhone.setError("Field cannot be empty");
        regPhone.requestFocus();
    } else {
        regPhone.setError(null);
        return true;
    }
    return false;
}

private boolean validateCPassword() {
    String val = regCPassword.getText().toString();
    String val1 = regPassword.getText().toString();

    if (val.isEmpty()) {
        regCPassword.setError("Field cannot be empty");
        regCPassword.requestFocus();
    } else if (!val.equals(val1)) {
        regCPassword.setError("Password doesn't matches");
    } else {
        regCPassword.setError(null);
        return true;
    }
    return false;
}

private boolean validateEmail() {
    String val = regEmail.getText().toString();

    if (val.isEmpty()) {
        regEmail.setError("Field cannot be empty");
        regEmail.requestFocus();
    } else if (!pat.matcher(val).matches()) {
        regEmail.setError("Please Enter a valid Email");
        regEmail.requestFocus();
    } else {
        regEmail.setError(null);
        return true;
    }
    return false;
}
```

Figure 4.7 show the user home page of Household Solid Waste Management Application. The user will be directed to this page once they login. On top of the interface will be the search bar for household solid waste for sorting purpose. The bottom of this interface is a navigation bar which consists of home, camera, profile and log out function. The four images in the center represent for four systems which are household solid waste information area, search and filter system, booking system, and collection tracking system. The user will be directed to the responsive system by clicking the image.
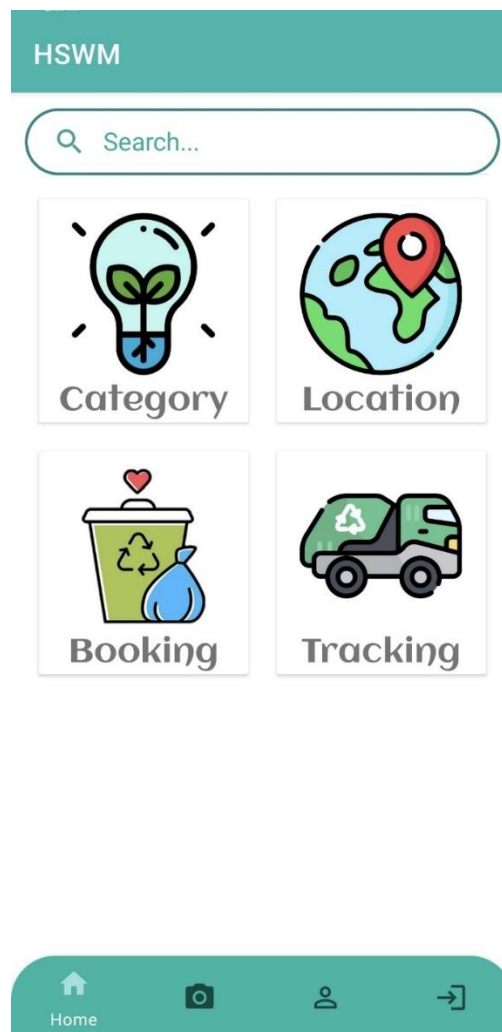
Figure 4.7 User Home Interface

Figure 4.8 show the search function of Household Solid Waste Management Application. If the user tends to get the information of household solid waste, one of the efficient way is with the help of searching function. A dropdown menu will be displayed when user click the search bar. Then, the information of the household solid waste will be displayed based on the item selected by the user.
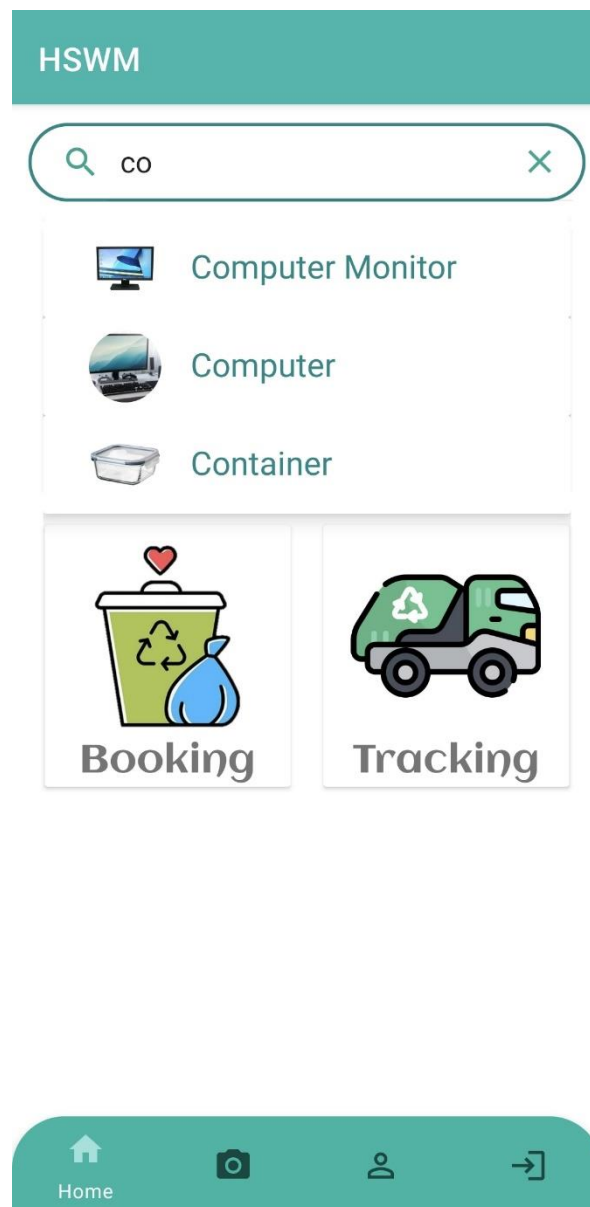
Figure 4.8 Search Function Interface

Figure 4.9 show the category of household solid waste contain in Household Solid Waste Management Application. For example, if user click the image of plastic category which is light brown bin, the system will displayed a list as shown in Figure 4.10. All the household solid waste displayed is under plastic category. If the user tends to know more about the information of container, the user have to click the box with "container" and detail information of it will be displayed as shown in figure 4.11.

Figure 4.9 Infographic Of Household Solid Waste Based On Category
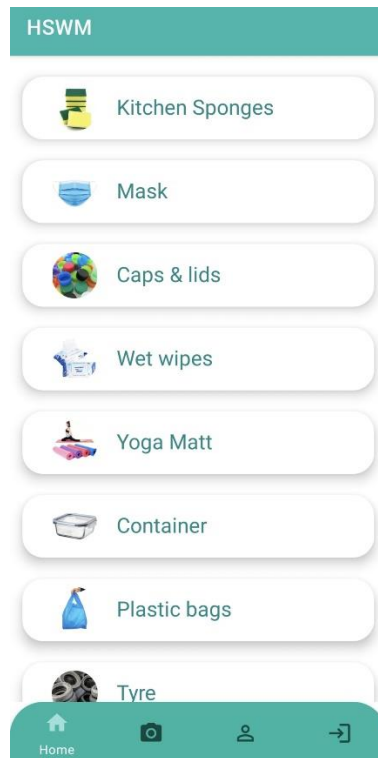
Figure 4.10 Household Solid Waste Item List Based On Category

Figure 4.11 Detail Information of Household Solid Waste

Coding:

```
    GridLayoutManager gridLayoutManager = new
GridLayoutManager(Plastic.this, 1);
    recyclerView.setLayoutManager(gridLayoutManager);
    AlertDialog.Builder builder = new
AlertDialog.Builder(Plastic.this);
    builder.setCancelable(false);
    builder.setView(R.layout.progress_layout2);
    AlertDialog dialog = builder.create();
    dialog.show();
    dataList = new ArrayList<>();
    adapter = new MyAdapter(Plastic.this, dataList);
    recyclerView.setAdapter(adapter);
    databaseReference =
FirebaseDatabase.getInstance().getReference("Android
Tutorials").orderByChild("dataTitle").equalTo("plastic");
    dialog.show();
    eventListener = databaseReference.addValueEventListener(new
ValueEventListener() {
        @Override
        public void onDataChange(@NonNull DataSnapshot snapshot) {
            dataList.clear();
            for (DataSnapshot itemSnapshot: snapshot.getChildren()){
                DataClass dataClass =
itemSnapshot.getValue(DataClass.class);
                dataClass.setKey(itemSnapshot.getKey());
                dataList.add(dataClass);
                intent.putExtra(EXTRA_MESSAGE, LoginID);
            }
            adapter.notifyDataSetChanged();
            dialog.dismiss();
        }
        @Override
        public void onCancelled(@NonNull DatabaseError error) {
            dialog.dismiss();
        }
    });

}
```

Once the user enters the interface, the user are required to turn on the GPS location as shown in Figure 4.12. After that, the system will displayed the current location of the user as shown in Figure 4.13. Then, the user can search the nearby recycling center within specific location by using the search bar as shown in Figure 4.14. Then, the system will display the result which is the most nearest recycling center in Mid Valley Megamall as shown in Figure 4.15.

The user can also search the nearby location within 10km by clicking the "Recycling center", "E-waste", "Cloth" button. The red marker display in the map is the location of recycling center. To create a route that direct user to the recycling center, user just need to click the blue arrow button in the bottom right corner. To get more info about the displayed marker location, user can click the map icon in the bottom right corner too. To go back to current location, user need to click the dot in top right corner.
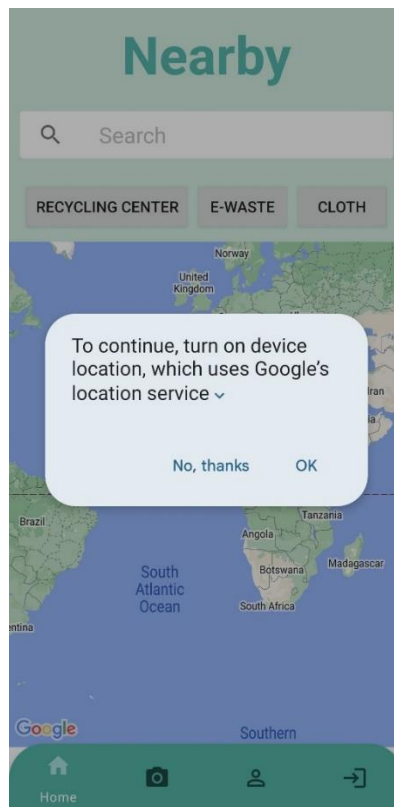
Figure 4.12 Turn On GPS
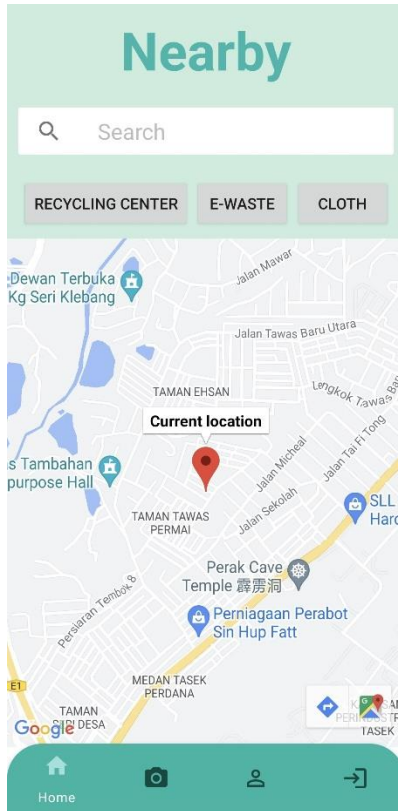
Figure 4.13 Current Location
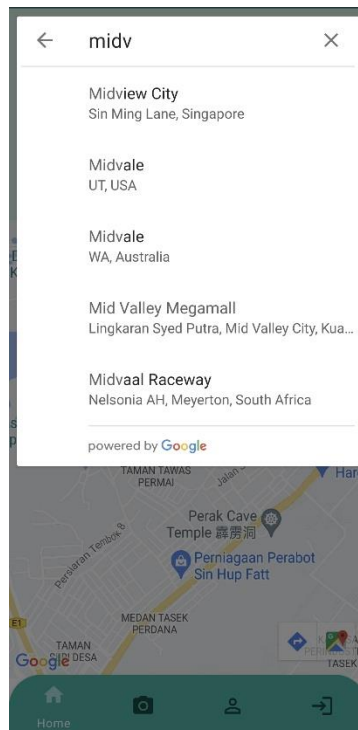
Figure 4.14 Search Nearby Recycling Center Within Specific Location

Coding:

```
autocompleteSupportFragment.setPlaceFields(Arrays.asList(Place.Field.ID,Place.Field.LAT_LNG,Place.Field.NAME));
autocompleteSupportFragment.setOnPlaceSelectedListener(new PlaceSelectionListener() {
    @Override
    public void onError(@NonNull Status status) {


    }

    @Override
    public void onPlaceSelected(@NonNull Place place) {
        final LatLng latLng = place.getLatLng();
        Log.i("PlacesApi", "OnPlaceSelected: "+
latLng.latitude+"\n"+latLng.longitude);
        StringBuilder stringBuilder = new
StringBuilder("https://maps.googleapis.com/maps/api/place/nearbysearch
/json?");
        stringBuilder.append("location="+ latLng.latitude + "," +
latLng.longitude);
        stringBuilder.append("&radius=10000");
        stringBuilder.append("&keyword=recycle");
        stringBuilder.append("&sensor=true");
        stringBuilder.append("&key=AIzaSyArAv9aWWe3ZWaqEVpKKPbC9-
sx3xwG9Cg");

        String url = stringBuilder.toString();
        Object dataFetch[] = new Object[2];
        dataFetch[0]=mMap;
        dataFetch[1]=url;

        FetchData fetchData = new FetchData();
        fetchData.execute(dataFetch);

    }
});
```
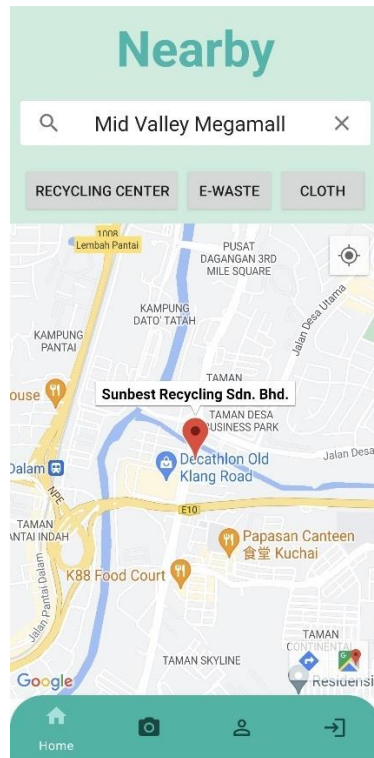
Figure 4.15 Result of Searching Mid Valley Megamall
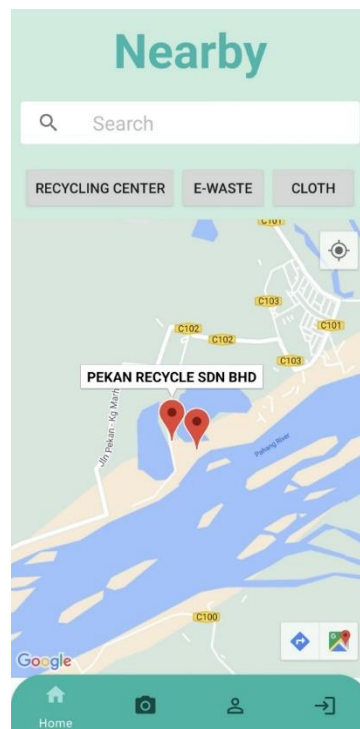
Figure 4.16 Result of Clicking "Recycling Center" button

Figure 4.17 show the booking system of Household Solid Waste Management Application. There is a drop-down menu for the user to select the type of item they want to send to the recycling center. They have to fill up the pickup point before clicking the submit button. Remarks is an optional field.

Figure 4.17 Booking System Interface

Coding:

```java
sub_btn.setOnClickListener(new View.OnClickListener() {

    @Override
    public void onClick(View view) {
        if (validateDetails()){
            String address = order_address.getText().toString();
            String remark = order_remark.getText().toString();
            String item = autoCompleteTxt.getText().toString();
            String order_status = "PENDING";
            String dev_name = "";
            String estimate_date = "";
            String id = username.toString().trim();

            Calendar calendar = Calendar.getInstance();
            String currentDate = new SimpleDateFormat("dd/MM/yyyy",
Locale.getDefault()).format(new Date());
            String currentTime =
DateFormat.getTimeInstance().format(calendar.getTime());

            orderClass.setDate(currentDate);
            orderClass.setTime(currentTime);
            orderClass.setOrderAddress(address);
            orderClass.setOrderRemark(remark);
            orderClass.setOrderType(item);
            orderClass.setOrder_status(order_status);
            orderClass.setUsername(id);
            orderClass.setDev_name(dev_name);
            orderClass.setEstimate_date(estimate_date);

            String ts =
String.valueOf(TimeUnit.MILLISECONDS.toSeconds(System.currentTimeMilli
s()));

reference.child(ts).setValue(orderClass).addOnSuccessListener(new
OnSuccessListener<Void>() {
                @Override
                public void onSuccess(Void unused) {
                    Toast.makeText(UserBooking.this, "Booking
Successfully", Toast.LENGTH_SHORT).show();
                }
            }).addOnFailureListener(new OnFailureListener() {
                @Override
                public void onFailure(@NonNull Exception e) {
                    Toast.makeText(UserBooking.this, "Booking
Failure", Toast.LENGTH_SHORT).show();
                }
            });

            Intent intents = new Intent(UserBooking.this,
UserHome.class);
            intents.putExtra(EXTRA_MESSAGE, username);
            startActivity(intents);


        }
    }}
```

Figure 4.18 show the tracking system of Household Solid Waste Management Application. It will display all the necessary booking details like booking date, booking time, item type, remarks, order status, pickup point and most importantly the order status. The order status consists of "PENDING", "ACCEPTED", "OUT FOR DELIVERY" and "COMPLETED"
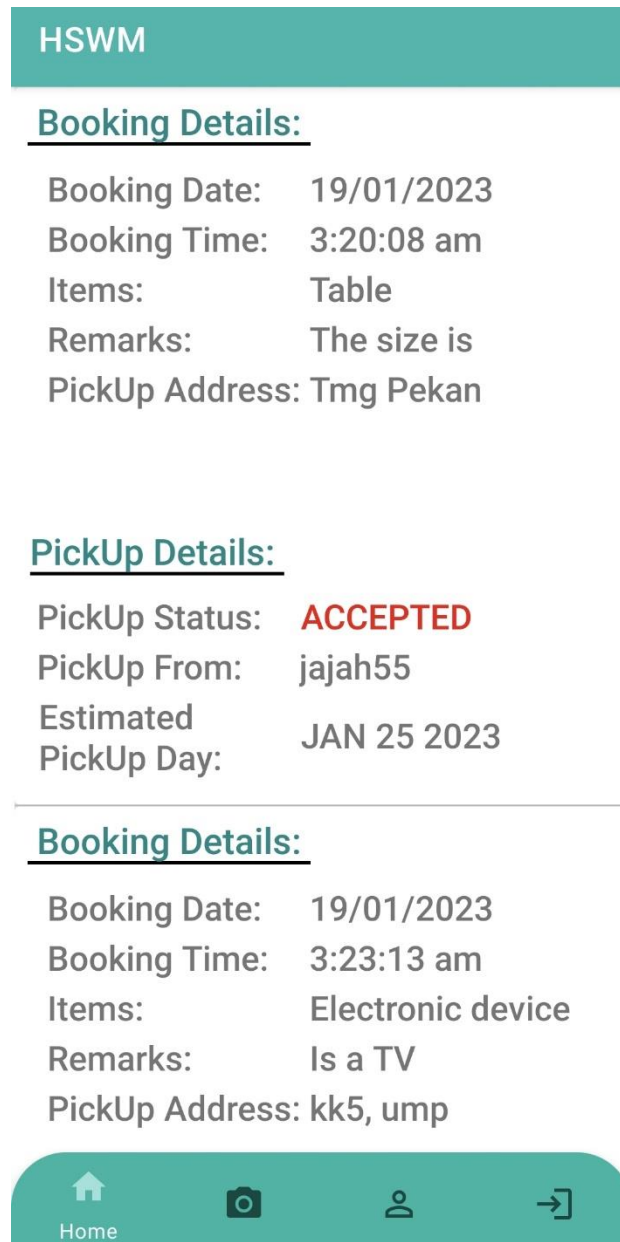
Figure 4.18 Tracking System Interface

Figure 4.21 show the user scan interface of Household Solid Waste Management Application. When an image is insert as an input either by uploading from the gallery or capturing by the camera, it will provide information on which bin the household solid waste should be thrown.
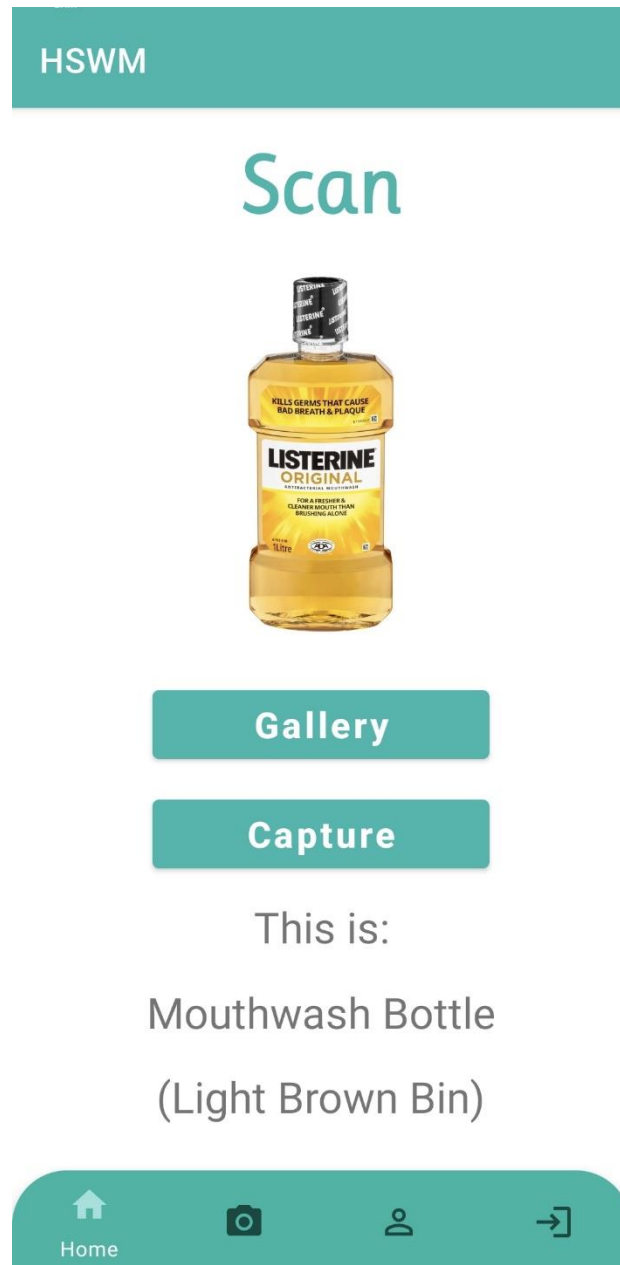
Figure 4.19 User sorting interface

Coding:

```java
public void onActivityResult(int requestCode, int resultCode,
@Nullable Intent data) {

        if(resultCode == RESULT_OK){

        if (requestCode == 1 ) {
            Bitmap image = (Bitmap) data.getExtras().get("data");
            int dimension = Math.min(image.getWidth(),
image.getHeight());
            image = ThumbnailUtils.extractThumbnail(image, dimension,
dimension);
            imageView.setImageBitmap(image);

            image=Bitmap.createScaledBitmap(image, imageSize,
imageSize, false);
            Classifyimage(image);

        }else{
                Uri uri = data.getData();
                Bitmap image = null;
                try {
                    image =
MediaStore.Images.Media.getBitmap(this.getContentResolver(), uri);
                    imageView.setImageBitmap(bitmap);
                } catch (IOException e) {
                    e.printStackTrace();
                }
                imageView.setImageBitmap(image);
                image=Bitmap.createScaledBitmap(image, imageSize,
imageSize, false);
                Classifyimage(image);
            }
        }

        super.onActivityResult(requestCode, resultCode, data);
    }

}
```

Figure 4.19 show the staff home interface of Household Solid Waste Management Application. It will display a booking list from the user as shown in Figure 4.19. The staff need to click the list and it will direct staff to an extended page so that the staff can accept the booking as shown in Figure 4.20. Once accepted, the staff can click the "My Order" button the view the record. The staff then need to update the booking status from "Pending" to "Collect Today" or "Completed". Besides that, the staff also required to select an estimate Pickup Day as shown in Figure 4.22 so that the user can do early preparation about the pickup.
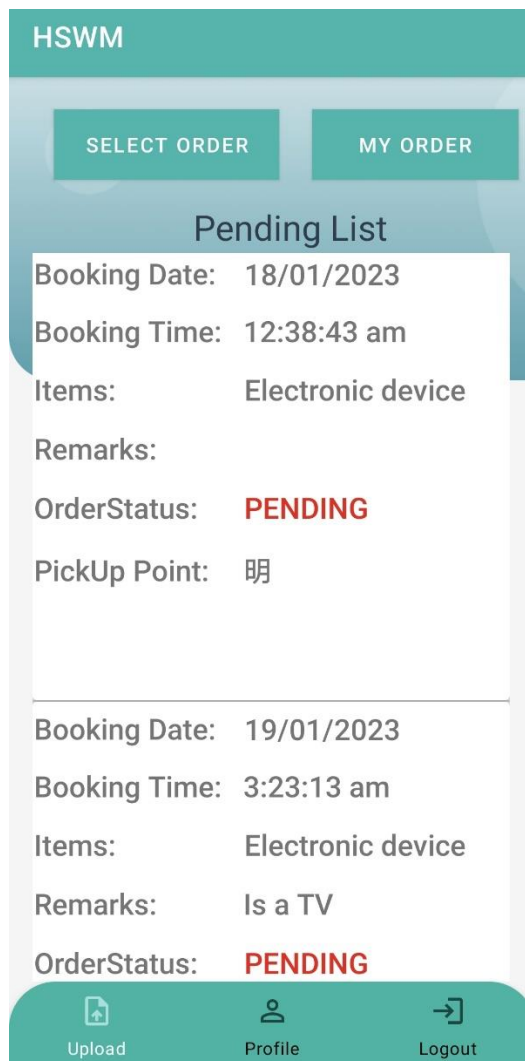
Figure 4.20 Staff Home Interface
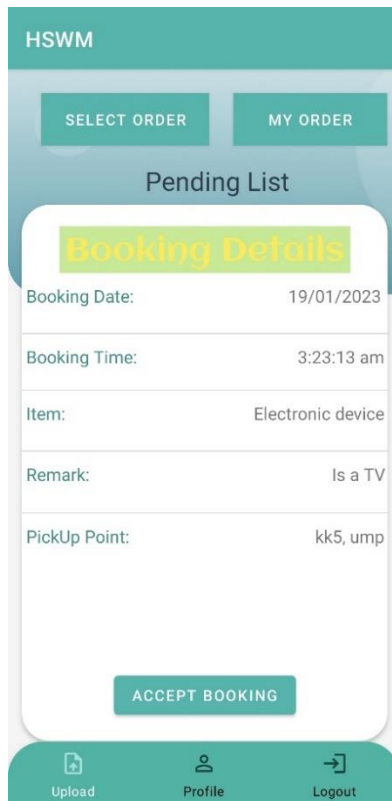
Figure 4.21 Accept Booking Interface
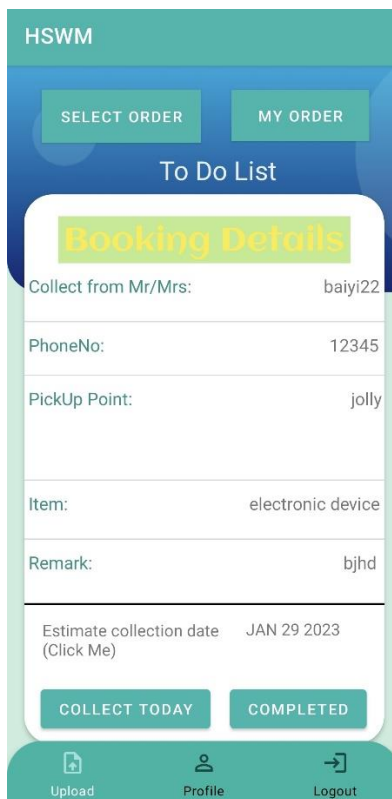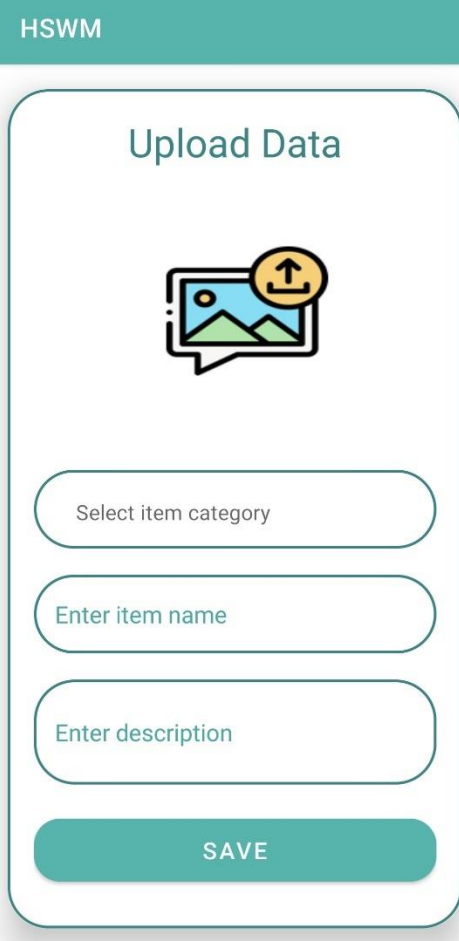
Figure 4.22 Booking Details Interface

Figure 4.23 show the staff upload interface of Household Solid Waste Management Application. The user can upload the information of household solid waste by select a picture and fill in the data required like household solid waste category, household solid waste name, and its description.

Figure 4.23 Upload information of household solid waste

Figure 4.24 show the profile update interface of Household Solid Waste Management Application. The user can update their email, profile picture, password, and phone number at this interface. The interface for staff and user is the same.
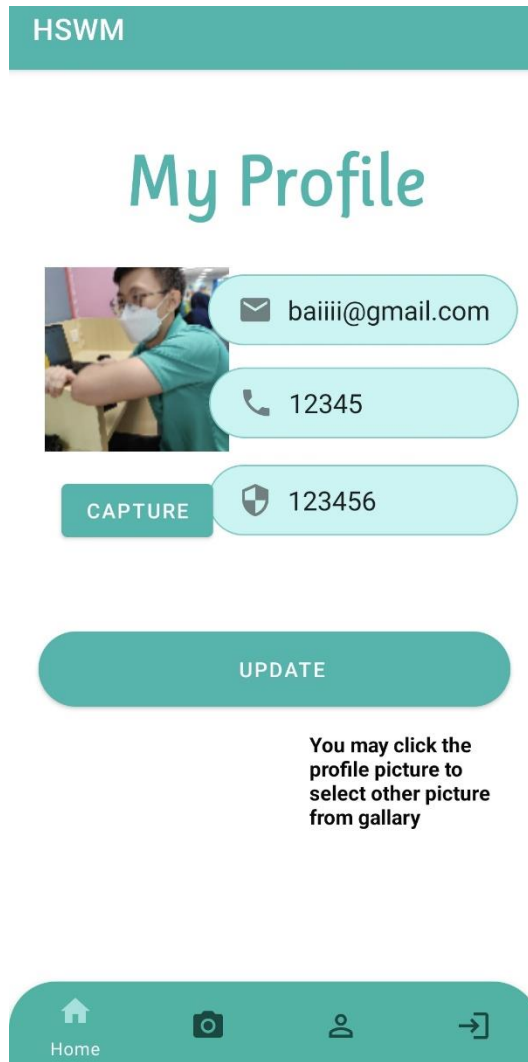
Figure 4.24 Update Profile Interface

4.4 Testing and Result Discussion

Based on the Agile methodology, testing will be carried out after the mobile application is successfully developed to detect ant bugs or error. The testing is conducted using User Acceptance Test (UAT) by (University Malaysia Pahang) UMP fourth year students. The purpose of the testing is ensuring the mobile application development meets the proposed requirements stated in Chapter 3.3.1.

Table 16 Sign Up function testing

Module	Manage Sign Up				
Objective	To let user, sign up an account and login to the application				
Test ID	Test Case	Input	Actual Result	Expected Result	Test Status
TC01-01	User sign up with blank input	Blank input	Display error message	Display error message	PASS
TC01-02	Sign up using wrong username format (at least 1 digit+ at least 1 letter + not less than 6 characters)	"220299" "yew" "yew22"	Display error message	Display error message	PASS
TC01-03	Use wrong email address format	"yewjiayieg mail"	Display error message	Display error message	PASS

TC01-04	Password less than 6 character	"12345" "abcd" "123a"	Display error message	Display error message	PASS
TC01-05	Confirmation password not the same	"1122" "psm" "321a"	Display error message	Display error message	PASS
TC01-06	Login without sign up	"jiaye220299@gmail.com" "1234Yew"	Display error message	Display error message	PASS
TC01-07	Login with wrong user type	"Staff" "User"	Display error message	Display error message	PASS
TC01-08	Login with wrong username or password	"yew99" "123yew	Display error message	Display error message	PASS
TC01-09	Able to sign up when "Sign Up" button is clicked	"Register" button is clicked	Sign Up successful	Sign Up successful	PASS
TC01-010	Able to login when "Log In" button is clicked	"Log In" button is clicked.	Login successful	Login successful	PASS

Table 4.217 Recognition function testing

Module	Manage Recognition				
Objectives	To recognise household solid waste by the image input				
Test ID	Test Case	Input	Actual Result	Expected Result	Test Status
TC02-01	Camera function	Click "Capture" Button	Ask permission and open camera.	Ask permission and open camera.	PASS
TC02-02	Display captured image	Confirm image captured	Display captured image	Display captured image	PASS
TC02-03	Choose image gallery	Click "Gallery" Button	Open gallery	Open gallery	PASS
TC02-04	Able to recognise household solid waste when an image is inserted	Image input	Sorting result is displayed	Sorting result is displayed	PASS

Table 4.3 Sorting Search function testing

Module	Manage Sorting Search				
Objective	To let the user search specific household solid waste in Firebase				
Test ID	Test Case	Input	Actual Result	Expected Result	Test Status
TC03-01	Able to display list of household solid waste	Search bar is clicked.	Display a list of household solid waste	Display a list of household solid waste	PASS
TC03-02	Able to search from the list	Click a household solid waste in the list	Display information of the household solid waste	Display information of the household solid waste	PASS

Table 4.4 Nearby Search function testing

Module	Manage Nearby Search				
Objective	To let the user search nearby or specific location of recycling center				
Test ID	Test Case	Input	Actual Result	Expected Result	Test Status
TC04-01	Able to search nearby recycling center	Click "Recycling center" button	Display nearby recycling center	Display nearby recycling center	PASS
TC04-02	Able to search nearby E-waste collection point	Click "E-waste" button	Display nearby E-waste collection point	Display nearby E-waste collection point	PASS
TC04-03	Able to search nearby cloth bin	Click "Cloth" button	Display nearby cloth bin	Display nearby cloth bin	PASS
TC04-04	Able to search specific location of nearby recycling center	"UKM" "KLCC" "Intel, Kulim"	Display specific location of nearby recycling center	Display specific location of nearby recycling center	PASS

TC04-05	Able to turn on GPS location	Click "Yes" when the application request location permission	Display current location	Display current location	PASS
TC04-06	Able to return to current location after searching for nearby recycling center	Click the current location icon	Display current location	Display current location	PASS
TC04-07	Able to create route in google map after clicking the location marker	Click the marker then click the get direction icon	Display route in Google Map	Display route in Google Map	PASS

Table 4.5 Booking system function testing

Module	Manage Booking System				
Objective	To let the user book a service from the recycling center				
Test ID	Test Case	Input	Actual Result	Expected Result	Test Status
TC06-01	Able to select item	Click the item from the drop-down menu	Display the item selected	Display the item selected	PASS
TC06-02	Submit the booking form with blank address input	Blank address	Display error message	Display error message	PASS
TC06-03	Able to submit the booking form	Click the "Submit" button	Display "Booking Successfully" message	Display "Booking Successfully" message	PASS

Table 4.618 Collection Tracking function testing

Module	Manage Collection Tracking				
Objective	To let the user book a service from the recycling center				
Test ID	Test Case	Input	Actual Result	Expected Result	Test Status
TC07-01	Able to view the booking details and pickup details	Click the collection tracking system icon	Display booking details and pickup details	Display booking details and pickup details	PASS
TC07-02	Able to update the pickup status	"PENDING" "OUT FOR COLLECTION" "DONE"	Display the update status	Display the update status	PASS

4.5   Potential Tester List

The proposed application is face to face test by the tester.

Table 4.7 Tester Information

Name	Matric ID	Current Year Student	Feedback
Tang Xin Zhe	CA19101	Fourth Year Student	Nice interface
Benedict Hwong Nai Yi	CA19109	Fourth Year Student	Attractive and friendly interface
Chan Hue Wah	CA19059	Fourth Year Student	Limited household solid waste can be scan
Choo Yong Han	CA19088	Fourth Year Student	Simple and easy understand
Khor Weng Hui	CA19042	Fourth Year Student	Useful application
Tan Yi Tiang	CA19073	Fourth Year Student	Really help me a lot when I recycle
Kee Hui Ting	CA20074	Third Year Student	The accuracy of recognition can be improved
Kong Choon	CA19108	Fourth Year Student	Very good

Tua Yong Liang	CA19103	Fourth Year Student	The font type used in the system should change
Wong Seng Kuan	CA19049	Fourth Year Student	Good. Hope to see this application have more function in future

CHAPTER 5

-

CONCLUSION

5.1   Introduction

This thesis consists of five chapters. The first chapter focus on the objectives, scope and problems and finally leads to the proposed system. The second chapter discuss on the comparison made on three existing system with their advantages and disadvantages. Based on the comparison made some parts of the system such as machine learning image recognition function is inspired by the existing system as these existing system does not have the ability to make recognition based on the user input household solid waste. The chapter three discuss on methodology and API implemented for the proposed mobile application. The system flowchart and machine learning recognition framework are discussed at here. Chapter 4 is the output of the developed mobile application. The system interfaces, function and coding will critically explain. After the development phase, testing are carried out to ensure the developed mobile application meet the requirements proposed as stated in Chapter 3.3.1.Chapter 5 will look after limitation of the proposed mobile application and future work can be done to improve it.

5.2   Objective Revisited

As stated in Chapter 1, there are three objectives of this project. There are to identify the current limitation of the existing application of the recycling system, to develop a mobile application that helps provide information regarding sorting recycled solid waste into categories based on image recognition using a neural network, and to evaluate the functionalities of the proposed system.

The first objective is achieved where the existing application does not have machine learning image recognition functionality. The second objectives is achieved too. The household solid waste sorting and recognition recycling system is successfully developed at the end of the project. The last objectives is also achieve as well where the functionalities of the proposed mobile application are evaluated with UAT.

5.3 Objective Revisited

The limitation of the household solid waste sorting and recognition recycling system are this mobile application can only be installed in Android device only. In addition, the proposed mobile application require an Android device with Android 11 operating system with API level 30 to run it. The proposed mobile application can only recognise 30 household solid waste with ample accuracy. Besides that, the user needs to key in specific and accurate word to be able to search household solid waste item for sorting and location search. For the recycling location nearby search, the maximum searching area(radius) is 50km.

5.4 Future Work

The future work aims to improve the limitation stated above. The machine learning training model should increase the dataset of household solid waste from 30 to 100 so that diverse household solid waste can be scanned by the user. The second improvement can be let the user manual adjust the searching area (radius) of nearby recycling location.

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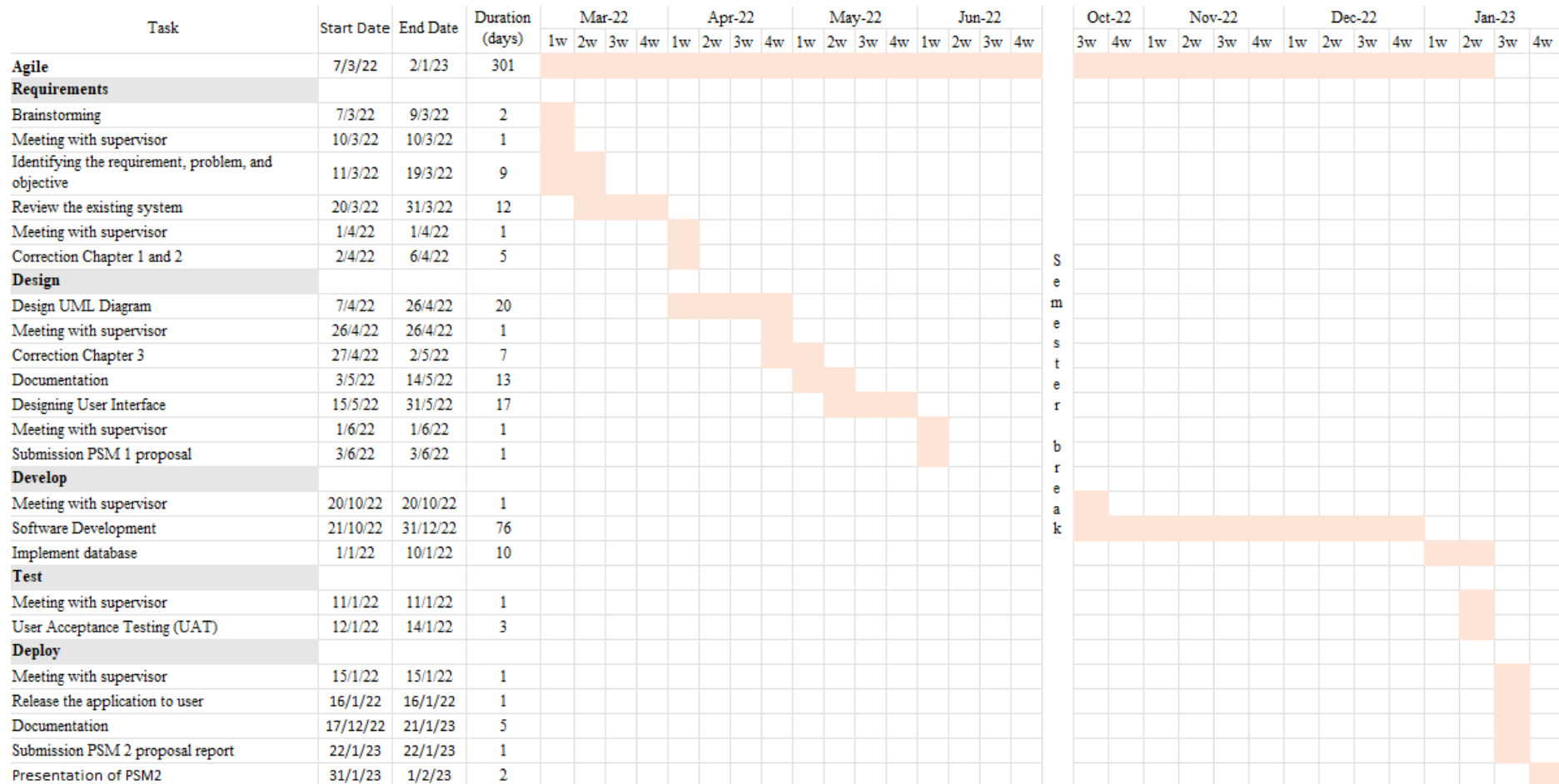| Task	Start Date	End Date	Duration (days)
Agile	7/3/22	2/1/23	301
Requirements			
Brainstorming	7/3/22	9/3/22	2
Meeting with supervisor	10/3/22	10/3/22	1
Identifying the requirement, problem, and objective	11/3/22	19/3/22	9
Review the existing system	20/3/22	31/3/22	12
Meeting with supervisor	1/4/22	1/4/22	1
Correction Chapter 1 and 2	2/4/22	6/4/22	5
Design			
Design UML Diagram	7/4/22	26/4/22	20
Meeting with supervisor	26/4/22	26/4/22	1
Correction Chapter 3	27/4/22	2/5/22	7
Documentation	3/5/22	14/5/22	13
Designing User Interface	15/5/22	31/5/22	17
Meeting with supervisor	1/6/22	1/6/22	1
Submission PSM 1 proposal	3/6/22	3/6/22	1
Develop			
Meeting with supervisor	20/10/22	20/10/22	1
Software Development	21/10/22	31/12/22	76
Implement database	1/1/22	10/1/22	10
Test			
Meeting with supervisor	11/1/22	11/1/22	1
User Acceptance Testing (UAT)	12/1/22	14/1/22	3
Deploy			
Meeting with supervisor	15/1/22	15/1/22	1
Release the application to user	16/1/22	16/1/22	1
Documentation	17/12/22	21/1/23	5
Submission PSM 2 proposal report	22/1/23	22/1/23	1
Presentation of PSM2	31/1/23	1/2/23	2

Figure 5.1 Gantt chart for development of Sorting and Recognition Recycling Application