

**SMART SHOPPER – GROCERY INGREDIENT FILTERING WITH AUGMENTED
REALITY**

By

Yap Pei Pei

A REPORT

SUBMITTED TO

University Tunku Abdul Rahman

in partial fulfilment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONOURS)

Faculty of Information and Communication Technology

(Kampar Campus)

JAN 2021

UNIVERSITI TUNKU ABDUL RAHMAN

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I declare that this report entitled “**SMART SHOPPER – GROCERY INGREDIENT FILTERING WITH AUGMENTED REALITY**” is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

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Date : _____ 14 April 2021 _____

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to my supervisor, Dr. Ng Hui Fuang who has given me this bright opportunity to engage in a product design project. It is my first step to establish a career in Information Systems field. A million thanks to you.

I must say thanks to my parents and my family for their love, support, and continuous encouragement throughout the course.

ABSTRACT

Groceries shopping is essential for most of the individual in their daily life. However, there is a wide range of similar products located on the shelf in the supermarket. People often spend a lot of time in the supermarket in reading the ingredient list on the nutrition facts label to choose the best product they want. Despite time-consuming, the main obstacle for shopper especially who are allergic to certain ingredient is they having difficulties to filter and search for the products that are perfectly free from all allergic ingredients. Hence, a smart shopper mobile application with ingredient filtering function using AR technology is proposed to improve the groceries shopping. The proposed application has the ability in assisting the user to filter and personalise the ingredient that user desire. In this development, AR technology is implemented in this project in the form of marker-based AR. By using marker-based detection, an actual object can be detected by scanning with a smartphone camera, then, the ingredient list in the virtual form will be displayed on top of the object. The project also provided a function that allowed a user to differentiate products with colour tags. Users can compare the products by just checking the checkbox of allergic ingredient. Also, this project intends to develop an Android platform mobile application which is free-of-charge to let users enjoy convenience and affordable mobile application. In comparison to previous work, a head-mounted device which is extremely expensive is required in order to experience a smart shopper with AR technology. Therefore, this project is beneficial to an individual who wishes to make groceries shopping with affordable AR experience.

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LIST OF ABBREVIATIONS

<i>3D</i>	3 Dimensional
<i>AI</i>	Artificial Intelligent
<i>API</i>	Application Programming Interface
<i>AR</i>	Augmented Reality
<i>DSDM</i>	Dynamic Systems Development Method
<i>GPS</i>	Global Positioning System
<i>HMD</i>	Head-Mounted Display
<i>RAM</i>	Random Access Memory
<i>RFID</i>	Radio-Frequency Identification
<i>SA</i>	Situated Analytics
<i>SDK</i>	Software Development Kit
<i>UI</i>	User Interface
<i>VR</i>	Virtual Reality
<i>XP</i>	Extreme Programming

CHAPTER 1: INTRODUCTION

1.1 Problem Statement and Motivation

The problem statements of this project are:

- People often think that grocery shopping is time-consuming which shoppers will spend more than 1 hour in the supermarket for selecting the best product they want. Making a fast decision is hard for people and thus will bring to a waste of time.
- There are too many similar products with different ingredients in the supermarket that will need a lot of time for the user to filter out the product that is suitable to the user. Asking the staff is simply too inefficient as the staff may also unclear about the ingredients inside the products.

The targeted users that will be facing these problems might be the housewife, people who have allergies to some ingredients such as milk or nuts, people with diseases such as diabetes which they have to avoid high sugar level products. There are a lot of products that have different types of ingredients regardless of having a chance to cause allergies. For instance, the most common ingredients that might cause allergic reactions are milk, peanuts, wheat, and others. This show how important if there is a system that could help the user to filter out the unwanted ingredients before purchasing the wrong products. Besides, it is important to come out with a solution to assist a user in making fast decisions in order to reduce the amount of shopping time spend in the supermarket. If there exist mobile applications that not only emphasis on the convenience and portability but also the user experience, a user might benefit all the time. Thus, the motivation of this project is to develop an AR mobile application to assist a user in decision making, ingredient filtering and thus enhancing the experience in grocery shopping.

1.2 Background Information

Technology has revolutionised the world and is getting more advanced nowadays. A lot of technologies such as Artificial Intelligent (AI), Virtual Reality (VR), Augmented Reality (AR) that have invented many applications which could bring a big impact to daily life. Augmented Reality (AR) is one of the innovative inventions that could apply in different fields and debuting across the market. Early, the first AR technology was developed by Ivan Sutherland (a computer scientist) in the year 1968. He has created an AR head-mounted display system as known as HMD which is a display device that can be used in several fields such as medical, gaming and others.

AR is a blend of the physical and virtual world through some sort of devices in a real environment. Smartphone, headset and goggles are the popular devices that apply AR technology to ease human life. AR has evolved rapidly from the past until now and been used in several fields like manufacturing, education, gaming, and others. One of the biggest benefits of AR is it has the capability in displaying the related information by overlaying the information on the real scene. In order to achieve high portability of AR, developers have implemented AR technology in mobile applications. There are plenty of AR mobile applications at the moment either in gaming or daily life usage. For example, Pokémon GO (AR mobile app game), IKEA Place (AR furnishing app), Measure (AR measurement app), Sephora (AR making app), and others. One of the most successful AR game is the Pokémon GO which allows user to experience and communicate with the virtual Pokémon in real life. In Pokémon GO, users are able to place a Pokémon once the camera detected a flat ground.

Nevertheless, in order to interact with the actual object with a a virtual piece in real life, marker recognition is immersed with AR technology as known as marker-based augmented reality. Marker-based AR will require a static image and will look for the specific image pattern in the actual environment and thus overlay a virtual plan on top of the object. Hence, the camera of a smartphone or any AR device will constantly be scanning for a specific item and therefore trigger a virtual content which stored in the database to display it on the actual object. Figure 1.1 shows the example of how marker-based AR works. In this project, the focus is placed on marker-based AR which is AR smart shopper that perform ingredients filtering and decision-making.



Figure 1.1: Example of Marker-Based AR. (Marker-based vs markerless augmented reality: pros & cons | Overly app, 2020)

In a real store, there will be a large number of products placed on the shelves in the supermarket. Traditionally, the user tends to look for the products by searching every related item along the aisle and level of the shelves. After picking the pleasing items, a user has to look for the nutrition facts label and read through one by one in order to determine whether it is the right products. A little bit more advanced way, which searching the products using non-AR assisted applications. Such a method is not advisable as there will be an opportunity that the desirable products may not be found. On the other hand, non-AR assisted is less efficient and more time-consuming in selecting the right products. According to Lynkova (2019), 71% of shoppers more often prefer utilising augmented reality to purchase at a retailer. Unlike non-AR assisted based application, AR-assisted based application help to reduce the amount of shopping time as a user omit the steps of inspecting the packaging of the products to look through the nutrition label. AR shopping assistant able to guide the user in selecting suitable products. Also, shop with AR mobile application will bring to a more enjoyable and realistic experience.

1.3 Project Objectives

The proposed project aims to:

1. To develop an application in assisting the user to filter and compare the ingredients of the right products in a short time.
 - Ability to customise the option of ingredients that user want and avoid the products with unwanted ingredients with red colour tags embedded with a cross symbol.
 - To benefit user especially housewife, people who have allergies to certain ingredients and people who have diseases like diabetes.
2. To create a cost-free application in recommending an appropriate product based on user preference.
 - To enjoy a free-of-charge mobile application.
 - To maintain a low maintenance cost.
3. To ease the user by blending the virtual environment with reality using AR to overlay the information of products on the screen.
 - To reduce the amount of time taken to look for the nutrition facts label on the packaging of the products.
 - To enhance the shopping experience with the used of AR.

1.4 Proposed Approach / Study

This project is a grocery shopping with ingredient filtering smart shopper app which applied AR technology. This proposed application is built in Android mobile platform. Android platform is common in used nowadays for every age groups. The graphical user interface of the application is designed simple and easier to use.

The AR Scanner is the main features in this application to detect and collect the features points of the image target and overlay a virtual object on top of the physical object. The devices camera is important here to allow system to scan through the products.

Furthermore, the products details and user account details are saved to Firebase and Vuforia database. The system will communicate with the database after interaction between the user and the system.

1.5 Impact, Significance and Contribution

At the completion of this project, a significant contribution of this project can be seen. The proposed application is helpful to reduce the time taken for the shoppers to spend in the supermarket. The application can recognise the selected products from the camera of the smartphone of the consumers and overlay the ingredients information contained inside the product using augmented reality (AR). Hence, the consumers are able to make a fast decision in selecting the best product they wish to buy as the ingredients of the products are shown clearly on the screen. Consequently, this will reduce the time in deciding on grocery shopping.

Besides, this system could also benefit the consumers who need to filter the unwanted ingredients of the product they want. As they are a large number of similar products with different ingredients that placed on the shelf in a supermarket, a consumer could find out difficult in filtering out the ingredients which the product consists. An undesirable way is asking the staff however the staff may be unacquainted about the ingredients inside the products. Therefore, this application advantage the consumers by filtering unwanted ingredients and showing green and red colour tags to distinguish between suitable products and unsuitable products. On the other hand, the system is benefits to those who have allergies to certain ingredients and for those who suffer from some diseases like diabetes that trying to avoid high sugar level products. Users were able to customise and personalise the products with the ingredients they desired.

With this flourishing technology, people around the world are able to take advantages with this system during grocery shopping and this system will be widely used for future reference and ahead of market trend.

1.6 Report Organization

The report is divided into 6 chapters. Each of the chapter consists of separate information which pertaining to the chapter section by section. Chapter 1 is mainly focus on the general idea of this project such as the background information, project objectives, proposed approach, and others. This chapter principally discussed about the purpose of introducing this application and what is the problem that trigger the initialization of this project.

A brief explanation about the functionality and all the important details will be discussed in following chapters.

For chapter 2, previous researcher work that have done by other researcher will be reviewed and compared since similar work is done. It consists of the idea of augmented reality and some comparison on AR framework that tested by other researchers. Besides, there are also some literature review about different type of ingredient filtering application with different functionalities and limitations that need to be done in future work. On top of that, each of researcher work will be compared and contrasted to analyse the strength and weakness of the existing works. Therefore, a comparison is done between previous works and proposed solution.

Afterwards, Chapter 3 is focused on system design of the proposed system. This chapter basically describe briefly about how the system being developed. Each of the process is explained in detail with the use of top-down system design diagrams and each block indicate the functionality of the system. The functionality and flow of the system is also illustrated using use case diagram and activity diagram.

For chapter 4 and 5, the important blocks of the top-down system diagram are described in this chapter. Moreover, some sections are allocated in chapter 4 such as methodology used, hardware and software tools, system analysis and design implementation, implementation issues and challenges, and user requirements. The prototype of the proposed system will be discussed as well. While in Chapter 5, implementation and testing will be discussed. Validation plans is designed for testing purpose in order to identify any possible errors based on the results obtained.

Finally, chapter 6 is about conclusion. This chapter covered project review, discussions, challenges that discover from the system. Novelties and contribution of the proposed system are highlighted in this chapter as well so that the limitations that previous researcher faced can be solved. Before concluding the project, future work is discussed in this chapter to signify improvements or further developments that can be made to this system in the coming times.

CHAPTER 2: LITERATURE REVIEW

2.1 Augmented Reality

Augmented Reality is known as AR was invented in the 1960s where physical and virtual world environment is blended which able to enhance the human perception reality. (Zhu et al. 2004) Although AR was incepted first with a head-mounted display device, smartphones are still the predominant platform in providing an experience for AR to the users. The rapid growth of installation of AR application regardless of the embedded or standalone app with AR is statistically significant since the year 2016. The embedded AR mobile application stood 340.8 million of downloads rate in 2016. (Tankovska 2020) AR mobile applications provided a lot of benefits, for example, they encourage mobility and provide portable experience to the consumers. Besides, mobile AR acts as a mechanism for more personal experience with AR and enables the consumers to consolidate experience within specific contexts. (Elizabeth et al. 2013)

2.1.1 Comparison of AR framework

As there are quite a number of AR framework for users to utilise AR technologies, the performance of different AR framework might also be different. To support the Android platform, ARCore, Vuforia, and MAXST are the popular commercial AR frameworks for Android environment. The experiments had been conducted either in a lab or real store to measure the performance of these tools. The experiments were conducted with the comparisons in 4 dimensions which were distance, perspective of view, occlusion, and simultaneous recognition.

In the experiment, maximum recognisable distance, number of tracking and occlusion, and minimum recognizable distance were measured. In the lab experiment, Vuforia did a good job in occlusion among other AR frameworks. MAXST and ARCore had the problems in recognising large numbers of targeted items, unlike Vuforia that had no limitation in recognising a greater number of products. In recognising distance, MAXST is able to detect the longest distance of products better than Vuforia followed by ARCore. While in recognising viewing angel, MAXST and Vuforia had better performance in viewing box type products and

pouch type products. ARCore outperformed MAXST and Vuforia in detecting cup and pouch type products from the left side. In simultaneous recognition, ARCore had the worst performance among the other 2 AR framework. Vuforia had the best performance in tracking the products in a different orientation. Although ARCore having the worst performance, however, Vuforia and MAXST still not able to perform best simultaneous recognition.

In a real store experiment, Vuforia and MAXST had similar performance results in the grocery store while ARCore not is implemented in a real store experiment due to its having difficulty when applying to a real environment. MAXST have greater performance than Vuforia in tracking the number of products from a distance. In performing recognition with different shelf levels, Vuforia also did not perform well recognition on the third level while MAXST did.

In all, the result showed that Vuforia and MAXST outperformed ARCore after the experiment. However, MAXST is a commercial tool as users have to pay for this tool every month for using it. Hence, Vuforia is the most common framework to use in developing a low-cost application. Nevertheless, some issues needed to be considered which similar products with the same size might not be recognised correctly. Besides, in the real store, the products placed on the shelf will lead to the overlapping of the virtual content. The other limitation is that the recognition performance is affected by the structure or the position of the shelves. Therefore, the researchers had proposed to be carefully designed the AR content and UI of the application in order to avoid the problems mentioned above. (Lee et al. 2020)

2.1.2 Occlusion

Augmented reality interface often involves overlaying of virtual imagery on the real object in real-time. (Lee et al. 2004) This visual overlay is known as occlusion. The researchers had discussed occlusion-based interaction from the perspective of occlusion detection and interaction design. To detect the occlusions, 2 methods were used to detect occlusions which were boundary marker method and the estimated marker projection method. For a single interaction marker, at least 2 boundary markers were used to surround the interaction marker. The interaction marker is occluded if the boundary marker is not detected. Figure 2.1 shows the interaction markers surrounded by boundary markers.

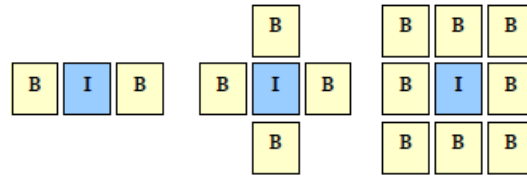


Figure 2.1: From the paper “Occlusion based interaction methods for tangible augmented reality environments” by Lee et al.

For multiple interaction markers, hybrid markers were the neighbours of interaction markers that been tested. To detect occlusion, hybrid markers play the role in both boundaries and interaction point of itself. Figure 2.2 shows the hybrid markers.

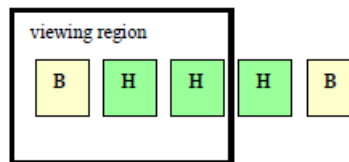


Figure 2.2: From the paper “Occlusion based interaction methods for tangible augmented reality environments” by Lee et al.

For the estimated marker projection method, this method can estimate the 3D orientation of invisible markers that comparative to the camera. The estimated marker only required 1 visible marker to check the occlusion compared to boundary marker method. Figure 2.3 below show the estimated marker projection method.

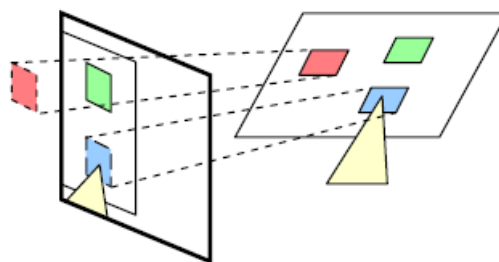


Figure 2.3: From paper “Occlusion based interaction methods for tangible augmented reality environments” by Lee et al.

The limitations of the boundary marker method are that it is hard to avoid marker wastage. The users also needed to ensure the boundary markers are in the current view. While for the estimated marker projection, there exist the issues of incorrect estimation due to the falsification of the camera lens.

While for interactive design, the researchers have proposed 3 methods which are time out constraints, sub-marker level measurement, and tip point marker detection. Time out constraints able to support selection as this technique allowed users to stay above objects for a period of time. Sub-market level measurement was helpful on interfaces that need to deal with continuous input. This technique can decrease the number of needed markers. In tip point marker detection, this technique could handle the unwanted occlusion of markers on the interaction between users and objects.

In general, occlusion-based interaction provide low cost, simple, and natural development for a system. To tackle with the limitations found in the occlusion interaction, the researchers proposed future works like exploring more likely feature tracing methods to allowed better performance for occlusion. (Lee et al. 2004)

2.1.3 Dynamic Contextualisation

With the implementation of dynamic contextualisation, retailers were able to customise the products setting virtually and the interest flow of the consumers would be controlled. Dynamic contextualisation was aware of 3 requirements which are location context, user context, and product context. User context was the profile of the consumers including the buying habits and history of each consumer in the store. Whenever the consumers' checkout, the purchasing history would be recorded in the database. The shopping patterns of the consumers were learned by the system in order to generate personalised information. Location context was used in acquiring the location of the users whether where were the users located. This also applied in products to determine the location that the products been placed. Product context associated complementary products with the focal product to influence users' attitude. Functional, aesthetic and sociocultural complementary products had discussed in products context which was the purchase influencers, design and patterns of the products, and consumption activities of the products by the consumers.

2.1.4 Augmentation and Diminishments

Many of the researchers implemented visual contextualization to locate complementary products with focal products in 3D visualisation with accordance to the perception of the users to the focal product. For instance, users were allowed to place an item with different 3D settings on a website and select their preferable combination of the items. Based on the research stated, visual contextualisation would bring a better shopping experience in terms of consumer experience, purchasing intention, and brand attitude. Visual contextualisation consists of augmentation (augmenting context) and diminishments (diminishing context). According to Zhu et al. (2004), augmenting context is very common in the implementation of augmented reality systems. The research had proposed augmenting context to the focal product in their project and the result show that the system was able to provide information of consumers about the focal product which was not possible to be done by traditional media. The information about the focal product could appear in 2D pictures or pasted beside the products with 3D objects or in different manners in terms of position or even engaged with the shelf display. The displayed content with deeper depth create a virtual extension of the spaces in the shelf and occluded the physical object in front of it. With this context, the focal product can be occluded with proper occlusion.

Diminishments highlight the focal product by hiding product items from the surrounding. With this context, the sales volume would be highly increased as information would be displayed by the retailers to the consumers. Diminishments could be done by manipulating the occlusion model to the undesirable final images. Researchers of Promo Pad had applied this concept which replaces the surrounding competition with specific suggested products from the retailers. The researchers had shown examples of augmentations and diminishments in figure 2.4. (Zhu et al. 2004)

Focal Products	Augmentations	Diminishments
Digital camera	Picture slideshow, feature demonstration, accessories	Outmoded models, security locks and latches, film camera
PDA	PDA keyboard, PDA software, Wireless Internet access, memory	Security locks and latches, laptop computers
Perfume	Flowers, romantic pictures	Disliked brands or scent of the consumer*
Pen	Notebook, grade report, back to school picture	Crayon, scissors
Candy bar	Cartoon characters, ice cream	Mint drops, energy bar
Wine	Glasses, roses, picture of a grand banquet	All other than the bottle under inspection
Detergent	Picture of silk or wool, movie clip shows the effect after use	Unfavorable ingredient varieties*

Figure 2.4: From paper “Personalized In-store E-Commerce with the PromoPad: an Augmented Reality Shopping Assistant” Zhu et al.

2.2 Shopping in Augmented Reality

There are some works regarding shopping assistant that has done by other researchers. However, there are still many challenges and limitation exist in their works. Hence, several relevant methods regarding shopping in AR will be reviewed including the limitations and some proposed solutions.

2.2.1 Personalized In-store E-Commerce with PromoPad

In this article, the researchers proposed a shopping assistant by utilising AR technology to provide a personalised and in-store e-commerce shopping assistant with the concept of dynamic contextualization. This system aims to provide a user-friendly environment for use with less user effort in either the shopping mall or grocery store.

This paper had criticised the traditional concept of context-aware computing which some researchers had developed a common retail system which can only manage shopping lists or navigate the user to the shelf in the grocery store. Most of them applied context-aware computing to provide users with an automated electronic shopping assistant that could aid the shopping process.

To enhance the above system, this paper applied dynamic contextualization to replicate the situations of users that had the ability to affect the perception of shoppers to a brand and

decision to purchase certain products. The researchers had stated about dynamic contextualisation able to perform 3D visualisations to a real product which the perception of real-world has been modified. The system that introduced by this paper consists of 2 components with the concept of client-server architecture which are front-end client component and also back-end server component. For front-end components, a Tablet PC with a camera attached is used. While for back-end components, 1 or more servers containing several information such as inventory database and user profiles. Besides, the system implemented content customisation and personalisation to ease different kinds of user's requirements.

Several issues were discussed in this paper such as in-store tracking, video see-through systems, registration, zooming and composition. The location of the shoppers relative to the products and shelves are learned by the in-store tracking system. In video see-through systems, the view seen from the screen of Tablet PC performed derivation by using graphics frustum model so that the virtual objects are aligned nicely with images of the camera. The system also provided zooming function which able to zoom the image properly. As the window of Table, PC is larger than the camera image, thus more augmentations able to be accommodated. Finally, to compose the real image and virtual objects, dynamic contextualisation is employed. Although the product settings have been changed by the retailers, with the help of dynamic contextualisation, the system was able to handle my modifying the focal context information virtually.

In this system, dynamic contextualisation is based on 3 context which consists of location context, user context, and product context that been implemented in this system. Based on the location context, the location of users and products are tracked by the in-store tracking system in this paper. User context means the customer's profile where the shopping behaviours and habits of the user will be learned by the system. In the product context, similar yet related products will be recommended by the system. Other than that, the system can also replace the background with suggested complementary products and display the information with the concept of dynamic contextualisation in AR. This paper also introduced the augmenting context and diminishing context which are the common implementation of AR systems.

However, there are some limitations found in this paper. Firstly, the user's privacy issues arisen the time when retailers intend to predict the shopping behaviour of the consumer based on previous activities. Hence, the privacy of the user may be leaked unintentionally. However, this is an unavoidable problem. Some users may still be willing to sacrifice with their

private information. The other limitations are that the user's flexibility in this system will be affected. As this system intends to promote automation, thus, the design has limited the user's control over the system. To deal with such problems, the researchers proposed to give a survey for users either they support automation or user flexibility. (Zhu et al. 2004)

2.2.2 Healthy Grocery Shopping via mobile AR

In this paper, the researchers had introduced a mobile-based AR system to aid the consumers in finding healthy food in the grocery stores in order to reduce the amount of time taken for users to find their desired products and avoid unhealthy food. AR overlay tagging on the products are demonstrated in order to allow users to look for healthy products quickly.

According to Katz et al (2009), there are thousands of products regardless of the packaging either in boxes, bottles, or others that make shoppers felt challenging in deciding to select healthy food. Therefore, providing nutrition facts by introducing AR in the point of purchase could help improve the decision making in picking healthy food. The researchers had claimed that AR technologies were able to provide greater visual interaction with a real-time environment with augmentation and occlusion method. The previous work in this paper had mentioned that AR tags can overlay in the house so that instruction can be provided for example time for taking medicine, washing shirts, and others. Some previous researchers claimed that supermarkets are a suitable location to apply information overlaying where the shoppers were able to capture the items and matched in the database to retrieve and display the information on the actual products. Nevertheless, the mentioned system required users to know where the products are located. Hence, this paper intends to compare the performance of 4 mobile grocery assistant application in real-time grocery stores. There is 2 focus discussed in this paper which is the time for AR tagging of recommending products in helping users to choose for healthy food, while another focus is whether the tagging products were able to reduce time to avoid unhealthy products.

In turn, the system introduced in this paper is able to support navigation by using AR technologies. The system consists of 3 components which were image labelling service, a remote cloud server component, and also a mobile component. The system was able to determine the initial location of users and then estimated motion of a user by using a commercial image labelling services known as IQEngines (Ahn et al. 2015). To localise users

to the aisle, the bounding box was constructed around every aisle where the range of x-axes was bounded by the width of the regular aisle in the store. Before that, the user had to input the health profile to avoid the products that contain these unsuitable products. The server has the ability to access the information and filter the suitable products to the user. The system used the OpenGL library to render the AR tags that were shown in 3D depth perspective. The application also considered dietary food constraints where people who have allergies could select the options such as low sugar, low sodium or no milk. The applications will then displayed the real products on the aisle of the grocery store. This function was helpful as when user walked along the aisle, he or she could easily get the information about the product that advised by the system. In order to differentiate whether the food is considered healthy or unhealthy, coloured tags were used where green colour indicates healthy food, while the red colour indicates unhealthy food. Figure 2.5 shown the example screenshot of the mobile application.



Figure 2.5: From paper “Supporting Healthy Grocery Shopping via Mobile Augmented Reality” by Ahn. J et al.

Moreover, the system had implemented static and dynamic motion AR-tag display. Static AR-tag displays were able to provide users with a static display in which the tags can be view in a fixed position while dynamic motion able to allow the tags to change position and aligned properly based on the user. Other than that, the system was able to recommend healthy food matching with the history of the user’s profile. The conducted survey showed that when this system is applied, the shopping speed of users is improved to double or triple.

However, there are some limitations found in this paper where users will not always be holding the phone consistently when walking along the aisle. This would lead to the incorrect of accelerometer sensor detection. To solve the problems, the algorithm needed to be modified in order to tackle the sudden change in the orientation of the sensor. Another solution was the motion of the component is limited in the direction parallel to the y-axes of the aisle. (Ahn 2015)

2.2.3 Situated Analytics

In this paper, the researchers implemented a new interactive decision-making technique (Situated Analytics) which combined Visual Analytics with Augmented Reality which can be used in both handheld and HMD devices based on supermarket shopping context. The researchers have designed several approaches for analysis, visual representations, and interactions.

This paper had evaluated some methods from other researchers. Previous work like data in White and Feiner's SiteLens system was built in multidimensional form. Some researchers intend to classify AR visualization into 3 categories which are data integration, scene manipulation, and context-driven. Data integration enhanced the bending of virtual objects with physical objects; scene manipulation helped to operate scene of real environment to augment data; context-driven would alter the information of visual presentation based on context information. However, the unprepared environments, tracking were still an open question. For AR information visualisation, previous researchers had implemented 3 approaches which are complexity reduction, layout optimisation, and interaction techniques. Previous researchers performed this approach on filtering techniques using occlusion which used the location of users to visualise the occluded layers of the building. Some of the researchers also utilised layout optimisation to visualise text labelling. Besides, AR information interaction has also been considered from researchers in previous work by using this approach in exploring details on demand (DoD) (Feiner, cited by ElSayed). However, this cannot be worked with other data types. While for analytics, most of the previous researchers faced the problem where filtering techniques would cause masking of large quantities data and many tasks were rendered incompatible.

However, this system was not able to support real-time analytics interactions. Hence, this paper will apply visual presentation by displaying the results and information in a multidimensional way. In this system, the user would be asked to select, rank, and filter the items based on ingredients, prices, and nutrition. For filtering techniques, this paper intends to resolve the problem by developing visual representation that overlaid partially the physical objects with transparent visual objects. The physical object that highlighted in green rectangle indicated the wanted produces while the highlighted half-transparent black mask indicated unwanted items. For ranking, users were allowed to check or unchecked the physical items to perform the ranking technique. Situated Analytics (SA) promoted interaction and exploration with information and presented them as virtual object overlaid on the physical products. Besides, users are allowed to explore the ingredients that had printed on the packaging of the products then visual analytical information about the ingredients such as the number of fats or sugar that the products contain would be displayed virtually. SA was also allowed analytic and comparison the information between the products. For example, the system would show the comparison analytics result when 2 products are placed to each other. Figure 2.6 shows the SA system interaction and visual representation. (ElSayed et al. 2016).

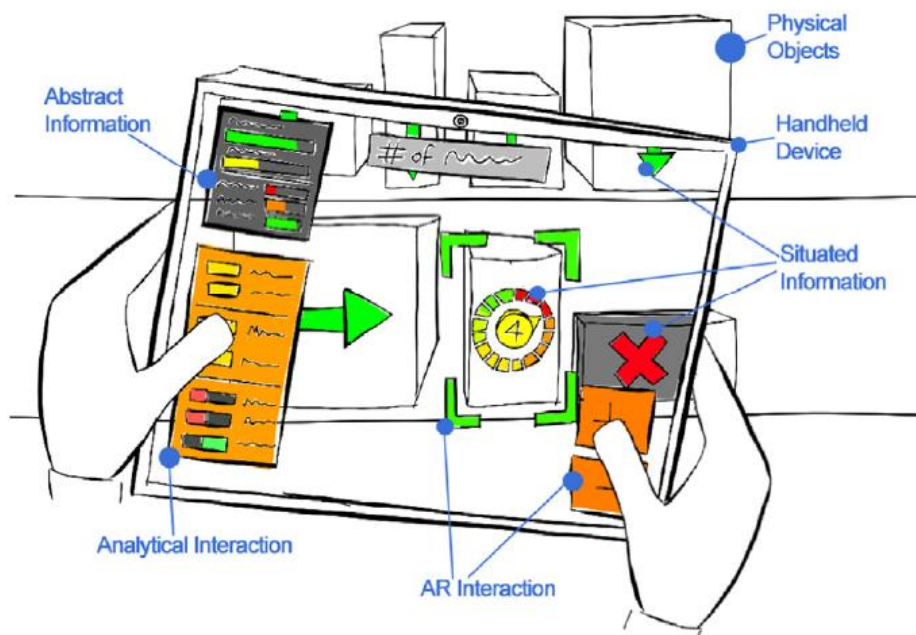


Figure 2.6: From paper “Situated Analytics: Demonstrating immersive analytical tools with Augmented Reality” by ElSayed et al.

The results showed that the tasks could be performed quickly and accurately using situated analytics prototype. Unfortunately, some limitations could be found in this paper. The

system is expensive as it can only be applied in either handheld or HMD devices. The system can only be used in a simulated supermarket instead of an actual supermarket. Besides, evaluation in real life is still needed for the whole system, for example, replacing the simulated supermarket with a supermarket in a real environment.

2.2.4 PHARA

In this paper, the researchers intend to introduce an AR system namely PHARA which able to support decision-making at the supermarket. Food recommendations are still on demand because of not much research on the actual delivery of food recommendation results to users. Hence, these papers intend to introduce grocery stores, health assistants, together with the concepts of AR technologies.

In this paper, some existing works were done by other researchers. Some of the researchers proposed using a mobile phone as a grocery shopping assistant with traditional content-based which based on user profiles and database of the products. Another researcher implemented healthy food recommendations using crowdsourced service by searching for food alternatives. Besides, a simple nutrition-based recommendation system is proposed by other researchers to promote eating healthy food but lack of time to compare nutrition. For the most comparable system to this paper which the researchers used colour-based tags in searching healthy items in the supermarket. In-store navigations system and single colour-based label were implemented in the system.

Consecutively, this paper introduced both hands-free health assistant. The system architecture can be shown in figure 2.7.

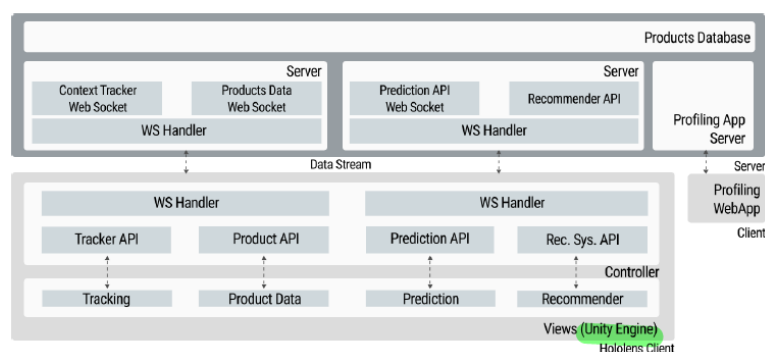


Figure 2.7: From Paper “PHARA: a personal health augmented reality assistant to support decision-making at grocery stores” by Guti´errez et al.

The system allowed users to apply in HMD devices and execute tasks using a command like hand gestures. The data was streamed from the servers on demand to ensure the responsiveness of the system. Recommendations and predictions were done in the server instead of tracking printed labels or barcodes. For the user interfaces of this system, the AR card component layout was used in this paper to foster related products recommendation and impact on health components that will predict the impact on the user's body. Besides, the description of nutrients show would be shown in intuitive visualisation. For the recommendation system in this paper, the recommendation is generated based on similar products, user's profiles, and healthy products. Users would be prompted to create a new profile with their data such as allergies to certain ingredients. Then, users were asked to choose 10 favourite products for training the system. After done creating the users' profile, a dashboard was shown together with the recommended products. Figure 2.8 shows the recommendations, health impact predictions and product information.



Figure 2.8: From Paper “PHARA: a personal health augmented reality assistant to support decision-making at grocery stores” by Guti´errez et al.

However, there also exist some limitations to this paper. The first issue regarding the accuracy and diversity when users had experience incomplete display of descriptions. Moreover, the uncertainty of data quality has occurred during processing and presentation to the users. These problems might able to be solved by the proposed solutions by the researchers. This prototype may need refined and explored the effect itself in greater and larger diversity. The precision of food recommendations needed to be explored again and different visualisations will be evaluated based on the personal health data of users.

2.2.5 ARMart

In this article, the researchers intend to introduce an AR-based mobile application which could help consumers to select the packaged groceries based on 2 factors which are calories and overall products scale rating. This paper had criticised some related previous work. For example, there are some works done where the researchers label the grocery items with colour using AR but the information did not overlay properly on the packaging of the items but it mapped of the shelf.

In turn, these papers introduce a new working principle where the system has an independent location in which the history location will not recall and can be used even in the kitchen. The front-side packaging of the products is captured by the camera of the smartphone and the relevant data such as products name, brands, price, calories and others were sent for object detection. A single input of each product is captured within 1 meter. The products are then overlaid with a coloured rectangular shape with ARKit which is an iOS AR framework. The researchers stated that the products can be captured either spreading on the table, user self-picked or when it was on the shelf. Figure 2.9 shows the system flow of the application.

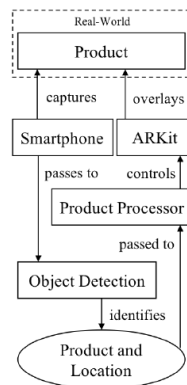


Figure 2.9: From paper “ARMart- AR-Based Shopping Assistant to Choose and Find Store Items” by Röddiger.T, Doerner.D, Beigl.M

Moreover, this paper had introduced 3 focus on the functionalities of the application including filtering, searching and exclusion. For filtering, consumers can select filtering options based on calories, sugar level and so on. Then, the system will be based on the factors selected by consumers and overlay a colour rectangle shape on the products. The colour assigned to the items is based on the common adult’s daily consumption recommendation; green colour is very good while the red colour is very bad. For searching, the database will

query and item the products when users entered the products name or brands. For exclusion, the system will alert the user about which products containing the allergy items.

Nevertheless, there were some limitations to this application. Based on the researchers, the applications could only work on the products that locally stored on the user's smartphone. Besides, the applications only supported products with a rectangular shape, other than that are not applicable. In response to these problems, the researchers had proposed to add an insight function in order to understand the user's interaction. Furthermore, the researchers wish to improve the system architecture so that a large number of items at scale is anticipated. Increasing the products in the database is proposed by the researchers in order to improve the overall applications. (Röddiger, Doerner & Beigl 2018)

2.2.6 AR Shopping Assistance in Physical Store

In this article, the researchers had introduced a shopping assistant app by utilising the AR technologies. The system would provide personalized advertising together with an in-store shopping assistant. For instance, customisation of product information to the users. The system would also be able to predict the interest products of the consumers based on their previous shopping habits.

This paper had discussed some existing system from previous researchers. Some of the researchers introduced web-based AR conventional shopping experiences and found that applying AR tools in e-commerce would give positive impact towards the shopping experiences. Other researchers also proposed AR dressing room by using mapping skeleton that allowed users to try before buying the items. Many of them introduced shopping assistance for fashion purpose but not many proposed for health purpose. Anyway, there are also some researchers proposed e-commerce applications that would concern about the promotions, shopping lists, in-store navigations. Researchers proposed a mixed reality shopping by making use of both physical and virtual augmented recommendations with the use of VR Box. Another researcher had introduced a shopping assistant application which combining both virtual experiences and augmented reality visualisation. Various researchers had explored using in-store GPS with RFID.

However, the conceptual framework of this system consists of shopping assistance applications, in-store tracking and dynamic conceptualisation in the mobile app. The researchers suggested associating in-store navigation system together with the capability of dynamic context in terms of AR to act as personalised shopping assistant. The AR mobile application will navigate the users to locate the products they want in the shopping mall by using in-store GPS. The tracking system able to navigates the users with the shortest route for desired products. Users were allowed to scan a certain product or even the entire shelf by using the camera of their smartphones. Various information would be like promotions, products information would be retrieved and displayed. Besides, dynamic contextualisation also applied in the system where the retailer can change the product settings virtually or remove any products and even attracted the numbers of people in the shopping zone. The user profile proposed in terms of user context which the products is recommended based on consumer’s buying history. The system was able to aggregate the behaviour of users based on the shopping history, shopping experience, and also demographic differences. These technologies tend to understand the shopping pattern of consumers and thus recommend a brand or product. This application could help the shopper in seeking discount products, offers, and others. (Kumar et al. 2020)

Nevertheless, the main limitation that happened here was the privacy issues of the users as the application was able to predict the interest of consumer based on the shopping behaviour. The most crucial solution proposed by the researcher is it is important to balance the trade-off between automation and privacy of both consumers and retailers.

2.3 Critical Remarks for previous works

1. PromoPad

Table 2.1: Strength and Weakness of PromoPad.

Strength	Weakness
<ul style="list-style-type: none"> • Utilise concept of client-server architecture 	<ul style="list-style-type: none"> • Users’ privacy issues • Design limited to users control over the system

<ul style="list-style-type: none"> • Implement content customisation and personalisation • Location of shopper relative to product and shelves are learned by an in-store tracking system 	
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2. Healthy Grocery Shopping

Table 2.2: Strength and Weakness of Healthy Grocery Shopping.

Strength	Weakness
<ul style="list-style-type: none"> • Can localise user to the aisle with AR • Allow user input of health option • Show colour tags to indicated healthy or unhealthy food • Able to recommend healthy food based on user profile 	<ul style="list-style-type: none"> • Incorrect accelerometer sensor detection

3. Situated Analytics

Table 2.3: Strength and Weakness of Situated Analytics.

Strength	Weakness
<ul style="list-style-type: none"> • Able to show a dashboard of visual analytic information • Allow AR interaction with the user 	<ul style="list-style-type: none"> • Do not support real-time analytic interactions • The system can only apply to HMD or handheld device • Cannot be implemented in an actual supermarket

4. PHARA

Table 2.4: Strength and Weakness of PHARA.

Strength	Weakness
<ul style="list-style-type: none"> • Able to scan the bar code of a product and display nutrients descriptions • Able to predict health impact based on ingredients 	<ul style="list-style-type: none"> • Incomplete display of description • Uncertainty of data quality

5. ARMart

Table 2.5: Strength and Weakness of ARMart.

Strength	Weakness
<ul style="list-style-type: none"> • Able to capture object within 1meter • The product can be capture either spreading on table or holding • Able to filter ingredient • Quality indicator for product 	<ul style="list-style-type: none"> • Only support iOS device • The product can only be stored locally in user smartphone • Can only detect product with the rectangular shape

6. AR shopping Assistance

Table 2.6: Strength and Weakness of AR shopping Assistance.

Strength	Weakness
<ul style="list-style-type: none"> • Provide in-store tracking • Provide recommendation based on user profile • User can scan the product or shelf 	<ul style="list-style-type: none"> • Privacy leak

Comparison between Previous Work and Proposed Solution**Table 2.7:** Comparison between previous works and proposed solution.

Features	User-friendly interface	AR functionality	Free-of charged	Ingredient Filtering	Compare multiple products	Check out function
Proposed Application	√	√	√	√	√	√
PromoPad	x	√	x	x	x	x
Healthy Grocery Shopping	√	√	√	x	√	x
Situated Analytic	x	√	x	√	√	x
PHARA	√	√	N/A	x	x	x
ARMart	√	√	x	√	√	x
AR Shopping Assistance	x	√	N/A	x	x	x

CHAPTER 3: SYSTEM DESIGN

3.1 System Overview

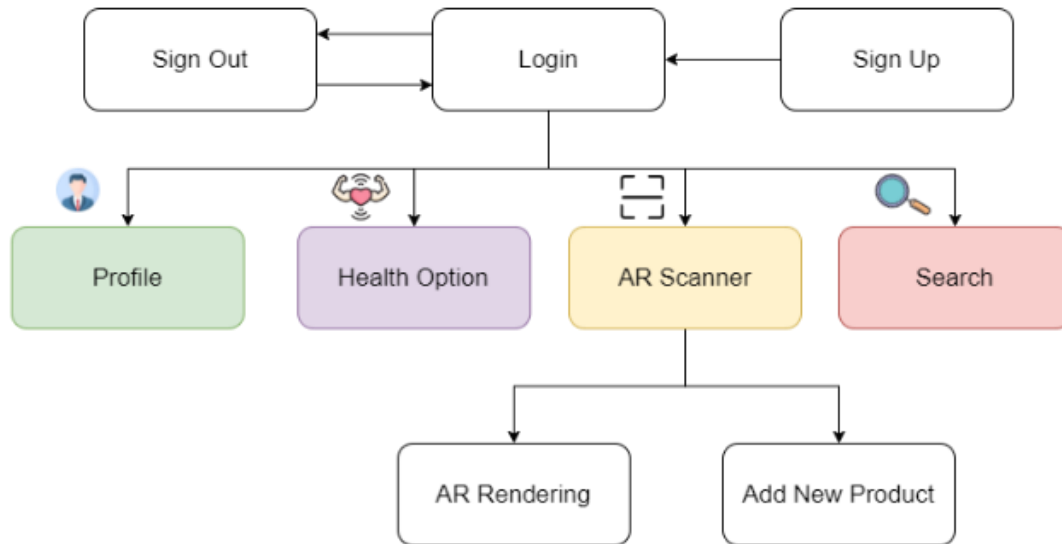


Figure 3.1: System Flow Diagram.

Figure 3.1 shows the general system flow diagram idea of the application in this project. First and foremost, the application required a user to log in before using the application. If a user does not have an account, the system allowed a user to create an account before logging in. Of course, there is a sign out function provided by the system to allow the user to log out from the application. After logging in, there are some options for the user to carry out different activities. Firstly, the profile which allow user to make changes to their user account. Then, health option allow user to make user preferences about the allergen that they wish to filter out. Besides, there is an AR Scanner which is the main features that provided by this system. There are 2 key functionalities that will be specified in this feature such as AR rendering and adding new products. The process of both functionalities will be discussed in detail in the following sections. Last but not least, the search function provided by the system where user can search the existing products in the database. There are in total 200 of products that originally stored in database. The system will retrieve and return the products that search by user and product details will be shown.

3.1.1 User Account Creation

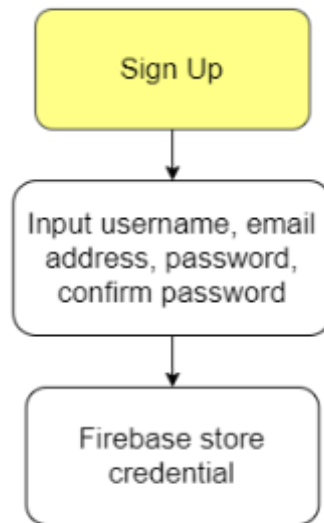


Figure 3.2: Block diagram of sign-up function.

In order to create a user account, user input such as username, email address, and password are prompted to user. The system will then prompt user to confirm the password by retyping the password for the second times to ensure the correct password was entered. The system will validate the password that user entered by ensuring the password having minimum number of characters of 6. If the password lesser than 6 character, an error message will prompt to user to warn user re-enter the password. After submitting the form, Firebase Authentication will register the user or store the user credentials. Figure 3.2 shows the block diagram of sign-up function.

3.1.2 Login Account

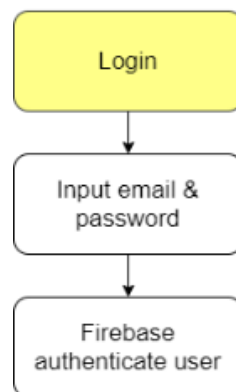


Figure 3.3: Block diagram of login function.

Figure 3.3 shows the block diagram of login function. The system will prompt user to input email address and password before the get to sign in into the account. Firebase will then authenticate the user by using Firebase Authentication. Firebase Authentication make easy to end users and developers where it will keep the data secure anytime. Each user will have a unique identifier to identify the user distinctly thus ensure the user are authorized to access. Once user being authenticated, the information of a user will be returned to the application and the user is logged in.

3.1.3 Manage user profile

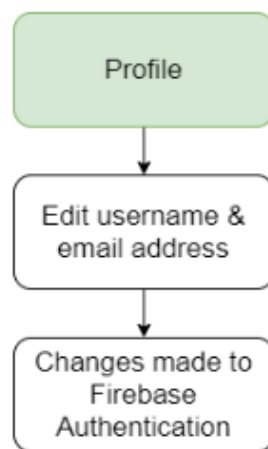


Figure 3.4: Block diagram of user profile.

Moreover, the system allows users to manage the user account. There are 2 fields for user to make changes such as username and email address. Firebase will check the current user active in the system and match with the unique user identifier, then get the updated information and finally make changes to the Firebase Authentication. Figure 3.4 shows the process of managing user profile.

3.1.4 User preference on health option.

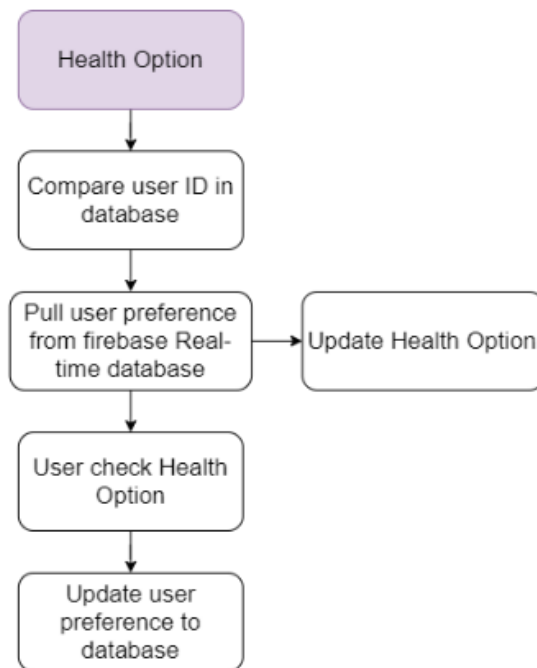


Figure 3.5: Block diagram for user preference.

Figure 3.5 shows the block diagram of user preference on health option. This feature allow user to select the desired allergen and save it to the database so that the system will auto filter the undesirable ingredient during AR rendering. First of all, the system will compare the current user identifier in database. After that, the system will pull all the user preference that previously saved by the user from Firebase Real-time Database. After getting all the data, the system will return the data and update the toggle in Health Option. On the other hand, if the users are newcomer, and do not make any user preference before, the system allow user to select the allergen by checking the checkbox of each allergen. After submitting, the system will update user preference to the database. Each time the user saves the changes, the system will update the database with the latest changes made.

3.1.5 AR Scanner

(a) AR Rendering

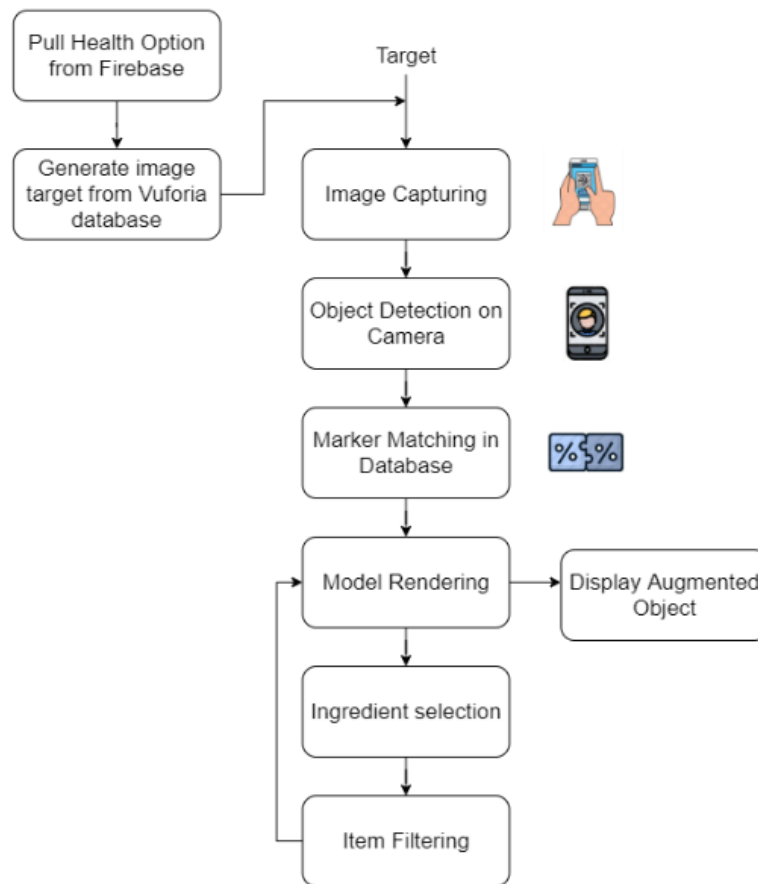


Figure 3.6: AR Rendering process.

Before AR rendering process, the system will pull the health option that user selected from the Firebase. The system will then generate image target from Vuforia database to get ready for image capturing in the next step.

Image Capturing

The input of the system is the packaging of the product. In the image capturing phase, the packaging of an object is captured using the smartphone camera. Front view of the packaging of the object should be exposed to the camera for marker detection in the next steps.

Object Detection on Camera

The system will continue to perform object detection after user exposing the packaging of the product to the camera. On object detection, the system will track the image based on image

features. The system will extract the feature points from the product image as a marker to perform marker matching in the next steps.

Marker Matching in Database

After extracting the feature points, the system will then match the features points extracted from the image with the marker in the database. If the image is matched with the marker, the system will augment the ingredient list of the product accordingly. If the image does not match with any marker, there will not be any augmentation done on the screen.

Model Rendering

After the image has successfully matched, the system will implement model rendering to fetch the information of the product like brand, ingredients to display on a plane as AR content. In fact, if user do not select any preference in health option, the system will augment the ingredient list on the product. If user had made any user preference in health option, the system would augment a green box or red box based on the allergen that consist in the product and match it with the health option.

Ingredient Selection

The system by default has provided a list of allergic ingredients for example milk, nuts, cereal, and others. Users are allowed to select the ingredient that they want to filter by taking the checkbox beside the ingredient.

Item Filtering

After selecting the ingredient, the system will filter the product according to user preferences. The augmented plane of the products will be changed accordingly, for example, a green plan with a “tick” in the centre point for the product without the allergic ingredient while a red plane with a “cross: in the middle is for the product with allergic ingredients.

(b) Adding new product

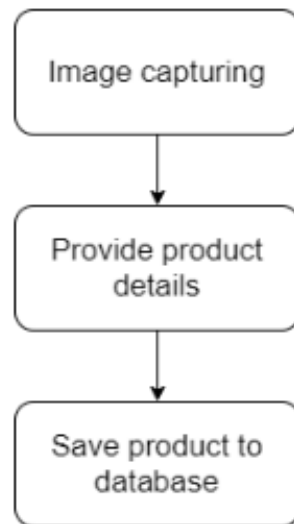


Figure 3.7: Block diagram for adding new product.

Beside AR rendering, the AR scanner do provide another function which is adding a new product. Figure 3.7 shows the block diagram for adding a new product. First, the front view of the product will be capture using the AR camera. After that, a box will pop out to prompt user for providing the product details. The product details will then be saved to the Firebase Storage where the image of the product will be saved into “ProductImages” folder while the product details will be save into “IngredientList” folder. The database will be updated with the new added product for a particular account.

3.1.6 Search existing product

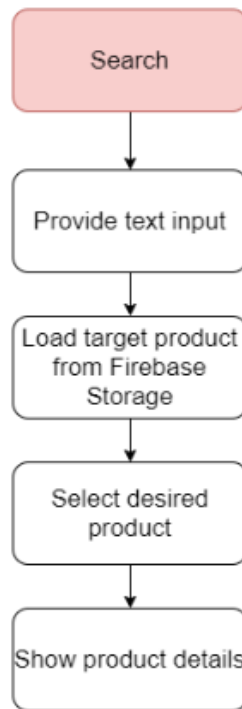


Figure 3.8: Block diagram of search function.

Figure 3.8 shows the block diagram of search function. The system allow user to search a product from database to view the product details. The system will need a text input to search for certain product. After submitting, the system will load target product from Firebase Storage. Firebase Storage will return all the possible product to the system and all the relevant search result will be shown. Then, the system allow user to select the desired product and after selecting, the product details will be shown by the system.

3.2 System Architecture Design

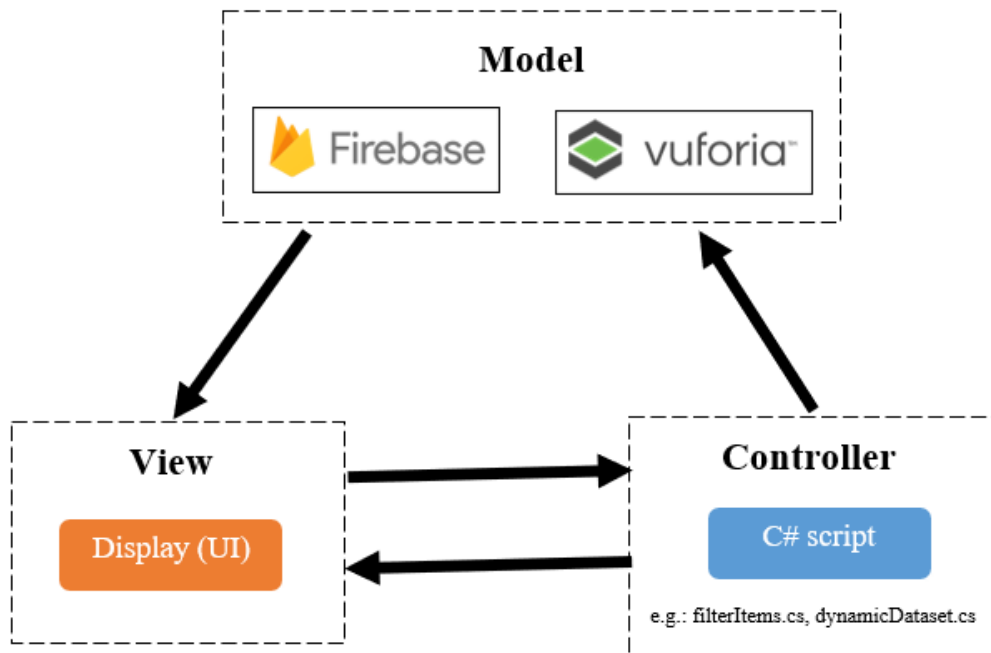


Figure 3.9: MVC architectural pattern.

To describe the application of this project, Model-View-Controller (MVC) architectural pattern is used. MVC architectural pattern will separate the presentations and interaction between the system into 3 main logical components such as model, view, and controller. Each component will have their respective responsibilities. Figure 3.9 shows the MVC architectural pattern of this system. Model component mainly managing the data and schema that used by the application. In this project, Firebase and Vuforia will be responsible for storing the user data and image target that are pre-defined in Vuforia Database. On the other hand, View component basically is like a presentation layer which defining the user interface of the system. This component will manage the data that updated from model and presented to user. Moreover, the controller is a logical layer which contains logical control function to manage the user interaction. Communication between Model component is happened here to retrieve the data and then send back to the View component. In this project, the controller is the C# scripts for example filterItems.cs, dynamicDatasets.cs and others to manage the events and interaction and pass it to View and Model component.

3.3 Application Features

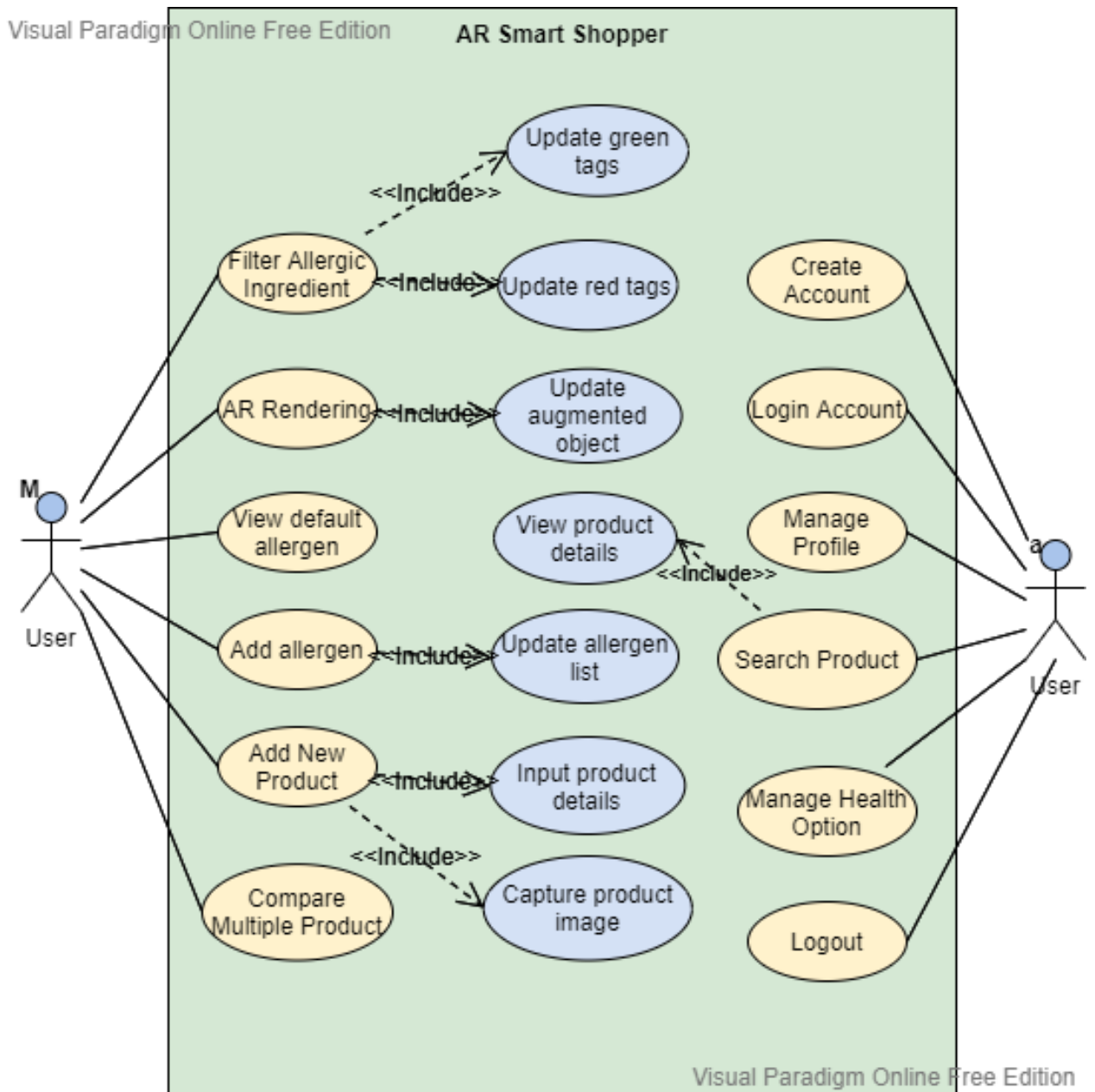


Figure 3.10: Use Case Diagram of the Application.

3.3.1 A001 Create Account

Table 3.1 shows the use case description of Create Account. User must have internet connection before creating the account.

Table 3.1: Use Case Description of Create Account.

Use Case ID	A001	Importance Level	High
Use Case Name	Create Account		
Primary Actor	User	Use Case Type	
Precondition	User's smartphone must have internet connection.		
Brief Description	Describes how user register an account for the application.		
Trigger	User select Sign Up button.		
Normal Flow of Events	1	User select Sign Up button.	
	2	User input the username, email address, password, and confirm password.	
	3	System display "Account Created!".	
	4	System direct user to user login page.	
Alternate/Exceptional Flows	2.a.1	User input a registered email address.	
	2.a.2	User may input the confirm password that does not match the password.	

3.3.2 A002 Login Account

Table 3.2 shows the use case description of Login Account. Users are able to login to their own account once they have created an account.

Table 3.2: Use Case Description of Login Account.

Use Case ID	A002	Importance Level	High
Use Case Name	Login Account		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account.		
Brief Description	Describes how user register an account for the application.		
Trigger	Users select Login button.		
Normal Flow of Events	1	Users select Login button.	

	2	User input the details such as email address and password.
	3	System display “Login Successfully!”.
	4	System direct user to user menu page.
Alternate/Exceptional Flows	2.a.1	User input an invalid email address or password.

3.3.3 A003 Manage Profile

Table 3.3 shows the use case description of Manage Profile. Users are able to edit their own username and email address.

Table 3.3: Use Case Description of Manage Profile.

Use Case ID	A003	Importance Level	Low
Use Case Name	Manage Profile		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account.		
Brief Description	Describes how user edit their username and email address.		
Trigger	Users wish to edit the username or email address.		
Normal Flow of Events	1	Users select “Profile” button.	
	2	Users retype the username and email address.	
	3	Users select “DONE” button.	
	4	System direct user to user menu page.	
Sub Flows	S-1	Users go back to main menu.	
	S-2	Users select side menu button.	

3.3.4 A004 Manage Health Option

Table 3.4 shows use case description of Manage Health Option. The user is able to select the allergic ingredient as the default allergen.

Table 3.4: Use Case Description of Manage Health Option.

Use Case ID	A004	Importance Level	Medium
Use Case Name	Manage Health Profile		
Primary Actor	User	Use Case Type	

Precondition	User must have a user account and internet connection.	
Brief Description	Describes how user select the default allergen.	
Trigger	Users select “Health Option” button.	
Normal Flow of Events	1	Users select “Health Option” button.
	2	Users select the allergic ingredients.
	3	Users select “Save” button.
Sub Flows	S-1	Users go back to main menu.
	S-2	Users select side menu button.
Alternate/ Exceptional Flows	2.a.1	Users update the allergic ingredients.

3.3.5 A005 AR Rendering

Table 3.5 shows use case description of AR Rendering while Figure 3.11 shows the activity diagram of AR Rendering process.

Table 3.5: Use Case Description of AR Rendering.

Use Case ID	A005	Importance Level	High
Use Case Name	AR Rendering		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account and allows the application to access the camera.		
Brief Description	Describes how user can view the product details when exposing the product packaging to the camera.		
Trigger	Users select “AR Scanner” button.		
Normal Flow of Events	1	Users select “AR Scanner” button.	
	2	Users expose the front view of the product packaging to the camera.	
	3	Users will be able to view the details of the product on the screen.	
Alternate/Exceptional Flows	3.a.1	When users show a product that do not contain inside the database, no details will be shown on screen.	

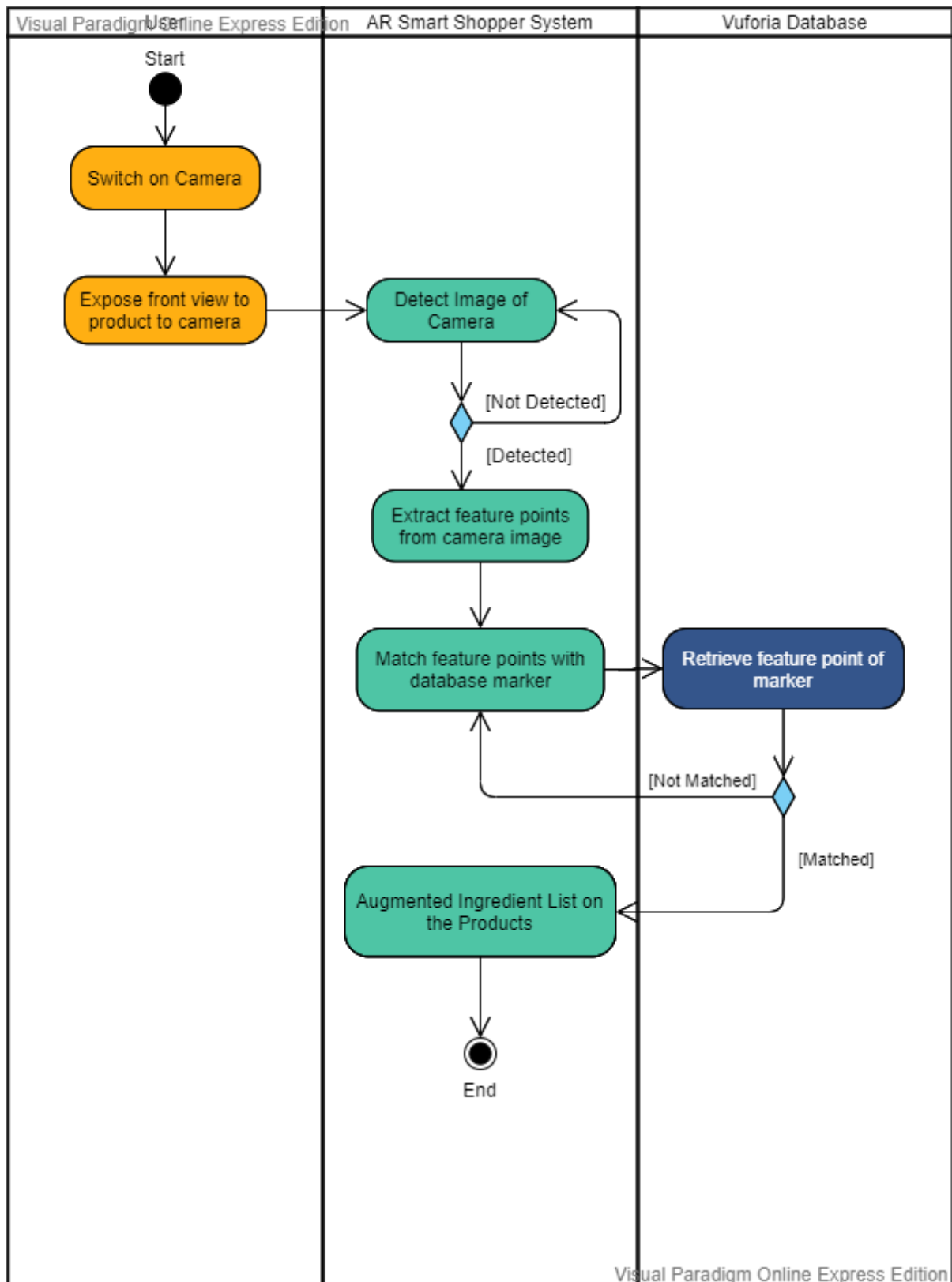


Figure 3.11: Activity Diagram of AR rendering.

3.3.6 A006 Filter Allergic Ingredient

Table 3.6 shows the use case description of Filter Allergic Ingredient while Figure 3.12 shows the activity diagram.

Table 3.6: Use Case Description of Filter Allergic Ingredient.

Use Case ID	A006	Importance Level	High
Use Case Name	Filter Allergic Ingredient		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account and allows the application to access the camera.		
Brief Description	Describes how user filter the allergen based on the default health option or manual selection.		
Trigger	Users wish to filter the undesirable ingredients.		
Normal Flow of Events	1	Users select allergic items at the checkbox.	
	2	Users expose the front view of the product packaging to the camera.	
	3	Users will be able to view a color box on top of the products.	
Sub Flows	S-1	User selected an allergen that do not contain in the products, green box will be shown.	
	S-2	User selected an allergen that contain in the products, red box will be shown.	
	S-3	Users add a new allergen when there is no such item on the allergen list.	
Alternate/Exceptional Flows	3.a.1	User do not select any allergic ingredients or do not select the default health option.	

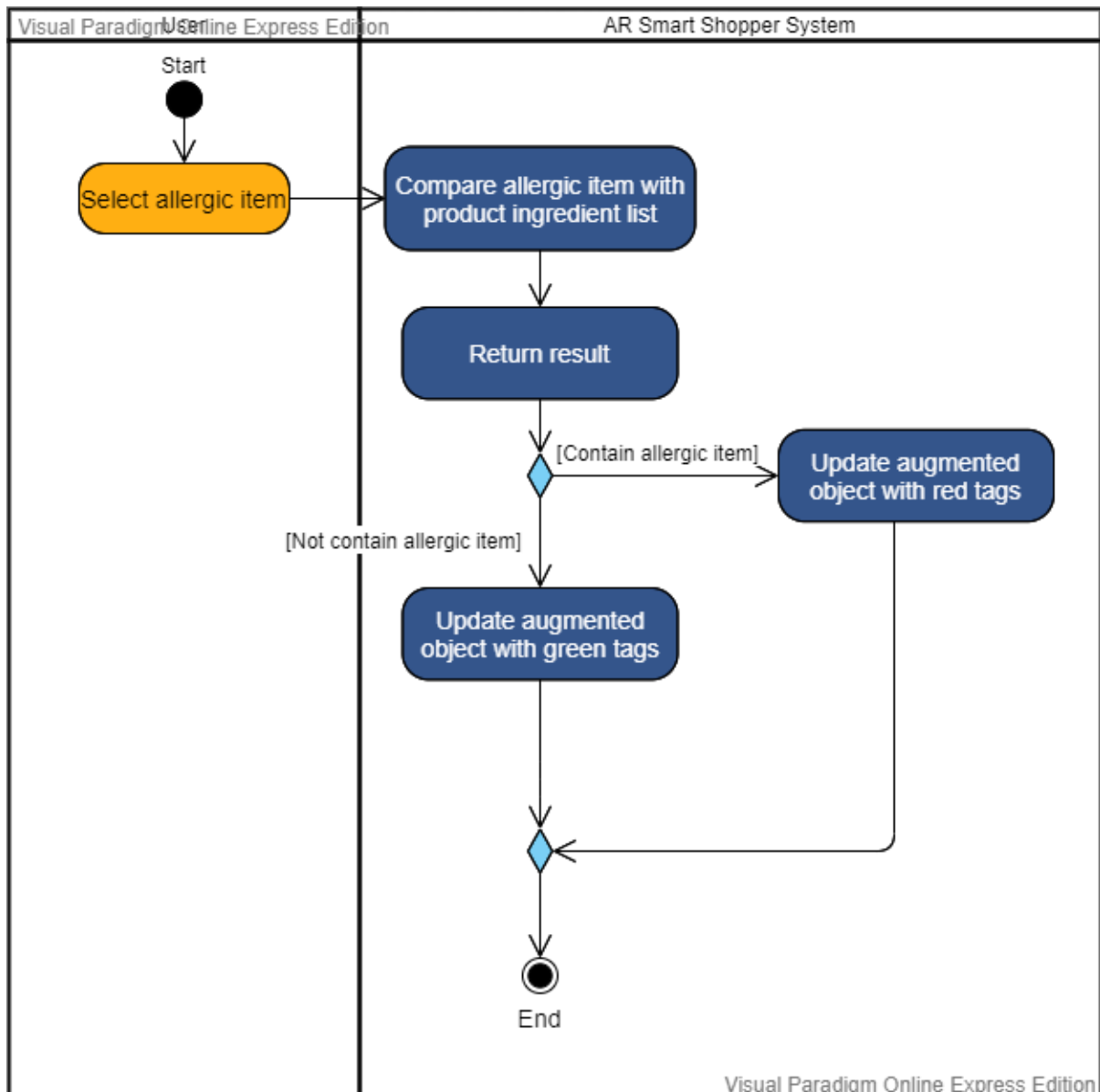


Figure 3.12: Activity Diagram of Filter Allergic Item.

3.3.7 A007 Compare Multiple Product

Table 3.7 shows the use case description of Compare Multiple Product:

Table 3.7: Use Case Description of Compare Multiple Product.

Use Case ID	A007	Importance Level	High
Use Case Name	Compare Multiple Product		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account and allows the application to access the camera.		

Brief Description	Describes how user compare several products with different ingredients.	
Trigger	Users wish to select the desired products.	
Normal Flow of Events	1	Users select “AR Scanner” option.
	2	Users expose the front view of the product packaging to the camera.
	3	Users select the allergen.
	4	Users will be able to see different color box on top of different products and make comparison.
Sub Flows	S-1	Users scan the similar products with different brands.
	S-2	Users scan different type of products.
Alternate/Exceptional Flows	3.a.1	User do not select any allergic items or do not select the default health option.

3.3.8 A008 Add New Product

Table 3.8 shows the use case description of Add New Product. Users must allow their devices access to the camera.

Table 3.8: Use Case Description of Add New Product.

Use Case ID	A008	Importance Level	Medium
Use Case Name	Add New Product		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account and allows the application to access the camera.		
Brief Description	Describes how user add a new product to the existing product database.		
Trigger	Users wish to insert a new product as there is no such product in the database.		
Normal Flow of Events	1	Users select “AR Scanner” option.	
	2	Users show the front view of the products and capture with the camera icon on the screen.	

	3	Users input all the product details such as brand, product name, and allergen(s).
	4	Users select “SUBMIT” button.
Sub Flows	-	
Alternate/Exceptional Flows	3.a.1	Users cancel inserting a new product and close the panel.

3.3.9 A009 Search Product

Table 3.9 shows the use case description of Search Product. Users have to make sure they have already connected to internet connection.

Table 3.9: Use Case Description of Search Product.

Use Case ID	A009	Importance Level	Low
Use Case Name	Search Product		
Primary Actor	User	Use Case Type	
Precondition	User must have a user account and must have internet connection.		
Brief Description	Describes how user search a product to view the details information.		
Trigger	Users wish to search a desired product.		
Normal Flow of Events	1	Users select “Search” option.	
	2	Users input product name.	
	3	Users click “SEARCH” button.	
	4	All the possible search result is shown, users select the desired product.	
	5	Users able to view the details of the products.	
Alternate/Exceptional Flows	2.a.1	Users enter an invalid name.	

CHAPTER 4: SYSTEM IMPLEMENTATION

4.1 Design Specifications

4.1.1 Methodologies and General Work Procedures

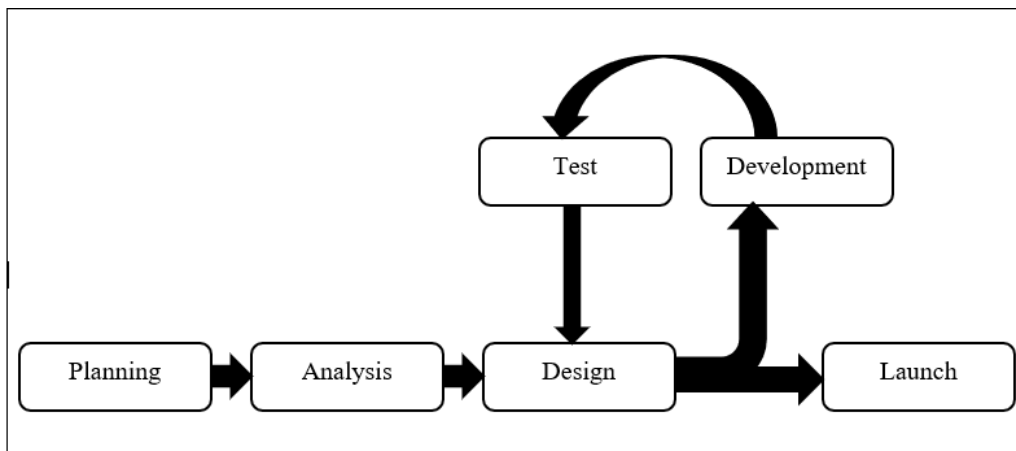


Figure 4.1: Agile Development Approach.

There are a lot of development approaches that can be used in mobile application development. In this project, the methodology that applied is an agile development approach. Business often operated in a fast-changing requirement situation. Producing an application with a stable requirement is seemed to be difficult as the application must evolve with the business needs. Hence, an agile development approach is best in reducing the working time of an application as it can eliminate the time spend for documentation. The agile development approach emphasised on iterative development of an application. There is some example of agile development methodologies such as Scrum, extreme programming (XP), Dynamic Systems Development Method (DSDM) and others.

Figure 4.1 shown the cycle of agile development methodologies. There are 6 main phases in the agile development approach: Planning, Analysis, Design, Development, Test, and Launch. In mobile application development, the testing phase is the most fundamental and crucial in the development process because unexpected error often occurred during this phase. Therefore, agile development approach is more effective to cope with these problems. In this project, such circumstances might occur frequently thus agile approach is selected in the development of this application.

2. Android Mobile Application Development

At the end of this project, a mobile application in Android platform will be developed. To develop a mobile application, Unity Editor is able to develop an Android platform mobile application. Besides, Firebase is also a Google platform that is used to store the details of the product in this project. The services such as Authentication, Realtime Database, Storage will be used to store all the information in this application. Firebase authentication will store the user account details; Realtime Database will store the health option of each user; Firebase Storage will store the product images and also the ingredient list.

3. AR Content Creation

In this project, a shopping assistant mobile application is implemented with the concept of AR to bring advantages in term of convenience to the users. Several components will be covered in AR content for example AR interface, occlusion-based interaction, and AR filtering visual representation.

In this project, a simple yet interactive AR interface will be created to produce a user-friendly environment. In order to display the nutrition facts label, this project intends to bring out the ingredients contained in the products by implementing the concept of occlusion-based interaction. Occlusion involved overlaying virtual imagery on the physical product in order to promote 2 ways interaction in an AR environment. This project will display the ingredients by overlaying the virtual ingredients list on the real product when consumers selected a certain product and then display on the screen. Figure 4.2 shown an example of occlusion-based interaction.



Figure 4.2: Example of Occlusion Based Interaction.

Besides, this project also implemented filtering visual representation where the colour tag is used to differentiate the suitable or not suitable products. The products will be filtered based on consumers preferences whether it contained any allergic or unwanted ingredients. Despite the 2-dimensional interface, this project considered spatial contextualization. The interaction of consumers with the virtual imagery object and the physical objects involving the accuracy of tracking the feature points of the products. Figure 4.3 shown the visual representation of product filtering.



Figure 4.3: Filtering Visual Representation.

Several commercial AR frameworks used to support the development of AR mobile applications such as ARCore, Vuforia Engine, ARKit, MAXST and others. These AR frameworks are known as augmented reality software development kit (SDK). ARCore,

Vuforia Engine, MAXST are applied in the Android platform while ARKit is applied in the iOS platform. To perform AR content in this project, the tools that are used were Vuforia and Unity. Vuforia is an AR SDK for the creation of AR applications by recognising an object and interact with the spaces in real life. Vuforia library is an open-source environment that provided a set of spatial programming services or API to create an AR environment. On the other hand, Unity is a game engine that can be applied in different fields such as virtual reality (VR), augmented reality (AR), and others. In this project, Unity is used to create AR content with the help of Vuforia library in overlaying virtual imagery on physical products.

4.1.2 Tools to Use

Software:

1. Unity

Unity is a cross-platform 2D or 3D game engine or IDE (Integrated Development Environment) which developed by Unity Technologies. Unity was written in C++ and C#. Since 2018, Unity is offered to support more than 25 platforms such as Android, Linux, Windows, and others. This engine is able to be used to create 3D, 2D, virtual reality (VR), and augmented reality. Besides, Unity also included machine learning tools and have introduced Mixed and Augmented Reality Studio (MARS) that provide additional functionality for a rule-based generation of AR applications in June 2020.

2. Vuforia Library

Vuforia is an AR software development kit (SDK) for making AR applications. It uses computer vision technology in recognizing and tracking images and 3D objects in the actual world. Vuforia support development of several AR applications for example iOS, Android, and others. Vuforia engine is easily embedded to any project such as Unity.

3. Firebase

Firestore is a framework that developed by Google for purpose of creating mobile and web apps. It started out as a standalone business in 2011. Firestore projects are the containers for your applications to share the features for example real-time database and analytics. Besides, it contains the service like authentication, Firestore database, Real-time database, Storage, Hosting, and Machine Learning.

4. Microsoft Visual Studio Code

Microsoft Visual Studio Code is a free source code editor which produce by Microsoft. It Visual Studio is written into TypeScript, HTML, JavaScript, and CSS and available for an operating system like Windows, Linux, and macOS. The features that provided by Visual Studio Code is debugging, highlighting syntax, and others.

Hardware:

1. Laptop

Table 4.1: Laptop Specifications.

Operating System	Windows 10 (64-bit)
Processor	Intel® Core™ i7-8550U CPU @ 1.80GHz 1.99GHz
RAM	12.0 GB
Graphics Card	NVIDIA® GeForce® MX130 GDDR5 2GB

2. Smartphone

Table 4.2: Smartphone Specifications.

Processor	Hisilicon Kirin 950
RAM	4.0 GB
Storage	128 GB
Display	6.0 Inch IPS Screen, 1920 x 1080 Pixel with 368 PPI
Camera	Rear Camera: 16.0MP (F2.0) + Front Camera: 8.0MP (F2.4)
Operating System	Android 8.0

4.1.3 User Requirements

User Requirements:

- The user shall be able to detect and recognise an object.
- The user shall be able to filter more than one allergic ingredient that is undesirable.
- The user shall be able to insert new ingredient that originally not contain inside the ingredient list.
- The user shall be able to view the ingredient list of a product on a virtual plane that overlay on the actual object.
- The user shall be able to view colour tags where red is to avoid and green is to consent to differentiate the desirable or undesirable product.
- The user shall be able to check out the selected item.
- The user shall be able to scan 10 products at once.
- The user shall be able to save their product image to the database for future use.

Non-Functional Requirements:

- The system shall be able to scan and detect multiple objects in various kind of environmental conditions and angles.
- The system shall be able to detect an object within 1 second.
- The system shall be able to overlay the virtual plan with information within 2 seconds.
- The system shall be able to run on the Android platform.
- The user shall be able to run on portrait or landscape form.

4.1.4 System Performance Definition

In this project, the system can detect and recognise a grocery product and display an augmented object on top of the actual object. Firstly, the system should be able to start up without the latency of time to achieve better user satisfaction.

To achieve better performance, high accuracy of object detection should be fulfilled. The proposed application should allow a user to capture an image from the camera to allow the implementation of marker-based AR. The system should be able to detect the target object in various angle. For instance, the user is able the show the object target in several angles

regardless of the degree of the angle as long as the front view of the object is shown to the device camera.

In terms of speed, the system should be able to detect the targeted object in minimal timespan. Once the object is shown to the camera, the object will be overlaid with the ingredient list information within 1 second. On the other hand, the system allows a user to filter undesirable ingredients and display colour tags with cross and tick symbol. The virtual colour plane can be overlaid on the actual object within 2 seconds.

4.2 Prototype

4.2.1 Mobile Application Interface



Figure 4.4: App icon.



Figure 4.5: App Splash Screen.

Figure 4.4 shows the icon of the application. The name of this app is “GrocIng”. There is a trolley in the logo to emphasize this application is mainly for the grocery shopping purpose, while the name of the app is so called “GrocIng” because “Groc” is meant by grocery and “Ing” is meant by ingredient filtering which related to the idea of this project. Figure 4.5 shows the splash screen interface of this application. The splash screen consists of the logo of the application meanwhile it also means the application is still loading when launching the app.

Figure 4.6 shows the main scene of the application. There are 2 options in the main scene which are “LOGIN” and “SIGN UP” buttons. When “LOGIN” button is pressed, the system will navigate the user to the login page. If “SIGN UP” button is pressed, the system will navigate the user to create account page.

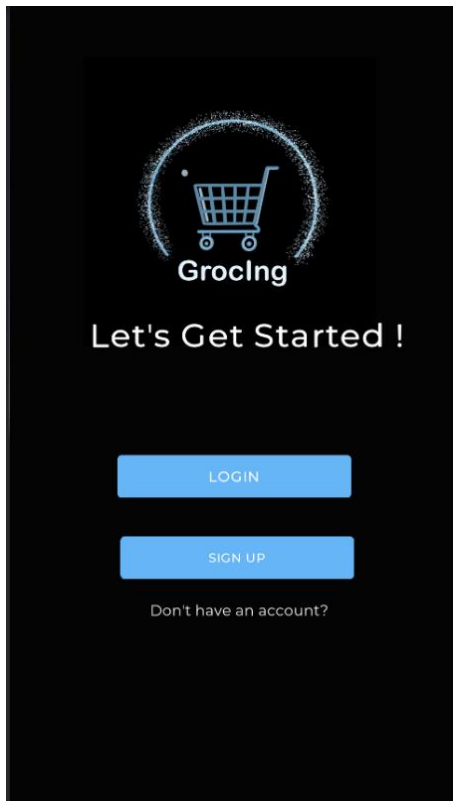


Figure 4.6: Main scene of the application.

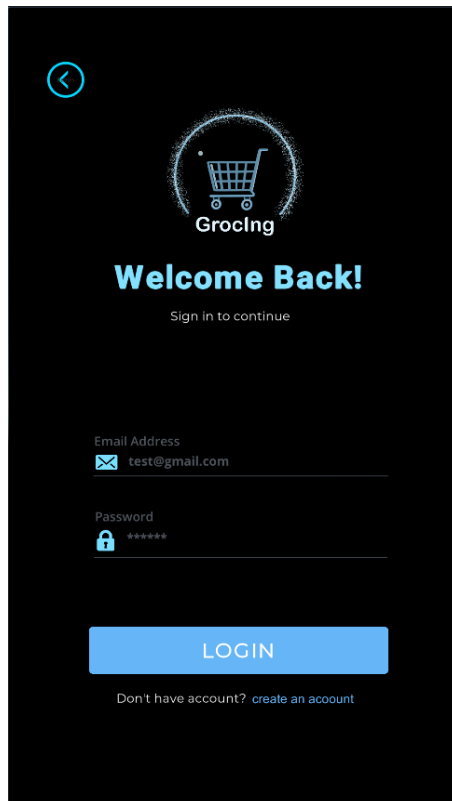


Figure 4.7: Login Page.

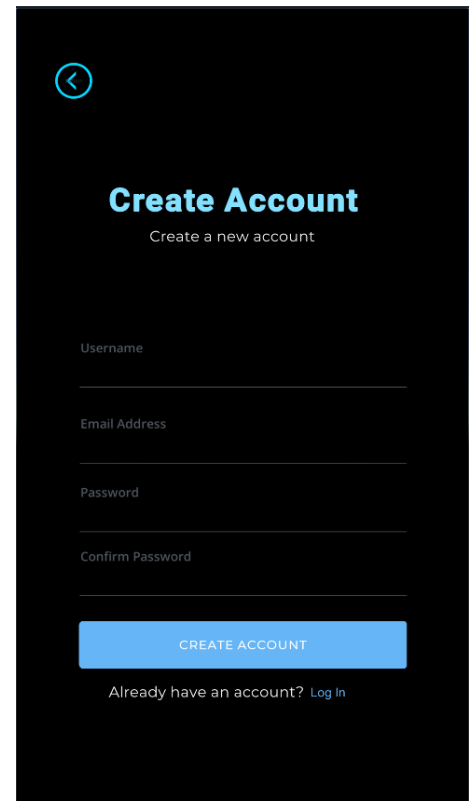


Figure 4.8: Create Account Page.

Figure 4.8 shows the create account page. Users have to input some details such as username, email address, and password. After that, users are required to confirm the password by retyping the same password as above. The system will check whether both password is matched. If the password does not match, the system will not be able to create the account for the user. If the password less than 6 digits, user will not be able to create an account. Besides, users are unable to register an account with an existing email address. If user already have an account, the user may click the “Log In” to navigate user to the login page. When user successfully create an account, the system will alert user and direct the user to the login page and the details of the user will be saved to Firebase Authentication.

Figure 4.7 shows the login page. If user do not have an account, the user may click the “create an account” and the user will be directed to the create account page as shown in Figure 4.8. In login page, email address and password are required for user to input before they can log into the application. User is unable to login to their account when an invalid email address or password were entered. An alert text “Login Successfully” will be shown, and user will be directed to menu page if user successfully login to the system. Furthermore, user is able to return to the main page by pressing the back button on the top left corner.

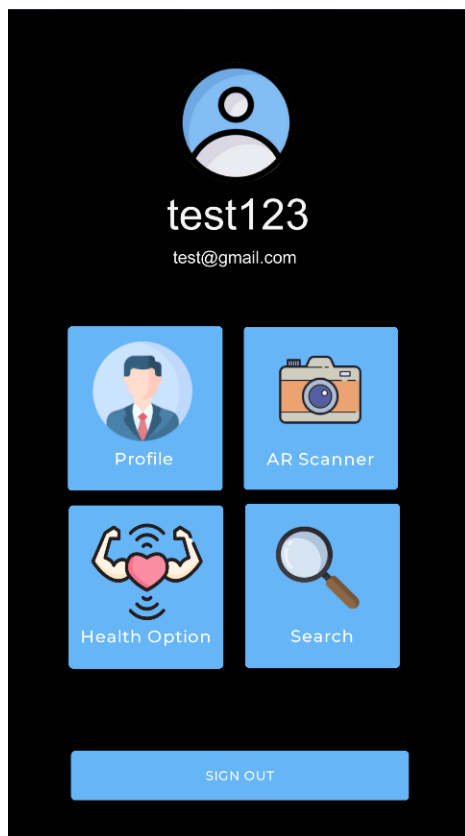


Figure 4.9: Interface of app home page.

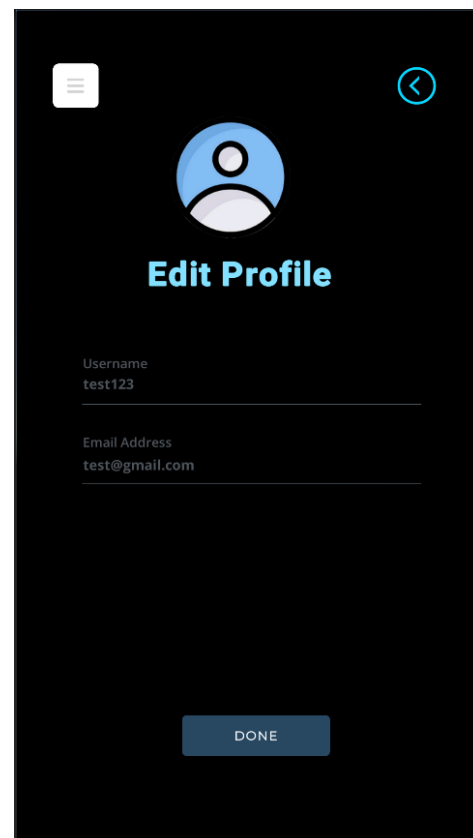


Figure 4.10: Manage profile interface.

After successfully login, the user is navigated to home page as shown in Figure 4.9. The username and email address of a particular user account will be display on top of the page (“test123” and test@gmail.com). As shown in Figure 4.9, there are 4 options for the users to select which are “Profile”, “AR Scanner”, “Health Option”, and “Search” and user will be navigated to each of the page respectively. If user wish to log out the application, there is a “SIGN OUT” button at the bottom of the page. After signing out, the system will direct user back to the login page.

When “Profile” is selected, user will reach the edit profile interface as shown in Figure 4.10. The user can edit both the username and email address. Before making any changes, the “DONE” button will be disabled until any changes are made to any input field. After clicking “DONE”, changes made by the user will be save and user is now navigated back to the home page as shown in Figure 4.9.

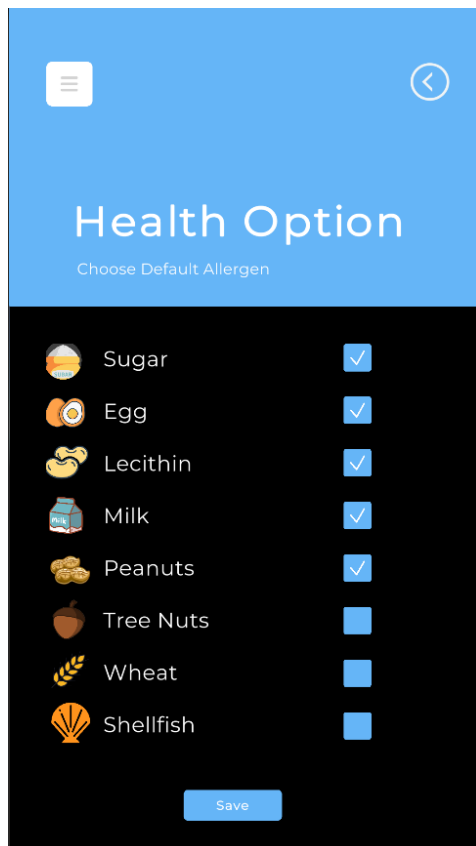


Figure 4.11: Health Option Interface.

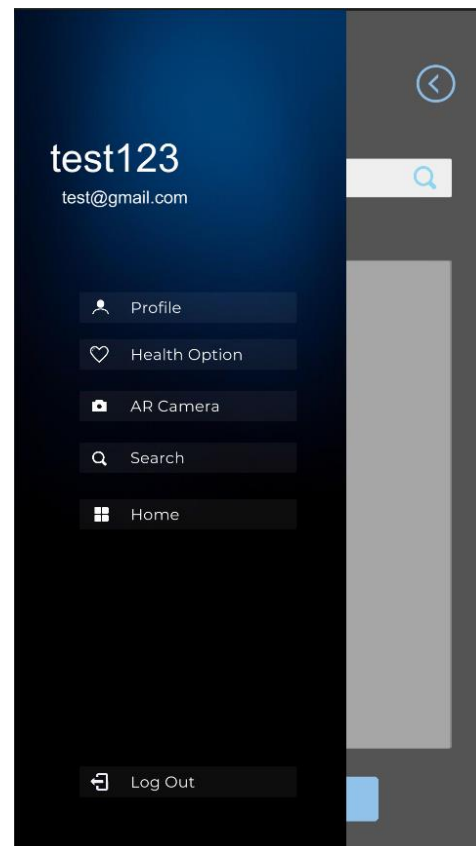


Figure 4.12: Side Menu Interface.

Figure 4.11 shows interface of health option. There is some default allergen list to let user select the ingredients that they allergic to. Users are able to choose the default allergen by selecting the desired allergen. The “Save” button will not be shown until users select one of the checkboxes. The selected allergen will be stored in Firebase Real-time database for each user. When user come back to the application again, the default selected allergen will still be there as the system will pull the database from the Firebase based on the user ID. At the top left corner, there is a side menu button. When user click on the button, a side menu panel will be shown as Figure 4.12. Based on Figure 4.12, the username and email address will be displayed in the side menu. The purpose of the side menu is to ease the user to reach any of the

page such as profile, health option, AR camera, and others. Moreover, when user click on the background, the side menu will collapse and back to the previous page.

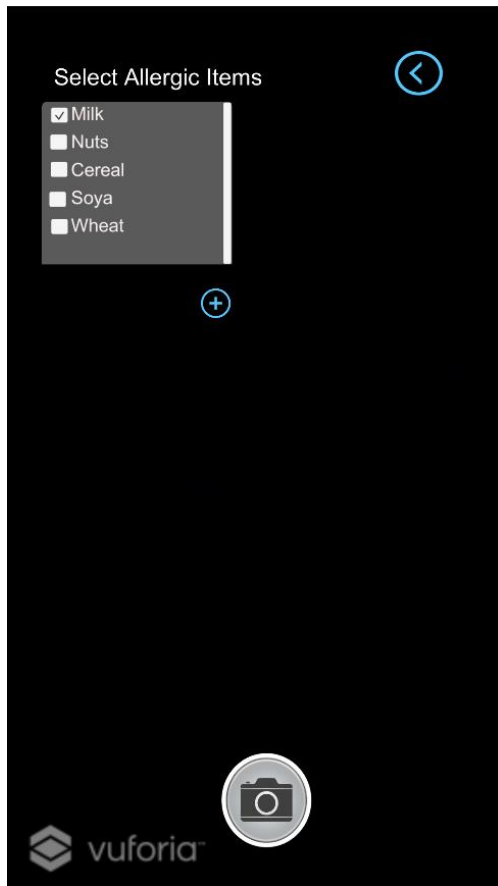


Figure 4.13: AR Scanner Interface.

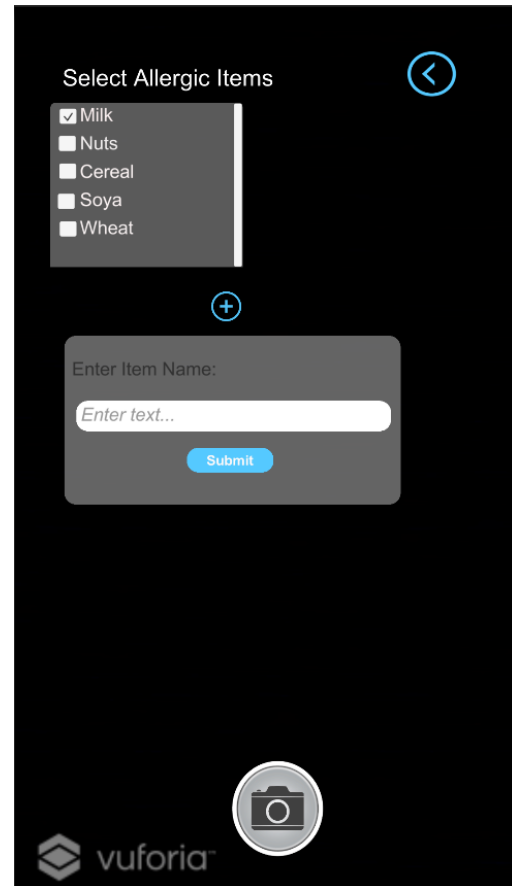


Figure 4.14: Input box interface for adding new allergen.

Figure 4.13 shows the interface of AR Scanner where permission is needed to access the camera. The system will automatically check the allergic item that the user had checked previously in Health Option page. The top left corner of Figure 4.13 shows the results when user enter the AR Scanner page. Users are able to add more allergic item to the list by clicking the add button and a dialogue box will pop out to prompt user enter the item name. User can click submit button and the new added allergen will appear below the default allergen list. Besides, at the bottom of the scene, there is a camera button for user to capture the product and save to database.

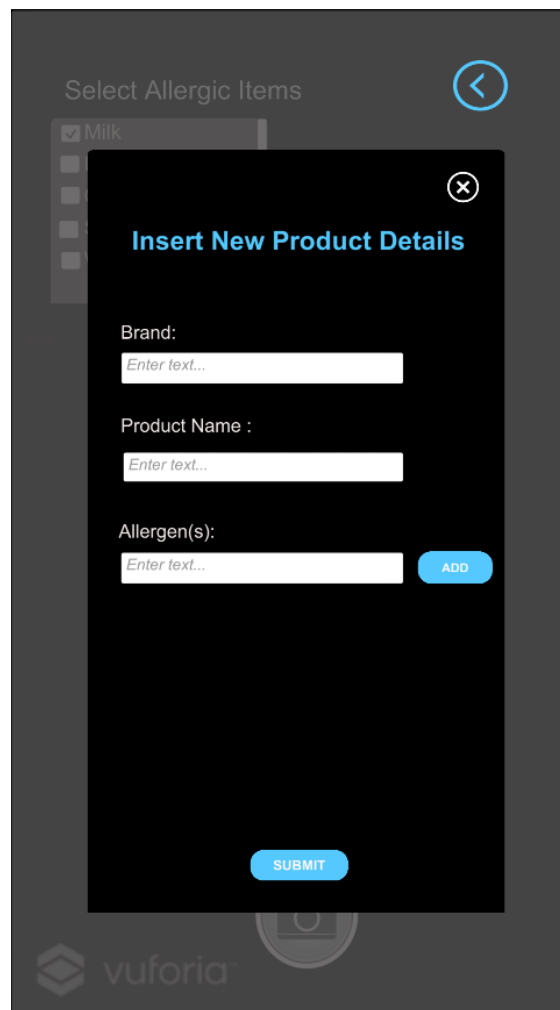


Figure 4.15: Add product details interface.

Figure 4.15 shows the interface when the camera button is pressed. A panel will pop out to prompt user to enter the product details such as brand, product name, and allergen. Users can add more than one allergen by selecting the “add” button. After all the details has been entered, user can click the “SUBMIT” button and the new product will be added to the Firebase Storage. Then, an “Product Save to Database!” alert text will be shown. Besides, if user wish to cancel adding the new products, user can click the cross button at the top right corner of the panel. The insert new product panel will be closed, and user will back to the AR scanner scene.

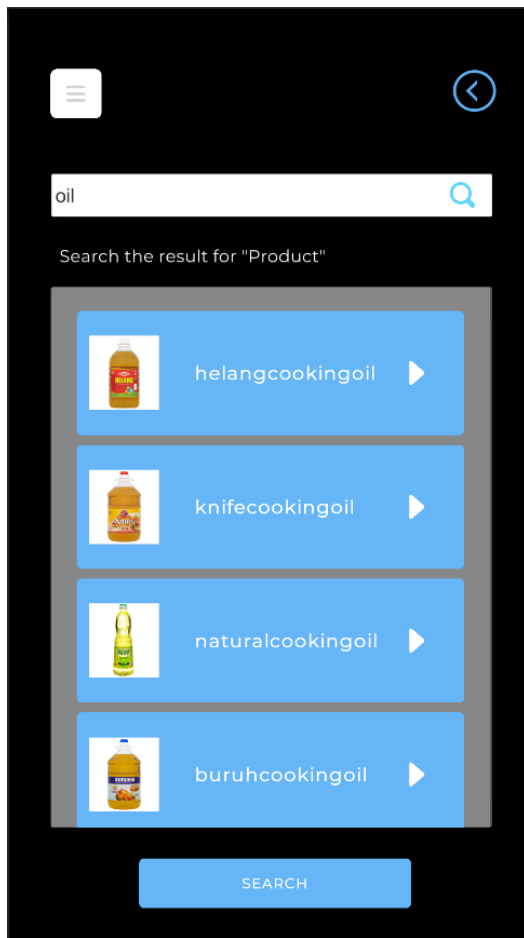


Figure 4.16: Interface of Search Panel.

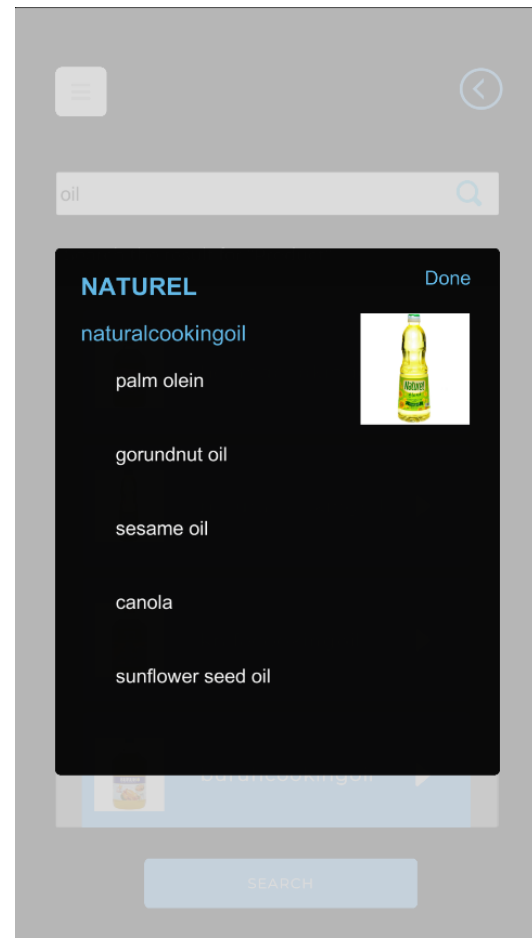


Figure 4.17: Product details Interface.

Figure 4.16 shows the interface of the search panel. As shown in Figure 4.16, there is a search bar for user to enter the product name or any keyword of a product. User can click either the “magnifying glass” icon on the search bar or the “SEARCH” button to search for the results. Any possible product that contains the keyword will be shown in the panel with the product name and picture. Now, user may select the desired product to view the details information. The system will fetch the product information such as images, brand, product name and ingredients. Figure 4.17 shows the information of the selected products. After done viewing the details, user may select “Done” button at the top right corner to close the panel and back to the search result page.

4.2.2 Sample Products

There are a total of 200 products stored in the database with different type of shape and categories. All the 200 products most probably can be found in most of the supermarket nowadays for example cooking ingredients, snacks, dressings and so on. Table 4.3 show the sample products in the database with different shapes.

Table 4.3: Sample Products in Database.

Product	Details	Shape
	<p>Brand: TC BOY</p> <p>Product Name: Tuna Chilli Padi</p> <p>Ingredients: tuna, soybean oil, sugar, chilli padi, celery</p>	Cylinder
	<p>Brand: NESTLE</p> <p>Product Name: KoKoKrunch</p> <p>Ingredients: cereal, gluten, corn, soya, cocoa, tree nuts, milk, hazelnut, almond, lecithin</p>	Rectangle
	<p>Brand: YOGOOD</p> <p>Product Name: Wildberry Muesli Bar</p> <p>Ingredients: oat, yogurt cream, lecithin, cereal crisps, wheat, cornflakes</p>	Square
	<p>Brand: CED</p> <p>Product Name: Pure Honey</p> <p>Ingredients: pure honey</p>	Cone
	<p>Brand: LADYS CHOICE</p> <p>Product Name: Real Mayonnaise</p> <p>Ingredients: soybean, egg, gluten, fish, milk, celery, vinegar</p>	Irregular

	<p>Brand: MAEPRANOM</p> <p>Product Name: Sweet Chili Sauce</p> <p>Ingredients: sugar, chilli, garlic, salt</p>	<p>Irregular</p>
	<p>Brand: NUTELLA FERRERO</p> <p>Product Name: Hazelnut Cocoa Spread</p> <p>Ingredients: sugar, hazelnuts, cocoa, milk, lecithin, vanillin, palm oil</p>	<p>Irregular</p>

Figure 4.18 shows the products that store in the Vuforia database:

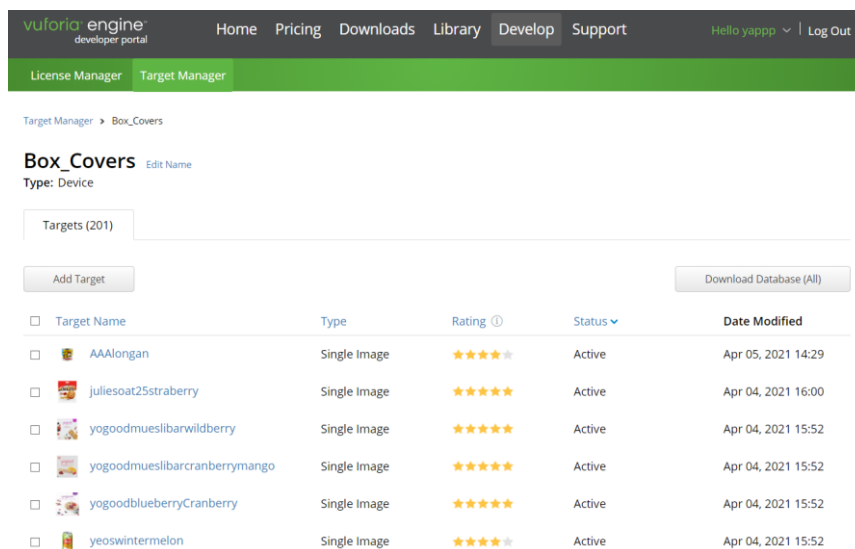


Figure 4.18: Products stored in Vuforia database.

4.3 Implementation Issues and Challenges

During the development of AR smart shopper, there are several implementation issues and challenges that exist while some of them are unavoidable. The key challenge of the proposed application is the generation of dynamic image target for the marker in the database. A complicated function is needed to be implemented in order to dynamically generate multiple image targets for the marker in the marker tracking database. If only 1 image target is needed, the image target can be created manually in the application. However, in this project, a large dataset of image target which can up to hundred and thousand require a complex algorithm to create the image target dynamically. Besides, some graphic bugs occurred when implementing the system on a certain phone. The reason may be the camera graphic on the smartphone is distorted due to its hardware problem and it does not support current Vuforia engine tools. When building the project into a smartphone, the smartphone experiences purple and screen lines as well as smudges on the screen. Hence, the proposed application might have a graphic bug on a certain smartphone.

On the other hand, there will be constantly changing the packaging design of the products. This is because some company will regularly update the design of the package for each season to attract more customer for purchasing the products. When a user captures the same product with different packaging design, the product cannot be detected and augmented. Hence, constantly update in the database is required to ensure or the product is detectable. Furthermore, there is absent of camera autofocus mode originally. Sometimes, the object is hard to be detected as the camera of the smartphone has a lower quality which required an autofocus mode in Vuforia. Therefore, research on camera autofocus should be attempted to make sure the AR camera can detect an object all the time.

4.4 Timeline

Smart Shopper - Grocery Ingredient Filtering With Augmented Reality

University Tunku Abdul Rahman
Project Lead : Yap Pei Pei

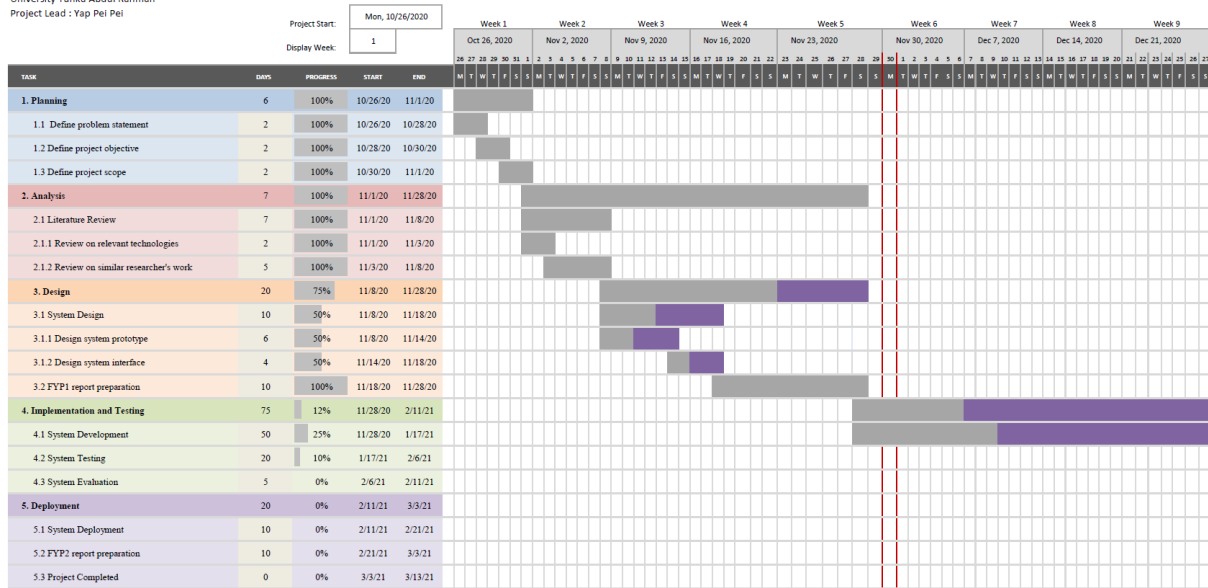


Figure 4.19: Timeline of the proposed system.

Figure 4.19 shows the estimated timeline for the deliverables of this project. The planning of the project development is based on Agile Development methodology from the beginning to the end of this project. The tasks are categorised into 5 major phases which are Planning, Analysis, Design, Implementation and Testing, and Deployment. The first stage is the planning phase where the activities involved in this phase are the definition of the problem statement, project objective, and project scope. The tasks in the planning phase have been 100% determined. In the analysis stage, review on relevant technologies and some related previous researcher’s work is done. The pros and cons of each system are identified and are compared to the proposed solutions. In the third stage which is the design phase, the design of system prototype and the interface is planned to be done in 20 days. Furthermore, report 1 is estimated to do at the end of this stage. In the implementation and testing stage, system development is planned to carry out in 50 days. In project 1, the system is completely developed at about 25% and is testing. The evaluation is scheduled to be done in 5 days. Next, the deployment stage is estimated to be done in 20 days after system evaluation. Lastly, report 2 is allocated 10 days for documentation. After that, the proposed application is estimated to complete within 2 trimesters (21 weeks).

CHAPTER 5: SYSTEM TESTING

5.1 Verification and Validation

5.1.1 Verification Plan

The groceries shopping with AR ingredient filtering application is developed to allow users to filter undesirable ingredients using marker-based augmented reality technology. The system should be able to detect a single or more than one image target of a product. Besides, the system should be able to display the ingredient list on the top of the product image once the image is detected. The system should also be able to allow the user to filter the undesirable ingredients and differentiate the best product with colour tags. Table 5.1 to 5.3 show the verification plans of the proposed application.

1. Single image target

A single image target is chosen for scanning. The system can detect a single image of a product and overlay a plane with an ingredient list and brand on top of the marker in real-time.

Table 5.1: Verification plan T1.

Procedure Number	T1
Method	Testing
Application Requirements	Detect a product image then overlay a plane with ingredient list and brand on top of the marker in real-time.
Purpose / Scope	To detect an image of a product with different shape and display ingredient lists of certain products.
Items Under Test	Image of tuna, mayonnaise, sweet chilli sauce
Precautions	User should make sure the clarity of the image of the product is clear and not to use a luminous exposure image.
Special Conditions / Limitations	If the image is a blur or high exposure, the system may not be able to detect the image.
Equipment / Facilities	Android smartphone (Android 8.0.0), laptop webcam
Data Recording	None
Acceptance Criteria	The system overlays the ingredient list on the product image.

Procedures	<ol style="list-style-type: none"> 1. Switch on the camera. 2. Show the product image in front of the camera. 3. The system overlay ingredient list on the top of the product image.
Troubleshooting	<ol style="list-style-type: none"> 1. Adjust the view of the image. 2. Repeat the procedure.
Post-Test Activities	None

2. Filter product

A default allergic ingredient list is provided. The system is required to filter the undesirable ingredients selected by the user and show red or green colour tags to represent right or to be avoided product.

Table 5.2: Verification plan T2.

Procedure Number	T2
Method	Testing
Application Requirements	<ol style="list-style-type: none"> 1. Detect a product image 2. Filter undesirable one or more ingredients then overlay a colour plane with a symbol on top of the marker in real-time.
Purpose / Scope	To filter the undesirable ingredient that user selected.
Items Under Test	Image of different type of products
Precautions	User should make sure the clarity of the image of the product is clear and not to use a luminous exposure image.
Special Conditions / Limitations	If the image is a blur or high exposure, the system may not be able to detect the image.
Equipment / Facilities	Android smartphone (Android 8.0.0), laptop webcam
Data Recording	None
Acceptance Criteria	The system shows colour tags (red or green) with a symbol (tick or cross) on top of the product image.
Procedures	<ol style="list-style-type: none"> 1. Switch on the camera.

	<ol style="list-style-type: none"> 2. Show the product image in front of the camera. 3. Check the checkbox with undesirable ingredients. 4. The system overlays a colour tag on top of the product image.
Troubleshooting	<ol style="list-style-type: none"> 1. Adjust the view of the image. 2. Repeat the procedure.
Post-Test Activities	None

3. Multiple image target

2 or more image target are exposed to the camera. The system is required to recognise 2 or more product image shown in front of the camera and display the ingredient list. Besides, the system is able to differentiate the best product based on ingredients that the user filtered and show colour tags.

Table 5.3: Verification plan T3.

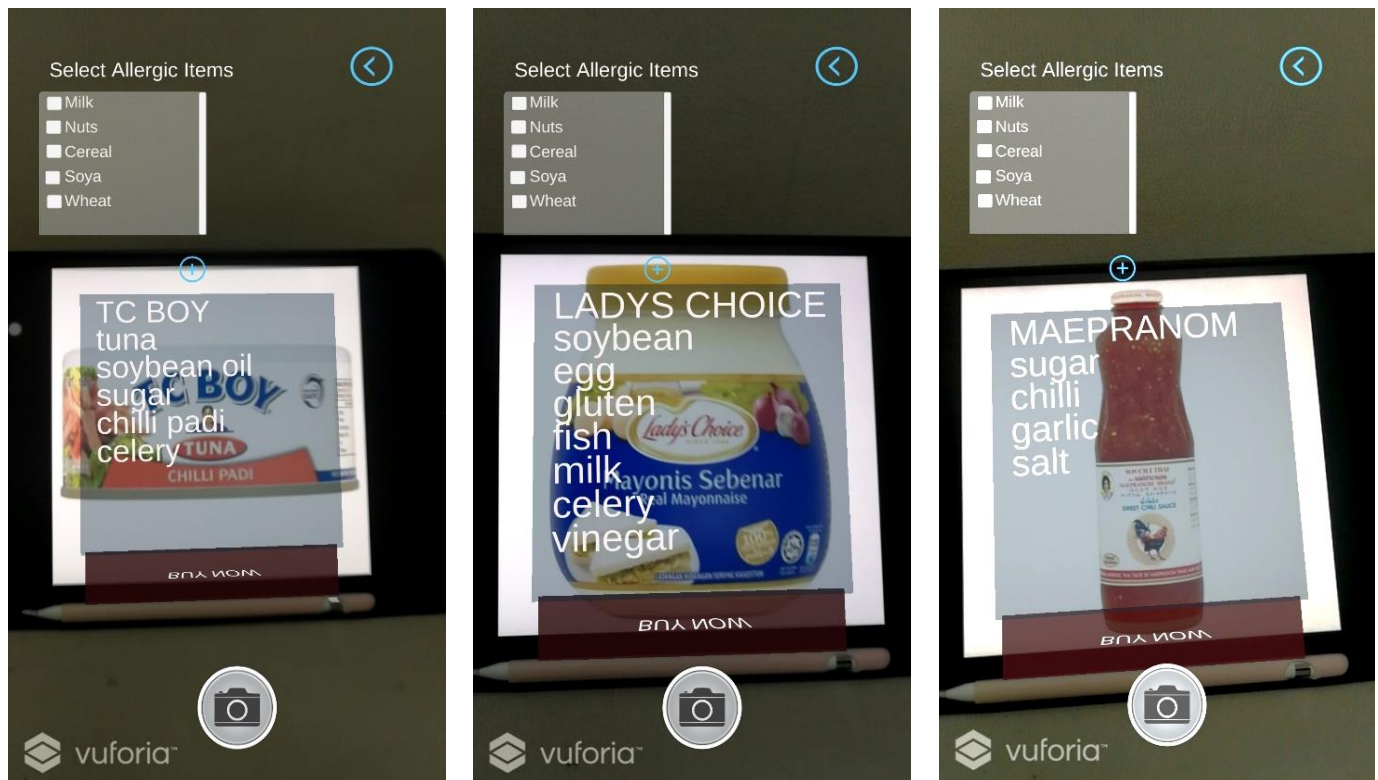
Procedure Number	T3
Method	Testing
Application Requirements	<ol style="list-style-type: none"> 1. Detect 2 or more product images then overlay a plane with ingredient list and brand on top of the marker in real-time. 2. Filter product from 2 or more product image based on an ingredient that is chosen from the user.
Purpose / Scope	To detect and filter multiple product images.
Items Under Test	Image of different type of products.
Precautions	User should make sure the clarity of the image of the product is clear and not to use a luminous exposure image.
Special Conditions / Limitations	If the image is a blur or high exposure, the system may not be able to detect the image.
Equipment / Facilities	Android smartphone (Android 8.0.0), laptop webcam
Data Recording	None

Acceptance Criteria	The system overlays the ingredient list or displays colour tags on the product image.
Procedures	<ol style="list-style-type: none">1. Switch on the camera.2. Show multiple product images in front of the camera.3. Select undesirable ingredients from the list.4. The system overlay colour tags on top of the product image.
Troubleshooting	<ol style="list-style-type: none">1. Adjust the view of the image.2. Repeat the procedure.
Post-Test Activities	None

5.1.2 Verification Result and Analysis

The verification plans that mentioned in 5.1.1 are implemented to test the developed application. The results of each verification plans will be analysed and explained in detail in this section.

1. Single image target



(a) Cylinder Shape

(b) Irregular Shape (1)

(c) Irregular Shape (2)

Figure 5.1: AR Rendering on single image target with different shape (a), (b), (c).

As shown in Figure 5.1, the application can detect and recognize a certain product with different shapes. The camera of the smartphone will detect the packaging of the product once the user shows the image to the camera. The system will perform feature detection to match the feature point of the actual image with the feature point of the target image which stored in the Vuforia database. Only the products that stored in the database will be able to recognise by the application. The system will extract the feature points from the image at first. The system will then perform marker matching by comparing it with the feature point in the database. Once the marker has been identified, the image is matched successfully. After the image has successfully been matched, the system will implement model rendering to fetch the information of the product such as ingredients, and brands to display on a plane as AR content. As shown

in figure 5.1, a blue plane with a list of product information and a “BUY NOW” button is overlaid on the coco crunch image. If the image of the product has lesser feature point, the system will hard to recognise the product and it may take a longer time. As a result, different shape of product can be detected successfully.

2. Filter Item

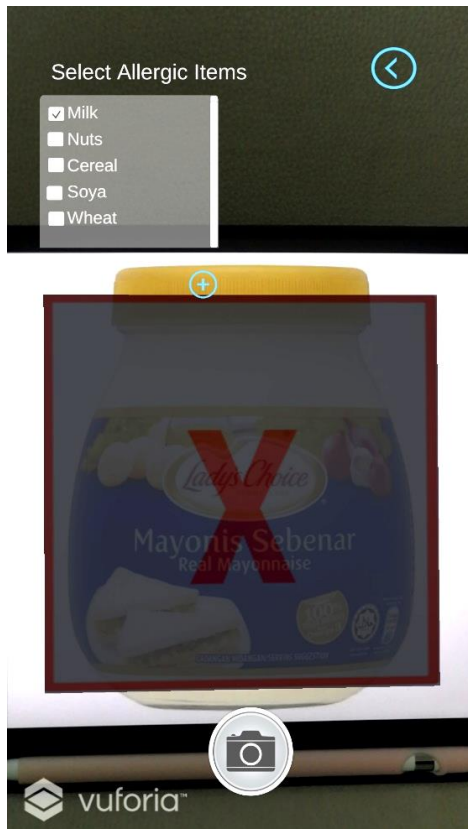


Figure 5.2: Red plane shown when there is allergen in the product.

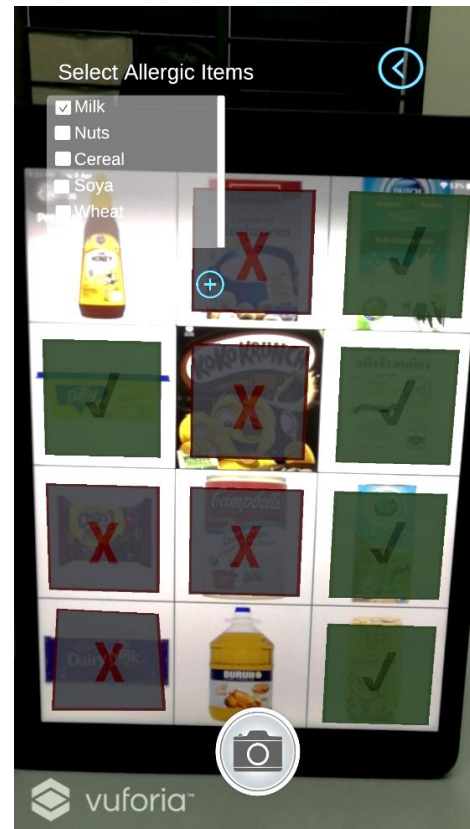


Figure 5.3: Comparison between multiple products.

After successfully detect the product image and AR Rendering, the application allow user to filter some allergic ingredient that a product contained. On the top left corner of the screen, there is a list of allergic items listed with a checkbox beside each of the items. If the user has made some user preference at health option, the system will fetch the default selected health option to the allergic items list. In this way, the application will straight away filter the ingredient based on the user preference. Other than default health option, user can select the more allergic item from the item list. Once the item is selected, the system will search from the

database whether the selected ingredients contained in the products. If the selected item does not contain inside the product list in the database, an AR green colour plane with a “tick” symbol is overlaid on the product image which means the item is safe to purchase. If the selected item contains inside the ingredient list of the product, an AR red colour tags with a “cross” symbol will be overlaid on the product image which means the products are to avoid. Figure 5.2 show the output when the product contains an allergic ingredient.

Figure 5.3 shows the comparison between multiple products. The system has the ability to filter multiple products which up to 20 products at a time. The system can filter the allergen with different type of products. As figure 5.3 show there are different allergen in different products, hence the system will show different color of plan to indicate which product contains the selected allergen.

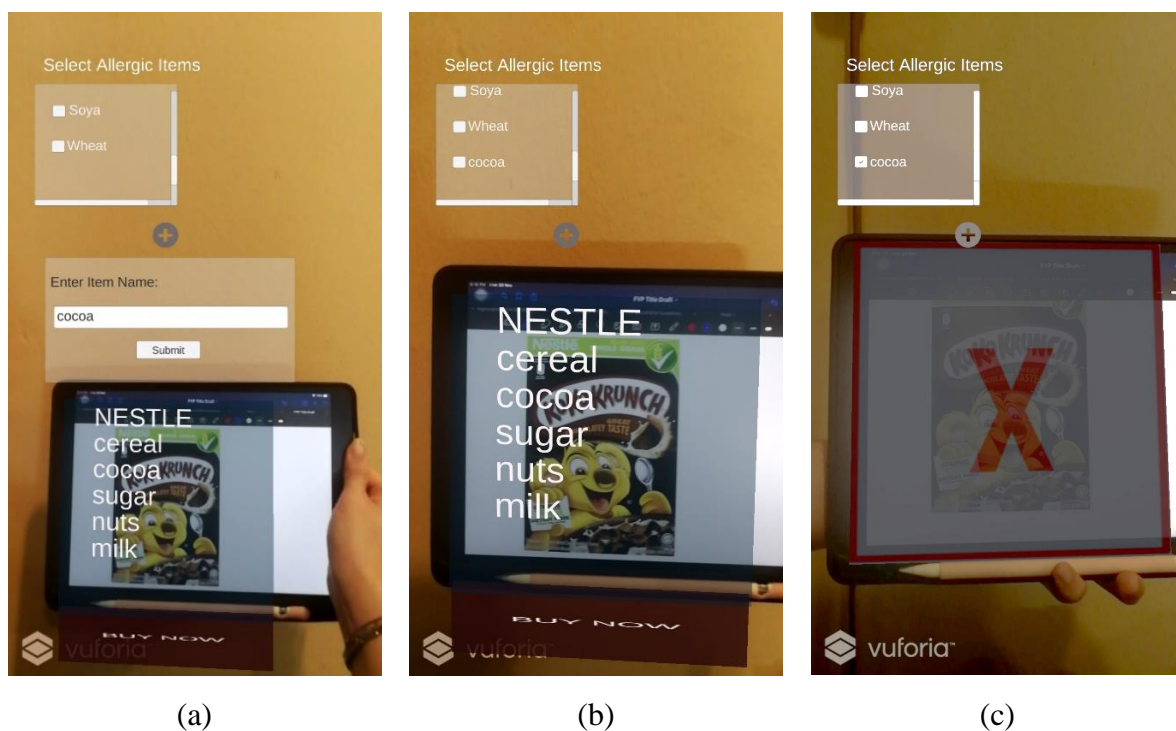


Figure 5.4: User adding new allergic items.

Meanwhile, the system can allow a user to insert a new item to the allergic ingredient list that originally does not contain inside. When the add button is clicked, an alert box will prompt the user to enter an item name. Figure 5.4 (a) show “cocoa” is entered, the system can allow a user to click submit button and “cocoa” is added to the ingredient list as shown in figure 5.4 (b). After successfully inserting the item “cocoa”, the filter function is work which shown in figure 5.4 (c). As a result, the system is able to filter the allergic items successfully.

3. Multiple Item

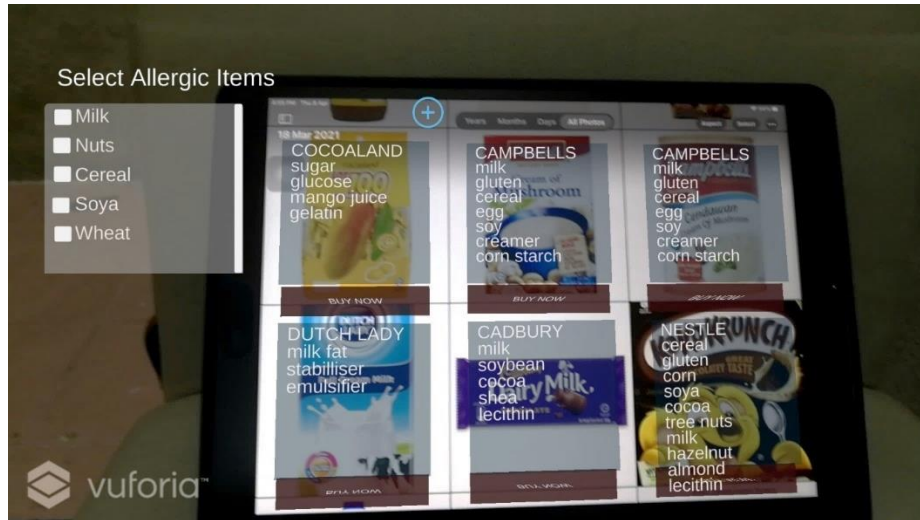


Figure 5.5: System able to detect multiple products in landscape mode.

Moreover, the application can detect multiple products even in various kind of angles as long as the image is not in luminous exposure condition. As the image target was detected in different angles, the AR content will be overlaid in different angle as well. Other than that, the system can recognise the image in either landscape or portrait mode as shown in both figure 5.5 and figure 5.6. In a nutshell, AR rendering is successfully performed in this project.

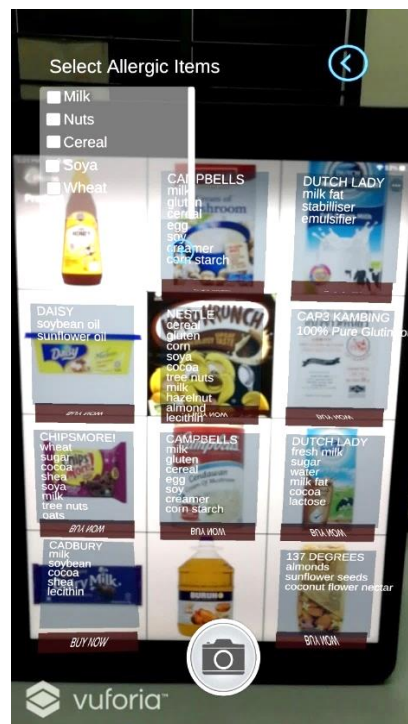


Figure 5.6: System able to detect multiple products in portrait mode.

5.2 Black Box Testing

To test features of the application, black box testing is used for software testing purpose. The functionalities of the applications are tested without any knowledge about the implementation of internal structure and coding. In this testing stage, the input and output are the main focus which means only the requirements are tested. The tested output will then be compared with the expected outputs. Only the wrong output will be re-invoked and tested again. Table 5.4 shows the features to be tested later.

Table 5.4: Features of applications to be tested.

ID	Feature Name	Test Level	Severity
A001	Create Account	System	High
A002	Login Account	System	High
A003	Manage Profile	System	Low
A004	Manage Health Option	System	Low
A005	AR Rendering	System	High
A006	Filter Allergic Ingredient	System	High
A007	Compare Multiple Product	System	Medium
A008	Add New Product	System	Medium
A009	Search Product	System	Low

5.2.1 Use Case Testing

The black box testing that used to test the system is use case testing which will test the functionalities of the system. There are a total of 9 main features that will be tested in this section and the results are shown in the tables below.

Table 5.5: Use case testing of A001 Create Account.

Use Case ID		A001		
Use Case Name		Create Account		
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to sign up page.	System direct user to login page.	PASS
	2	Provide valid username, email address and password.		
	3	Click Create Account button.		
Alternate Flow	1	Input a registered email address.	Account will not be created.	PASS
	2	User input different password as the confirm password.		

After creating the account, the user account information will be saved to Firebase Authentication as shown in Figure 5.7. When user wants to login the account, the system will match the email address and the password in Firebase Authentication. Figure 5.7 shows the expected result of the use case testing.

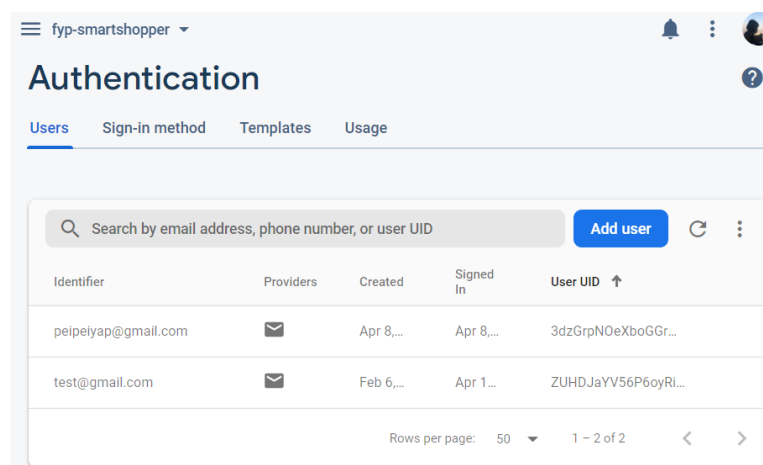


Figure 5.7: Firebase Authentication that stored user account details.

Table 5.6: Use case testing of A002 Login Account.

Use Case ID	A002			
Use Case Name	Login Account			
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to login page.	System direct user to user menu page.	PASS
	2	Provide valid email address and password.		
	3	Click login button.		
Alternate Flow	1	Input an invalid email address or password.	User not logged in to the account.	PASS

Table 5.7: Use case testing of A003 Manage Profile.

Use Case ID	A003			
Use Case Name	Manage Profile			
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to user profile page.	System saves the changes and direct user back to menu page.	PASS
	2	Edit username and email address.		
	3	Click done button.		

Table 5.8: Use case testing of A004 Manage Health Option.

Use Case ID	A004			
Use Case Name	Manage Health Option			
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to health option page.	System saves the default allergen to database.	PASS
	2	Select allergic ingredients as default allergen.		

	3	Click save button.		
Alternate/Exceptional Flows	1	Update allergic ingredients.	System updates the allergen.	PASS

Figure 5.8 shows the results of health option use case testing:

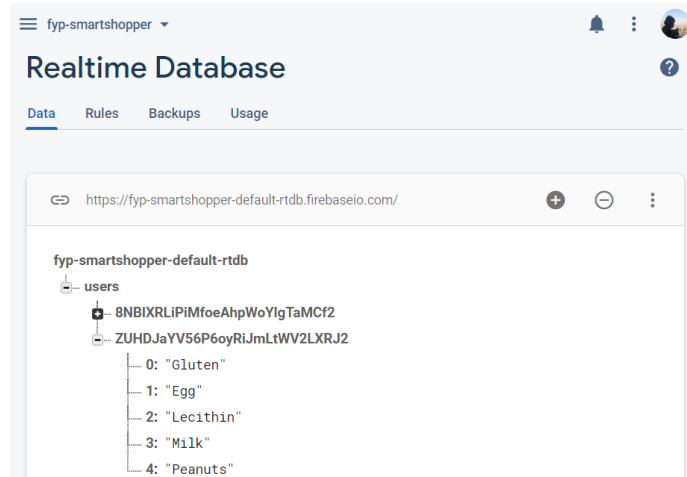


Figure 5.8: Result of default user preference.

Table 5.9: Use case testing of A005 AR Rendering.

Use Case ID		A005		
Use Case Name		AR Rendering		
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to AR Scanner page.	System shows virtual plane with ingredient list.	PASS
	2	Expose front view of product packaging.		
Alternate/Exceptional Flows	1	Product does not contain in database.	No virtual plane will be shown.	PASS

Table 5.10: Use case testing of A006 Filter Allergic Ingredient.

Use Case ID		A006		
Use Case Name		Filter Allergic Ingredient		
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to AR Scanner page.	System shows green plane if no allergen while red plane if there is allergen contained.	PASS
	2	Expose front view of product packaging.		
	3	Select allergic ingredient		
Alternate/Exceptional Flows	1	Do not select any allergic ingredients.	System shows ingredient list plane.	PASS

Table 5.11: Use case testing of A007 Compare Multiple Product.

Use Case ID		A007		
Use Case Name		Compare Multiple Product		
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to AR Scanner page.	System shows green plane if no allergen while red plane if there is allergen contained.	PASS
	2	Expose front view of multiple products packaging.		
	3	Select allergic ingredients.		
Alternate/Exceptional Flows	1	Do not select any allergic ingredients.	System shows ingredient list plane.	PASS

Table 5.12: Use case testing of A008 Add New Product.

Use Case ID		A008		
Use Case Name		Add New Product		
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to AR Scanner page.	System shows “Product added to database”.	PASS
	2	Capture front view of product.		
	3	Input product details		
	4	Click submit button.		
Alternate/Exceptional Flows	1	Cancel insert new product.	System back to the AR Scanner page.	PASS

Table 5.13: Use case testing of A009 Search Product.

Use Case ID		A009		
Use Case Name		Search Product		
	Step	Action	Expected Result	Test Status (PASS/FAIL)
Main Flow	1	Navigate to Search page.	System shows details of products.	PASS
	2	Input product keyword.		
	3	Select desired product.		

CHAPTER 6: CONCLUSION

6.1 Project Review, Discussions and Conclusions

In a nutshell, groceries shopping is a time-consuming process where a user could spend more than 1 hour in the supermarket. One of the main problems that slow down the process of shopping is the time to spend on deciding which product is better and suitable for purchasing. Furthermore, there are a lot of products that provide the same effect but with different ingredients existing in the market. This has caused extra effort for the people who are allergies to a certain ingredient such as milk, nuts and so on. They will need to spend more time reading the ingredient list carefully in order to ensure that it does not contain the allergen.

As such, an application which can help the user to filter the products automatically will significantly reduce the time spend on choosing the right and hence, reduce the time of the shopping process. The user will only need to provide the user input to the system. In this situation, AR technology plays an important role in order to achieve the expected performance and enhance user experience. In addition to image recognition, AR provides the capability to overlay content virtually on actual product in a real environment. This will greatly improve the effectiveness of the system.

In this project, a system is proposed to develop an AR mobile application that helps the user to filter the products which contain the allergen. When the system detected the product, it will augment the ingredient list of the product on it. After that, if the user selected the allergen, the application would check the ingredient list of the product and return a result to the user. The augmented plane of the product will also change accordingly which indicating that whether the product contains the allergen. The system also emphasis on user preference so that the application would know what ingredient that user allergic to so that they can try to avoid it.

6.2 Novelties and Contributions

This project has contributed to everyone not only housewife but also to people who have allergic. This allows them to easy search through the ingredient list of a product as they no need to go through every nutrition facts label. When they wish to compare some similar products with different brand, this application is benefits to them because they can scan multiple products on the rack and make the decision. In this situation, the time taken for grocery shopping will be reduced and shopper can make decision in a faster way. Furthermore, especially in this COVID-19 pandemic, this application allow user to have contactless shopping experience as the user does not need to contact every product to prevent spreading of the viruses.

On the other hand, the system is developed with a better performance in terms of accuracy, timing, and speed. The system can start up without any delay on timing to achieve better user satisfaction. Besides, time taken for the system to detect the target object is short without any latency. The system can also overlaid the ingredient list or augmented object on top of the product within 1 second. The application can detect the object in various kind of environment condition for example low light condition which is valuable all the time.

6.3 Future Work

Even though the applications have its own advantages, this project is still having some limitations that can be improved in the future. For example, the application can improve the product database by implementing Artificial Intelligence to auto updating the product database from time-to-time. This feature can increase the reliability of the application as the image in the database will always up to date. The database in this application has to be updated manually. If the packaging of the product change frequently, the developer needs to keep updated. With AI technology, the system will have the latest version of products in the database. Thus, user will not be worry if there are some products not found in the database.

Besides, there is absent of AR interaction for user to check out the item. It is better to have a direct interaction between user and virtual overlaid object such as the “BUY NOW” button on the virtual ingredient list plane. In this way, user can check out the product by using the application so that they no need queue for a long time to make payment.

CHAPTER 6 CONCLUSION

Furthermore, there are no such function which allow the application to detect the current location of user so that the database can switch accordingly based on the location of the user. For instance, when user in AEON, the system can detect the location of the user and switch the database to AEON while if user at TESCO, the system will switch the database to TESCO database. With the flexible database, users are not limited to a certain supermarket for grocery shopping.

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 Faculty of Information and Communication Technology
 Bachelor of Computer Science (Hons)

PREPARED BY YAP PEI PEI SUPERVISED BY DR. NG HUI FUANG

SMART SHOPPER - GROCERY INGREDIENT FILTERING WITH AUGMENTED REALITY



Tools to Use:

- Vuforia Engine
- Unity
- Flutter
- Android Studio



AR RENDERING

User can expose product's package to the camera. The system perform feature detection to match feature point in database. A plane with product information is augmented on top of the product.



FILTER INGREDIENT

User is allowed to filter allergen and able to select more than 1 allergic item. If allergen exist, AR green colour tags is augmented on top of the product. If allergen not exist, AR red tags is augmented.



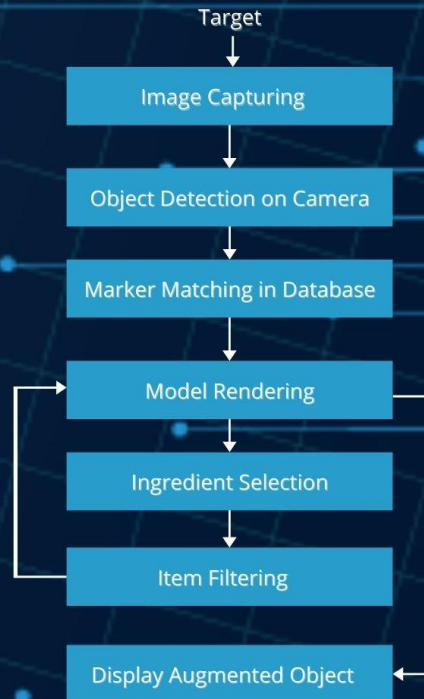
DECISION MAKING

User can compare 2 or more products with selected allergens. If red plane is augmented on the actual product, that product means to be avoided.

INTRODUCTION

Groceries shopping with augmented reality. A Android platform smart shopper with ingredient filtering function using marker-based AR technology is essential to assist user in decision making and ingredient filtering.

METHODOLOGY



CONCLUSION

- time taken spend in supermarket reduced
- consumers able to make fast decision to select desirable product
- benefits to housewife, users who allergy to certain ingredients,

PLAGARISM CHECK RESULT

Smart Shopper - Grocery Ingredient Filtering with Augmented Reality

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

Signature of Supervisor

Name: Dr. Ng Hui Fuang

Date: 15/4/2021

Signature of Co-Supervisor

Name: _____

Date: _____

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√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
-	List of Symbols (if applicable)
√	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
-	Appendices (if applicable)
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)

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

I, the author, have checked and confirmed all the items listed in the table are included in my report.  <hr/> <p>(Signature of Student) Date: 14 APRIL 2021</p>	Supervisor verification. Report with incorrect format can get 5 mark (1 grade) reduction.  <hr/> <p>(Signature of Supervisor) Date: 15/4/2021</p>
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