ARGROCERY: AN AUGMENTED REALITY-ASSISTED GROCERY SHOPPING MOBILE APPLICATION

BY

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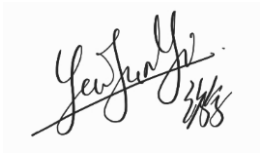

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ABSTRACT

In the context of grocery shopping, making judgments about what to buy at physical stores may be difficult since there are so many options that are comparable. Hence, people typically spend a lot of time in the store in reading the ingredient labels on the nutritional information on the packaging to pick the best product they desire. Even while it takes time, the primary challenge for shoppers, especially those who are allergic to a particular component, is that they find it difficult to filter and look for items that are completely devoid of all allergenic substances. In this paper, a mobile application that uses Augmented Reality (AR) technology to identify products, display product information, and perform ingredient filtering is proposed to assist shoppers in decision-making. The system utilized marker-based AR to identify the product with a smartphone camera and display the product information such as product name, brand, and ingredient list. Furthermore, the proposed system uses AR tags with colours to make it easier for users to recognise and differentiate both suitable and not suitable products. This project is beneficial for shoppers to have a richer shopping experience with more comprehensive and detailed realistic commodity information by using AR technology with a mobile phone.

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LIST OF ABBREVIATIONS

AR	Augmented Reality
MAR	Mobile Augmented Reality
SAR	Shopping with Augmented Reality
SDK	Software Development Kit
BaaS	Backend-as-a-service
IDE	Integrated Development Environment
UI	User Interface
2D	Two-dimensional
3D	Three-dimensional
API	Application Programming interface
DB	Database
GUI	Graphical User Interface

Chapter 1: Introduction

1.1 Problem Statement and Motivation

People in supermarkets often follow a basic process when shopping: browse the products, select the product, pay for it and leave the store. In this process, there are some typical scenarios that happened, which are written as problem statements below.

People spend a lot of time selecting products and think that grocery shopping is time-consuming.

When people do not know the products, people can only get a general idea of the product through the packaging. They need to constantly find the location of information on the packaging such as product description, ingredients, date of manufacture and other information. The process brings a waste of time when it comes to purchasing several products at one time. Moreover, some products might have small or difficult-to-read text, which can further add to the difficulty of finding the necessary information. This problem statement highlights the need for a more efficient and user-friendly way of accessing product information during grocery shopping.

People face difficulty in choosing the same type of good.

There are many brands and forms of the same type of goods. When facing different brands, styles, and prices of the same category of products, it is difficult to know which one has the better quality, hence, people have difficulties in choosing products. People need to remember the product information so they can filter out the suitable product. Furthermore, in some supermarkets, it is also difficult to find a shopper at any given moment and the shopper’s presentation may be suspect. The targeted users that have these problems might be housewives, people who have allergies to certain food ingredients, and people who are strict in their healthy diet. For example, milk, and nuts are the common ingredients in most food, at the same time, there is a group of people who have allergies to milk and nuts. In this case, they must filter out the unwanted ingredients by looking at each of the product information or else they might purchase a product that causes allergic reactions. This can result in a frustrating shopping experience and may even lead to the purchase of products that do not meet the consumer's needs or expectations.

People who are strict in their healthy diet may find it challenging to compare products based on their calorie and carbohydrate content.

People who are strictly following a healthy diet have to be mindful of the number of calories and carbohydrates they consume. These individuals often need to compare products to determine which options are the best fit for their dietary needs. However, this process can be time-consuming and difficult, especially when trying to compare multiple products at once. In some cases, it may even require the use of external resources, such as nutritional charts or online resources, to make informed decisions. Without the ability to easily compare products based on their calorie and carbohydrate content, people on a strict healthy diet may feel overwhelmed and discouraged when grocery shopping. They may also feel like they are missing out on certain food options that they enjoy but are unsure if they fit into their dietary goals.

The motivation of this proposed project is to improve users' purchasing experiences by incorporating basic augmented reality with photographs and annotations data and allow people to acquire and share knowledge more naturally from what they see in reality. In this era, practically everyone has a gadget such as a mobile phone. By integrating AR technology into mobile applications, users may improve their vision of the real world by superimposing the created product picture over their view of the real world. With such enhancements to the product visual representation, people are more likely to utilise mobile augmented reality applications and see how the goods would seem in the real world. In short, including physical and virtual experiences in the buying experience will boost consumers' involvement with the mobile augmented reality application in grocery shopping. This will result in a higher likelihood of acquiring the product as it allows for on-site dietary information assistance.

1.2 Objectives

The proposed project aims to:

1. To develop an augmented reality-based mobile application that displays product information by overlaying it on the screen during grocery shopping.

The project aims to integrate virtual environment information with real-world information by using Augmented Reality technology so that the system is able to allow users to view one or multiple product information in a single view. The brand, name and ingredients of the product should be overlaid on the product. Users can have a better understanding of the basic information of the product.

2. To develop an AR-assisted grocery shopping mobile application that can recognize and differentiate products that contain specific food allergens.

The purpose of this project is to enable users to specify the ingredients and differentiate the items by looking at the AR colour tags, items to avoid are highlighted in red, whereas okay groceries are highlighted in green. This improves decision-making about foods for housewives, people with allergies, and people with a healthy diet.

3. To develop an AR-assisted grocery shopping mobile application that can assist users to compare products by calorie and carbohydrate intake.

The project focuses to enable users to compare the products by calorie and carbohydrate intake. This will be achieved by displaying calorie bars and generating a colour-coded comparison table that contains the product name, calorie, and carbohydrate levels for easy comparison.

4. To develop a mobile application that allows users to create a shopping list by adding and removing items they need to purchase.

The main purpose of the shopping list feature is to help users organize their shopping and ensure that they do not forget any essential items while they are at the store. By creating a shopping list in this project, users can easily add and remove items as they remember them, helping to reduce the likelihood of forgetting important items. The shopping list feature can also help users save time by allowing them to quickly refer to the list and locate the products they need in the store.

1.3 Project Scope

This project developed a marker-based AR shopping assistant mobile application in assisting users during grocery shopping. The mobile application will be delivered on the Android platform. The sample products for this database are taken from Lotus's website [1] and mainly focus on snacks, groceries, and beverages. The product information is taken from Lotus's website including the product brand, name, and ingredients.

As users navigate a grocery store aisle, the AR tags displaying product information will change based on the products they face. The application overlays virtual content on physical products to display information such as product name, brand, and ingredients. In addition, users can specify their purchase choices by selecting allergy items. The AR tags turn green with a tick symbol for products that meet their requirements and red with a cross symbol for those that do not. Users can create a health profile in their account by selecting allergens or ingredients to filter when scanning products, and the information of products and users is saved to Firestore.

Besides selecting allergy items, users can also compare the calorie and carbohydrate intake of multiple products simultaneously. The detected products on the screen will lead the system displays calorie bars and generates a colour-coded comparison table that contains the product name, calorie, and carbohydrate levels for easy comparison, users can quickly and easily identify which products fit their dietary requirements. This can assist users to choose a healthier product. Besides that, users can create a shopping list in the mobile application before grocery shopping.

1.4 Contribution

The proposed project has several impacts, significance, and contributions. One of the primary benefits of this project is that it provides a convenient and efficient way for users to access crucial product information. By leveraging augmented reality, the mobile application can quickly recognize selected items through the camera of the user's smartphone and overlay relevant ingredient information onto the product. This will empower consumers with critical product information at the point of purchase, enabling them to make better-informed decisions regarding which products to buy. Consequently, this approach will streamline the grocery shopping process, allowing consumers to make faster purchasing decisions.

Secondly, the project will be of significant benefit to people with food allergies as it will enable them to quickly identify items that contain specific allergens. This can save time and reduce the risk of accidental exposure to allergens, improving their quality of life. Thirdly, the project's feature of comparing products by calorie and carbohydrate intake can help users make informed decisions about the products they purchase, potentially leading to healthier dietary choices. This can have significant long-term health benefits for users and contribute to public health efforts to combat obesity and related health conditions.

Finally, the shopping list feature can help users save time and reduce the likelihood of forgetting important items while shopping, making the shopping experience more convenient and efficient. Overall, the proposed project has the potential to make a significant contribution to improving the grocery shopping experience for users, promoting healthier food choices, and enhancing the quality of life for people with food allergies.

Overall, this project can help the supermarket industry with how consumers purchase products in grocery stores. Mobile Augmented Reality (MAR) helps to overcome these dilemmas by seeing the goods. With AR, shoppers can view virtual objects in real-time, and spend more time visualizing and configuring products in the real world. Hence, this can reduce their uncertainties about their purchase.

1.5 Report Organization

The report is divided into seven chapters, each addressing different aspects of the project. Chapter 1 provides an introduction to the project and is divided into five sections. The first section is the problem statement and motivation, which explains the reasons behind the development of an AR-assisted grocery shopping mobile application. The second section is the objectives of the project, which outlines what the project aims to achieve. The third section is the project scope, which defines the boundaries of the project, including what will be included and excluded. The fourth section is the contributions, which explain what the project adds to the existing knowledge. Finally, the fifth section is the report organization, which explains how the report is organized.

Chapter 2 is the literature review, which provides an in-depth analysis of existing AR-based mobile grocery shopping applications. This chapter is divided into four sections. The first section provides an introduction to the chapter, while the second section presents a review of AR-based mobile grocery shopping applications. The third section compares the proposed system with the previous work, and the fourth section provides a summary.

Chapter 3 is the system methodology/approach, which explains the methods and general work procedures used to develop the system. This chapter is divided into seven sections, including the methodology and general work procedures, tools used, system flowchart, system architecture diagram, use case diagram, use case description and activity diagram.

Chapter 4 is the system implementation, which explains the software setup and configuration, as well as the development of the AR camera scene and sample product. This chapter is divided into four sections, including software setup, setting and configuration, system operation, and implementation issues and challenges.

Chapter 5 is the system evaluation and discussion, which provides a verification plan, verification result and analysis, use case testing, and objectives evaluation. This chapter evaluates the system's effectiveness and compares it to the project objectives.

Chapter 6 is the conclusion and recommendation, which summarizes the project and provides recommendations for future work. This chapter is divided into three sections, including conclusions, novelties and contributions, and future work. The conclusion section summarizes the project, while the novelties and contributions section highlights the project's contribution to existing knowledge. Finally, the future work section outlines potential areas for future research and development.

Chapter 2: Literature Review

2.1 Introduction

This chapter reviews the previous work done on using augmented reality to enhance consumers' in-store shopping experiences. Several relevant approaches for shopping in AR will be explored and reviewed. The pros and cons of the precious work done be discussed in this chapter.

2.2 Review of the Technologies

2.2.1 Augmented Reality

Augmented Reality (AR) is a technology that allows users to experience an enhanced version of reality by overlaying virtual objects in the real world. AR Applications are on the rise because of the high mobility of mobile devices. Mobile Augmented Reality (MAR) is getting increasingly popular due to its great portability, convenience, and increasing chemical capabilities. The field of Augmented Reality is gaining popularity among researchers and development professionals. The use and spread of Mobile Augmented Reality will be a trend in the coming years. There are two main types of AR: marker-based and markerless AR. Marker-based AR uses a visual marker, such as a QR code or image, to trigger the display of virtual content. On the other hand, markerless AR uses sensors and cameras to detect the user's environment and overlay virtual content without the need for a physical marker.

Since its creation, AR has advanced quickly and is currently employed in a variety of industries, including phobia treatment, education, gaming, and shopping. AR technology has been used to create interactive and immersive gameplay experiences. One notable example is the popular game Pokemon Go, which uses AR to allow players to catch virtual Pokemon characters in real-world locations. In education, AR has been used to create interactive and engaging learning experiences. For instance, AR applications can display 3D models of historical sites or scientific phenomena, enabling students to explore and understand the subject matter in a more immersive way.

AR has also been applied to the retail industry, with the development of AR-assisted shopping applications. These apps use AR technology to overlay product information, such as ingredients, nutrition facts, and reviews, on top of real-world products, enabling users to make informed decisions about their purchases. Additionally, AR-assisted shopping apps can help

users navigate through the store, find products, and create shopping lists. Overall, the use of AR in mobile technology has the potential to revolutionize the way we interact with digital content, offering new possibilities for education, entertainment, and commerce.

2.2.2 Software Platform

In recent years, the use of Augmented Reality (AR) has gained popularity in various fields, including education, gaming, and retail. As a result, several AR frameworks have been developed to facilitate the creation of AR applications. This section will compare four popular AR frameworks: ARCore, ARKit, Vuforia, and AR Foundation.

ARCore and ARKit are two of the most widely used AR frameworks developed by Google and Apple, respectively. Both frameworks use markers and mapping technology to create an AR experience. ARCore is designed for Android devices, while ARKit is developed for iOS devices. The advantage of using these frameworks is their ability to track the user's location and movements accurately. However, the main disadvantage is that the user's device must have the required hardware and software to support ARCore or ARKit.

Vuforia is another AR framework that is widely used for AR development. This framework uses image recognition technology to identify real-world objects and overlays AR content on top of them. Vuforia can be used on both Android and iOS devices, making it a versatile option. Moreover, it has a robust library of features and tools that simplify AR development.

AR Foundation is a cross-platform AR framework that uses ARCore and ARKit to create AR experiences for both Android and iOS devices. This framework simplifies AR development by providing a unified API, which developers can use to develop AR applications.

After comparing these frameworks, Vuforia appears to be the most suitable for developing the augmented reality-based mobile application described in this project. This is because Vuforia's image recognition technology can overlay virtual information on real-world objects, which aligns with the objective of the project. Additionally, Vuforia offers seamless integration with Unity, which simplifies the development process and reduces the learning curve for developers.

2.3 Review of AR-based mobile grocery shopping application

2.3.1 Shopping with Augmented Reality

In this paper, Piumali et. al [2] developed an AR-enabled grocery shopping mobile application and emphasized that this Shopping with the AR innovative application (SAR) will be a smart solution for Sri Lankan supermarket customers. This paper intends to help the customer choose items based on their budget and assist the customer in choosing the best options based on their diet plans and state of health. The application consists of 3 primary sections: offers a way for users to select the best item depending on their diet and health state, displays product information on the screen by using AR technology, and manages the user budget.

Figure 2.1: The user interface of the SAR application, displaying item details and special offers

Figure 2.2: The user interface of the SAR application, displaying the warning messages

Figure 2.3: The user interface of the application,
displaying warning message based on the user's budget

The figures above show the user interface of the application. From Figure 2.1, the product information such as the expiry date, price, ingredients, and discount are visualized for users to obtain the information quickly without touching the item. From Figure 2.2, the system will display a warning message in red colour to alert the user according to the user's healthy level. From Figure 2.3, the budget specified by the user at the start of the procedure is displayed on the screen. If users exceed the budget, the application displays a message to inform users to maintain the budget.

The system used Vuforia SDK to track the characteristics of the image by using natural feature marker-based detection approach. Three factors will be considered when extracting the image target which are the shape, percentage of deformation and the probability of deformation. After extracting the features of the image, the database is utilised to do a time comparison. The tracker uses computer vision algorithms to recognise real-world objects in video frames captured by the camera using the Vuforia SDK.

Strength of SAR

- The application can display the product information for people to obtain the information quickly without touching the items.
- The application can display a message when the product is not healthy or not suitable based on the user's health state. By providing more information, users can select healthier items.

Weaknesses of SAR

- Although the application can display ingredients on the screen, the ingredients are limited to sugar, fat, and salt only. When displaying product information, the ingredients are not complete which is not helpful in the user's decision-making.
- The information about the sugar, fat, and salt levels is not meaningful. As shown in the figures above, the application displays numbers to indicate the amount of nutritional level. However, users might not understand the meaning of the number shown on the screen.

2.3.2 ARShopping

In this paper, Xu et. al [3] presented a web-based prototype, ARShopping, for augmenting the in-store shopping experience with online product information such as product features and ratings through mobile devices. The application uses AR to identify products and display product information as visual glyphs which are able to indicate multiple features such as price, brand, protein, and calories. This helps the user to make comparisons between various products.

The prototype consists of two modules, a product detection module, and a user interface module, which is the AR content creation in the mobile interface. For product detection, the authors implemented marker detection and product image detection. AR.js library's built-in marker tracking function is used for marker detection. A marker with a unique ID is printed and encoded for each product, with the expectation that it would be put on the price tag of the actual product. This enables the product ID from the encoded data can be deduced and also the 3D location, rotation and size of the product can be determined. For product image detection, the TensorFlow object detection model is used to train the model by online images of each product. The output of the model includes the matching product ID, the centre location of the product, and the bounding box size for each object that is detected. The size and location data are used to determine the layout of the visualization properly by locating the nearest product to the marker and utilising its area, which is shown in Figure 2.4. On the other hand, when the product ID is detected, the online information of the products on the camera screen will be retrieved from the online database.

Figure 2.4: A comparison of product detection and glyph placement results with (a) marker detection only and (b) marker+object detection.

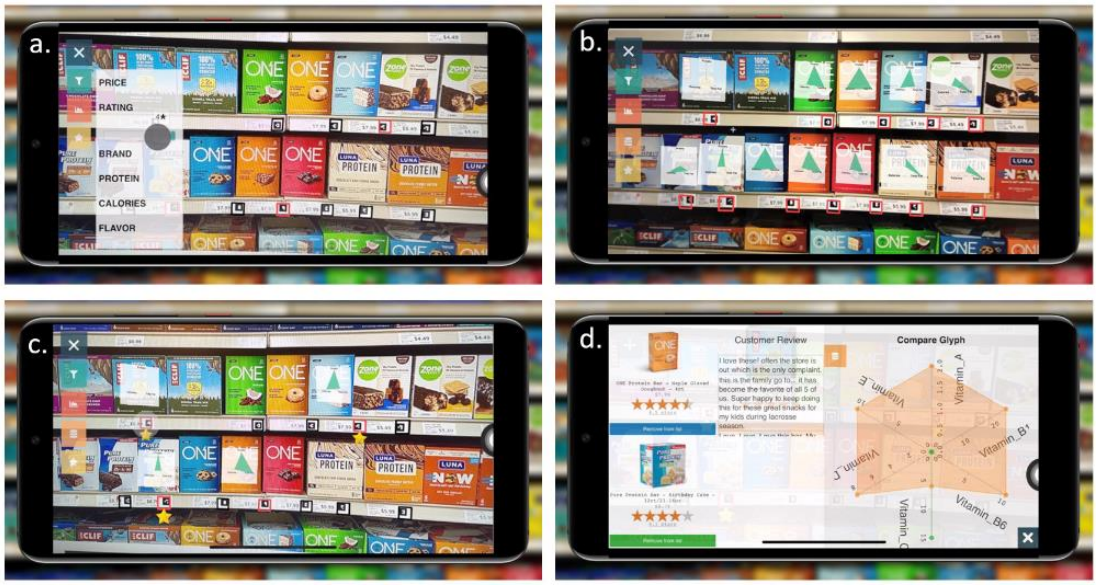


Figure 2.5: The ARShopping Interface. (a) Filtering. (b) Multivariate data glyphs. (c) Adding products to favourites. (d) Comparison view.

For the user interface module, the product information is represented with radar charts. Firstly, the user will filter the features such as brand, sugar, and calories, then the visual glyphs overlaid on the actual products. The glyphs are placed in superpositions to assist users in comparing product information.

Strength of ARShopping

- The web-based prototype can display multivariate product data for feature comparison.
- The user interface is tidy and neat where the information of each product will not overlap each other.

Weaknesses of ARShopping

- The design of the visualization is not user friendly. Text descriptions can be added while displaying the amount nutritional level in radar charts to make it more understandable.
- Real-world factors including natural light, shadows and the size of the markers and objects in the image might interfere with the accuracy of the product identified as the prototype is tested under virtual settings. Nevertheless, the authors claimed that real-world experience and performance will be evaluated in future work.

2.2.3 ARMart

ARMart is an AR-based shopping assistant for users to choose and find store items. Röddiger and his team [4] created a mobile application that allows users to pick products depending on criteria such as calories or sugar, which are evaluated on a scale of red indicating poor to green indicating green. This system recognizes an object based on the front side of the packaging of the product. Hence, it is not dependent on the user's location and does not require prior knowledge of where to obtain food. The application uses Apple's proprietary algorithm to detect images in 3D space and uses ARKit to overlays the products with a coloured rectangular shape. The application has three primary functions: filtering products based on a given criterion, searching for items based on the name or brand of the product, and exclusion products containing specified substances that might cause allergies. The functionalities are shown in the figures below.

Figure 2.6: The user interface of ARMart, filters items by different factors

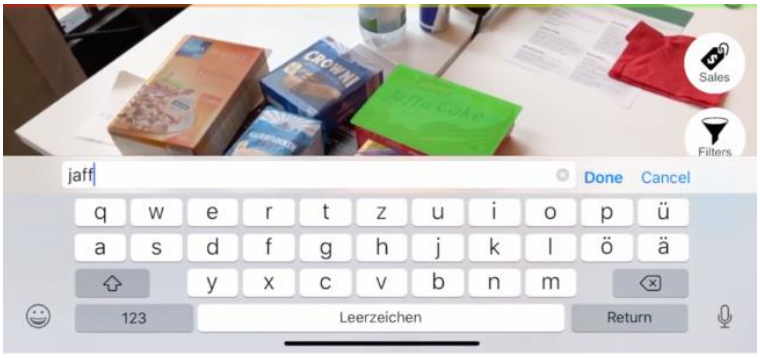


Figure 2.7: The user interface of ARMart, search for items based on name or brand

Figure 2.8: The user interface of ARMart, displaying warnings for items that contain nuts

Strength of ARMart

- The front side of the product is detected reliably at a distance of about one meter.
- Color labelling in between the two edge situations allows for good distinction. Red indicates a product that may have a negative impact on lifestyle, such as exceeding suggested intakes, while green indicates that staying within these limits is highly beneficial as shown in Figure 2.7.
- The application can exclude the product that contains a specified ingredient by overlaying a red rectangle shape on the image of the product.
- The products can be placed on a table, kept on a shelf, or picked up by the user for object detection and recognition.

Weakness of ARMart

- The application only supports iOS device.
- The application can only run with the products kept locally on the user's device.
- Only products with rectangular shapes are supported.

2.3.4 PHARA

PHARA is an AR mobile assistant that supports decision-making for food products at grocery stores. Authors from [5] built PHARA by bringing the concepts of recommender systems, visualization, and AR together to provide a context-aware, continuous AR experience to users.

Figure 2.9: The main screen of PHARA

Figure 2.9 shows the main screen of PHARA mobile app. The application uses Unity and Vuforia frameworks to render the visual components. The information is organized in different types of layouts to make the application user-friendly. The AR components used in PHARA include nutrition levels, calorie breakdown, calorie intake, nutrition guide, similar products, healthy alternatives, and products that users may like. In short, users allow using different visual components to assist them in the grocery store.

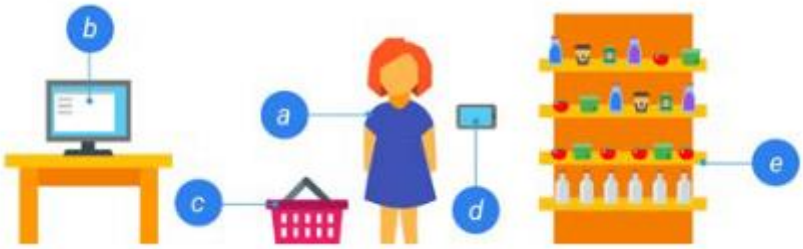


Figure 2.10: Use case of PHARA: a) user, b) desktop interface to create or edit the user profile, c) basket to place the food products, d) PHARA mobile app, e) store shelf

The recommendation is generated by the recommendation engine using user profiles, related products, and healthy products. As shown in Figure 2.2.4.2, users are required to fill up a profile through the web browser application together with personal information such as allergies, age, weight, height, and others. Users are then prompted to pick their top 10 items so that the algorithm can learn them. Once the user profiles had been created, a dashboard with suggested goods was shown, which is shown in Figure 2.2.4.1.

Strength of PHARA

- The application is able to compute recommendations and predictions based on user profiles.
- The application is able to read a product's bar code and show information about its nutrients.
- The application provides multiple types of visual components for users to check the nutrition content of a product.

Weaknesses of PHARA

- Throughout processing and user display, there has been a lack of confidence in the quality of the data.
- When consumers encountered an insufficient display of descriptions, accuracy and diversity were an issue.

2.3.5 Supporting Healthy Grocery Shopping via Mobile Augmented Reality

Researchers have become increasingly interested in AR as an emerging research area in the field of in-store shopping with AR. In this paper, Ahn et. al [6] built an indoor mobile augmented reality system for healthy grocery shopping by leveraging the sensing and AR capabilities of smartphones and healthy options to recommend products to purchase or identify products to avoid. It cuts down on the time for users to discover their preferred items and steer clear of bad food. The researchers aim to help users easily browse for healthy items with the use of AR overlay tagging, which is presented on the products.

The system has to be able to retrieve the user's location inside an interior space. A commercial image labelling service called IQEngines is used to identify the location of users. A bounding box is built around each aisle in which the x-range axis is constrained by the width of a typical supermarket aisle. In addition, the project employs the use of the OpenGL library to display AR tags with a 3D depth perspective. The size of the tags will differ depending on how close the product is to the user, the smaller the tag, the further away the product.

Figure 2.11 The user interface of the AR mobile shopping app from Ahn et. al

The figure above shows the AR-based user interface of the system. As shown in the figure, the application provides dietary food constraints function for users. Users who have allergies can select different ingredient requirements and the coloured tags display on the actual product, where green indicates healthy, advised to buy while red indicates unhealthy, not advised to buy. Besides that, product information such as name, brand, and nutritional information is displayed on the mobile phone when users tap on the tag. In order to make it easier for users to comprehend the information, the system has also included static and dynamic

motion AR tag displays. For static AR tags, the programme shows the tags in fixed positions. It gives the user a static display so that, despite dramatically shifting backgrounds, the tags can be read at specific fixed locations on the screen with ease. Second, when the user is roughly stationary in the aisle, the dynamic-motion tag display function is activated. At this stage, the screen enables tags to switch positions on the screen and rotate appropriately to face the user when the user pans the screen and aims the camera at a product on a shelf.

Strength of Supporting Healthy Grocery Shopping via Mobile Augmented Reality

- The system is able to provide food recommendations based on health profiles.
- The system is able to localise users in aisles.
- The system implements AR-coloured tags to indicate healthy and unhealthy, and display product information.

Weaknesses of Supporting Healthy Grocery Shopping via Mobile Augmented Reality

- The accelerometer sensor detected a stride wrongly when users change the mobile phone’s orientation.

2.4 Comparison of Proposed System and Previous Work Done

Table 2.1 Comparison of Proposed System and Previous Work Done

System / Features	Proposed Application	SAR	ARShopping	PHARA	ARMart	Healthy Grocery Shopping
AR feature	√	√	√	√	√	√
User-friendly interface	√	√	X	√	√	√
Display product information	√	√	√	√	X	√
Ingredient filtering	√	X	X	X	√	X
Compare multiple products	√	X	√	X	√	√
Free of charge	√	√	√	√	√	√
User account	√	√	√	√	X	√
Health profile	√	√	X	√	X	√

2.5 Summary

Ample evidence exists to support the use of augmented reality in product information retrieval and real-time product recommendation. They have all been shown to be beneficial for enhancing customers' in-store shopping experiences. However, most existing AR applications concentrate on detecting a single product at a time and are rarely applied in ingredient filtering. This causes trouble to the users who want to perform ingredient filtering by excluding the ingredients that cause allergies to them. Users need to scan the product and read the product information one by one and do filtering on their own in order to get the desired product. Therefore, by concluding the problem encountered above, an application that has ingredient filtering is needed to solve the problem.

Chapter 3: System Methodology / Approach

3.1 Methodology and General Work Procedures

The methodology chosen for this project is the Agile Software Development Methodology. Agile development is an incremental and iterative methodology which is suitable for a mobile application development project. This is because of the fast-changing requirement in business needs and frequently changing demands and updates. In short, to develop a good mobile app without additional revision, the agile methodology is the best option. The main phases in this approach are plan, design, develop, test, deploy, review and launch. These steps will be repeated and executed in a cycle if any changes and updates are made to the produced application.

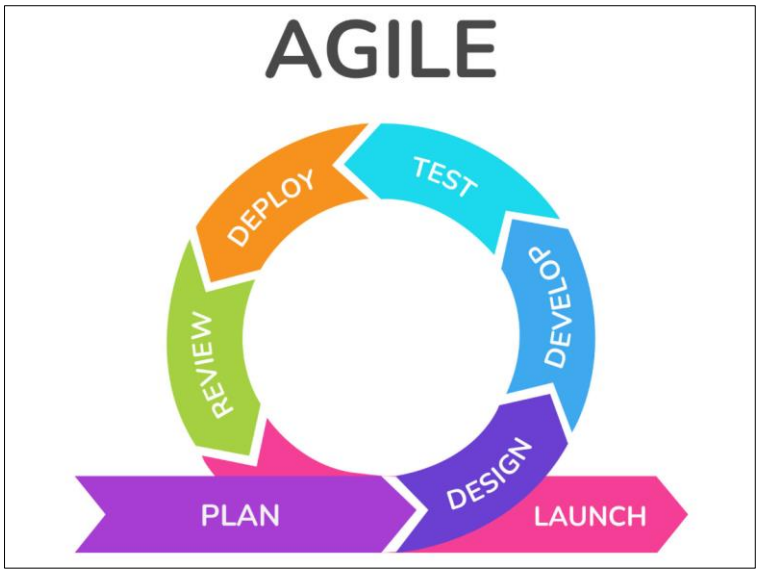


Figure 3.1: Agile Software Development Approach [7]

Plan

In the planning phase, user requirements will be identified and made up of the project scope. Besides that, the problem statements, project objectives, and project scope will be identified and discussed in this phase, followed by the project's existing and potential challenges. The timeframe and schedule will be established, along with a priority list of the functions that need to be built. The order in which the sub-modules will be finished is determined by the timeline. For example, the predefined image targets should be completed first before adding AR content.

Build

After the planning stage, the design, and develop phases will be carried out. The architectural design diagrams such as activity diagram and use case diagram will be designed, together with

the UI design and AR content design. Then, the application is built from scratch by using the tools required such as Unity, Vuforia, Visual Studio Code, and Firebase. The functions and user interfaces of the application are created with user-friendly concepts. This process is thought to take up the most time over the entire project development process.

Launch

The system is lastly tested before being made available to the user. The user can evaluate the software's features during a trial run of the application. The development cycle will be repeated in order to address any supervisory feedback or systemic faults until the result meets expectations. This is done to guarantee the developed modules are useful and serviceable, as well as the developed application's usability.

3.2 Tools to use

Hardware Specifications

The following hardware is needed to complete this project:

1. Laptop Model: DELL PRECISION M3800

Table 3.1: Laptop model for project development

Component	**Specifications**
Operating System	Window 10 (64-bit)
Processor	Intel® Core™ i7-4712HQ CPU @ 2.30GHz
RAM	16.0GB
Graphics Card	NVIDIA Quadro K1100M (2GB GDDR5)

2. Android Device Model: Galaxy Tab S6 Lite

Table 3.2: Android device model for project development

Component	**Specification**
Processor	Octa-core (4x2.3 GHz Cortex-A73 & 4x1.7 GHz Cortex-A53)

RAM	4GB
Storage	64GB
Camera	Rear camera: 8 MP Front camera: 5 MP
Operating System	Android 12, One UI 4.0

Software Specifications

The following software is needed to complete this project:

Table 3.3: Software involved in the development of this project.

Software	Specifications
Platform	Android 7.0 'Nougat' (API level 24) or higher
Integrated Development Environment	Visual Studio Code 2019
Programming Language	C# (C Sharp)
Game Engine	Unity 2021.3.12f1
Database system	Firebase – Cloud Firestore

3.3 System Architecture Diagram

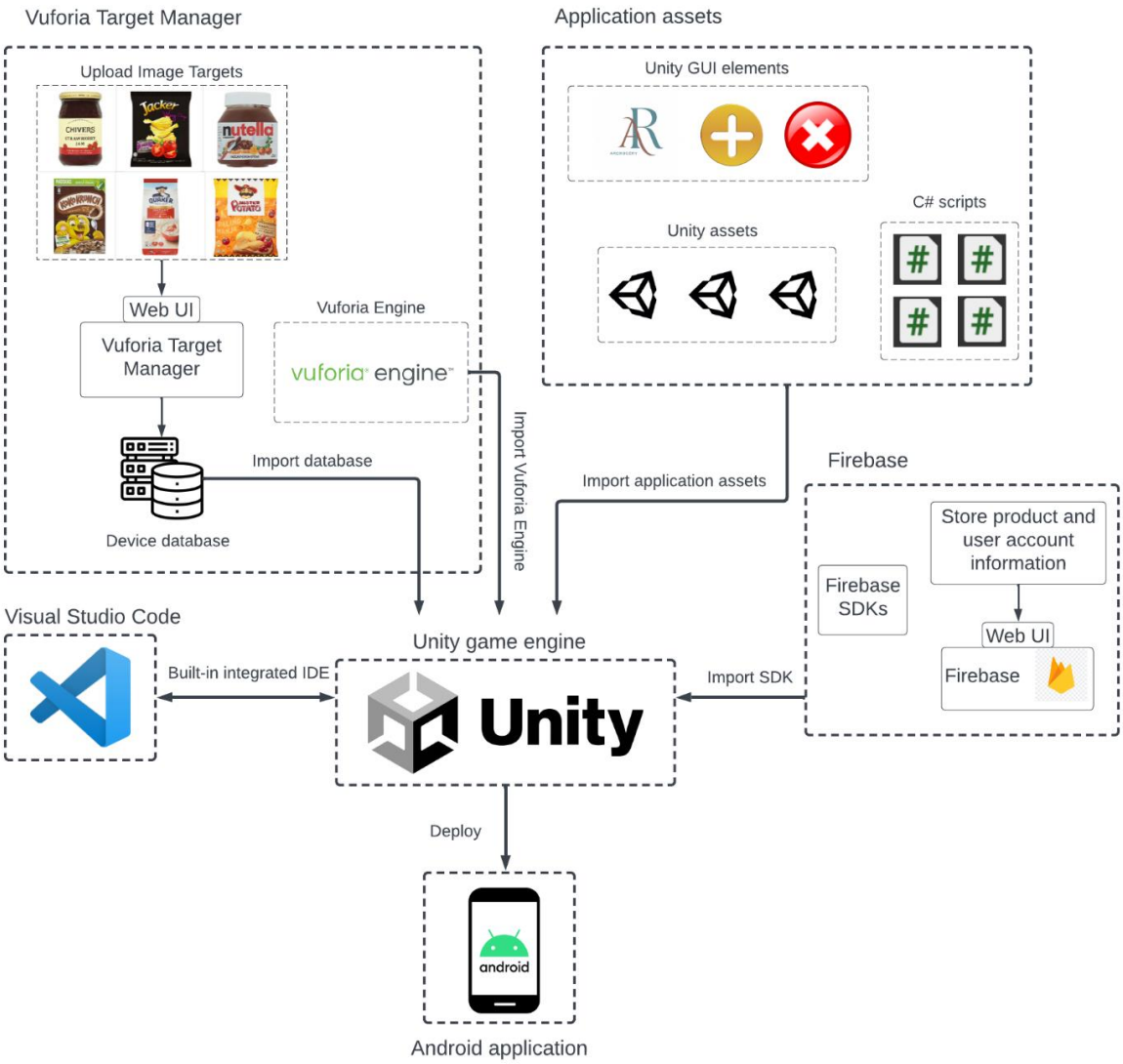


Figure 3.2: System Architecture Diagram of ARGrocery

Figure 3.2 shows the system architecture diagram of the application. A device database with the image targets is created in Vuforia Target Manager. Next, all of the GUI components, C# scripts, and application assets have been generated and integrated into the Unity engine. The completed application was developed on the Android platform.

After creating the device database in Vuforia, the product image targets of ARGrocery are uploaded to the device database through the web-based Vuforia Target Manager. The Vuforia Target Manager detects the feature points in these target images, which are then used to identify these target images in their actual surroundings. The device database will be

downloaded and added to the Unity environment. The C# programming language and Visual Studio Code are used for logic development. Unity 3D has been integrated with all of the application's design and development content. Additionally, Firebase is used to store the product and user account information and hence the Firebase SDK is installed in the Unity environment in order to connect to the Firebase database.

3.4 System Flowchart

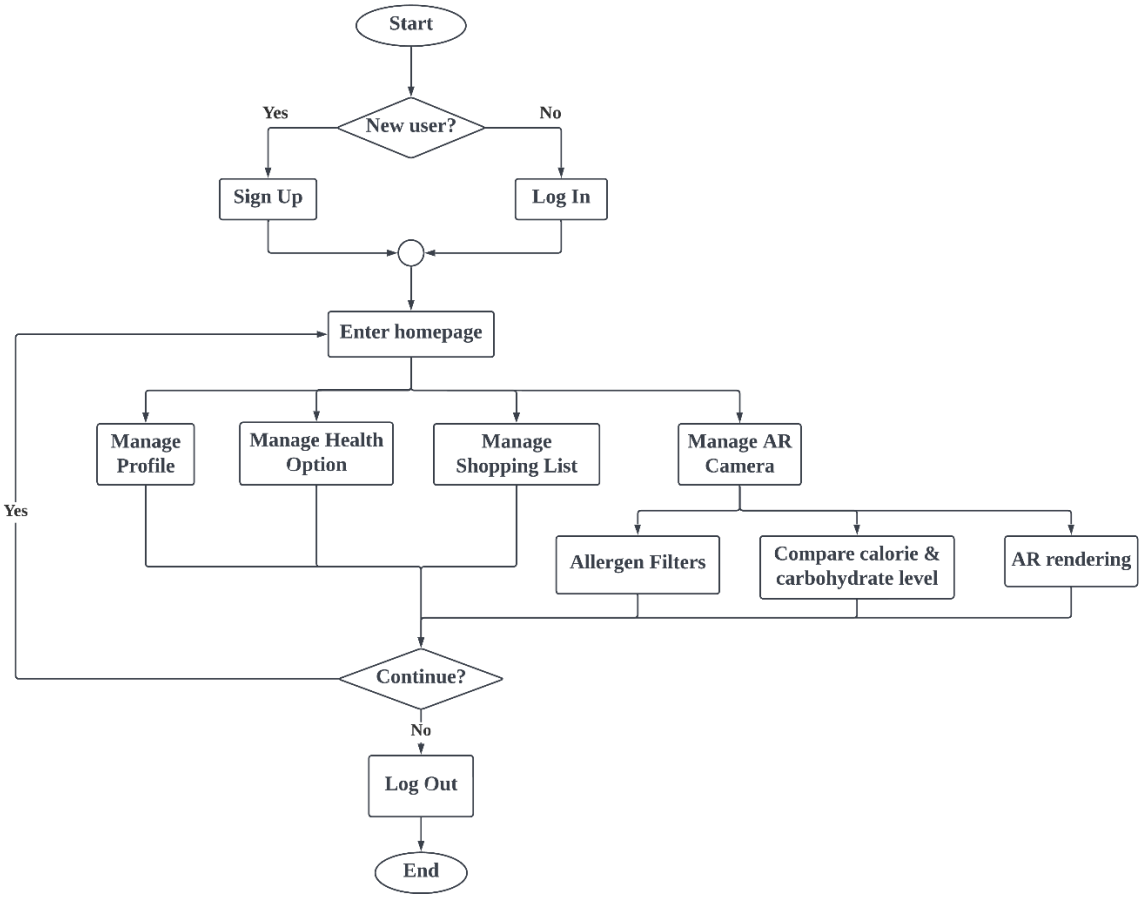


Figure 3.3: System flowchart of ARGrocery

The system flowchart shows the overview of the application's execution process. The application consists of several primary modules, including the account management module, health option module, AR camera module, and shopping list module.

Account Management Module

The primary function of this module is to process and manage user account and profile information. This component manages the user registration and login procedure. Users can also update and edit the data associated with their accounts and profiles such as usernames.

Health Option Module

Health Option Module has listed out the most common food allergens such as milk, peanut, and tree nut. By checking the option next to the food allergen, users can choose the food allergen to which they are allergic. Besides that, users can add new food allergic item that is not on the default food allergic item list.

AR Camera Module

This module provides users with a virtual view of product information through Augmented Reality and allows users to filter and compare multiple products. This feature allows users to pick their desired allergen and have a quick glance at the AR colour tags of each product on the device screen. Additionally, users can view and compare the calorie and carbohydrate intake of the products in one sight. Therefore, this module needs access to the users' device camera in order to view and use this feature.

Shopping List Module

This module enables users to write and add new items to a shopping list. The products from the shopping list will be presented in the AR Camera scene which can act as a reminder for users during grocery shopping.

3.5 Use Case Diagram

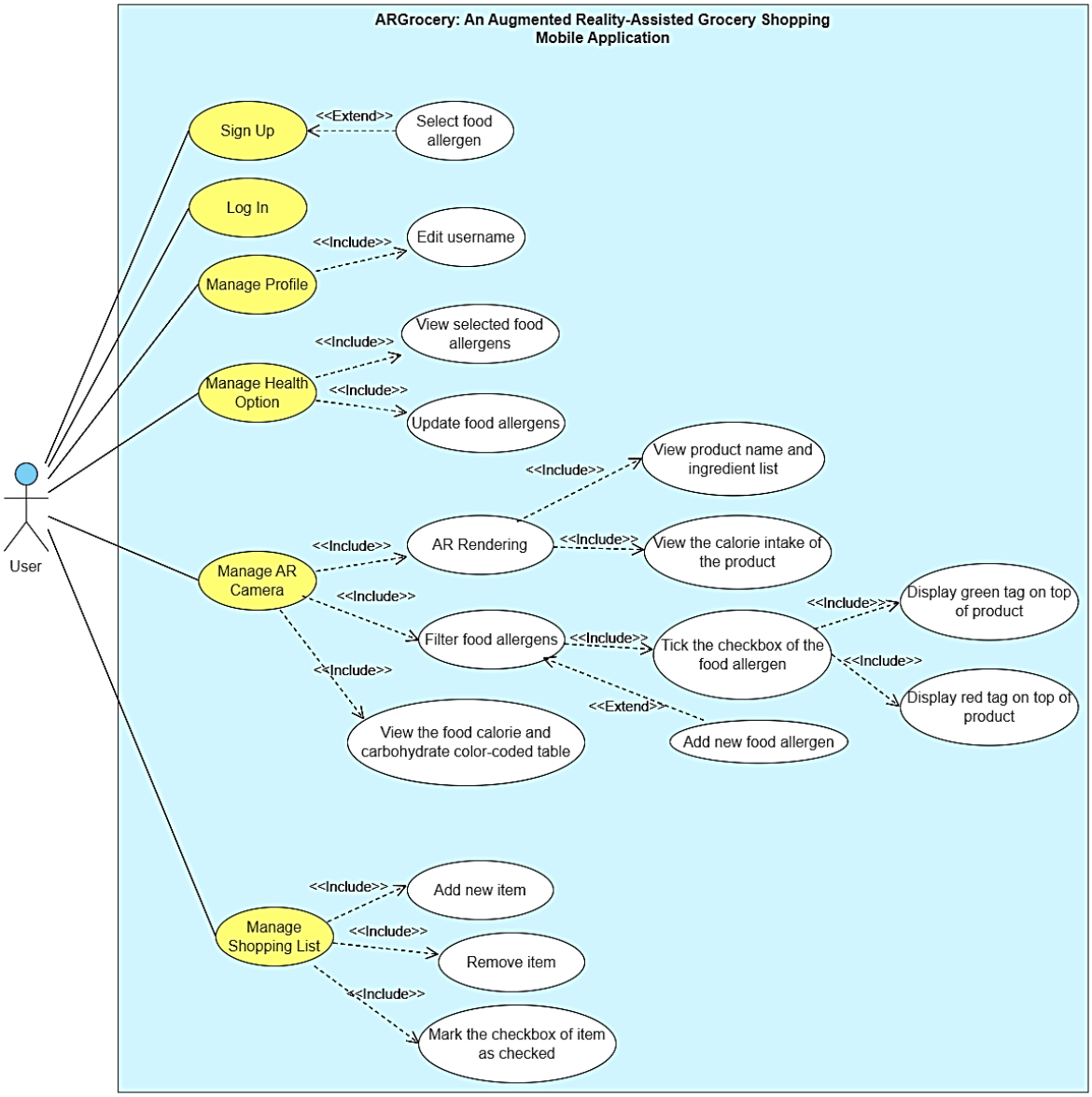


Figure 3.4: Use Case Diagram of ARGrocery

3.6 Use Case Description

Table 3.4: Use case description of Register Account

Use Case Name	Register Account		
Use Case ID	1	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user registers an account for the application.		
Trigger	The user wants to create a new account and hence selects the "Sign Up" button.		
Normal Flow of Events	1. The user selects the "Don't have account? Sign Up" button. 2. The user enters a username, email address, and password. 3. The user selects the food-allergic item from a given list that contains common food-allergic items. 4. The user presses the "Sign Up" button. 5. The system validates the username, email address and password. 6. The system saves the user's details. 7. The system redirects the user to the home page.		
Sub Flows	Not applicable.		
Alternate / Exceptional Flows	5a-1. The system displays the message "Email Already In Use" if the given email address is registered. 5a-2. The system displays the message "Invalid Email" if the given email address is badly formatted. 5a-3. The system displays the message "Invalid Password" if the given password is less than 6 characters.		

Table 3.5: Use case description of Login Account

Use Case Name	Login Account		
Use Case ID	2	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user logs in to his/her account in the application.		
Trigger	The user launches the application.		
Normal Flow of Events	1. The user enters the email address and password. 2. The user presses the "Login" button. 3. The system validates the email address and password. 4. The system redirects the user to the home page.		
Sub Flows	Not applicable.		
Alternate / Exceptional Flows	3a-1. The system displays the message "Invalid Email" if the given email address is badly formatted. 3a-2. The system displays the message "Wrong Password" if the given password does not match the password that is stored in Firebase Authentication. 3a-3. The system displays the message "Invalid Password" if the given password is less than 6 characters.		

Table 3.6: Use case description of Manage Health Option

Use Case Name	Manage Health Option		
Use Case ID	3	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user manages his/her food-allergic items.		
Trigger	The user selects the "Health Option" button on the home page.		
Normal Flow of Events	1. The user selects the "Health Option" button. 2. The system displays the list of common food allergens. and the status of the items which are selected or unselected during account registration.		

	3. The user selects the food allergen. 4. The user presses the “Update Now” button. 5. The system saves the updated food allergens.
Sub Flows	S-1. The user goes back to the home page.
Alternate / Exceptional Flows	-

Table 3.7: Use case description of AR Rendering

Use Case Name	AR Rendering		
Use Case ID	4	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user can view the product details when the product packaging is displayed to the camera.		
Trigger	The user selects the “AR Camera” button on the home page.		
Normal Flow of Events	1. The user selects the “AR Camera” button. 2. The user displays the camera the product packaging's front. 3. The system displays the product brand, name, and ingredients on the screen.		
Sub Flows	S-1. The user goes back to the home page. S-2. The user presses the “Allergic Filters” button. S-3. The user presses the “Calorie & Carbohydrate Intake” button. S-4. The user presses the “Got It!” or “Skip” button to view the shopping list items.		
Alternate / Exceptional Flows	3a. The system does not display any product information on the screen if the user shows a product that does not exist in the database.		

Table 3.8: Use case description of Manage Profile

Use Case Name	Manage Profile		
Use Case ID	5	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user can view his/her profile details and edit username.		
Trigger	The user selects the "Profile" button on the home page.		
Normal Flow of Events	1. The user selects the "Profile" button. 2. The system displays the username, email address, total count of selected food allergens, and the total number of items in the shopping list on the screen. 3. If the user selects the "Edit Profile" button S-1: Edit Profile sub-flow is performed.		
Sub Flows	S-1. The user selects the "Edit Profile" button 1. The user enters a new username. 2. The user selects the "Update" button to update the username. 3. The system saves the username into the database. S-2. The user goes back to the home page.		
Alternate / Exceptional Flows	S-1, 2a. The system displays an alert message if the user enters an empty username.		

Table 3.9: Use case description of Filter Food Allergens

Use Case Name	Filter Food Allergens		
Use Case ID	6	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user can filter ingredients by ticking the food allergens' checkboxes.		
Trigger	The user presses the "Allergic Filters" button on the "AR Camera" page.		

Normal Flow of Events	1. The user ticks the checkbox of the food allergens. 2. The user displays the camera the product packaging's front. 3. The system displays an AR colour plane on top of each detected product. 4. If the user selects the "Add New Allergen" button S-1: Add new allergen sub-flow is performed.
Sub Flows	S-1. The user selects the "Add New Allergen" button 1. The user enters a new food allergen. 2. The user selects the "Add" button to add the new food allergen. 3. The system saves the new food allergen into the database. S-2. The system displays a green colour plane with a tick symbol on top of the product if the product does not contain the selected food allergens. S-3. The system displays a red colour plane with a cross symbol on top of the product if the product contains the selected food allergens.
Alternate / Exceptional Flows	S-1, 2a. The user does not select food allergens in "Health Option" page.

Table 3.10: Use case description of View the food calorie and carbohydrate colour-coded table

Use Case Name	View the food calorie and carbohydrate colour-coded table		
Use Case ID	7	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user can compare multiple products by calorie and carbohydrate intake through a real-time generated colour-coded table.		
Trigger	The user presses the "Calorie & Carbohydrate Intake" button and the "VIEW MORE" button on the "AR Camera" page.		
Normal Flow of Events	1. The user displays the camera the product packaging's front.		

	2. The system displays the number of calories per serving and a calorie bar on each product. 3. If the user presses the "VIEW MORE" button S-1: View More sub-flow is performed.
Sub Flows	S-1. The user selects the "VIEW MORE" button 1. The system displays a colour-coded table that contains the product name, calorie and carbohydrate intake.
Alternate / Exceptional Flows	2a. The system does not display any product information on the screen if the user shows a product that does not exist in the database.

Table 3.11: Use case description of Manage Shopping List

Use Case Name	Manage Shopping List		
Use Case ID	8	**Importance Level**	High
Primary Actor	User	**Use Case Type**	Detail, Essential
Brief Description	This use case describes how the user can view his/her shopping list and edit the shopping list by adding or removing items.		
Trigger	The user selects the "Shopping List" button on the home page.		
Normal Flow of Events	1. The user selects the "Shopping List" button. 2. The system displays the items in the shopping list on the screen. 3. If the user selects the "Click here to add new item" button, S-1: Add Item sub-flow is performed. 4. If the user selects the "Delete" button, S-1: Delete Item sub-flow is performed.		
Sub Flows	S-1. The user selects the "Add Item" button 1. The user enters a new item. 2. The user selects the "Add" button to add the item to the shopping list. 3. The system saves the item into the database. S-2. The user selects the "Delete" button 1. The system deletes the selected item from the database.		

	2. The system displays the updated shopping list on the screen.
Alternate / Exceptional Flows	-

3.7 Activity Diagram

Login and Sign Up

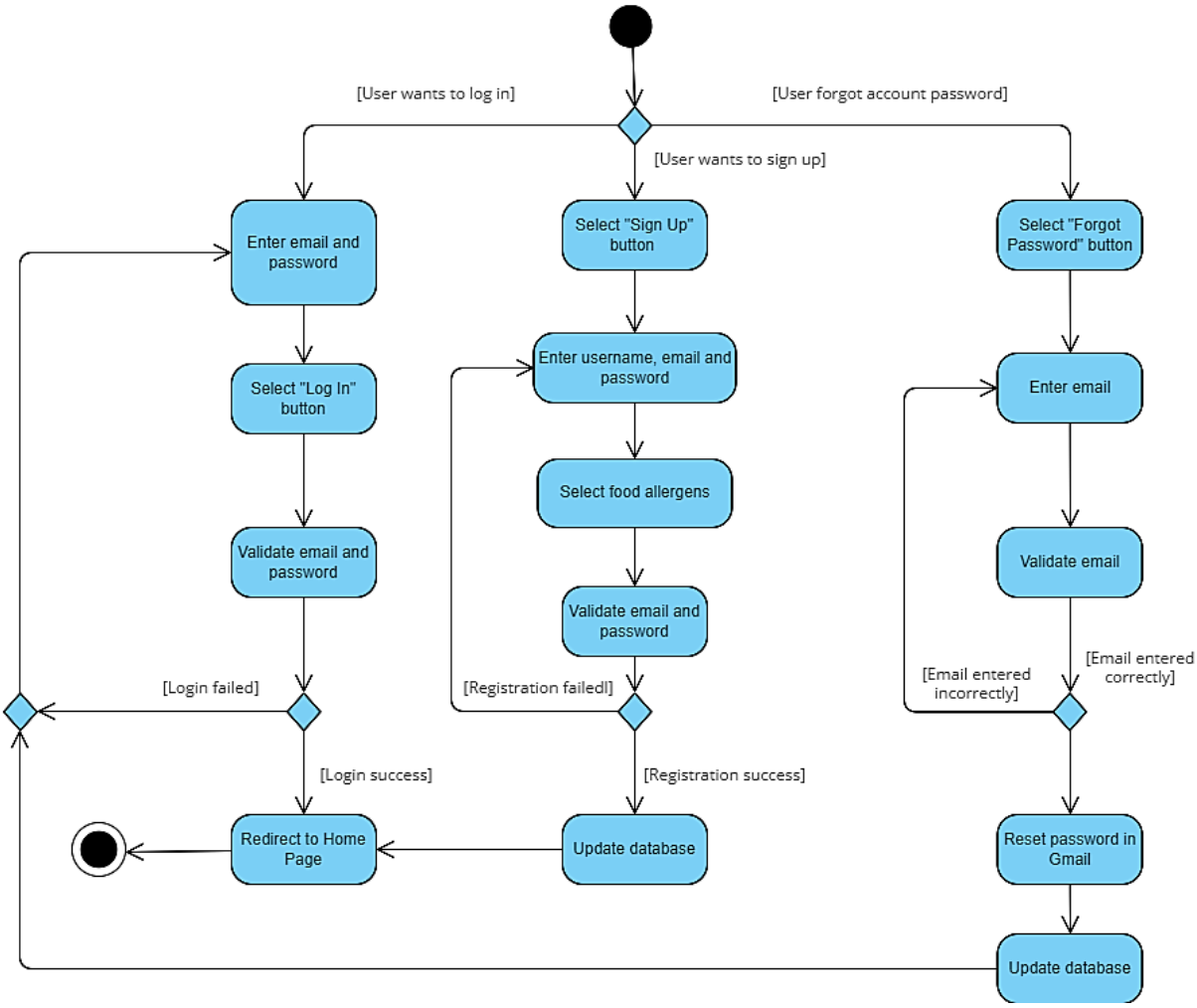


Figure 3.5: Activity diagram of Login and Sign Up

The activity diagram for login and sign-up demonstrates how users and admins log in and register with the system. For account registration, users are required to enter a username, an email address, and a password to create a new account. Additionally, users can select their food allergens by checking the checkbox of each food allergen during sign-up. However, this

action is optional for account registration. Users can still select or update their food allergens by selecting the “Health Option” button on the home page.

For the login function, a registered user can input his or her email and password to sign into the account. The user will be taken to the home page if the email and password are valid. If not, a notice with an error will appear. Furthermore, users could reset their password in the link given to their registered email if they forgot their password.

Manage Profile

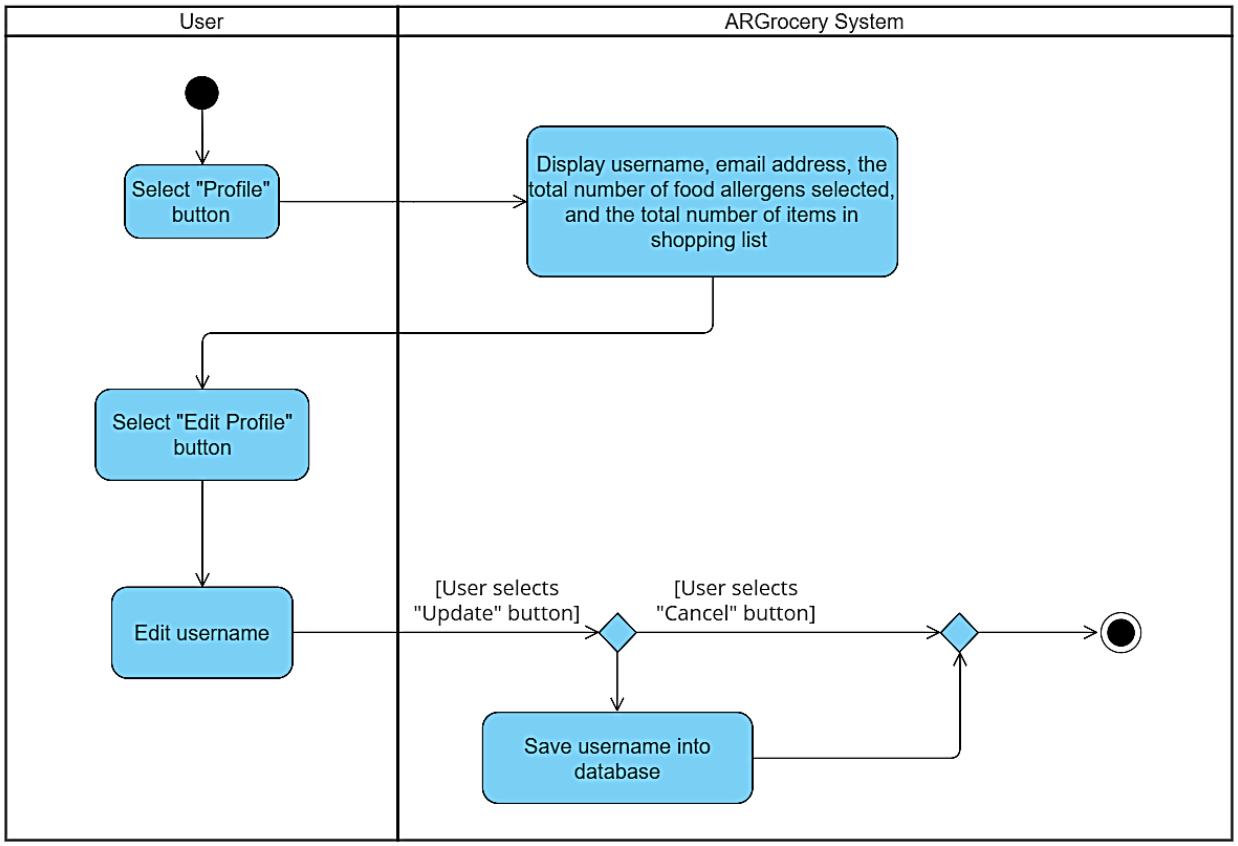


Figure 3.6: Activity diagram of Manage Profile

The application allows users to view and manage their profiles. When the user selects “Profile” on the home page, the application will redirect the user to the profile page. On the profile page, the user can view his or her username, email address, the total count of selected food allergens, and the total number of items in the shopping list. Users can manage their accounts by updating their usernames. If users select the “Update” button, then the updated username will be saved in Firebase.

Manage Health Option

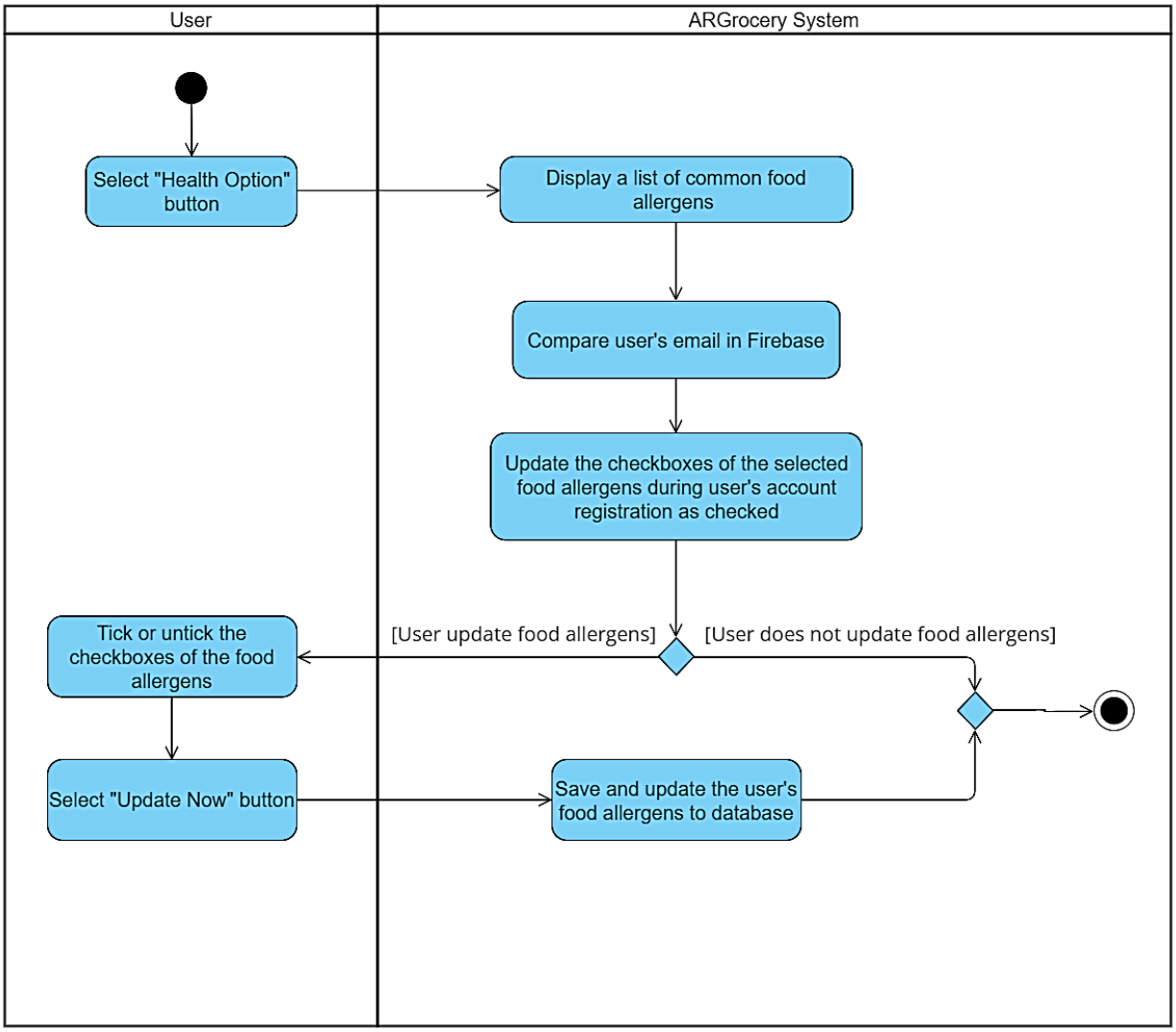


Figure 3.7: Activity diagram of Manage Health Option

Figure 3.7 shows the progress of how users manage their health options. With this function, users can choose and update their preferred allergy and save it in the database. Hence, the system displays the preferred allergy during AR rendering for users to perform ingredient filtering. When the user selects “Health Option” on the home page, the application displays a list of common food allergies and each food allergy comes with a checkbox for the user to tick and untick. Firstly, the system compares the current user’s email in Firebase and updates the checkboxes of the previously chosen food allergens as checked. Then, the user can tick or untick the checkboxes of the food allergens and selects the “Update Now” button to save and update the user’s latest preferred food allergens to the database.

AR Rendering

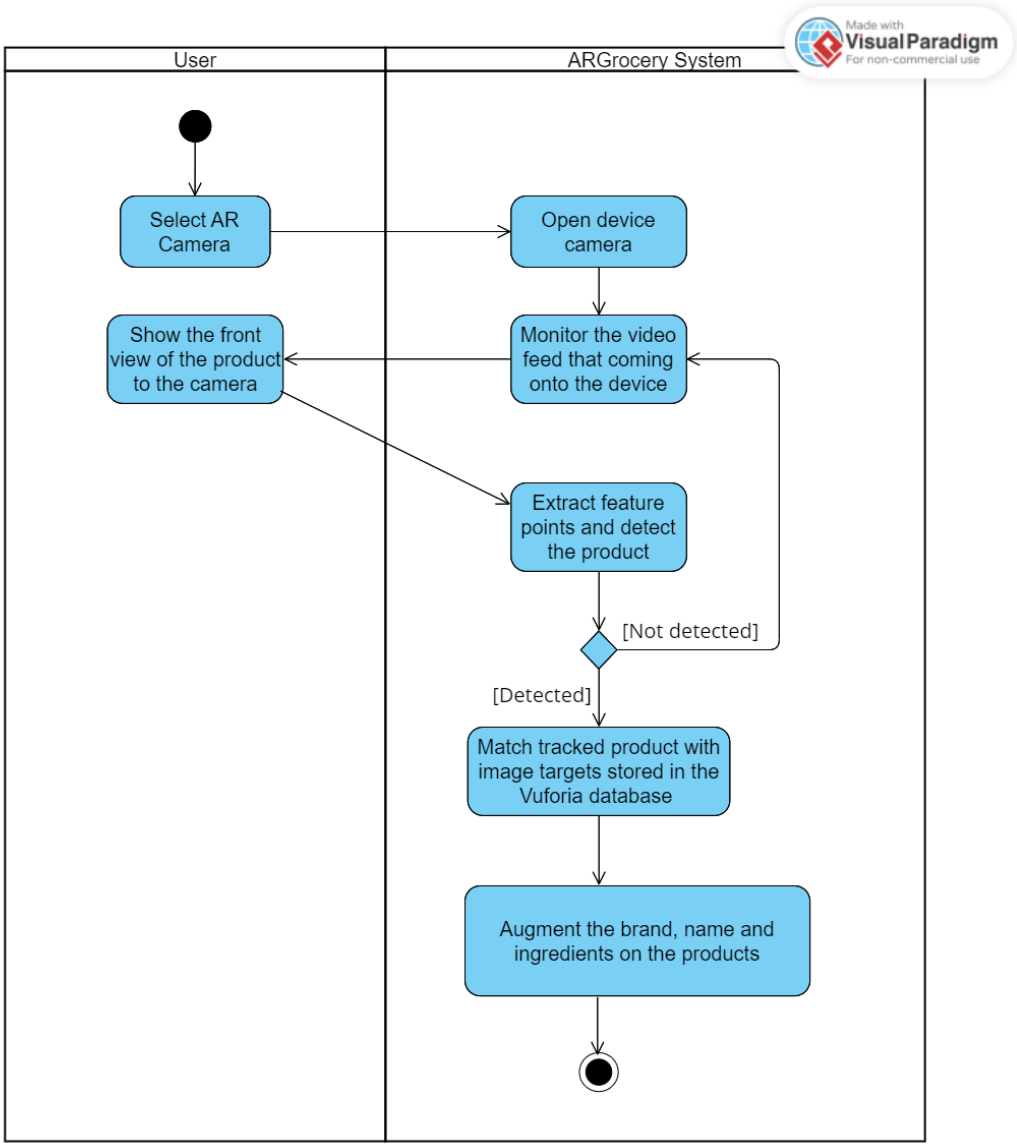


Figure 3.8: Activity diagram of AR Rendering

Figure 3.8 shows the process of overlaying the product information on the product during AR rendering. When the user selects “AR Camera” on the application home page, the system will request permission to turn on the device camera. Then, the system starts to monitor the video feed that comes onto the device and tracks the front view of the product. When the user shows the front view of the product to the camera, the system extracts the feature point and matches the tracked product with the image targets stored in the Vuforia database. Finally, the system fetches the tracked image prefab and augmented the product information such as brand, name, and ingredients on the product.

Allergic Filters

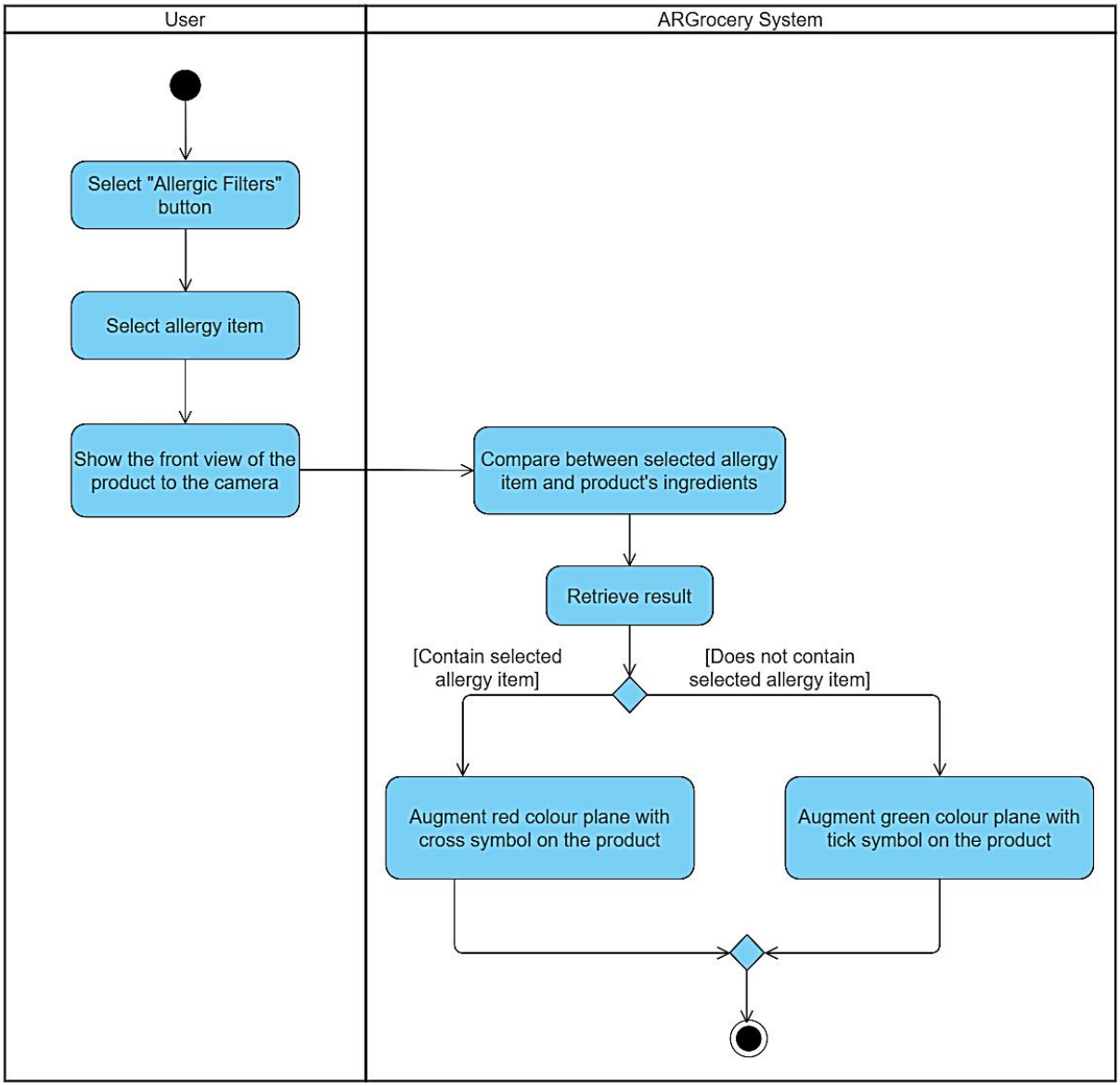


Figure 3.9: Activity diagram of Allergic Filters

The application will filter the products by selecting the food allergens after the user selects the “Allergic Filters” button. The food allergens according to the user’s health option will be displayed for the user to select. After that, an AR colour plane will be overlaid on the product according to two situations. A green colour plane with a tick symbol represents the product that does not contain the selected allergic item while a red colour plane with a cross symbol represents the product that contains the selected allergic item.

Calorie and Carbohydrate Intake

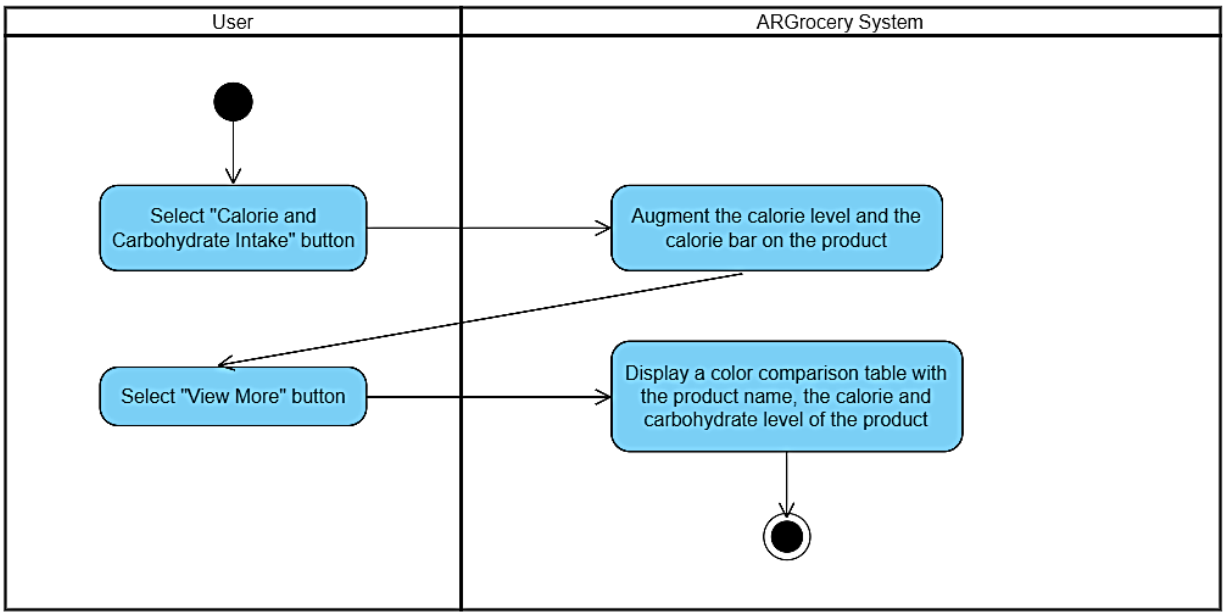


Figure 3.10: Activity diagram of Calorie and Carbohydrate Intake

The activity diagram depicts the flow of actions in the AR-assisted grocery shopping mobile application when a user wants to compare products by their calorie and carbohydrate intake. The first step is to select the “Calorie and Carbohydrate Intake” button, which indicates that the user is interested in comparing the nutritional information of the products. The second step involves augmenting the calorie level and the calorie bar on the product, which provides a visual representation of the product's nutritional value. After this, the user can select the “View More” button to access further details about the product. Finally, the application displays a colour comparison table with the product name, calorie and carbohydrate level of the product, which enables easy comparison of products based on their nutritional value.

Manage Shopping List

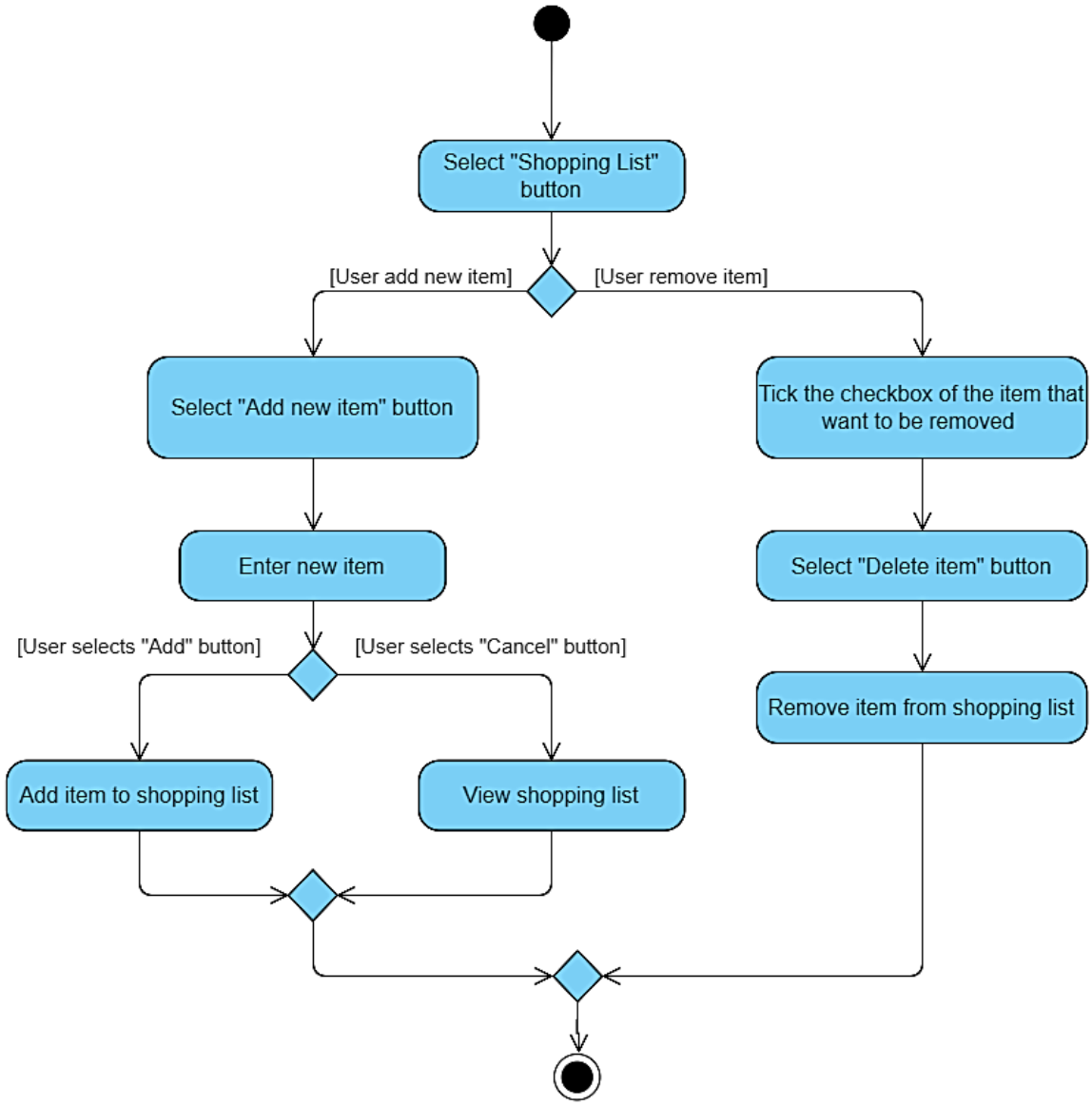


Figure 3.11: Activity diagram of Manage Shopping List

The activity diagram outlines the steps involved in using the “Shopping List” feature of the mobile application. The first step is to select the “Shopping List” button, which takes the user to the list of items. If the user wants to add a new item, they can select the “Add new item” button, which prompts them to enter the name of the item. Once the user enters the new item, the system adds it to the shopping list if the user selects the “Add” button. If the user wants to remove an item from the list, they can tick the checkbox next to the item they wish to remove, and then select the “Delete item” button. This removes the item from the shopping list.

Chapter 4: System Implementation

4.1 Software Setup

In this project, the entire game application is implemented in the Unity environment. The functionality, user interface design, and augmented reality components are all being developed and incorporated into the Unity environment. Besides, Visual Studio Code 2019 is also required to be installed and selected as the external script editor.

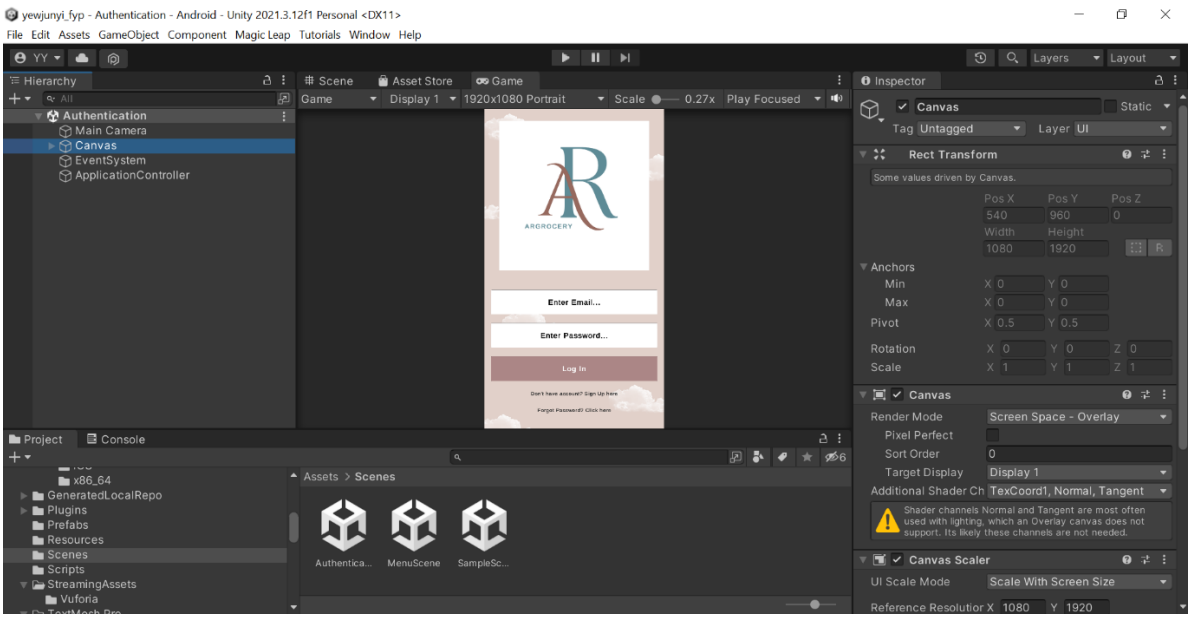


Figure 4.1: Unity environment

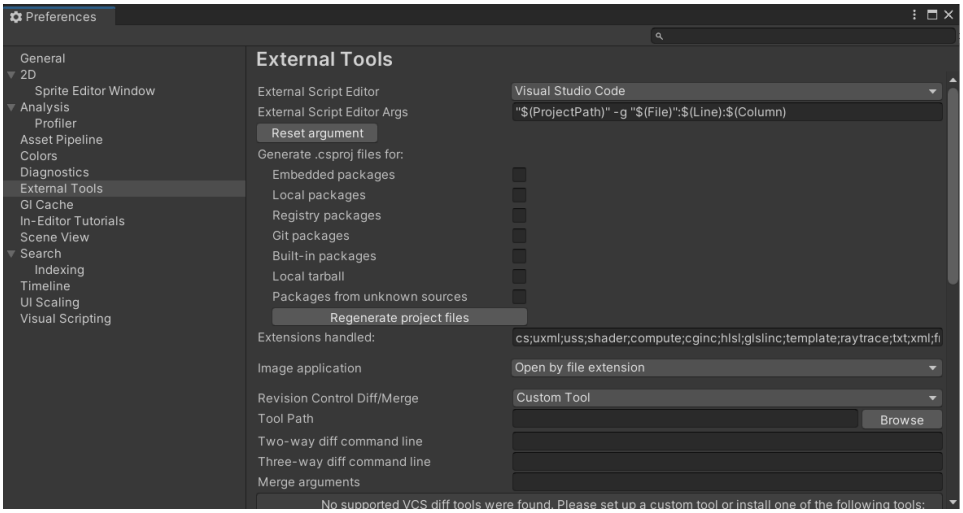


Figure 4.2: External Tools setting in Unity

4.1.1 Set up of Unity Environment

The JDK and Android SDK tools are installed with Unity as shown in Figure 4.3. In order for Unity to support Android platform development, the installation of Android Studio is also bundled with the Unity installation. The Unity version for this project is 2021.3.12f1.

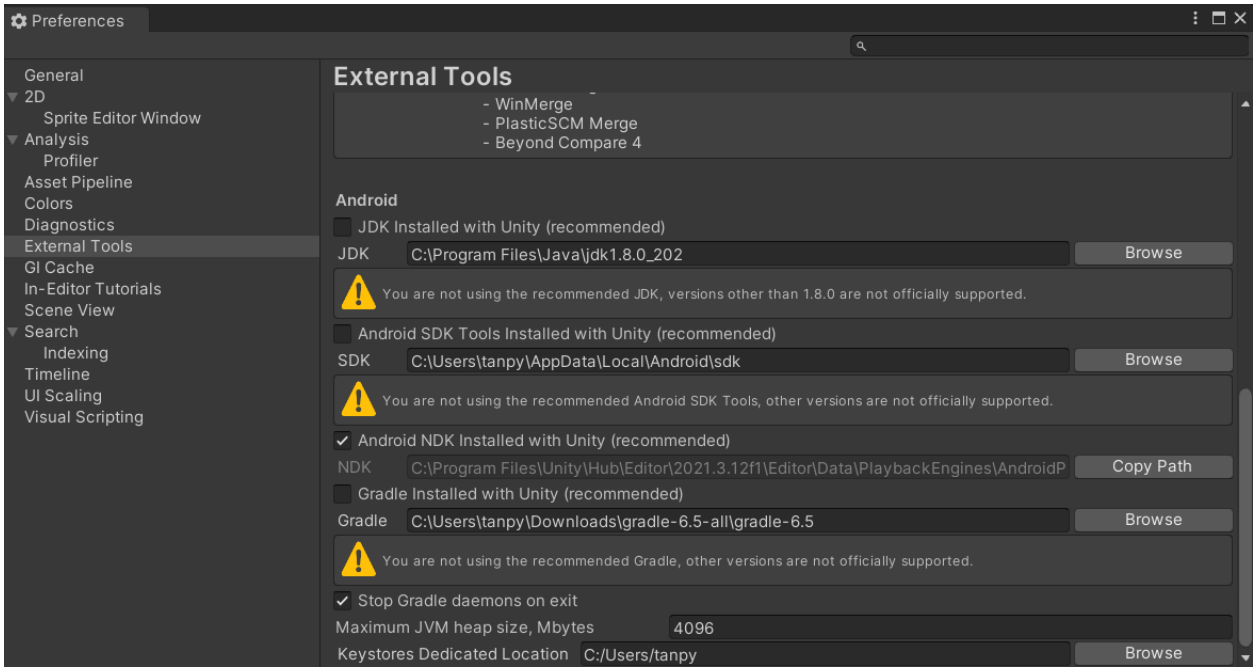


Figure 4.3: Android SDK and JDK Setup in Unity Preferences

4.1.2 Set up of Firebase

In Firebase, the Firebase Authentication and Cloud Firestore are used in this project. Firebase Authentication uses users' email addresses and passwords to verify their identity. It provides services to register a new user and manage users that use emails and passwords to log in to the application. Besides, Firebase Authentication also send emails for password resets. On the other hand, Cloud Firestore is set up to store and organize the data into sets of documents. The product's and user's details are kept as documents with fields and values mapped out. The documents are kept in collections. As shown in Figure 4.4, there are two collections named 'Products' and 'Users'. Each product or user is stored in a document with respective fields that kept the details. To plug Firebase into the Unity project, the Firebase configuration file, google-services.json and Firebase Unity SDK must be downloaded and imported into the Unity project.

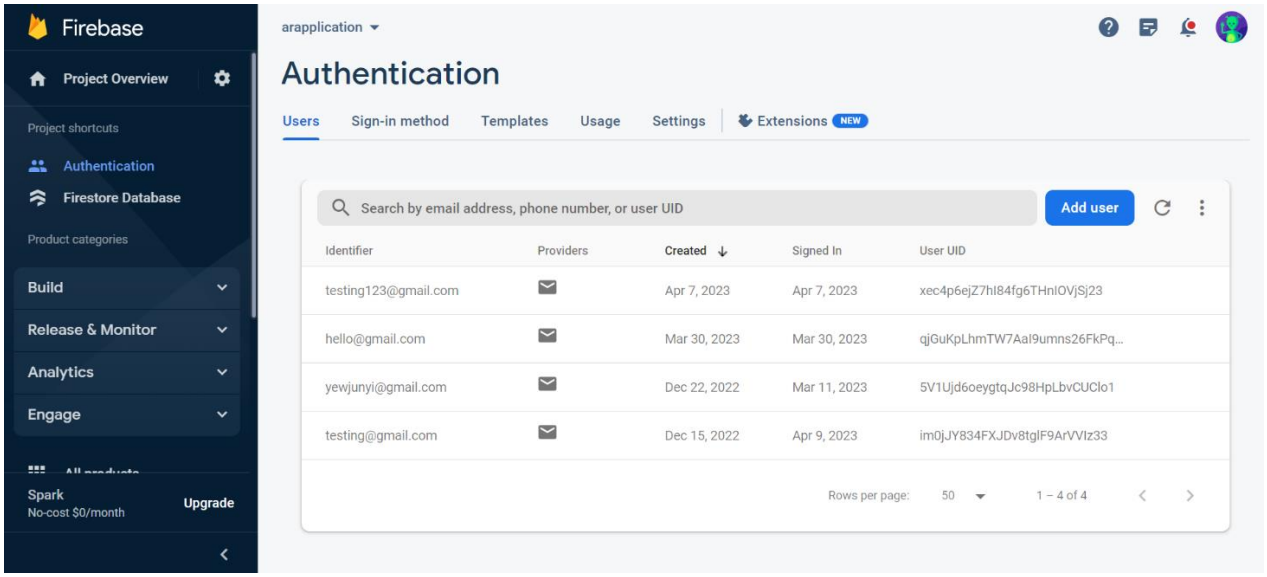


Figure 4.4: Firebase Authentication

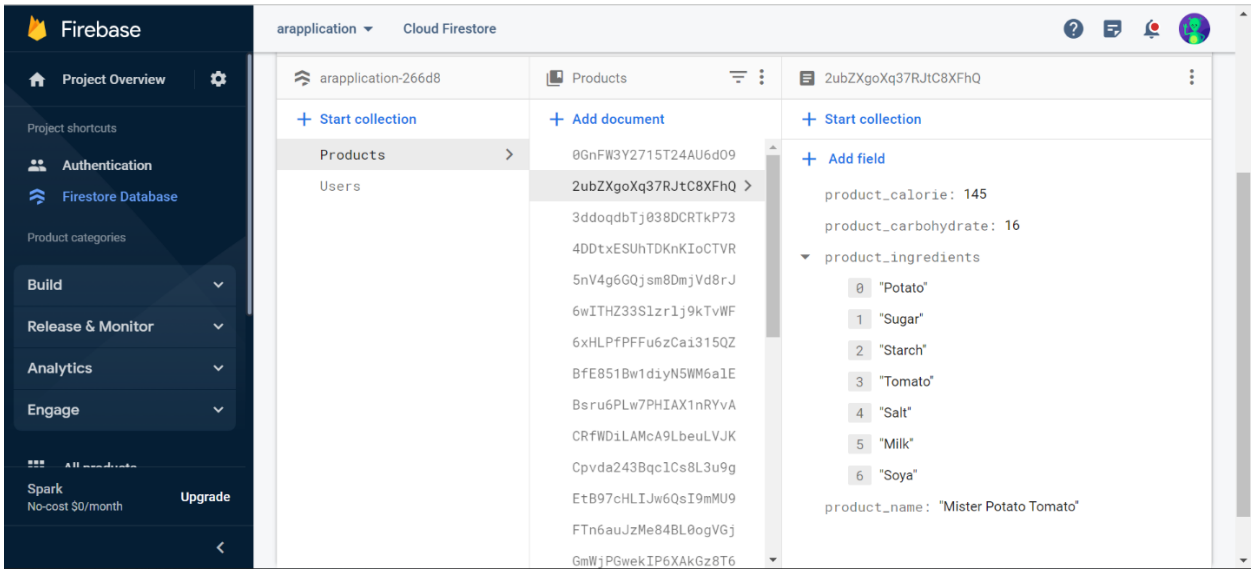


Figure 4.5: Cloud Firestore

4.1.3 Set up of Vuforia

Create Image Targets

Vuforia Developer Portal offers a web service for developers to create targets from 2D Images and store them in the database at Vuforia Target Manager. The images of the front view of product packaging are uploaded to the Vuforia database as image targets. After uploading all the images, the database may be downloaded with the. unitypackage extension and loaded into the Unity environment. Hence, the Vuforia Engine can detect and track the image and augments the AR content.

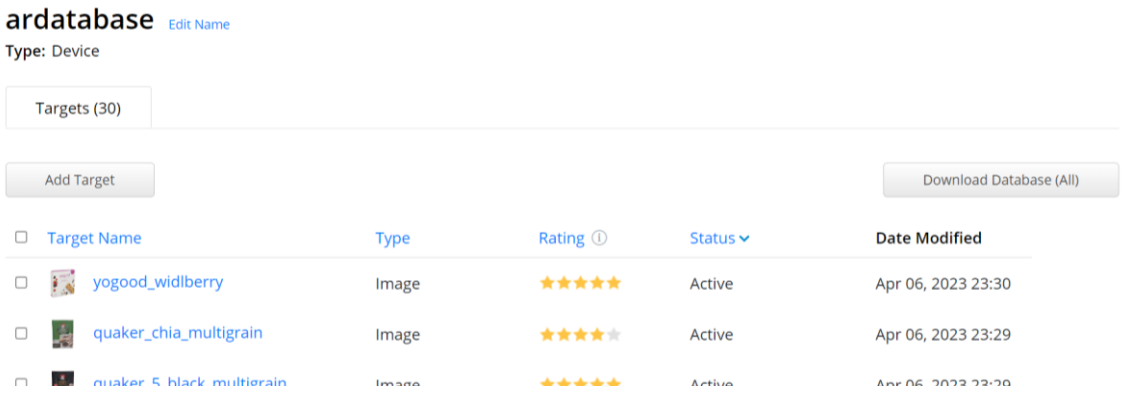


Figure 4.6: Vuforia Database that stores the image of product packaging

Vuforia device database uses a technique called feature detection and matching to recognize objects. The process begins by analyzing the object to identify unique features, such as edges, corners, and other distinct visual elements. These features are then converted into numerical values and stored in the device database as a reference pattern for the object. According to [8], image targets are detected based on the natural features that are extracted from the target images. Sharp details like triangle tips or high-contrast corners are typical examples of natural features in images. These features can be thought of as yellow crossings. For example, the figures below show the original product image and the analyzed product image target after tracking the natural features.

Figure 4.7: The image of Nestle KoKo Krunch product packaging

Figure 4.8: The features points detected by the Vuforia device database

When an Image Target is uploaded to a Vuforia database, it is automatically assigned a star rating based on how well it can be recognized and tracked by Vuforia's computer vision

algorithms. The star rating system ranges from one to five stars, with five stars indicating the highest level of tracking capability and one star denoting the lowest. The star rating is based on a number of factors, including the quality of the image, the contrast and brightness of the target, and the complexity of its features. A higher star rating generally means that an Image Target is more reliable and consistent in its tracking performance, making it more suitable for use in AR applications. The figure below shows an example of a good target where the image contains a higher number of features.

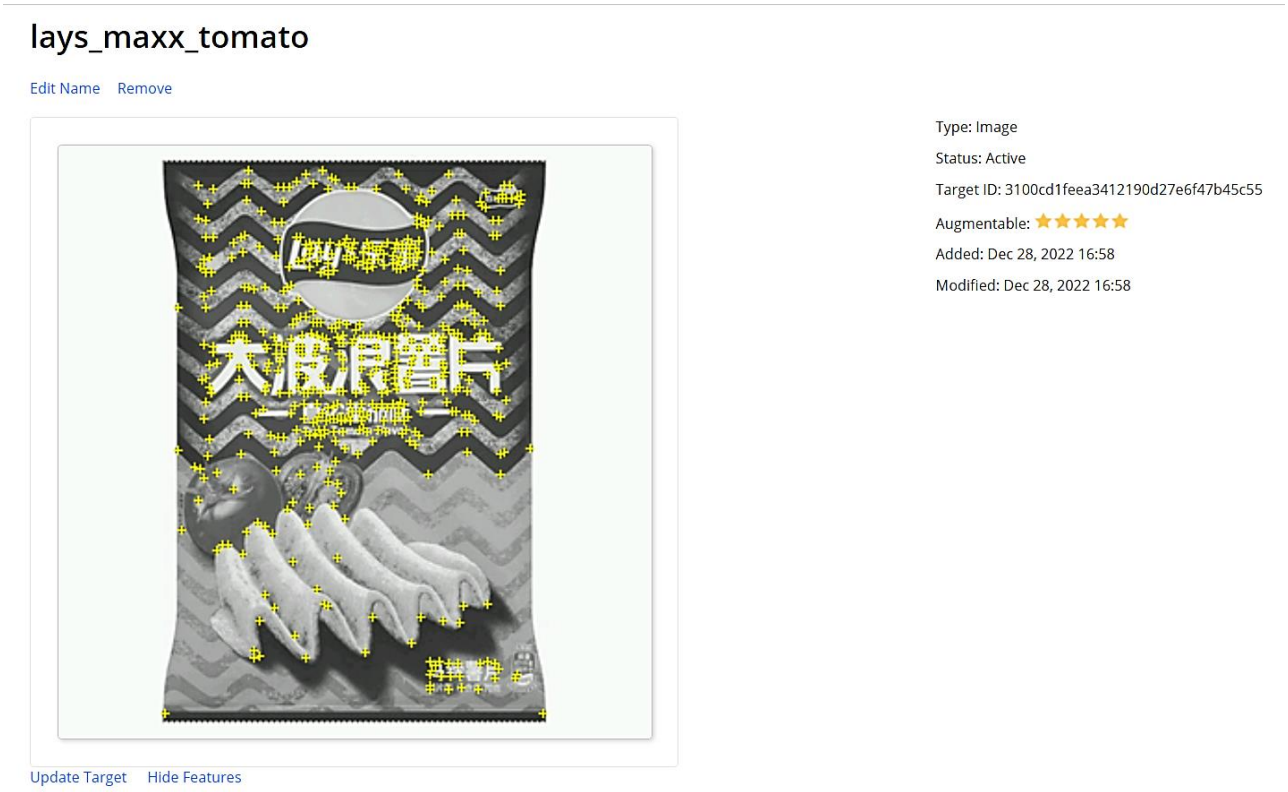


Figure 4.9: The feature points of a product named Lay's Maxx Pure Tomato

On the other hand, Figure 4.9 is a poor target since it has a less sharp edge and a cylindrical shape, making it harder for Vuforia to identify. Furthermore, the quality of the image is poor. These factors might cause the application to detect the product for a longer period of time.

Figure 4.10: The feature points of a product named Lady's Choice Strawberry Jam

4.1.4 Setting up Vuforia with Unity

Figure 4.11 shows the integration of Vuforia into the Unity project. The Vuforia Engine SDK must be downloaded and imported into the Unity project. The license key created during registration must be copied and pasted into the Unity Vuforia Configuration panel in order for the Vuforia to be used in the Unity environment.

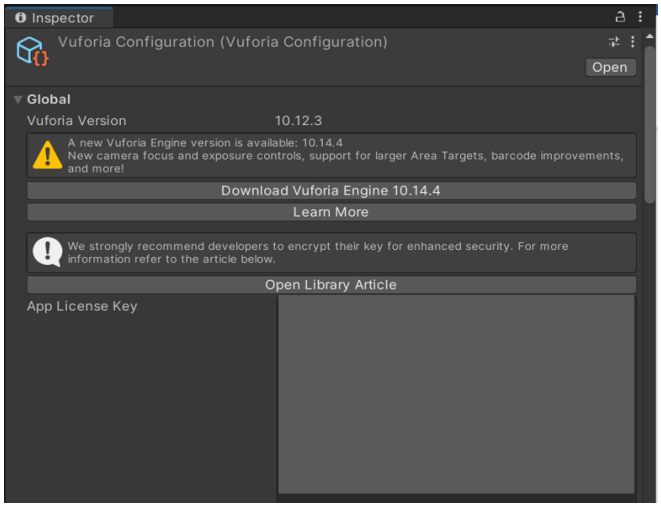


Figure 4.11: Setup Vuforia SDK in Unity

In order to use a Vuforia database in a Unity project, the corresponding .unitypackage file needs to be imported into the Unity environment. This will allow the Unity project to access the image targets and associated metadata defined in the database.

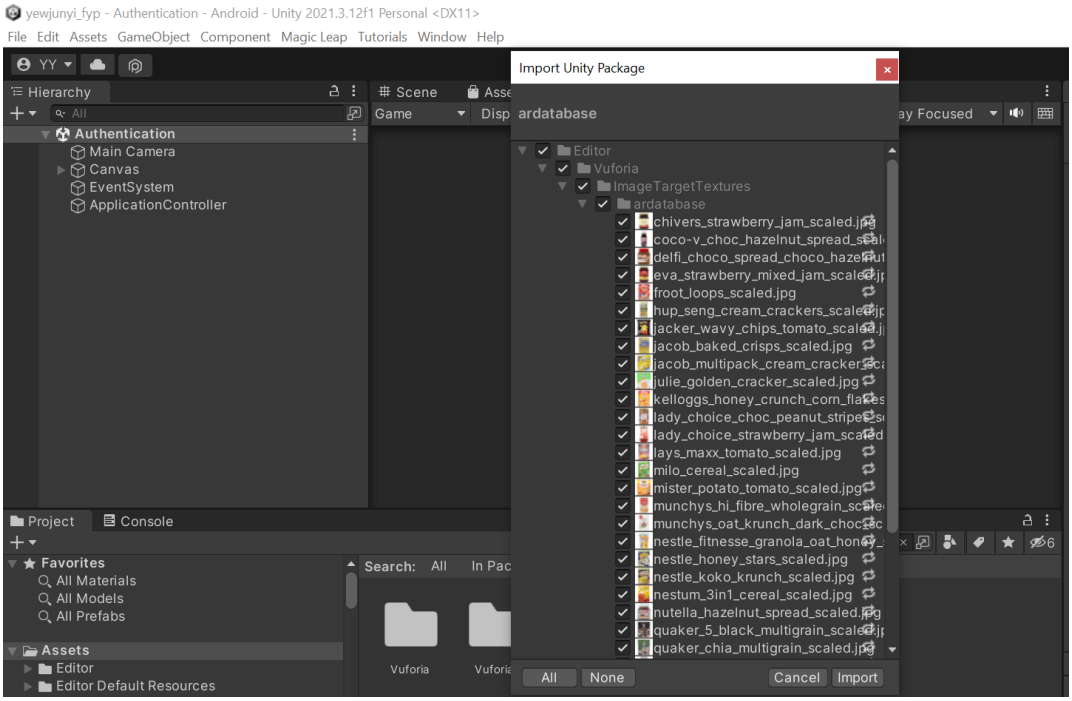


Figure 4.12: Import the Vuforia Database into Unity Editor

4.2 Development of AR Camera Scene

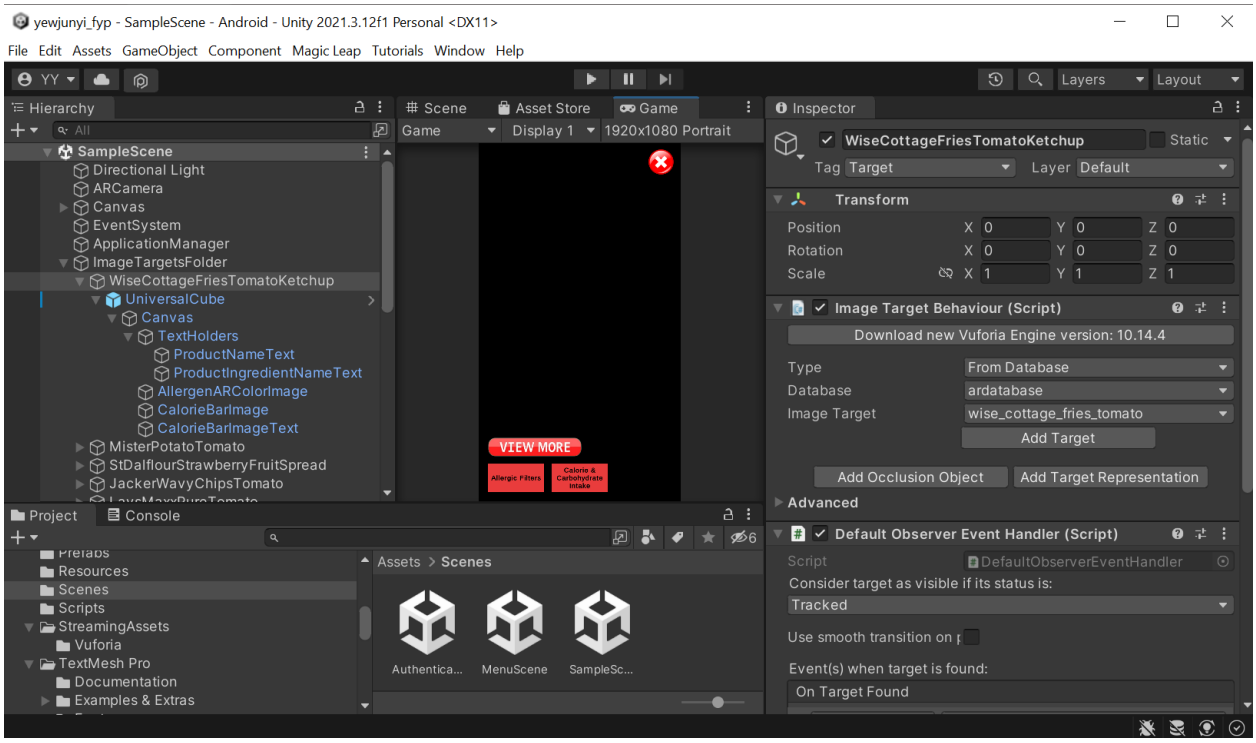


Figure 4.13: Development of AR Camera scene in Unity Editor

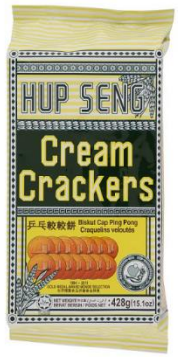
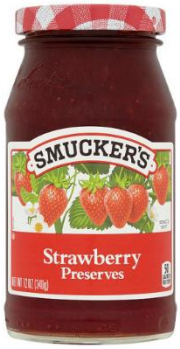
Figure 4.13 shows the Unity environment of the AR Camera scene. The fundamentals of the AR scene are set up by adding the AR Camera, Canvas, Application Manager, and Image Targets Folder. The Unity main camera is deleted and replaced by a Vuforia AR Camera to enable AR functionality. Next, the Canvas is the space for all the UI elements to be organized and rendered.

An Image Target Folder is created to store the AR templates and product image targets respectively. Each image target game object is given a name that corresponds to the product name without the whitespaces and is assigned to the product image target respectively from the database. Additionally, the prefab named “Universal Cube” is added for each image target. The prefab act as the template for the application to display product information (ProductNameText, ProductIngredientNameText), AR colour tags (AllergenARColorImage), calorie and carbohydrate intake (CalorieBarImage, CalorieBarImageText). Hence, this prefab will be overlaid on top of the product image target as augmentation in the AR Camera scene. Using C# scripts, the elements in the prefab will be activated or deactivated in accordance with the functions respectively.

4.3 Sample Product

In this section, a variety of sample food products that have been utilized in the system will be presented. These products have been chosen to demonstrate the functionality of the application, specifically in terms of filtering food allergens and displaying calorie bars and generating a colour-coded comparison table based on the product's calorie and carbohydrate content. The selection of the food products has been based on their popularity and availability in the market. The aim of this section is to provide a visual representation of how the application functions in a real-world scenario, thus aiding in the understanding of the system's capabilities.

Table 3.12: Sample products that are used in ARGrocery

Product	Details	Shape
	Name: Hup Seng Ping Pong Cream Crackers Ingredients: Wheat, flour, sugar, palm oil, corn, starch, salt, milk, yeast Calorie per serving: 154 kcal Carbohydrate: 22g	Rectangle
	Name: Smucker's Strawberry Jam Ingredients: Strawberry, corn syrup, sugar, pectin, citric acid Calorie per serving: 50 kcal Carbohydrate: 13g	Irregular
	Name: Delfi Choco Spread Choco Hazelnut Ingredients: Sugar, palm oil, milk, cocoa, hazelnut, soya Calorie per serving: 114 kcal Carbohydrate: 11g	Irregular

	Name: Yogood Wildberry Yoghurt Bar Ingredients: Oat, yoghurt, sugar, soya, wheat, gluten, milk, flour, salt, barley, apple, blueberry, pectin, raspberry Calorie per serving: 45 kcal Carbohydrate: 10g	Square
	Name: Nutella Hazelnut Spread Ingredients: Sugar, palm oil, hazelnut, milk, cocoa, soya, vanillin Calorie per serving: 80 kcal Carbohydrate: 9g	Irregular

4.4 System Operation

Figure 4.14 shows the splash screen of ARGrocery when users launch the application. the splash screen displays the application's logo, which also indicates that the app is still loading. The login interface is the first scene of this application. Users must enter their registered email and password to navigate the application's menu scene. Additionally, users may click the ‘Sign Up’ button to create a new account or the ‘Forgot Password?’ button to reset their password.

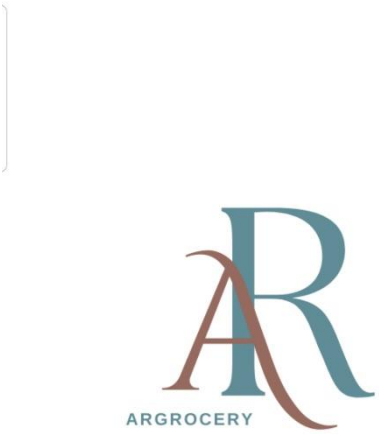


Figure 4.14: Splash screen of ARGrocery

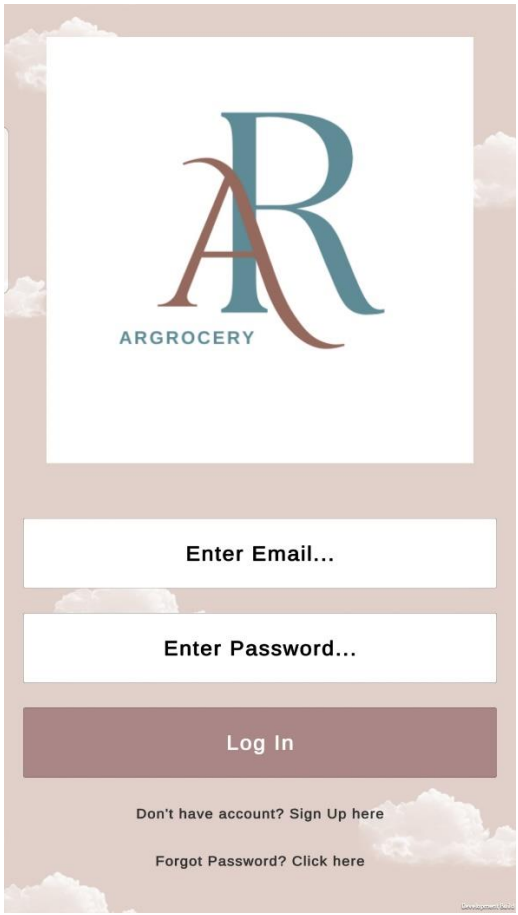
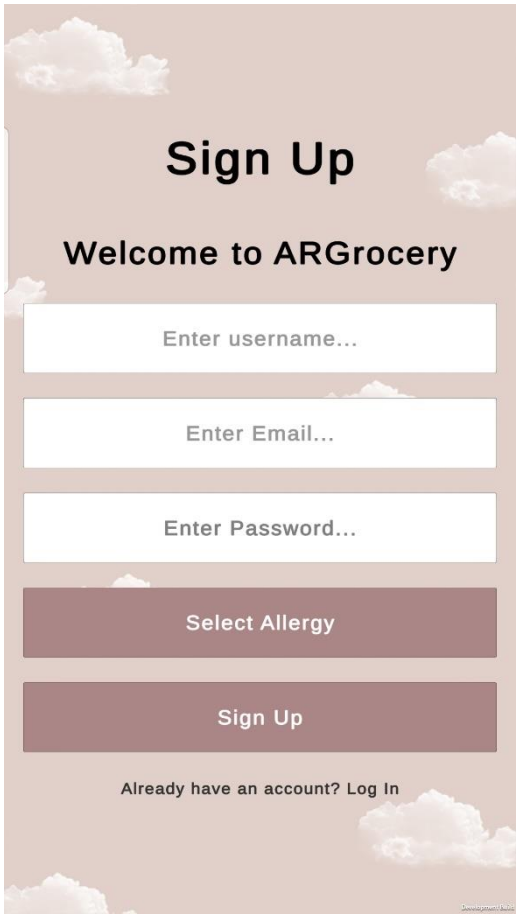


Figure 4.15: Login interface of ARGrocery

To create a new account, the user needs to enter a username, email address and password. The system will then verify the email and password to ensure they are both unique and have not been stored in the database. After that, the user may select his/her food allergens by ticking the checkboxes of the food allergens. Users can choose not to select a food allergy when creating an account. After logging in, users still can select and change their food allergens.

When the user forgets the password, the user can reset it by choosing the option and entering their email address. Users can reset their password by entering a new 6-digit password when the system sends a link to their registered email address.



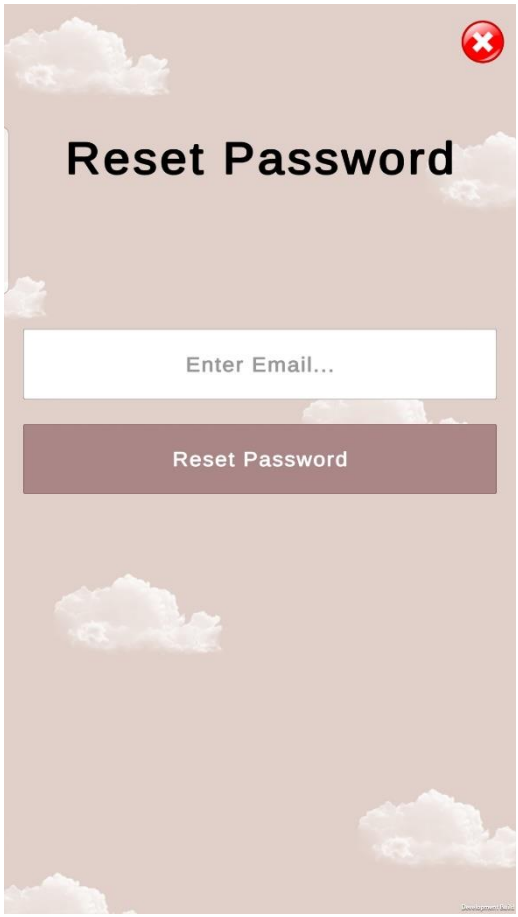


Figure 4.16: Sign Up interface of ARGrocery

Figure 4.17: Reset password interface of ARGrocery

There are six options on the menu interface, which are “Profile”, “Health Option”, “AR Camera”, “Shopping List”, “Quit” and “Sign Out”. Depending on the user's selection in the menu, the user will be directed to each page individually. The user can select the “Quit” button to quit the application or select the “Sign Out” button if the user wishes to log out of the application. The system will return the user to the login page when they log out.

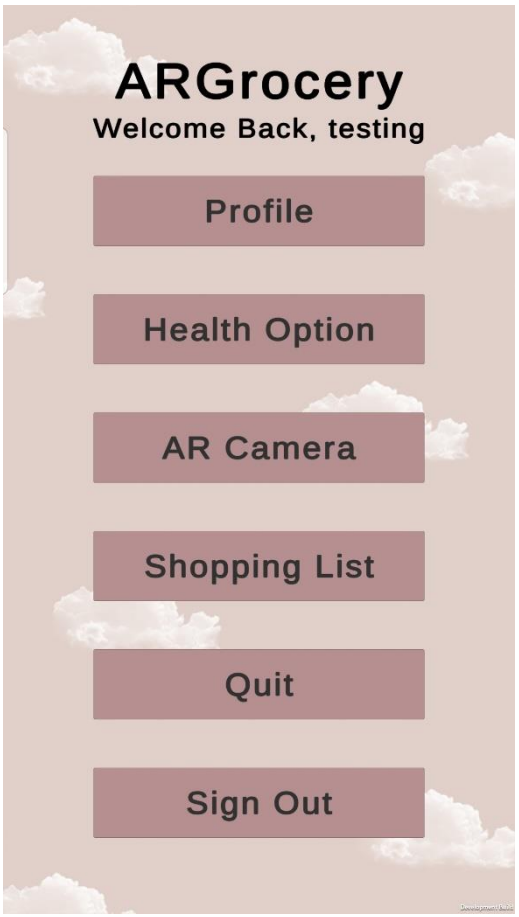
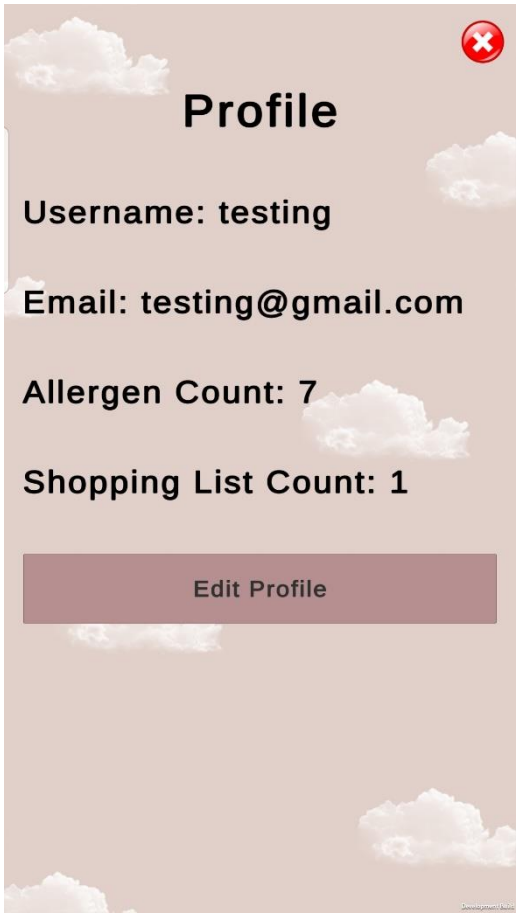


Figure 4.18: Menu interface of ARGrocery

Figure 4.19 shows the user’s profile interface. Users can view the username, email address, total food allergen count and total count of the shopping list items. Users can edit the profile by selecting the “Edit Profile” button, and the Edit Profile panel will pop up for users to edit the username. Users can choose whether to update the username and save it to the database using the “Update” and “Cancel” buttons in the panel.



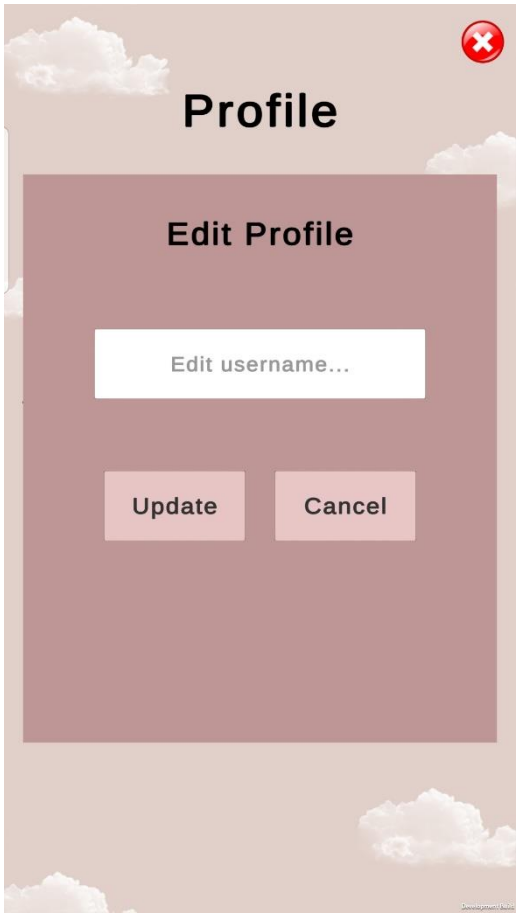


Figure 4.19: Profile interface of ARGrocery

Figure 4.20: Edit profile interface of ARGrocery

Figure 4.21 shows the health option interface if the user selects “Health Option” from the menu. Users can choose from a list of common food allergens by ticking the checkbox beside each food allergen. On top of that, the food allergens that are selected by users during account registration will display as ticked. Users can change the food allergens and select the “Update Now” button to save the details into the database. A message “Update Completed!” will be displayed on the interface if the details are saved into the database. The selected food allergens will still display as ticked when the user logs in to the application next time.

Figure 4.21: Health option interface of ARGrocery

Figure 4.22: Health option interface of ARGrocery showing “Update Complete!”

Figure 4.23 shows the interface if the user selects “AR Camera” from the menu where the device camera is needed. When the user’s device camera is turned on, there are three buttons which are the “Allergic Filters” button, the “Calorie & Carbohydrate Intake” button and a red cross button representing exit and back to the menu. The default scene of the AR Camera is to detect and track the product and display the product information on top of the product.

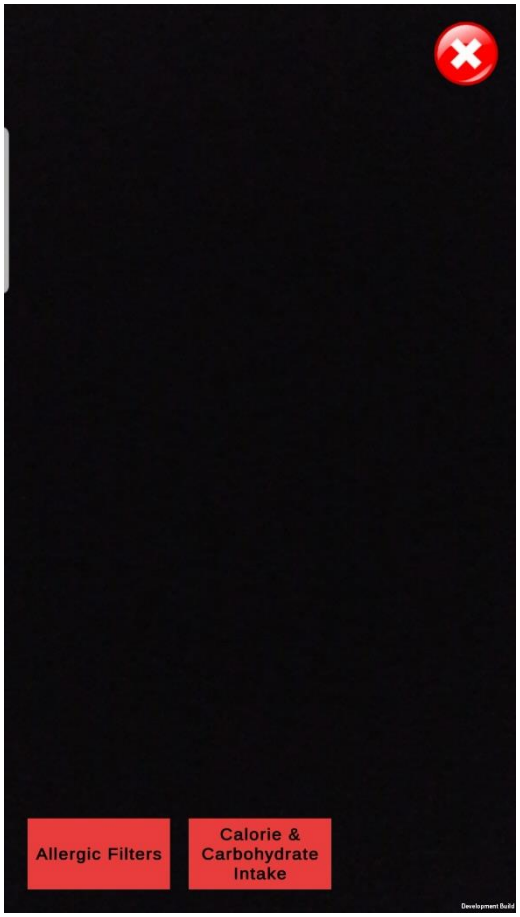
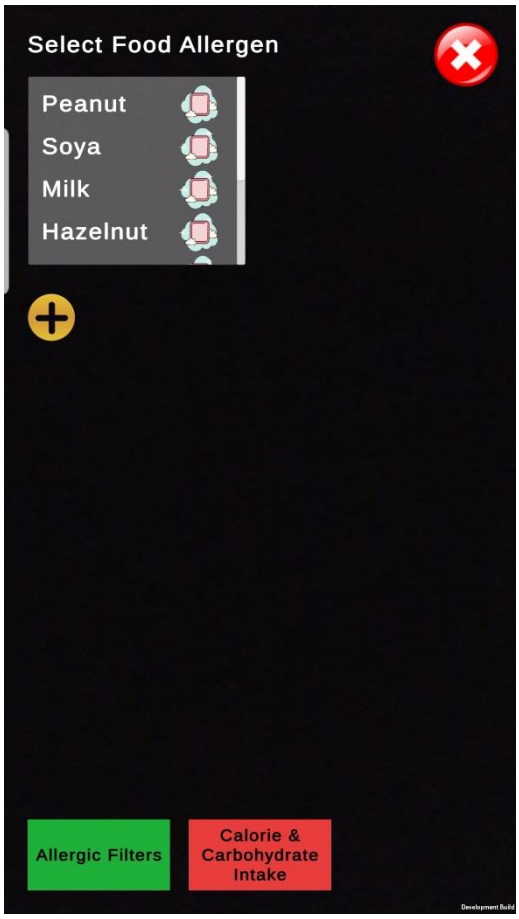


Figure 4.23: AR Camera interface of ARGrocery

If users tap the “Allergic Filters” button, the button will turn from red to green and the “Select Food Allergens” panel will pop up. The “Select Food Allergens” panel will show the food allergens that were chosen during account registration or the “Health Option” interface. Users can filter and compare products by ticking or unticking the checkboxes of the food allergens. Besides, there is an additional symbol button below the panel for users to add new allergens to the panel. A box will pop out for users to enter the allergen name and users can choose whether to add the new allergen and save it to the database using the “Add” and “Cancel” buttons in the panel. After the user clicks the “Add” button, the new item will be added in the “Select Food Allergens” panel in real-time. Last but not least, the user can tap the “Allergic Filters” again to close all the panels and the button will turn from green to red.



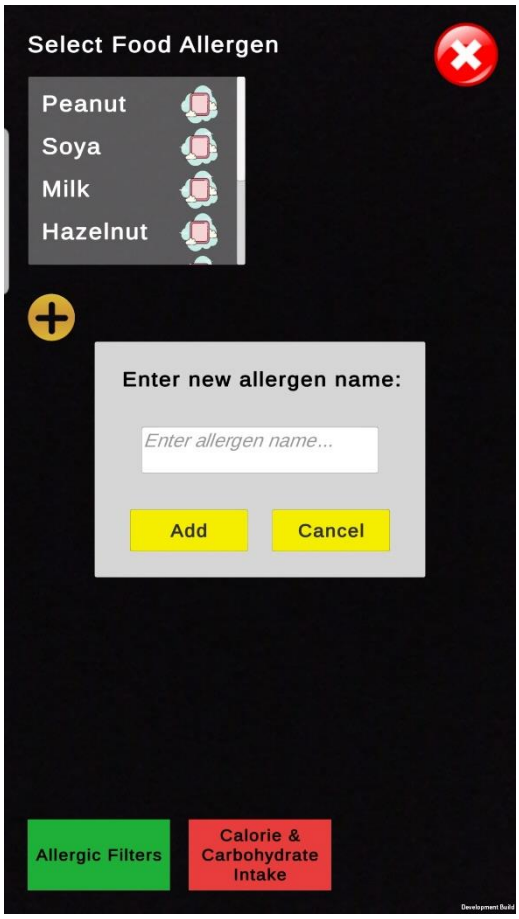
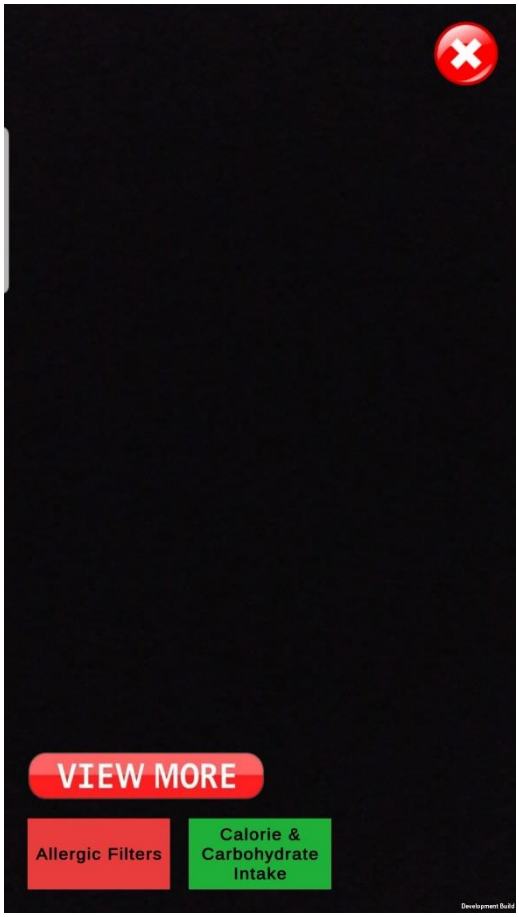


Figure 4.24: Select Food Allergen interface of ARGrocery

Figure 4.25: Enter new allergen name interface of ARGrocery

The “Calorie & Carbohydrate Intake” button allows users to view and compare the products by calorie and carbohydrate level per serving. Figure 4.26 shows the interface after the user selects the “Calorie & Carbohydrate Intake” button on the screen. Firstly, the “Calorie & Carbohydrate Intake” button will turn from red to green. At the same time, the “VIEW MORE” button appears, which is for the user to view the table that compares the calorie and carbohydrate levels of each product. The user can click this button to view the calorie and carbohydrate content as a table. The button will change from green to red when the user taps it once more to close the panels.



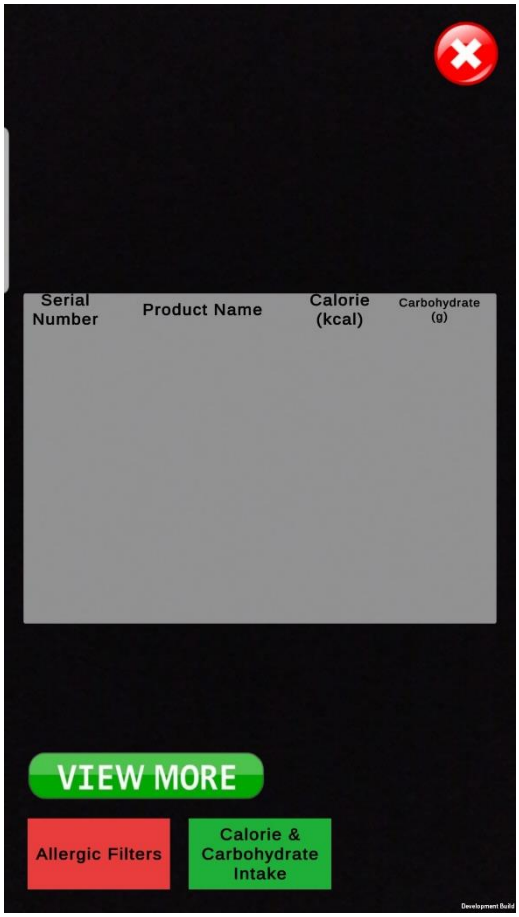


Figure 4.26: Calorie & Carbohydrate Intake interface of ARGrocery

Figure 4.27: "VIEW MORE" interface of ARGrocery

Figure 4.28 shows the shopping list interface of ARGrocery. There are two buttons on the figure, one is namely "Click here to add new item", which allows users to add items to the shopping list and "After tick, click here to DELETE", which allows users to remove the items from the shopping list. For example, the figure shows that there is one item named "Jam" shopping list. After the user has bought the item, he or she may tick the checkbox of the item to indicate the item had been purchased. After ticking the checkbox of the item, the user can click the delete button to remove the item from the shopping list or just leave the item as ticked in the shopping list.

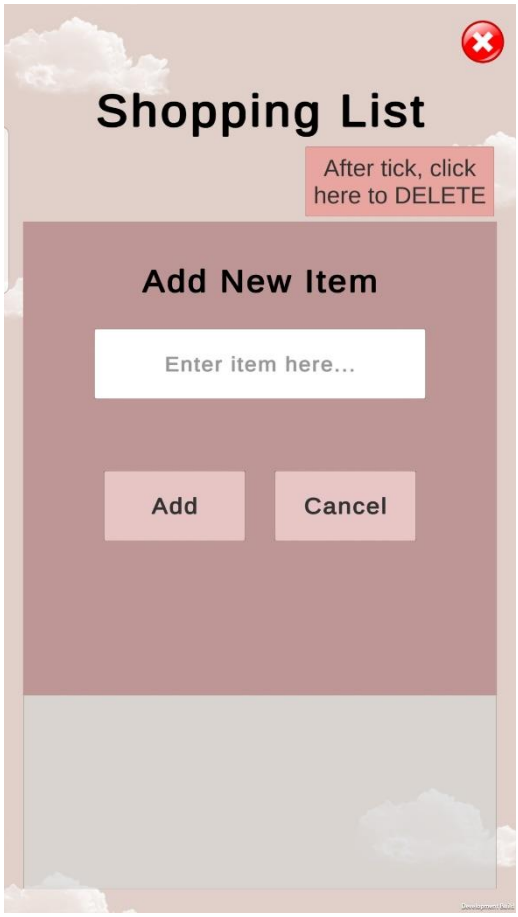


Figure 4.28: Shopping List interface of ARGrocery

Figure 4.29: Add new item interface of ARGrocery

4.5 Implementation Issues and Challenges

One of the main challenges encountered during the implementation of the AR-assisted grocery shopping mobile application was related to the integration of the Firebase Realtime Database with the Unity engine. Although Firebase provides comprehensive documentation and tutorials, the integration required advanced knowledge of C# programming language and Unity game engine. Additionally, due to some fields requiring complex data types and structures, it was challenging in mapping the database fields to the corresponding Unity objects.

Another implementation issue that I encountered was related to the performance of the AR camera and object recognition. Since the application was designed to be used in real-time, it was essential to ensure that the AR camera was fast and accurate in recognizing the food products. However, the AR camera was sometimes slow and inaccurate, which affected the

overall user experience. To overcome this challenge, the AR camera settings were optimized and used advanced algorithms for object recognition.

Besides, the implementation of the colour-coded comparison table for calorie and carbohydrate intake was also a significant challenge. Since the table was a crucial feature of the application, the table needed to be easy to read and understand by the users. Additionally, I had to find a way to map the calorie and carbohydrate data to the corresponding colours, which required some research and experimentation. Finally, a table that met the user requirements could be implemented and was intuitive to use.

In addition, there are difficulties I encountered when deploying the APK file from Unity to the mobile device. The build would often fail due to various issues, including incorrect build configurations and missing dependencies. Troubleshooting these errors was time-consuming and required extensive research and experimentation. In particular, there were issues with mismatched library versions, which caused conflicts and errors during deployment. These issues were resolved by thoroughly reviewing the dependencies and ensuring that all libraries were compatible and up-to-date.

Chapter 5: System Evaluation and Discussion

5.1 Verification Plan

ARGrocery is an application that allows users to do grocery shopping with augmented reality. The user can view the product information, filter food allergens, and make comparisons between multiple products. Therefore, it is critical that users can play the functions perfectly without making any mistakes, especially when it comes to the AR element, where a device camera is needed. Hence, only a few verification plans (key functions) are described below.

- AR Rendering

Table 5.1 Verification P1

Procedure Number	P1
Method	Testing
Applicable Requirements	Recognise one or more products and then instantly overlay the name and ingredients on top of the marker.
Purpose / Scope	To recognize the products with various shapes and then instantly overlay the name and ingredients on top of the marker.
Items Under Test	Device camera, product images such as jam, cereal and potato chips.
Precautions	The surroundings should have good illumination. Then, the product image should be clear and avoid using product image that is too bright or over-exposed.
Special Conditions / Limitations	If the product image is too bright or overexposed, the system may take a longer time to recognize the product or may not be able to recognize the product.
Equipment / Facilities	Android device camera
Data Recording	None
Acceptance Criteria	The system should be able to overlay the ingredient list and brand on top of the product image.
Procedures	1. The system opens the phone camera. 2. The user shows the product packaging's front to the camera.

	3. The system overlays the name and ingredients on top of the product.
Troubleshooting	Repeat the procedure
Post-Test Activities	None

- Filter food allergens

Table 5.2 Verification P2

Procedure Number	P2
Method	Testing
Applicable Requirements	Recognise one or more products, filter one or more food ingredients selected by the user, and instantly overlay a colour plane and a symbol on top of the marker.
Purpose / Scope	To filter one or more food ingredients selected by the user, and instantly overlay a colour plane and a symbol on top of the marker.
Items Under Test	Device camera, product images such as jam, cereal and potato chips.
Precautions	The surroundings should have good illumination. Then, the product image should be clear and avoid using product image that is too bright or over-exposed.
Special Conditions / Limitations	If the product image is too bright or overexposed, the system may take a longer time to recognize the product or may not be able to recognize the product.
Equipment / Facilities	Android device camera
Data Recording	None
Acceptance Criteria	The system should be able to overlay a colour plane, whether the plane is a red colour with a cross symbol or green colour with a tick symbol. The red colour plane represents the food containing the selected allergens

	while the green plane represents the food that does not contain the selected allergens.
Procedures	1. The system opens the phone camera. 2. The user selects the "Allergic Filters" button. 3. The user ticks the checkbox of the food allergen. 4. The user shows the product packaging's front to the camera. 5. The system overlays the colour plane on top of the product.
Troubleshooting	Repeat the procedure
Post-Test Activities	None

- Calorie and Carbohydrate

Table 5.3 Verification P3

Procedure Number	P3
Method	Testing
Applicable Requirements	Recognise one or more products and then overlay a calorie car and generate a colour-coded calorie and carbohydrate table.
Purpose / Scope	To overlay a calorie car and generate a colour-coded calorie and carbohydrate table.
Items Under Test	Device camera, product images such as jam, cereal and potato chips.
Precautions	The surroundings should have good illumination. Then, the product image should be clear and avoid using product image that is too bright or over-exposed.
Special Conditions / Limitations	If the product image is too bright or overexposed, the system may take a longer time to recognize the product or may not be able to recognize the product.

Equipment / Facilities	Android device camera
Data Recording	None
Acceptance Criteria	The system should be able to display the calorie bar and colour-coded table.
Procedures	1. The system opens the phone camera. 2. The user selects the “Calorie & Carbohydrate Intake” button. 3. The system overlays a calorie bar on top of the product. 4. The user selects the “VIEW MORE” button. 5. The system displays a colour-coded table that contains the product’s calorie and carbohydrate.
Troubleshooting	Repeat the procedure
Post-Test Activities	None

5.2 Verification Result and Analysis

- AR Rendering

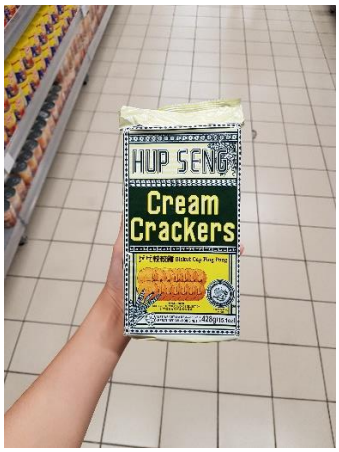


Figure 5.1: Single sample product

Figure 5.2: Multiple sample products

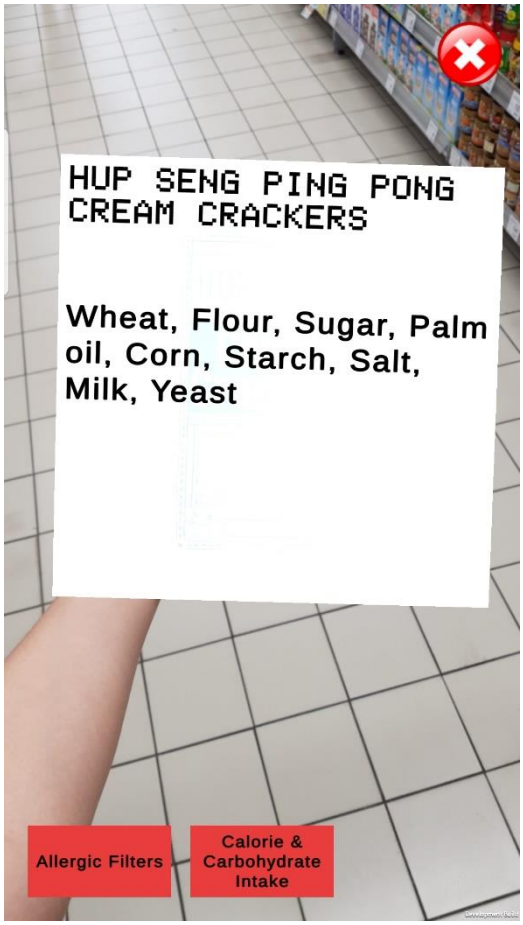


Figure 5.3: AR Rendering on a single product

Figure 5.4: AR Rendering on multiple products

There are some sample products have been provided to demonstrate the application's capabilities as shown in Figure 5.1 and Figure 5.2. In Figure 5.3, the presented mobile application demonstrates its capability to identify a specific product by using the device camera when the user shows the front view of the product. On the other hand, Figure 5.4 shows the application detects multiple products and displays the product information on the product respectively. The system can detect up to eight products simultaneously, comparing their features from the camera feed with the features stored in the database. After successfully detecting the product, the system matches the product information and overlays a semi-transparent white-coloured square prefab on top of the product, displaying its information. When the item is within the device's screen, the marker is superimposed on top of it and remains fixed to the top of the screen, moving along with the product, whether it is positioned horizontally or vertically. Additionally, the marker's size will vary depending on how close the item is to the camera on the device. The marker gets smaller as the item gets farther from the camera on the gadget. The marker enlarges as the item gets nearer to the camera on the gadget.

Figure 5.5: The size of the marker adjusts according to the item's distance

In general, AR cameras take a few seconds to identify and track a product. However, this time can be influenced by several things, such as the complexity of the object, lighting conditions, camera position, movement and the quality of the feature points. Low lighting conditions or changes in illumination may cause the camera to take more time to identify the object. If the camera moves too fast or is placed at an odd angle, the camera may take longer to recognise the object. If an object has a small number of feature points, or if the feature points are not easily distinguishable, the AR camera may take longer to recognise the object. On the other hand, if an object has a large number of high-quality feature points, the AR camera will be able to recognise it faster and more accurately.

- Filter food allergens

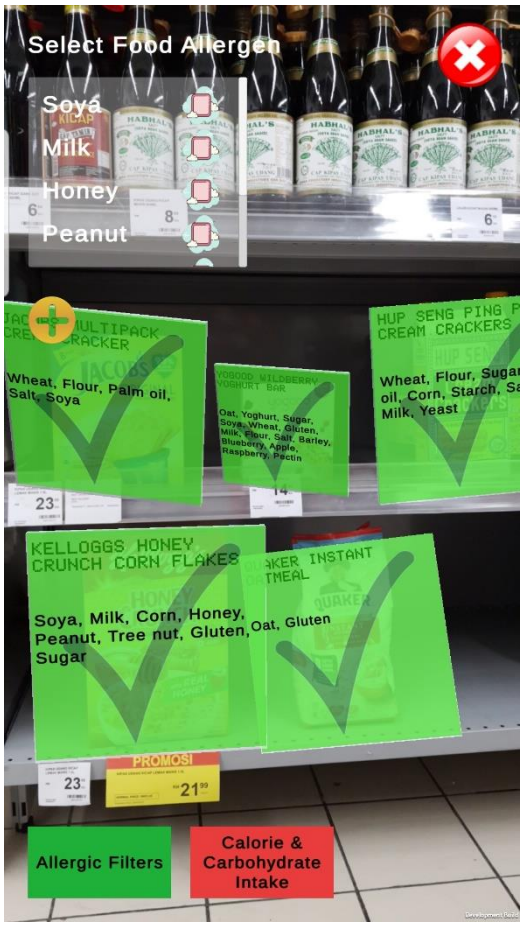


Figure 5.6: Default scene in Allergic Filters

Figure 5.7: Filter items by food allergens

In Figure 5.7, it is demonstrated how the application classifies different food products based on allergens and enables users to compare them. To do so, the user must present several

products to the device's camera, allowing the system to identify and extract the product information. Once the product information has been captured, the user can access the “Allergen Filter” button, which will trigger a panel to appear at the top left of the screen. This panel displays the list of food allergens that the user has pre-selected during account registration or selected in the Health Options settings. If the user does not select any food allergen, the default green colour plane will overlay on top of the product as shown in Figure 5.6.

To select a food allergen, the user may select more than one checkbox in the panel. If the food product contains any of the chosen food allergens, a red colour plane with a cross symbol will be overlaid on top of the product, indicating that it is best to avoid purchasing the item. Conversely, if the food product does not contain the selected food allergens, a green colour plane with a tick symbol will be overlaid on top of the product, indicating that it is safe to purchase the item. This feature provides users with an easy and convenient way to identify which products are safe for them to consume, reducing the risk of allergic reactions or other adverse health effects.

- Calorie and Carbohydrate

Figure 5.8: Calorie Bar displayed on food products

Figure 5.9: Colour scheme

In Figure 5.8, the application is demonstrated to display a calorie bar on food products to enable users to compare the calorie levels. The calorie bar is colour-coded, with a green hue indicating a low-calorie content, and a red hue indicating a high-calorie level (Figure 5.9). Besides, the amount of calories per serving is displayed within the calorie bar. Users may quickly determine how many calories are in each serving of the food product by looking at the calorie bar that is displayed on the product. This feature is particularly beneficial for shoppers who want to compare the nutritional content of various food products easily and quickly.

In addition to the calorie bar, the application generates a table that compares the calorie and carbohydrate levels of each product. The table is colour-coded, with red representing the greatest amount and green representing the lowest amount. As shown in Figure 5.10, the colour range between green and red can provide a visual representation of the nutritional content of

the food products. Users can easily tell which foods are high in calories and carbohydrates, and which one are low. When the application does not detect any products, the table is emptied and erased. This feature enables users to make more informed decisions about what they eat by providing them with a visual representation of the nutritional content of the food products. The calorie and carbohydrate comparison chart is an effective tool to encourage healthy eating habits and assist users in their efforts to make healthier decisions.

Figure 5.10: Calorie and carbohydrate level comparison table generate in real-time

5.3 Use Case Testing

Use case testing is an important part of software testing and focuses on verifying system functionality by testing use cases. Use case testing is an effective way to ensure that the system works correctly according to user expectations and to identify defects and errors that may affect the functionality of the system. In this part, a total of 8 use cases will be put to the test. The outcomes are displayed in the tables below.

Table 5.4: Use case testing of Register Account

Use Case ID	1			
Use Case Name	Register Account			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The system navigates the user to the "Sign Up" page	The system directs the user to the home page.	PASS
	2	The user enters a username, email address, and password and then selects food allergens.		
	3	The system validates the email address and password.		
Alternate / Exceptional Flows	1	The user enters a registered email address	Account will not be created.	PASS

Table 5.5: Use case testing of Register Account

Use Case ID	2			
Use Case Name	Login Account			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**

Main Flow	1	The user enters his/her username and password.	The system directs the user to the home page.	PASS
	2	The user presses the "Login" button.		
	3	The system validates the email address and password.		
Alternate / Exceptional Flows	1	The user enters an invalid email address or password.	The system displays an error message to the user.	PASS

Table 5.6: Use case testing of Manage Health Option

Use Case ID	3			
Use Case Name	Manage Health Option			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The system displays the "Health Option" page.	The system displays the message "Update Completed!" to the user.	PASS
	2	The user ticks or unticks the checkboxes of the food allergens.		
	3	The user presses the "Update Now" button.		
Alternate / Exceptional Flows	1	The user lost the Internet connection.	The system will not update the health option.	PASS

Table 5.7: Use case testing of AR Rendering

Use Case ID	4			
Use Case Name	AR Rendering			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The system opens the device camera.	The system overlays a plane with the product's ingredient list and brand on top of the product.	PASS
	2	The user shows product packaging's front to the camera.		
Alternate / Exceptional Flows	1	The product does not exist in the database.	No plane will appear on the screen.	PASS

Table 5.8: Use case testing of Manage Profile

Use Case ID	5			
Use Case Name	Manage Profile			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The system displays the "Profile" page.	The system displays the latest username on the "Profile" page.	PASS
	2	The user edits the username.		
	3	The user presses the "Update" button.		
Alternate / Exceptional Flows	1	The user lost the Internet connection.	The system displays an error message to the user.	PASS

Table 5.9: Use case testing of Filter Food Allergens

Use Case ID	6			
Use Case Name	Filter Food Allergens			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The system opens the device camera.	The system displays a green colour plane with a tick symbol on top of the product if the product does not contain the selected food allergen otherwise displays a red colour plane with a cross symbol if the product contains the selected food allergens.	PASS
	2	The user presses the "Allergy Filters" button.		
	3	The user selects the food allergen.		
	4	The user shows the front view of the product packaging to the camera.		
Alternate / Exceptional Flows	1	The user selects the "Add New Allergen" button	The system saves the new allergen and displays the newly added food allergen in the "Select Food Allergen" panel and is able to perform allergen filtering.	PASS
	2	The user enters a new food allergen.		
	3	The user selects the "Add" button to add the new food allergen.		

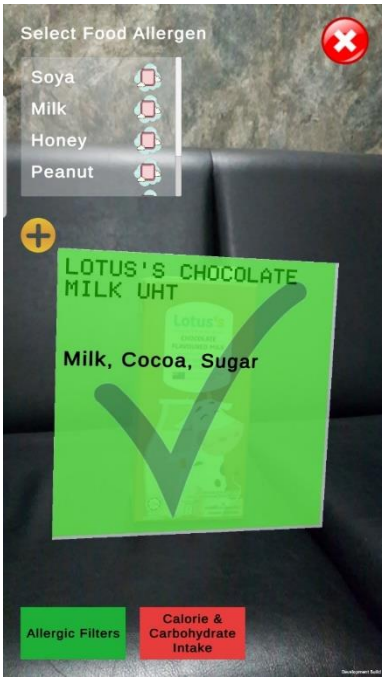


Figure 5.11: A default green plane is shown when no food allergen is selected.

Figure 5.12: Enter a food allergen named cocoa that does not appear in the default food allergen list

Figure 5.13: A red plane is shown when cocoa is selected.

Figure 5.14: The health option is updated with cocoa

Table 5.10: Use case testing of View the food calorie and carbohydrate colour-coded table

Use Case ID	7			
Use Case Name	View the food calorie and carbohydrate colour-coded table			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The user presses the "Calorie & Carbohydrate Intake" button	The system displays the latest username on the "Profile" page.	PASS
	2	The system displays a calorie bar range between green and red.		
	3	The user presses the "VIEW MORE" button.		
	4	The system displays a colour-coded table that contains the product's calorie and carbohydrate.		
Alternate / Exceptional Flows	1	The user lost the Internet connection.	No information will be shown on the plane and the table	PASS

Table 5.11: Use case testing of Manage Shopping List

Use Case ID	8			
Use Case Name	Manage Shopping List			
	Step	**Action**	**Expected Result**	**Test Status (PASS/FAIL)**
Main Flow	1	The system displays the "Shopping List" page.	The system displays the updated shopping list on the screen.	PASS
	2	The user adds a new item.		
Alternate / Exceptional Flows	1	The user ticks the checkbox of the item.	The system displays the updated shopping list on the screen.	PASS
	2	The user presses the delete button		

5.4 Objective Evaluation

The proposed project has four primary objectives aimed at developing an AR-based mobile application that assists users during grocery shopping. This section aims to evaluate the extent to which the objectives have been achieved.

The first objective of the project was to develop an augmented reality-based mobile application that displays product information by overlaying it on the screen during grocery shopping. Based on the analysis, the project has successfully developed an AR-based application that overlays basic product information such as the brand, name, and ingredients on the product. The system allows users to view multiple product information in a single view, thereby improving the users' understanding of the product.

The second objective was to develop an AR-assisted grocery shopping mobile application that can recognize and differentiate products that contain specific food allergens. The project has developed an AR-based application that can identify and differentiate food

products containing specific allergens. By using colour tags, the application highlights items to avoid in red, whereas okay groceries are highlighted in green. This feature improves decision-making about foods for housewives, people with allergies, and people with a healthy diet.

The third objective of the project was to develop an AR-assisted grocery shopping mobile application that can assist users in comparing products by calorie and carbohydrate intake. The project has developed a system that enables users to compare the products by displaying calorie bars and generating a colour-coded comparison table that contains the product name, calorie, and carbohydrate levels. This feature allows users to quickly compare nutritional information and make informed decisions about what to buy.

The fourth objective was to develop a mobile application that allows users to create a shopping list by adding and removing items they need to purchase. The project has developed a shopping list feature that allows users to create a list of essential items they need to buy, and they can easily add or remove items as they remember them. This feature helps users to organize their shopping and reduces the likelihood of forgetting important items.

In summary, the project has successfully achieved all its objectives, and the developed AR-based mobile application has the potential to improve users' grocery shopping experience. The application's features enable users to quickly and easily access essential product information, compare products by nutritional content, and create a personalized shopping list, all of which contribute to healthier eating habits and efficient shopping.

Chapter 6: Conclusion

6.1 Conclusion

In conclusion, the proposed project successfully developed an augmented reality-based mobile application that assists users in grocery shopping. By integrating virtual environment information with real-world information, the application provides users with an immersive and informative shopping experience. The application enables users to view product information by overlaying it on the screen during grocery shopping, making it easier for them to make informed decisions about the products they purchase.

The application also assists users with food allergies and dietary restrictions by recognizing and differentiating products that contain specific allergens. Additionally, the calorie and carbohydrate comparison feature helps users compare nutritional content and make healthier choices. The shopping list feature helps users organize their shopping and save time by allowing them to quickly refer to the list and locate the products they need in the store.

Overall, the proposed project contributes to improving the grocery shopping experience by providing users with a convenient and effective tool that combines real-world and virtual information.

6.2 Novelties and Contribution

The proposed mobile application, developed with the use of augmented reality, aims to provide assistance to consumers during their grocery shopping experience. With the application's ability to recognize selected items through the camera of the user's smartphone and overlay product information such as ingredients, consumers can easily access the information they need to make informed decisions. As a result, this can reduce the amount of time they spend at the store, making the shopping process more efficient.

One of the significant advantages of the proposed application is its ability to allow consumers to specify and customize the ingredients they want to avoid in the product. With a vast range of products available in grocery stores, selecting the right product can be a challenging task for consumers. By applying augmented reality in the mobile application, this problem can be solved, as users can easily filter the unwanted ingredients and distinguish between products with the help of AR green and red tags. This feature provides a personalized

experience for consumers, reduces the chance of shoppers purchasing the wrong or undesired products, and enhances their shopping experience.

The mobile application can have a significant impact on the supermarket industry as it transforms the way consumers purchase products in grocery stores. With the use of Mobile Augmented Reality (MAR), consumers can visualize and configure products in the real world, reducing their uncertainties about their purchase. By combining virtual and real-world information, the application can provide consumers with an enhanced shopping experience, allowing them to access the information they need to make informed decisions.

In conclusion, the proposed application provides a solution to the challenges faced by consumers during grocery shopping. Its ability to provide personalized information through the use of augmented reality can significantly improve the shopping experience for consumers. Additionally, the application can help the supermarket industry by improving the efficiency of the shopping process and providing consumers with a more enjoyable shopping experience. The use of Mobile Augmented Reality (MAR) can pave the way for the future of grocery shopping, enhancing the way consumers purchase products and providing retailers with new opportunities to engage with their customers.

The contribution of this project is significant as it explores the application of augmented reality in grocery shopping, providing a personalized shopping experience to consumers. The use of augmented reality can transform the way consumers interact with products, allowing them to access real-time information about products, customize their preferences, and make informed decisions. The project's approach can be applied to other industries, providing new opportunities for the application of augmented reality in enhancing consumer experiences. Overall, the proposed mobile application's contribution can be seen as a step towards the future of grocery shopping and the use of augmented reality in providing an enhanced shopping experience.

6.3 Future Work

The project's aims have clearly been completed when the implemented application provided the essential functionalities of a grocery shopping app using augmented reality.

However, because of the time limit, this project has several limitations that can be improved in the future.

Firstly, the database that stored the product image targets, which is the Vuforia device database is stored locally in the device. The system developer needs to update the database manually such as updating product information, adding a new product, and removing products from the database. Although there is a way for the system developer or system admin to add new image targets and product information to the database dynamically by using API or cloud database, there is still a problem with how to add the augmentation such as AR colour tags, product information plane to each of the product image target. Hence, Artificial Intelligence can be implemented in this project to auto-update the product database.

Furthermore, the project can be improved by allowing users to rate the product and write the product review in the future. For example, users can write their opinions and give taste ratings of the product in the application. Product ratings and reviews are important parts of decision-making during grocery shopping. Before making a purchase, consumers can have a thorough understanding of a product from reviews and choose whether the product is worth buying or not. By having honest feedback from consumers, consumers can have a better insight into the products and make comparisons between products.

Last but not least, the project shall include a recommendation engine and a more detailed health profile for users to input their health conditions. The product recommendation engine attempts to predict and display the products that are suitable for users based on their health profile. Hence, the application can more easily know what they want when the right recommendations are made at the right time and location. The satisfaction of customers when grocery shopping may be enhanced by this feature.

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	**Study week no.: 2**
Student Name & ID: Yew Jun Yi 19ACB04729	
Supervisor: Dr Ng Hui Fuang	
Project Title: ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Done allergen filtering function

2. WORK TO BE DONE

- Fix bugs occurred in the application

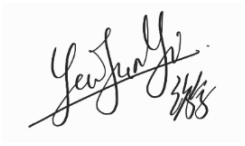
3. PROBLEMS ENCOUNTERED

- Unable to retrieve more than 30 products at one time.

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	**Study week no.: 4**
Student Name & ID: Yew Jun Yi 19ACB04729	
Supervisor: Dr Ng Hui Fuang	
Project Title: ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Able to retrieve more than 30 products information

2. WORK TO BE DONE

- Fix bugs occurred in the application
- Do calorie and carbohydrate comparison table

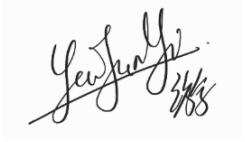
3. PROBLEMS ENCOUNTERED

- Table not displaying information

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	**Study week no.: 6**
Student Name & ID: Yew Jun Yi 19ACB04729	
Supervisor: Dr Ng Hui Fuang	
Project Title: ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Enhance UI

2. WORK TO BE DONE

- Fix bugs occurred in the application
- Do calorie and carbohydrate comparison table

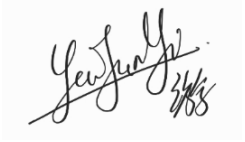
3. PROBLEMS ENCOUNTERED

- Unable to display table colour code

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	**Study week no.: 8**
Student Name & ID: Yew Jun Yi 19ACB04729	
Supervisor: Dr Ng Hui Fuang	
Project Title: ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Enhance UI

2. WORK TO BE DONE

- Fix bugs occurred in the application
- Do calorie and carbohydrate comparison table

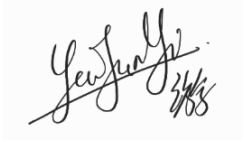
3. PROBLEMS ENCOUNTERED

- Unable to display table colour code

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	**Study week no.: 10**
Student Name & ID: Yew Jun Yi 19ACB04729	
Supervisor: Dr Ng Hui Fuang	
Project Title: ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Enhance UI
- Done calorie and carbohydrate comparison table

2. WORK TO BE DONE

- Fix bugs occurred in the application
- Do add new allergen

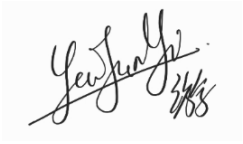
3. PROBLEMS ENCOUNTERED

- Apk file could not read data from firebase

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3Y3	**Study week no.: 12**
Student Name & ID: Yew Jun Yi 19ACB04729	
Supervisor: Dr Ng Hui Fuang	
Project Title: ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

- Enhance UI
- Done calorie and carbohydrate comparison table
- Complete all features
- Able to read data from database

2. WORK TO BE DONE

- Report writing and presentation

3. PROBLEMS ENCOUNTERED

- Google service json is not working in unity 2021. Had to manually type all the api keys into the script

4. SELF EVALUATION OF THE PROGRESS

- So far so good

Supervisor's signature

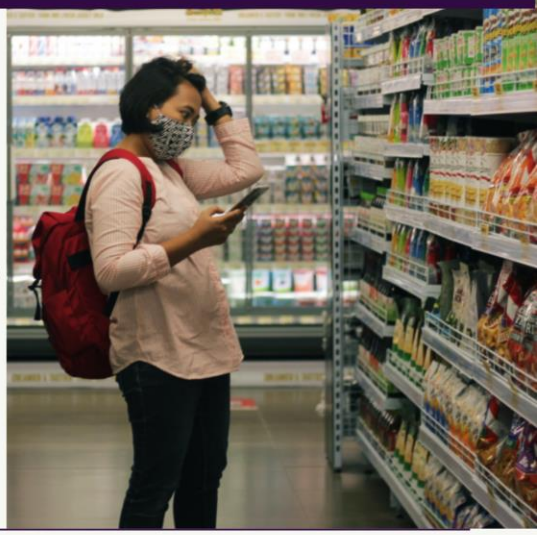
Student's signature

POSTER

UNIVERSITI TUNKU ABDUL RAHMAN
Faculty of Information and Communication Technology
Bachelor of Computer Science (Hons)

ARGrocery: An Augmented Reality-Assisted Grocery Shopping Mobile Application

Prepared by: Yew Jun Yi **Supervised by: Dr. Ng Hui Fuang**

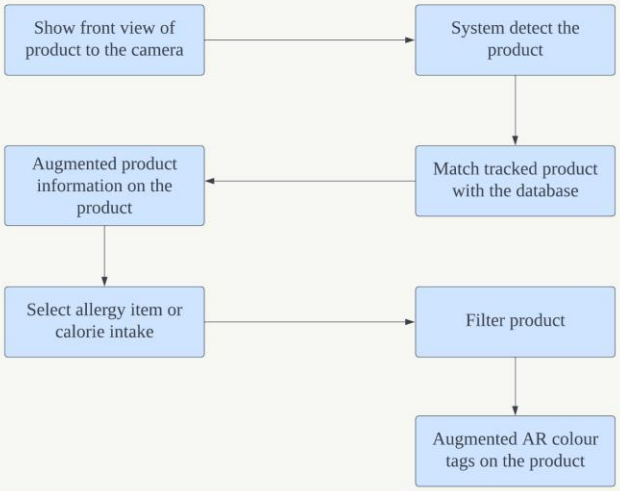


INTRODUCTION

The project aims to integrate virtual environment information with real-world information by using Augmented Reality technology so that the system is able to allow users to view one or multiple product information in one sight. In addition, this project also aims to enable users to specify the ingredients and differentiate the items by looking at the AR colour tags. The application also allows user to compare the calorie and carbohydrate level of multiple products.

METHODOLOGY

- Developed using Agile Methodology
- Use of Unity AR Foundation to create AR content
- Use of Visual Studio Code as IDE
- Use of Firebase to store information



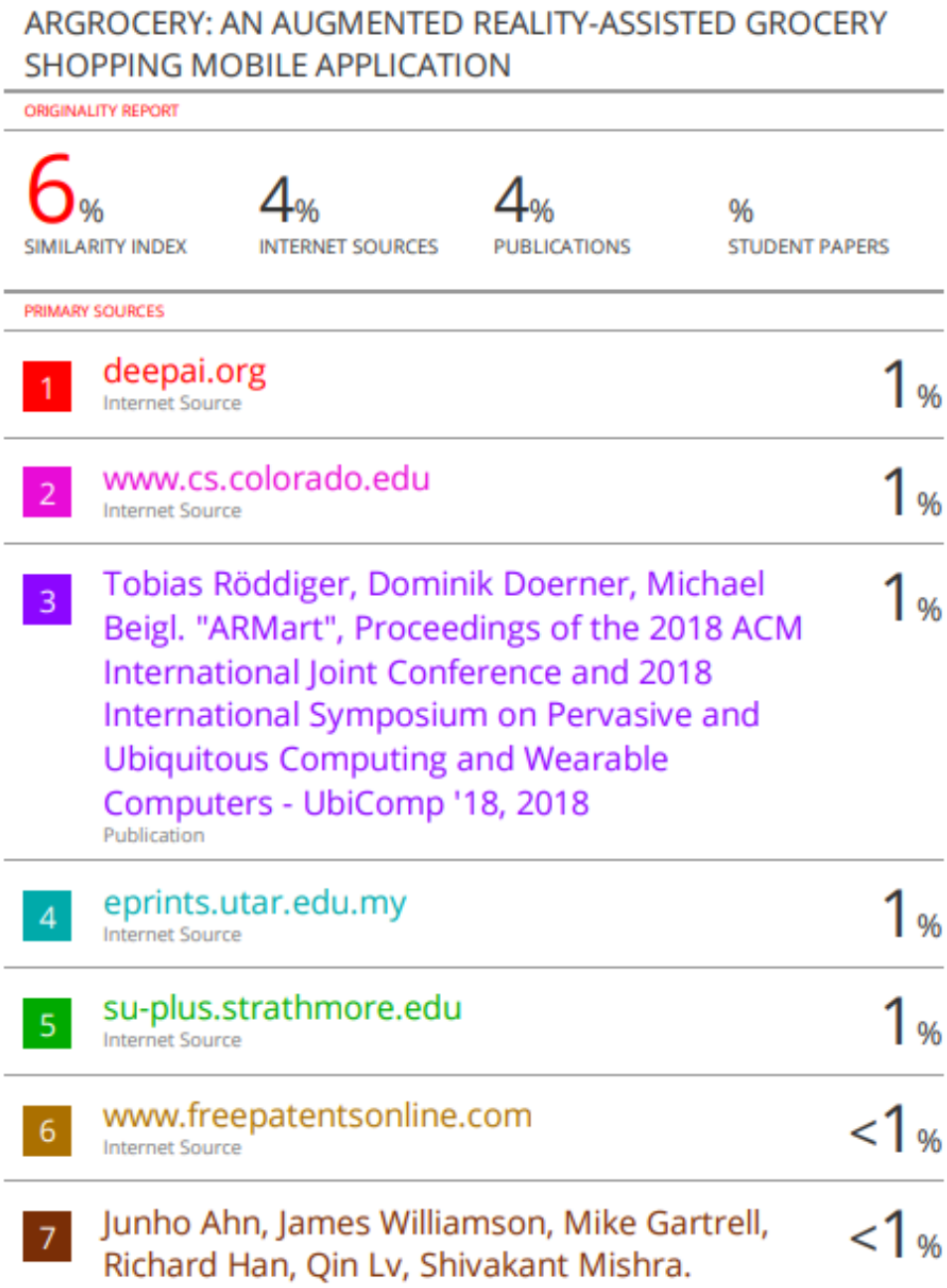
FUNCTIONS

- Overlay information of one or multiple products on top of front view of product in the screen.
- Distinguish product that contain specific allergy item
- Filter product by calorie intake
- Shopping List

CONCLUSION

- Shorten grocery shopping process, able to make a fast decision on selecting the products
- Reduce the chance of shoppers buying the wrong or undesired products and enhance their shopping experience.
- Helps to overcome these dilemmas by seeing the goods.

PLAGIARISM CHECK RESULT



ARGROCERY: AN AUGMENTED REALITY-ASSISTED GROCERY SHOPPING MOBILE APPLICATION

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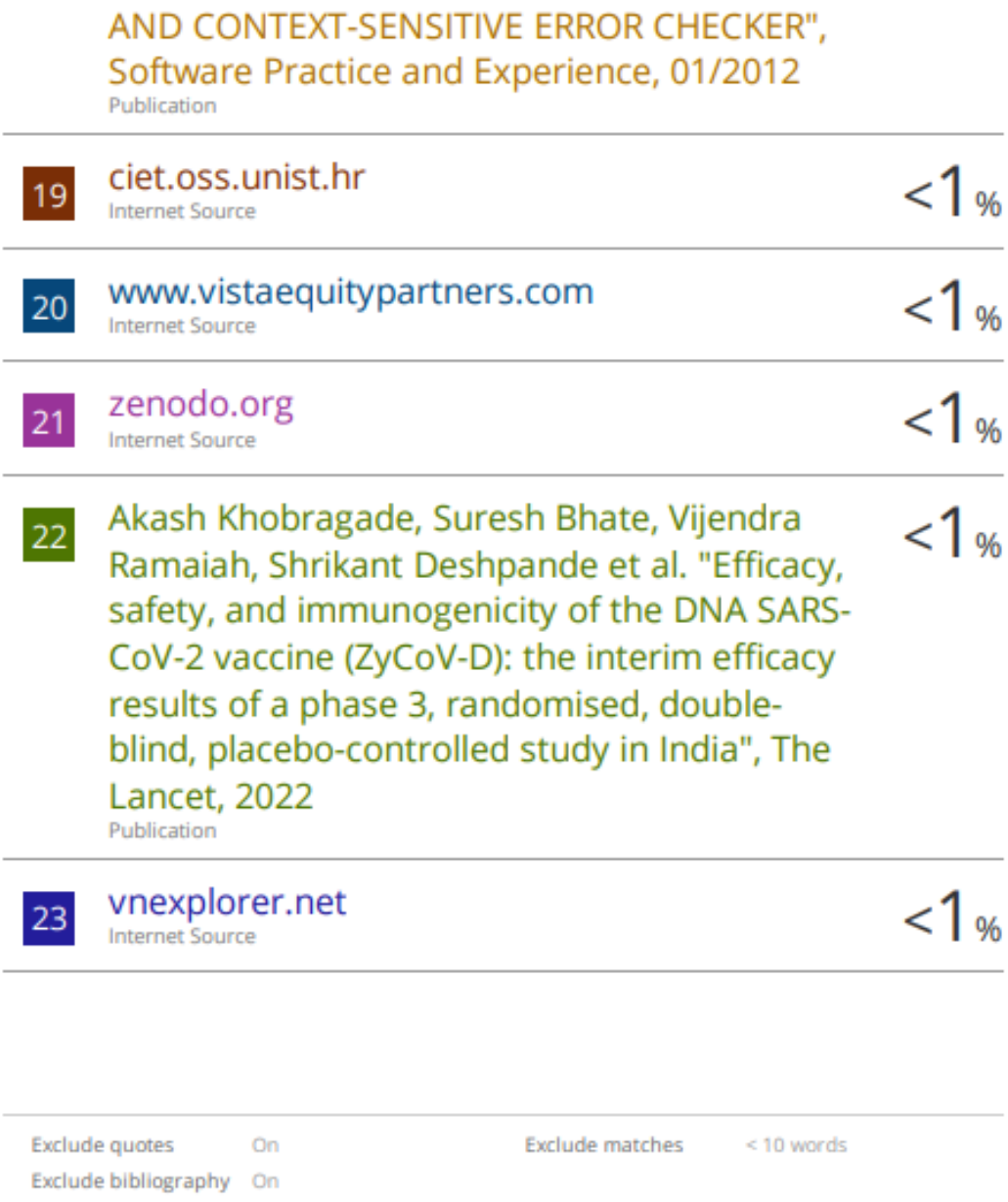
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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	YEW JUN YI
ID Number(s)	19ACB04729
Programme / Course	FICT / CS
Title of Final Year Project	ARGROCERY: AN AUGMENTED REALITY-ASSISTED GROCERY SHOPPING MOBILE APPLICATION

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)**
Overall similarity index: 6 % **Similarity by source** Internet Sources: 4 % Publications: 4 % Student Papers: 0 %	
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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: 28th April 2023

Signature of Co-Supervisor

Name: _____

Date: _____

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

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Student Name	YEW JUN YI
Supervisor Name	DR NG HUI FUANG

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
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√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

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

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

_____

(Signature of Student)

Date: 28th April 2023