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Title: Implementation of Augmented Reality in grocery stores to make user experience more interactive and immersive

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I hereby confirm that the work presented here in this report and in all other associated material is wholly my own work. I confirm that the report has been submitted to TURNITIN and that the TURNITIN results are on CD attached to this report. I agree to assessment for plagiarism.

Signature: Bishaka Gurung

Date: 29 April 2022

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ABSTRACT:

The aim of this project was to create an application for mobile devices like android which uses Augmented Reality to help people shop in grocery stores. Augmented Reality was used and focused as main to make user more immersive during shopping. Interactive feature like product details display in real world is created in the application representing Augmented reality to help people shop more easily and faster way. The produced application is supposed to be solution to problem faced by people during shopping like price label misplacements, difficult to find product details, product ratings and to navigate towards products. The evaluation of the software was done through questionnaire with different people by making them use my software and give feedback. Thus, evaluation confirmed that majority of the people agreed on using of Augmented Reality would be good idea to help people shop in grocery stores.

1. BACKGROUND

"One day, we believe this kind of immersive, augmented reality will become a part of a daily life for billions of people. "[11]

— Mark Zuckerberg, Founder and CEO of Facebook Inc. (2014)

Augmented Reality (AR) is an extended version of reality where elements from the virtual world are placed into our real world to enhance the experience of how we see, feel, and hear. For augmented reality to be shown it needs a camera-installed device

such as smartphones, tablets, and glasses etc. The device also needs to have AR software, which uses its computer vision technology to scan the video to show 3D models and holograms in it.

Adaptation of AR application has been done in many commercial industries such as communication, medicine, entertainment, and education. To be more specific, they are used mostly in medical training, repair & maintenance, retail, tourism, classroom education, designing and entertainment etc. Big companies use AR for the repair and maintenance of their devices and equipment like MRI machines, car motors, aircraft wires etc. It is mostly performed by using AR headsets and glasses where they view the device problems, possible solutions and additional information about the machine. [1] Boeing uses AR for repairing and maintenance of electrical wiring in aircraft. The AR solution gives technicians real-time 3D wire diagrams with the help of smart glasses which allows them to easily see which wiring is going for the aircraft fuselage. In this modern busy lifestyle, people want their shopping experience to be very less time consuming and easy. So, AR is capable of adding virtual elements in a retail environment in real-time and catapulting immersive shopping experiences to customers. Nowadays, Retail store uses advanced applications which use special tracking and computer vision helping customers to experience futuristic shopping and see real-time information about the products, just by a smartphone screen on their hand. AR is used in retail to facilitate product evaluation or obtain information of products before its purchase and delivers effortless access to products which helps the customer to reduce their uncertainty when making purchasing decisions. [4] A brand like Ikea is using augmented reality to let customers view the furniture from different angles in their home through their smartphones which uses 3D models as a design. According to a Neilson global survey from 2019, Augmented reality is listed as a top technology that consumers want in their daily life. Just over half i.e., 51% were agreeing to use this technology to access the products-[Nelison,2019]. As connecting these things, the field I will be doing this individual augmented reality project would be in retail especially grocery stores. The AR application to be created on this project is centered around the customers in grocery stores. The project will enable them to get real-time information about products and also allow them to access navigation routes to reach specified products. The shopper coming to buy in a grocery store could get information like price, nutrients, ratings just by pointing their phone in the given

product. The items having manual papers which are hard to use will be having a 3D animation explanation for customers to get easy go-on on items. A navigation feature made from indoor mapping will be added to make the shoppers experience looking for the products fast and easy.

A common problem customers face during their visits to stores is price labels being misplaced on a shelf, which makes them have a confusion about the actual rates of items. Having to spend 20-30 minutes in store just for searching for an item would be a bit unreasonable and a waste of their time if they're busy. Similarly, some people that are looking for best-reviewed items or wanting to try and learn about new goods will not always ask for assistance and return home in disappointment. The main agenda of this project is focused to make these problems solved by developing an AR-based application that can be easily used in any grocery store on a shopper's phone. The main deliverables of this project will be software i.e., an application that is centered for the customers in a grocery store to make their shopping experience informative and entertaining.

2. LITERATURE REVIEW

2.1 INTRODUCTION:

Today's world has entered into the era of augmented reality. We can see many overlayed information into the real world through applications on our smartphones like Snapchat, Google translate, Google maps etc. [5] The word "Augmented Reality" was first coined by Thomas P Caudell of Boeing in 1990 while they were developing an AR system display headset which included head position sensing and workplace registration system. [7] The initial system of augmented reality was first achieved by Morton Heilig in 1952 through cinematography where he invented Sensorama [6] by making an attempt of adding additional information to an experience. Even though many AR concepts were introduced the foremost AR prototype was developed by Ivan Sutherland (1968). [9] He invented a head-mounted display designed to facilitate the user in a stimulated 3D environment. [13] In 1974, Myron Krueger made one of the

most remarkable signs of progress in augmented reality. Video place was the name of the project, which integrated a projection system with video cameras to create shadows on the screen. The user felt as if they were in an interactive world because of this setup. [10] Similarly, in 1990 Tom Caudell and David Mizell presented a head-mounted display for construction workers that displayed the position of wires onto multifunctional, reusable boards with the use of eyewear. By the 1990s, mobile AR and wearable computers had surfaced and were being used for the first time, with AR becoming more influential in computer science as it became connected with 3-D technology, mobile technology, and virtual reality [12]. As a result, advances have been achieved in gaming, retail, military, navigation, medical, education, and tourism.

Figure 2.1 Head-mounted display by Ivan Sutherland [8]

2.2 AR CHARACTERISTICS:

AR is being tested by tech firms like Microsoft, Google, and Apple, as well as anything from children's textbooks to 3D modelling in games. AR is becoming more widely accessible, with several free content creation tools permitting anybody to build their own AR experiences.

Apps like Blippar, Zappar, and Aurasma provide AR content production inexpensive for smaller firms, education, and a range of other industries, as well as AR functions within current smartphone games and applications like Snapchat and Pokémon Go. Recent findings have taken into consideration to key characteristics of AR technology

to assess the potential impact on users. Interactivity, modality, immersion, vividness, and amplification were some of the features they identified.

Interactivity in Augmented reality refers to the ability of users to influence what they see in a combo of the real and virtual worlds. Virtual elements could be interacted with and presented in the actual environment through interactive augmented reality, making them easier to understand and work with. [14] Two complementary viewpoints exist that provide a thorough explanation of interaction and its function in operationalizing AR effectiveness: (1) technology outcome; (2) as a user impression. [15] Scholars emphasize the significance of technological features define interactivity as an effect arising from the features of the technology used or the technology's aptitude to allow people to engage with and be involved with material more easily (Edward J. Downes and Sally J. McMillan 2000). [15] Another widely held belief is that interaction is based on users' subjective views, with an emphasis on individual characteristics that promote interactivity. [16] A survey of 283 female internet shoppers in South Korea was conducted. Participants answered the questionnaire after shopping for cosmetics using an AR option in a mobile app. The results showed that the controllability and fun components of perceived interaction influence mental imagery, which influences shoppers' opinions toward a product and their intentions.

Immersion is achieved by ensuring that the environment behaves as expected by the user. Occlusion culling is used to create immersion by allowing the environment to interact with virtual objects [17]. [18] An international study was commissioned by Snapchat to learn more about the subconscious effects that individuals have when they interact with AR material in the Snapchat app vs other content and platforms. It sought volunteers for virtual, one-on-one study sessions in which they were instructed to browse various media platforms and watch internet videos in random order. Their level of immersion was rated by “Immersion Index” on a scale from 0 to 100 by measuring their heart rate with their brain engagement. In study finding’s
with an Immersion Index of 61 to 55, Snapchat was the most immersive of the platforms delivering AR experiences in its camera [18].

[19] Modality refers to the several forms of material offered by the medium, which might include music, voice narration, video, photos, text, and other audio and visual

formats that impacts a communication process (Javornik A. 2016). AR apps' content seems to be mostly visual, although it might take the form of 2-D or 3-D graphics, movies or animated stuff, or solely textual information. Modality strategies help for the establishment of more positive sentiments regarding a brand and associated items, as well as more intense purchasing intentions.

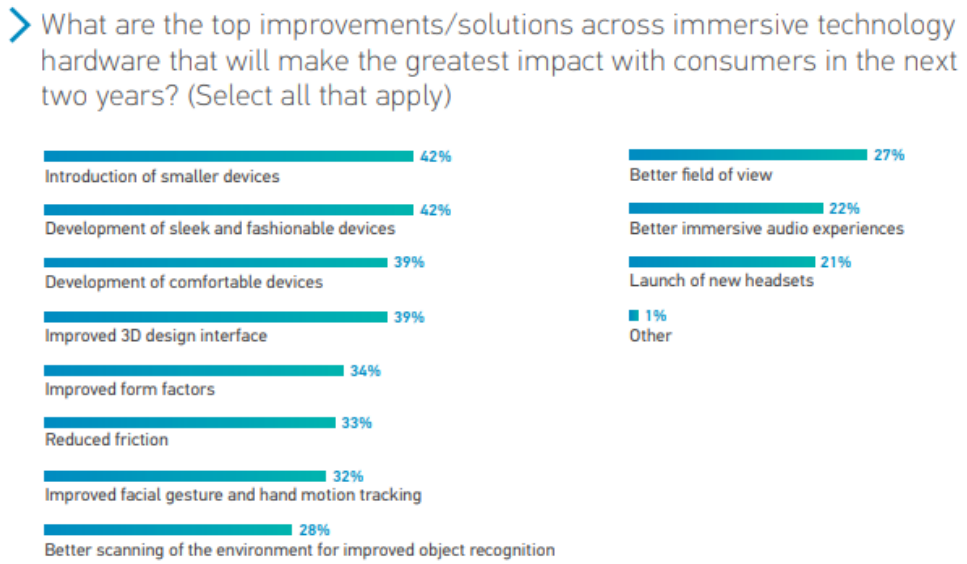

Figure 2.2 Annual Augmented and Virtual Reality Survey conducted in 2020 [20]

In figure 2.2 an augmented reality and virtual reality survey were conducted in 2020 where it showed the percentage of different factors or ideas where improvements could be done in immersive technology to have a possible great impact in the coming two years.

AR Characteristics	Authors
Interactivity	Edward J. Downes and Sally J. McMillan, 2000;

	Charvi Agarwal and Narina Thakur, 2014; Jungmin Yoo, 2020;
Immersion	Ellen Häger, 2017; Verity Burns, 2021;
Modality	Javornik A., 2018;

Table 2.2.1 AR characteristics researched on given literature.

2.3 AUGMENTED REALITY TECHNOLOGIES:

Augmented Reality (AR) is a type of technology that mixes virtual information and the real world. It is achieved by the different use of technologies like multimedia, digital displays (aural display, visual display) elements, 3D- models, tracking sensors, user interface, sound, Sensor, intelligent interaction and many more. Following decades of technological obstacles (such as a limitation of fast internet connection, limited mobile computing power, or inaccurate sensors) recent hardware & software developments have improved AR's capability as a large-scale technology. According's to data analysis done by research companies, over the next five years, global AR advertising sales are likely to skyrocket. According to one estimate, the market will grow from $428 million in 2018 to $2.6 billion in 2022 [21]. Back in the '60s and '70s had computer-generated graphics and projections up to now having new AR devices such as Microsoft HoloLens Developer Kit the technology and applications like Pokémon Go, Snapchat, Ikea, Google Lens and many more.

In 2016 Microsoft released its augmented reality headset, HoloLens with has multiple sensors, advanced optics and holographic processing that blends with its surroundings [22]. HoloLens use lots of optical sensors, with 2 on each side of the set for sensing its surroundings and one main facing camera for analysing hand movements. It has been used in many fields such as manufacturing, engineering & construction, healthcare education etc. Manufacturing companies like Mercedes-Benz, Loreal, Audi, Toyota has been innovating with HoloLens. For instance, Toyota Motor North America has been using Microsoft Dynamics 365 Guides and Dynamics 365 Remote Assist on Microsoft HoloLens 2 in their training programs so that trainers could quickly teach, create and update the content to several trainees at the same time without interrupting the manufacturing process which has now resulted in their inspection time being reduced by 20% [23]. [24] When the covid-19 pandemic began, Imperial College Healthcare NHS worked with Microsoft HoloLens while performing a surgery that solved their main problem of treating their patients with less exposure to the virus. Doctors were able to communicate with experts all around the world along with their patients placing the medical reports like an x-ray in the call. Despite that, there were also some drawbacks of HoloLens. The main flaw of the HoloLens was the extremely limited field of its view. The layout of the content was obstructive, and the text fonts were also very difficult to read.

Similar to Microsoft HoloLens, Google developed an optical head-mounted display called “Google Glass” [25] which were in the form of normal glasses. It was designed to display information like you get on smartphones through a pair of glasses and communicate with the user via internet voice commands. It had features to capture and record photos and videos of 5MP and 720p HD quality. The glasses were controlled by using a capacitive touchpad on their right side. Another way of controlling was through voice commands. But on January 15, 2015, google stated that it would be no longer manufacturing the Google glass prototype. There were many reasons for its failures. The most important criticism was the invasion of privacy. Since google lens was able to record and capture people in public because of privacy concerns they were being banned in certain places. Places like Banks & ATMs, vehicles, Hospitals, Schools, Movie Theatres, Bars and many more banned Google lens so that they could protect people and general data privacy. Even after having many setbacks, the glasses cost around $1500 which made people disappointed with the product. Google

lens only had a battery limit of 4 fours which meant you had to keep charging it every 4 hours. So, the battery could be drained anytime without our awareness, rendering it unusable until it is fully charged.

Likewise, there has been a rumour about “Apple glass” by Apple Company to be released around late 2022 or early 2023 [26]. Apple glasses will be using augmented reality to display information like texts, contents, maps, emails etc which are supposed to be integrated with iPhones. It does not have a problem of invasion of privacy like google glasses because apple glasses won’t have a camera included in them [27]. Apple glasses are suspected to be priced around $499 which may appear modest compared to Microsoft HoloLens 2. The glass does not only focus on providing AR experience but also help people in adjusting their vision issues like hypermetropia, near-sightedness etc. If we look at the potential of it, it could play an important tool in the medical field. While performing surgery, doctors must view all sorts of information like their heart rate, x-ray and blood pressure which may make them look into screens frequently. With the help of AR glasses, they would be able to see all those information in Infront of their visions. Having to see images or models of operating machines in those pairs of glasses could help in making fewer purchases of machines at the hospital.

As talking about Apple again, apple has developed an augmented reality platform for iOS devices called ARKit which allows developers from all parts of the world to create an augmented reality experience in an app using the device’s cameras and motion sensors. IKEA, Castorama, Target, QVC, Amazon are among the companies who have already incorporated ARKit into their main applications or are developing new AR shopping apps.

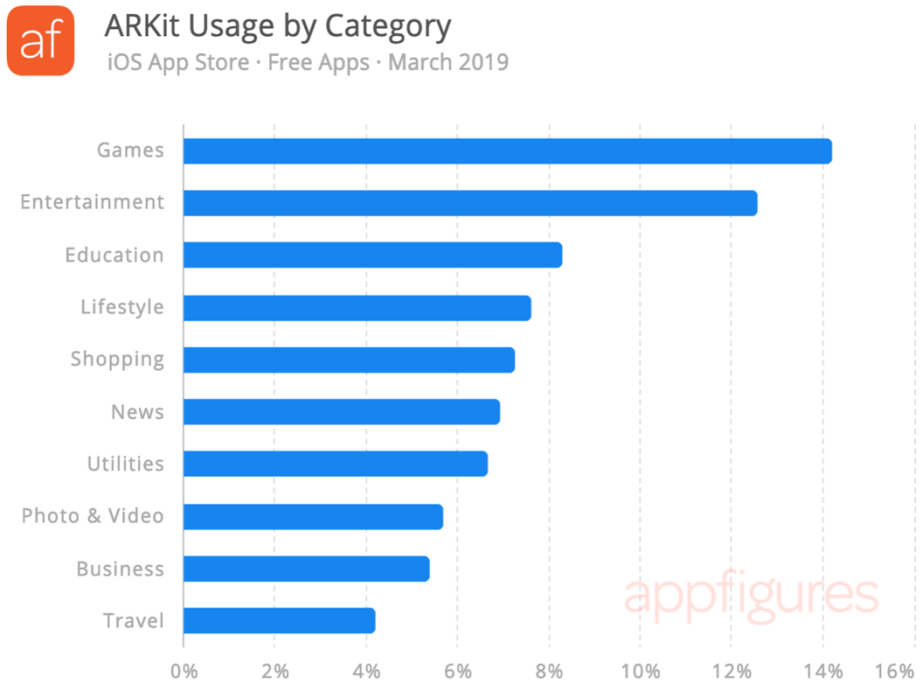

Figure 2.3 Use of ARKit in apps of different categories [28].

In figure 2.3, we can see that apps in the gaming industry are in the top place for using ARKit. One of the most famous AR gaming apps is called “Pokémon Go” which is considered to be the “first mainstream case of augmented reality applied to the masses” says Professor Jonah Berger [29].

Pokémon Go is a smartphone game that blends gaming with exploring the real world. Augmented reality features like location tracking and mapping technology are used in the game where players are supposed to catch and teach their Pokémon characters in real-world environments. The game battles made people do interactions with new people sharing a similar field of interest. Since it’s a game of walking, it encouraged people in doing physical activity and be active. Despite having its popularity, it also created many problems for people playing the game. It increased the chance for players to have an injury while playing the game because of them getting absorbed into it and forgetting to give enough attention to the surroundings. Many gamers have sprained ankles, stumbled, or collided with walls, street signs, and other objects. Also, due to being given the same access to Pokémon and Pokéstops in the same region, predators and thieves employ lures to get gamers to come seeking Pokémon. Many

people also have ended up trespassing private places in trying to catch Pokémon where they were not supposed to be.

2.4 AUGMENTED REALITY APPLICATIONS:

Augmented Reality Apps are software programs that mix digital visual (as well as audio) content with the user's actual environment. The market and investment business in augmented reality will grow as the technology grows to be more sophisticated and cost-saving. In the categories of AR applications, there has been some substantial research and developments which are listed below.

2.4.1 EDUCATION AND TRAINING

AR application can enhance a normal curriculum, by adding things like photos, videos, 3D models, text and audio that can be superimposed on a student's live view of their surroundings. [30] Hannes Kaufmann (2002) brought up Construct3D, a 3-dimensional geometry creation tool created for mathematics and geometry education. Students and tutors who are not in the same specific place may share a virtual learning environment enhanced with virtual elements and educational tools and engage with each other inside that environment. [31] Aurasma app was developed by a software company called Autonomy in England. Aurasma used image recognition technology in a tablet or phone camera which could detect real-world images, supplementing physical material with animations, films and 3D models. Students in classrooms can see 3D models, information, websites and videos links, audios just by pointing their device to the specific resource. Similarly, Math alive app is a secondary mathematics kit that educates beginning math topics learners using 3D augmented reality and game technologies. It creates an augmented reality experience using a combo of wildlife park flashcards and video designed to be used at both home and school environments to establish a strong relationship between house and school [32].

2.4.2 ENTERTAINMENT

Augmented reality elevates entertainment to the next level by allowing audiences to become active members in the presentation instead of being passive observers. AR works as a great marketing tool in the entertainment industry to strengthen

relationships between the characters and the audience. As we talk about the entertainment industry many AR applications have been developed in the fields of games, music and movies. The application named Zombie GO was developed by Ubisoft Montpellier which used immersive augmented reality to put 3D graphics of zombie characters in the real world. The app was run on iPhone, iPad where the player must move their phone around their surroundings and battle zombies. Similarly, Disney also has implemented the concept of augmented reality into a colouring book of a child where it allows children to colour in 3D characters from an art book. With the help of device cameras, it tracks and captures real-time images which then are mapped into a 3D malleable surface. Its focuses on allowing users to colour in 3D characters in a real-time environment with the help of a 2D colouring book.

Many social media platforms have been using augmented reality for delivering entertainment to users in form of Snap Chat filters and lenses, Instagram filters etc. Snapchat uses AR animation in its lenses allowing users to overlay animation in their images and videos. [34] This service is used by about 170 million individuals every day, or around three-quarters of the company's daily users. Snapchat developer company “Snap” has been estimated to have a market capacity of $113.4 Billion [34].

Figure 2.4.2 Disney using AR in helping children’s colour into 3D character [33].

2.4.3 RETAIL

AR can add virtual elements in a retail environment in real-time and catapult immersive shopping experiences to customers. Nowadays, Retail store uses advanced applications which use special tracking and computer vision helping customers to experience futuristic shopping and see real-time information about the products, just by a smartphone screen on their hand. It delivers effortless access to products and helps reduce the uncertainty of customers while making purchasing decisions. Brands like IKEA, Snapchat, Sephora have used augmented reality that creates user experience not only stand out but also draws the customer in. A study from the journal of consumer Psychology found that retail therapy not only makes people happier immediately, but it can also fight lingering sadness [35]. The famous brand IKEA, for instance, is one of the brands for making AR trend by using augmented reality to let customers view the furniture from different angles in their home through their smartphones which uses 3D models as a design. The app program uses a print catalogue to calculate the scale of the catalogue's contents and customer's real-life environment to make the 3D graphics show up in customers rooms through smartphones and let them place it to their liking. According to Deloitte research from 2020, AR has helped a handful of home-goods firms minimize returns by up to 30%, saving time and money [36]. Likewise, another famous makeup brand Sephora uses AR technology that allows user to upload their picture to make them try on makeup products virtually which helps them on making their purchasing decision. Its AR app uses facial recognition software that scans user facial features like lips, eyes to place the augmented product in them.

BRAND NAME	ENVIRONMENT	FUNCTION	SECTOR
IKEA (2016)	Online implemented	Use 3D furniture which allows users to view it virtually at home	In augmented app
TOPSHOP (2011)	In-store implemented	AR changing rooms which let	AR smart mirror

		customers try on different clothes on screens.	
NIKE (2016)	In-store implemented	Allows customers to customize sneakers through a tablet	AR app
LACOSTE (2018)	In-store implemented	Allows buyers to try on shoes virtually on their phones by scanning the barcode in stores.	AR app

Table 2.4.3 shows the AR application used in the retail field.

2.4.4 NAVIGATION

Augmented Reality technology plays a powerful weapon in the field of navigation by adding virtual objects like 3D in the real world where users can use these features to navigate routes and also see information about traffic on their phones. J. Rekimoto (2000) proposed the use of AR in a small video camera called NaviCam in which he uses fiducial markers for tracking the position of an object [37]. The user has to move the NaviCam around the real world to view the augmented things. The passenger's app of Gatwick airport was awarded the mobile innovation of the year award in 2018 [38]. They installed 2000 beacons inside the terminal of airports. The passenger app provided customized, real-time flights updates, navigation maps, terminal information etc. The passenger could use the indoor navigation tool to locate important stops like check-in, terminal gates, carousels for luggage. Similar AR City app which is owned by Blippar company is a navigation app where people can visit and explore different cities by using its navigation feature. [39] It uses AR and Computer Vision to shows 3D directions in the form of arrows in the display.

2.4 LIMITATIONS:

Despite having great achievements over the past years, it has confronted several technological obstacles which may cause setbacks to its future development. The main problem that could be a big thing in terms of AR is the lack of privacy. Augmented reality used in social media platforms extracts data and information from the user, which may be leaked in future if a hacker gain access to it. AR means augmenting the real world with virtual data information, if large access of data is being used then the display may be overcrowded with superfluous data. The user interface must adhere to certain criteria in order to avoid overloading of information while also preventing the user from being unduly reliant on the AR system to the point where environment cues are ignored. If we look up technical issues, AR devices have a limitation of their battery life. Back then, Google glasses was criticized by people for having a battery life of only four hours. If developers want AR to be widely used, then the cost of their gadgets will need to be reduced. Because of being around in virtual space 24/7, there might be a concern for people to lose out on their real-life events.

2.5 CONCLUSION:

The pieces of literature that have been reviewed have granted an insight into the current state of the Augmented Reality industry while also discussing its recently speculated future of it and highlighting some of its limitations; A prime of the future of Augmented Reality was provided in the upcoming Apple Glass as it could not only be used as a product for leisure but also be integrated into a variety of industries such as the ones discussed above including education, entertainment, retail, and more all for very different such as navigation which was also mentioned. As stated, before Augmented Reality still has many limitations that it needs to overcome like its inability to have longevity and inability to overflood the user with information. Even though it has its current limitations, Augmented Reality has come a long way since it was first conceptualized by Morton Heilig and Thomas P Caudell in the mid to late 1900s and it is good to see major companies such as Facebook, Apple and Google try to integrate it into modern-day society.

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3. SOFTWARE

The final prototype of software will be developed on Unity Engine using Vuforia development Package.

3.1 REQUIREMENTS:

- The application should only launch on android devices.
- The application should start with scene “Menu”.
- The Menu scene should consist of the start button with a background image.
- When the start button is clicked, it should new scene called Scan.
- The “Scan” scene should show an interface consisting of button to change scene, and a written note for user “Hover around the product for details”.
- When user hovers on food products, the application should show canvas written details of the products.
- The product details should consist of 4 panels.
- Panel 1 should have item name, price, rating, and ingredients used. Panel 2 should have a description about nutrients of the product. Panel 3 should show suggested item similar to hovered item with an image, name and price. Panel 4 should consist of YouTube and google link of the product information like how to use it.
- When the YouTube button and google button are clicked or touched it should lead the user to respective links. For example, when hovering to meat curry masala packet it should give YouTube and Google link about how to use the masala packet. When the link is touched, it should lead to a YouTube or Google Recipe video.
- User should be able to see details properly even after hovering screen close to canvas.
- When the button called “navigate to product” is clicked it should load a new scene called “Navigation”.
- The application should new interface on new scene called navigation.
- On the top right side of the screen, it should have a button called back to main which on clicked should take back to “Scan” scene.

- On the bottom left of the screen, the application should have a live map which shows the way for the user like on which are they moving.
- On the bottom right of the screen there should be a dropdown menu which will have different products name in them.
- The application also needs to consist of a toggle button which on clicked will show the navigation on colour green.
- When the user chooses a specific product in the dropdown box, the navigation should be showed towards that product.
- The user should use Toggle line visibility button after choosing an item/product on the drop box.
- The navigation path should be represented in green colour line. The destination is showed by a blue sphere in each targeted product.
- The application should be able to change different scenes when user click on buttons in the screen.

3.2 DESIGN

This section consists of UML diagrams which visualize how all the game object, events, and scripts are placed and connected with each other in our Unity application.

The AR application uses total of 3 scenes called menu, scan and navigation resp. The first scene is the menu of the app. It has a button to change the scene into 2nd scene called scan. In our 2nd scene the application plays the role of scanning objects and giving their information. Similarly, our 3rd scene is used to navigate the products by using navMesh and line Renderer.

The first scene(menu):

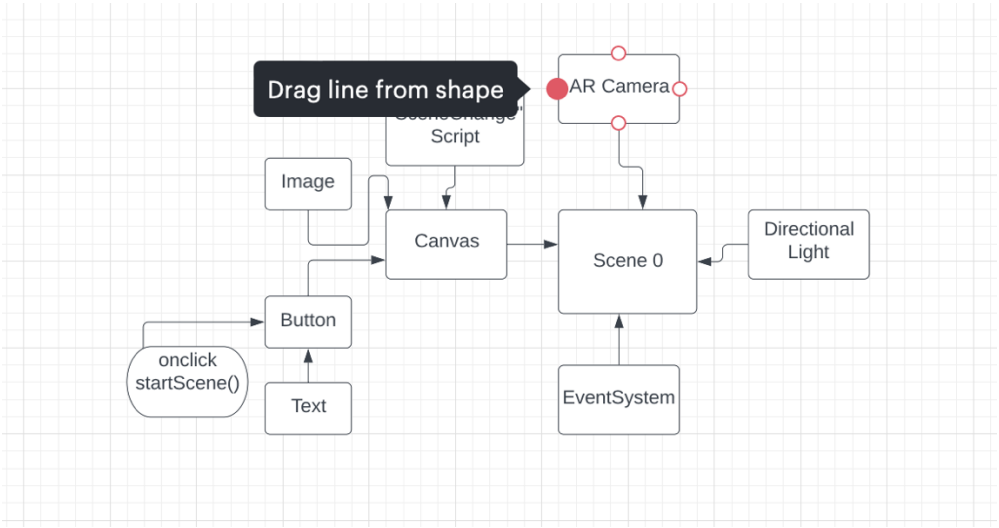


fig 3.2.1 first scene of AR application

The figure 3.2.1 shows the design representation of our application 1st scene in unity. The hierarchy consists of main AR Camera, EventSystem, Canvas, and Directional Light. Script “SceneChange” is added to the canvas. A background image and a button is also inserted in the canvas. The button has a event function i.e. onclick function startScene() is from the script which allows user to change scene when the button is pressed.

The second scene(scan):

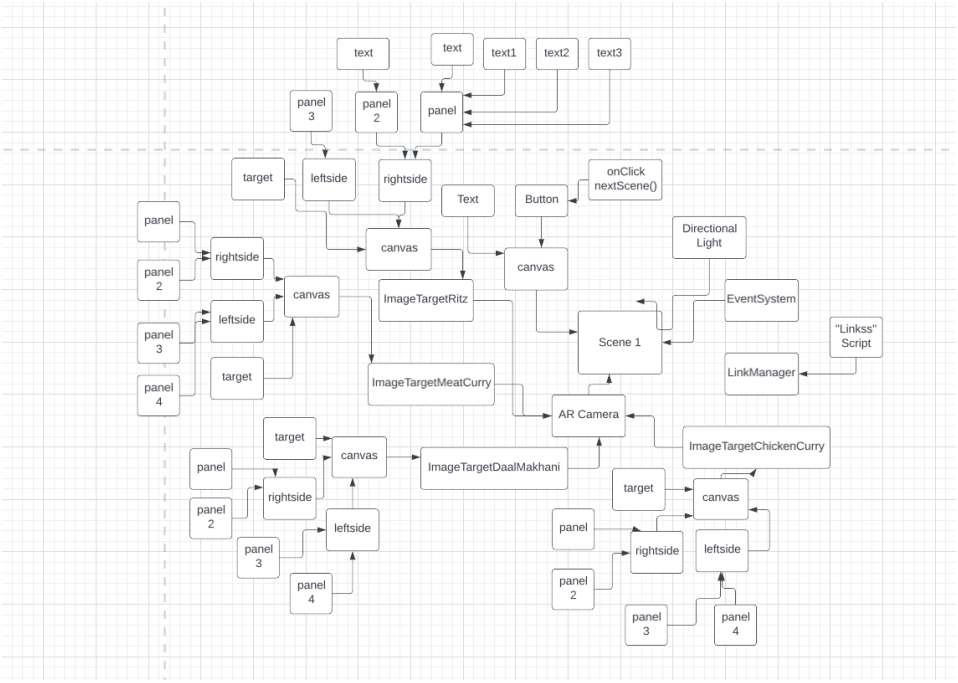


fig 3.2.2 second scene of AR application

The figure 3.2.2 shows the design representation of our application 2nd scene in unity editor. The hierarchy consists of main objects like AR Camera, Canvas, Directional Light, EventSystem, LinkManager etc. At first, AR Camera has 4 different image target attached to it called ImageTargetRitz, ImageTargetMeatCurry, ImageTargetDaalMakhani, ImageTargetChickenCurry . Similarly all the image targets has a canvas attached to it, where all the description of the products are written. All the description are separated into 4 different parts, i.e., canvas has 2 game objects in it which are rightside and leftside. 4 different descriptions of the product are given in 4 different panel where panel and panel2 are in rightside game object and panel3 and panel4 are in leftside game object. Panel and panel2 consist of text and quad, where quad is used to place an image there. Panel 3 also uses text and quads whereas panel4 uses text and buttons. The buttons called are youtubeimage and googleicon, which is responsible for opening YouTube and google links. A script is added to game object called LinkManager which is attached to those buttons. The script allows user to click the button and open the respective links. The main canvas in the hierarchy consists of button and a text. A script called “SceneChange” is added to canvas which is then loaded by the onClick event on button.

The third scene (Navigation):

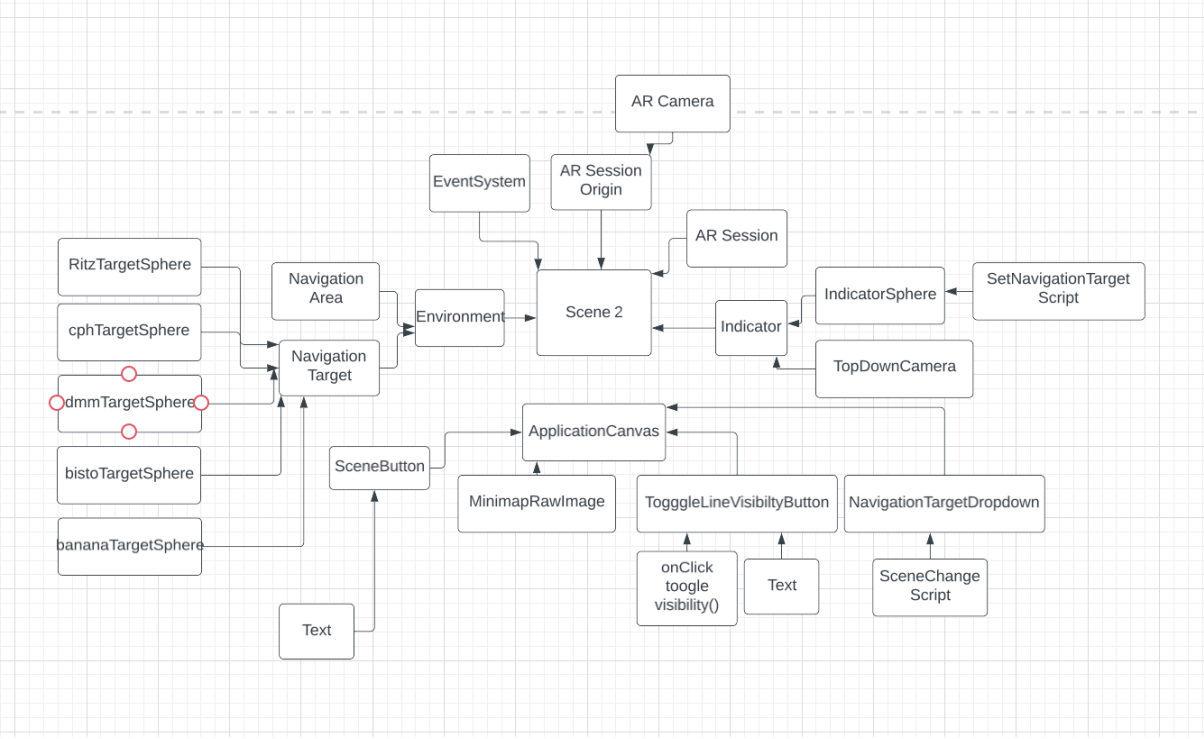


fig 3.2.3 third scene of AR application

The figure 3.2.3 shows the design representation of our application 3rd scene in unity editor. The hierarchy consists of main objects like AR Session Origin, AR Session, Indicator, ApplicationCanvas, Environment, EventSystem etc. An empty object called Indicator consist of 2 game objects. 1st is Indicator Sphere which has a script "SetNavigationTarget" added to it which is responsible to follow the target following navMesh lines. The indicator sphere is denoted as a user while using the application. Another object in the indicator is TopDownCamera which is responsible for showing the map in the application, where user can see in the map in which direction they are heading to. Similarly, ApplicationCanvas has a SceneButton, which is responsible to change scene and go back to main scene. It also consist of button called ToggleLineVisibilityButton, which is responsible to show the line renderer when we choose an product to navigate towards. On clicking the button toogle visibility() event occurs which lets the line to show on the map. The canvas also consist of a dropdown menu called NavigationTargetDropdown which consist of different types of product where user has the option to choose the product of their preferences they want to see the location.

4. IMPLEMENTATION

This section of the report describes about how the AR application was implemented following design phase. Following my Gantt chart, it took nearly 3 weeks to implement my application after my application. I used Unity, Vuforia Engine, Visual Studio Code, and a Vuforia object scanner to implement my application as it enables us to do the AR and 3d stuffs there. The version I used for my Unity was 2020.3.22f1 and for Vuforia engine I used version 9.8. All the scripts are written in C# language in visual studio code. As following my software requirements, I have made my implementation into different phases.

Setting up the application only for android

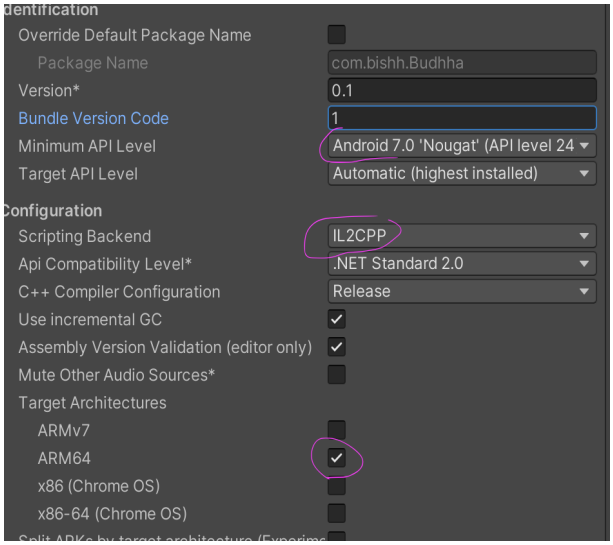


fig 4.1. player settings

At first, after opening my unity scene in build setting, I switched my platform to Android Devices. Then after going to the player setting, I changed my platform again to android. There should be some changes to be done in feature of the player for it to build properly so at first, I removed Vulkan component from Graphics APIs. Then I changed my minimum API Level to Android 7.0 'Nougat' and switched on the dynamic batching. Then the scripting backend was changed into IL2CPP and ARM64 target architecture was selected.

Starting scene menu

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class SceneChange : MonoBehaviour
{
    public void nextScene(){
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex + 1);

    }

    public void Back()
    {
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex - 1);
    }

    public void startScene(){
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex + 1);

    }
}
```

fig 4.2. SceneChange Script

By going to build settings again I chose my first scene to be displayed the "menu" scene. Then I added one canvas with sprite image which would act as an application background. Inside the canvas a start button was added to be as a medium to change scenes. A SceneChange script was written in order to change scene between scenes and was added in canvas. Then on button object I added an onClick function called startScene() which would change our scene into another scene if the button was clicked.

Create a scene again “Scan”

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class SceneChange : MonoBehaviour
{
    public void nextScene(){
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex + 1);

    }
```

fig 4.3 SceneChange Script

I created a new scene calling it Scan. This scene purpose was to display information about the product used as targets. Similar like in menu scene I added a button on a canvas to change the scene from one to another again. The SceneChange Script was added to the canvas and the onClick event was added on button with nextScene() functionality.

.

Adding image target and object target in scan scene

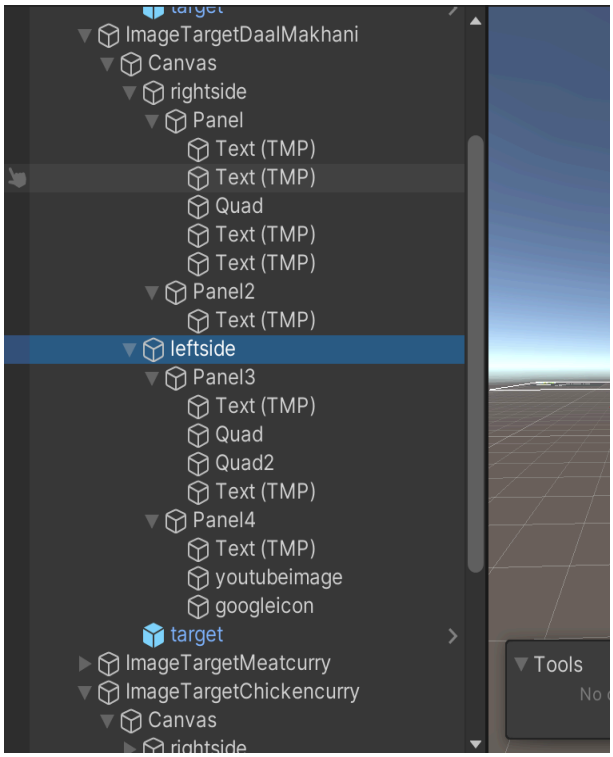


fig 4.4 ImageTargetDaalMakhani hierarchy

Since object target only works for Vuforia 9.8 archived version, I changed my version 10.6 into Vuforia 9.8 and added the licence key to it. I added four image targets through Vuforia engine. All the images were imported through the database I created in Vuforia official website. The image target was named as ImageTargetRitz, ImageTargetDaalMakhani, ImageTargetMeatcurry, ImageTargetChickencurry resp. All of the image targets had the canvas added to them with the rotation of x as 90 degrees for my canvas to be seen parallel to image target. I had an intension of having product detail box 2 in both sides, for that I created two empty game objects named " rightside " and " leftside " . Two panels named panel and panel 2 were added in rightside element whereas panel3 and panel4 was added in leftside element. All those panels were added text for item description, Quad to add small images and some button provided with links on them. Panel described about item name, price, ratings, ingredients and allergies. Panel2 described about the nutrient provided by the item. Panel3 showed product which were similar to the given product of different brands and different price, to let the user have option to choose similar type items in different prices. Panel4 was included in all image target except ImageTargetRitz. Panel4 provided the method to cook the product by providing YouTube links and Google links in form of buttons. For the links to open when clicked on button a script called "Linkss" was created. An empty game object was created again called LinkManager, where the script Linkss was linked into in. youtubeimage button added the onClick function to add openYoutube() function to it and googleicon button added the onClick function to add openGoogle() function to it. Not to forget I have also added a target pointer which look like its pointing the product, the target was imported from Unity Asset store.

After making the canvas ready, next step was to add animation in the panels to move it when our phone hovers in the image targets. From window, I added the animation tab where I recorded the animation by moving those panels left to right and right to left. All the animation were saved in animation folder in the asset. Then in all image targets on target found () and target is lost() is selected. Both rightside animator and leftside animator was used in both events but on target found () function play(int) was used whereas on target lost() function StopPlayback() was used. The animation will make the rightside game object to go right and leftside game object to go left.

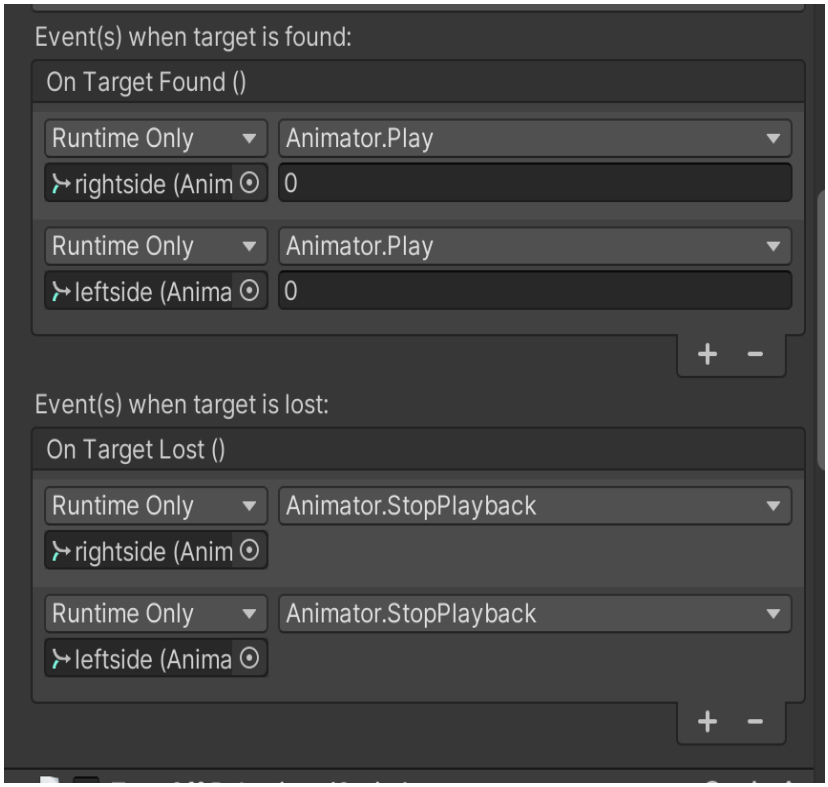


fig 4.5 An image target inspector using animator controller rightside and leftside on event On Target Found() and On Target Lost()

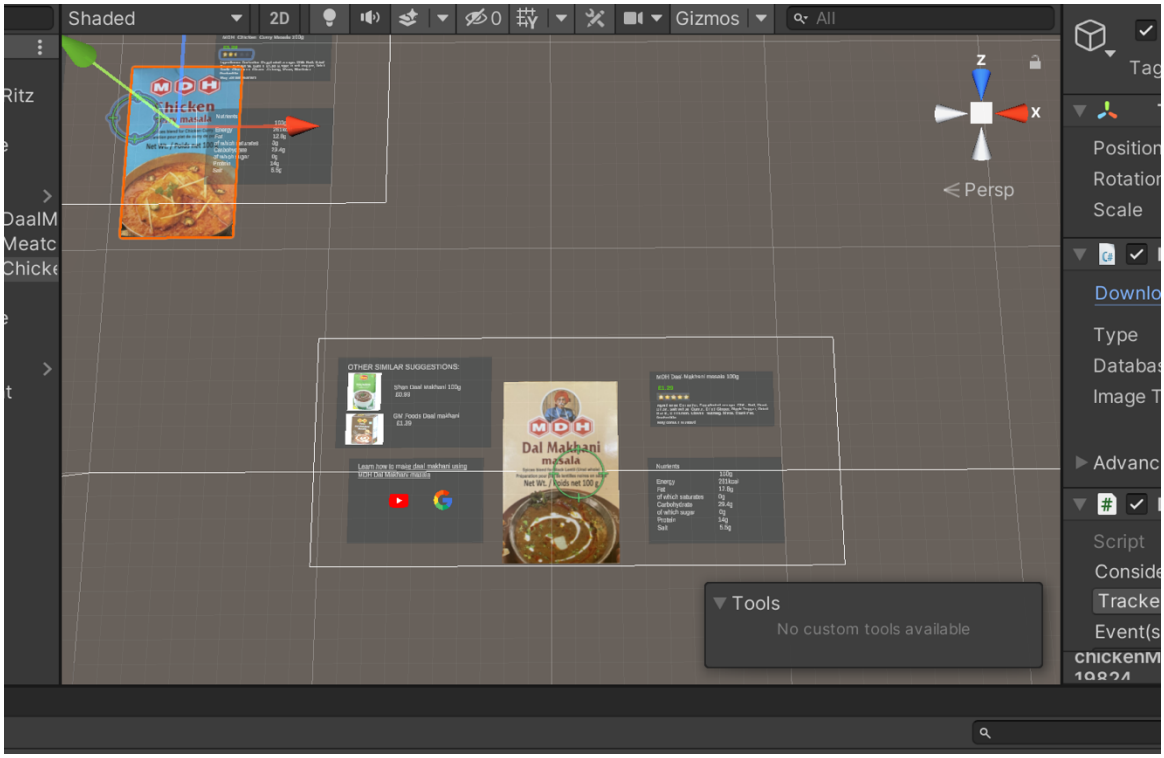


fig 4.6 Making canvas design for each image target.

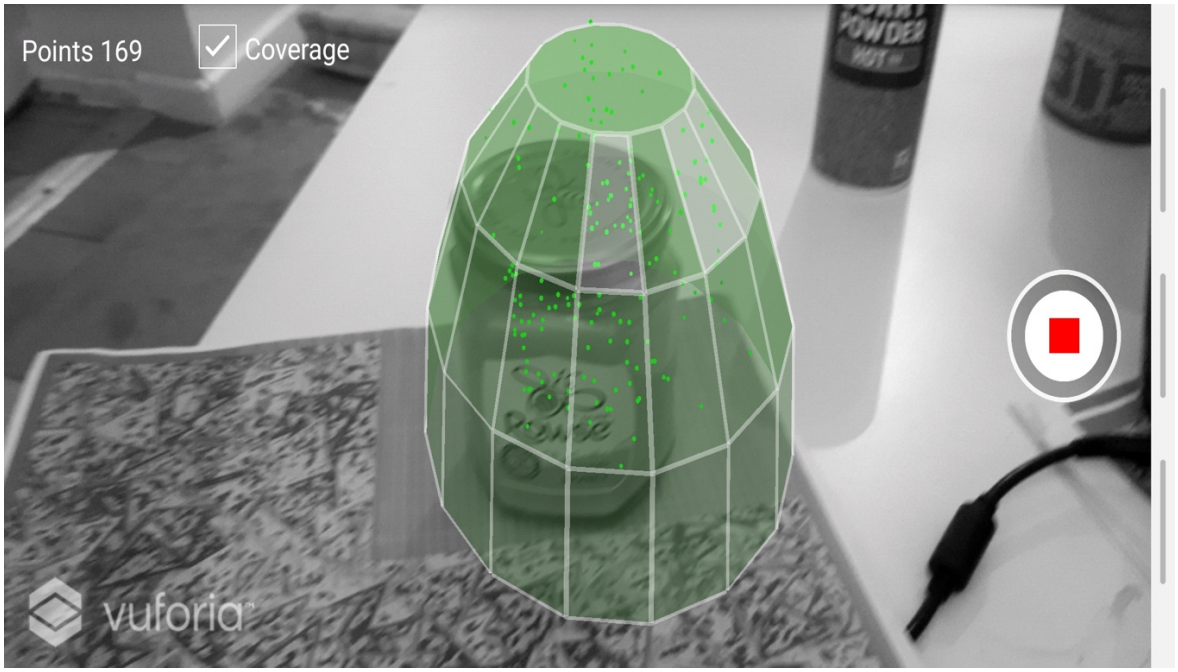


fig 4.7 Vuforia Object Scanner Application

For object target, I had to download Vuforia object scanner through Vuforia 9.8 archived version and transfer it to android device. On the scanner by placing the specific object(rowse honey container) on a barcoded background I scanned the object and got the 3d scan of it. After than the 3d scanned rowse.od file was imported back to my unity project. The scanned file was placed in object target and a sphere was associated with object target. For flat items I used image target but for 3d rigid different shaped items I used object target method.

Making new scene (navigation)

On “scan” scene I added a button and named it “navigate to products”, which on click leads to a new scene called navigate. At first, I downloaded ARCore from XR plu-in management and AR foundation from unity registry. Then I exported AR Session Origin and AR Session from XR game object. A sphere was called TargetSphere was added which would act as a target product when the user asks for location. A small map was made using cube for floor and walls and put in an empty object called NavigationArea. Separately on paint I made a rough drawing of the map of my house which later I imported and made it a material. The material was called floor and was added to the FloorCube. The reason I have taken my house map as example is because I could not go to an actual store to do it, so it just as reference showing map

similar to the store one. For the walls, I made another material named it wall and added a shader of occlusion and added that material floor to walls of the map which made them disappear. To look for items through navigation you need a starting point or an indicator, so I made an empty game object named Indicator and added a sphere named it IndicatorSphere. Now we needed to have a camera which could show the map of my house while running the application on the side. So, I added a camera inside Indicator and named it TopDownCamera and adjusted its position just above the map where it could see only the IndicatorSphere. A canvas called ApplicationCanvas was added to the scene. There in the canvas I added a button called ToggleLineVisibiltyButton which on click will run an event ToogleVisibility() and helps the user reach to its destination my showing him a path. The path in the map is shown by line renderer. On Indicator object I added the component line renderer, gave it a material line and changed its width to 0.1. Along with line renderer I added position constraint component and made it active. I had to make more 5 more targets so I changed the TargetSphere into RitzTargetSphere and added more 4 spheres and named them cphTargetSphere, dmmTargetSphere, bistoTargetSphere, bananaTargetSphere. All these 5 targets were placed into an empty object called NavigationTargets. Now both NaviagtionArea and NavigationTargets were placed inside a empty object called Environment. Similarly, a drop down box was added to ApplicationCanvas named NavigationTargetDropdown and was adjusted according to the canvas. On the dropbox, the option for dropboc were filled with names respective to the product name .

Now the script that was added to the indicator, before that I created a new script and named it Target. In the script I made a Target class and made is serializable which is everyone can few it in unity editor. In the SetNavigationTarget script Boolean variable lineToogle makes it possible for the line visibility when clicked the Button. At first the Start() function makes the line visibility invinsible because lineToggle are false. In the Update() method we check if the lineToggle is true and the current target position is not in the origin. If that happens we will calculate a path from our current transform to the target position on the NavMesh. The method SetCurrentNavigationTarget() takes the integer of selected value which is index, and resets the target position to Vector3.zero.

For the navigation part of my application I took some help from a YouTube channel which I have referenced below in my references[YouTube, F., 2022.].

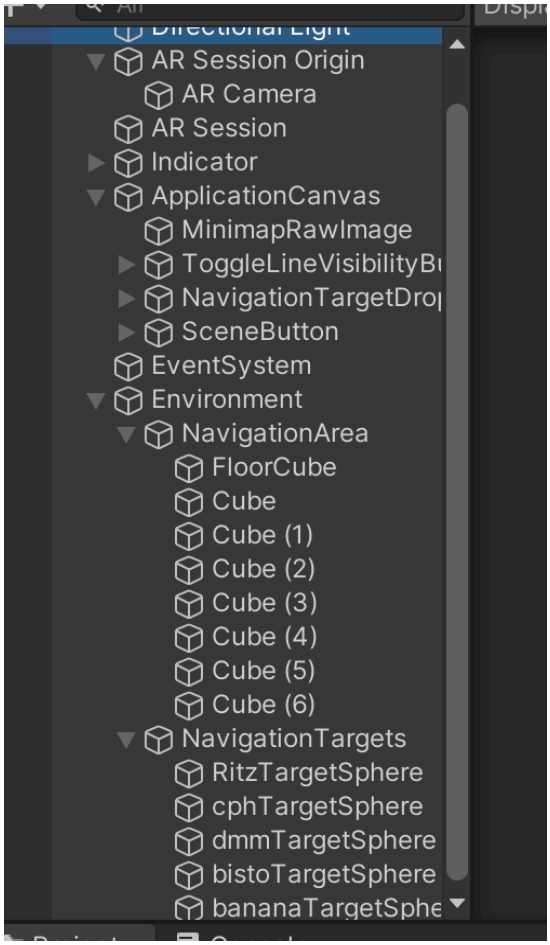


fig 4.8, Hierarchy of navigation scene.

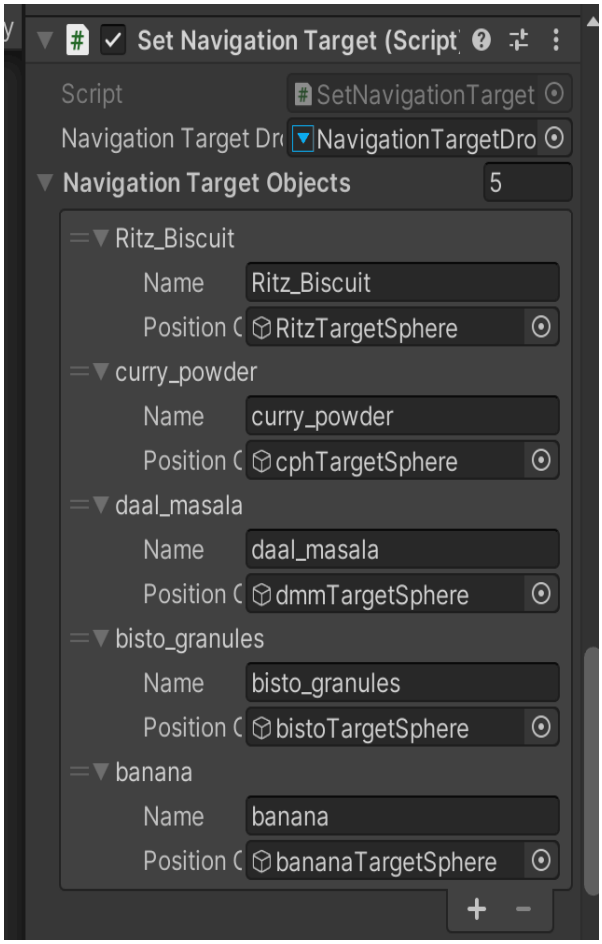


fig 4.9 Inspector of the Indicator.

```
private void Start() {
    path = new NavMeshPath();
    line = transform.GetComponent<LineRenderer>();
    line.enabled = lineToggle;
}

private void Update() {
    if (lineToggle && targetPosition != Vector3.zero) {
        NavMesh.CalculatePath(transform.position, targetPosition, NavMesh.AllAreas, path);
        line.positionCount = path.corners.Length;
        line.SetPositions(path.corners);
    }
}

public void SetCurrentNavigationTarget(int selectedValue) {
    targetPosition = Vector3.zero;
    string selectedText = navigationTargetDropDown.options[selectedValue].text;
    Target currentTarget = navigationTargetObjects.Find(x => x.Name.ToLower().Equals(selectedText.ToLowe
    if (currentTarget != null) {
        targetPosition = currentTarget.PositionObject.transform.position;
    }
}

public void ToogleVisibility() {
    lineToggle = !lineToggle;
    line.enabled = lineToggle;
}
```

fig 4.10 SetNavigationTarget Script

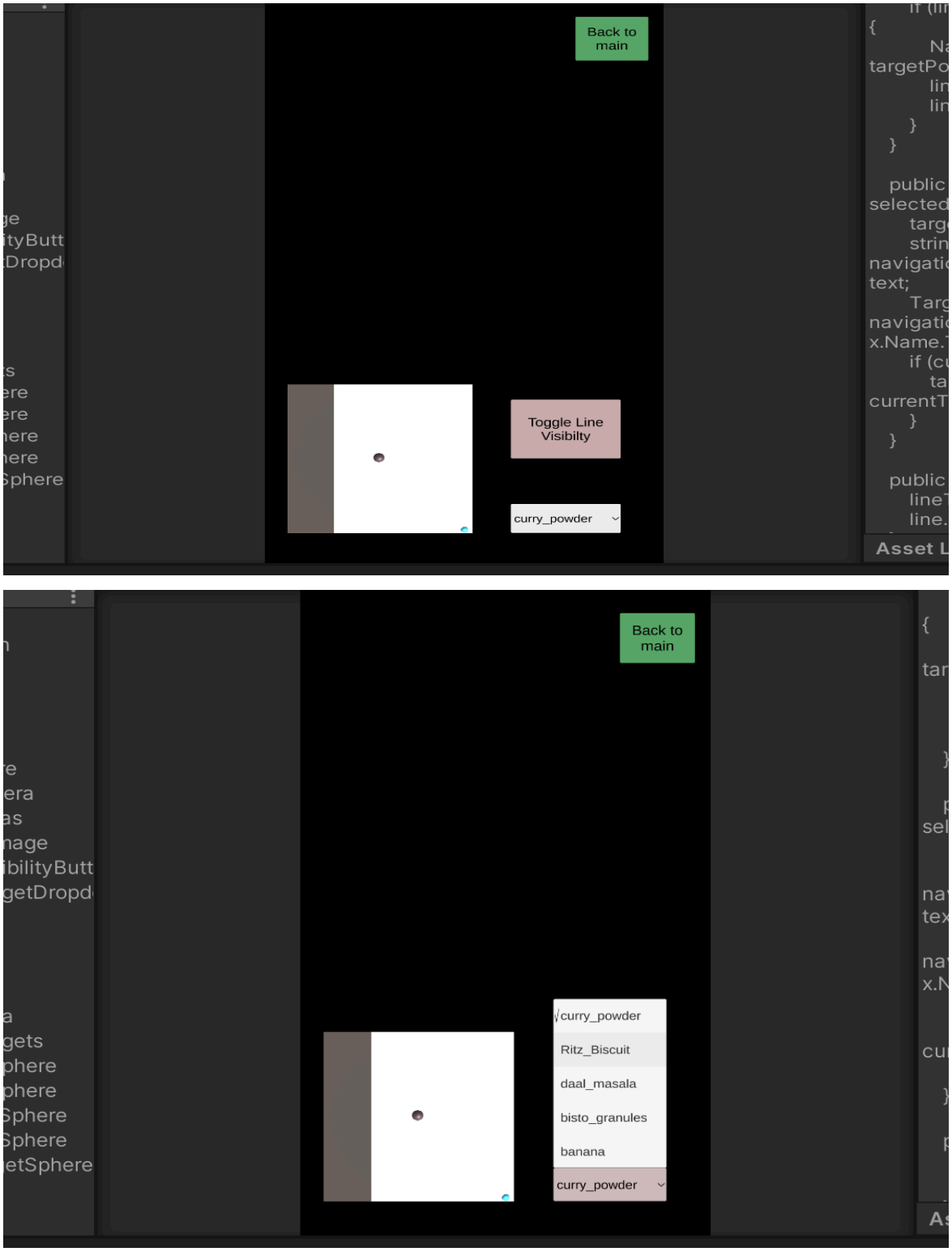
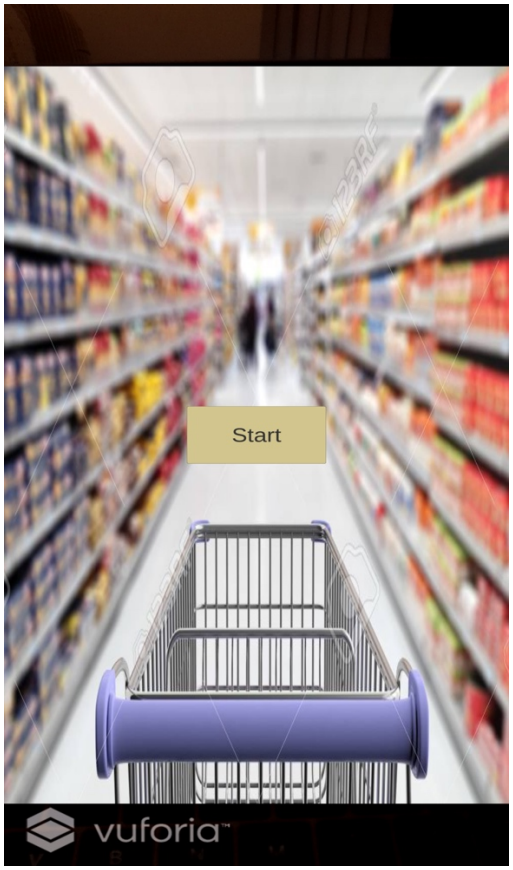


fig.4.11 Play mode view of the navigation scene on Game tab.

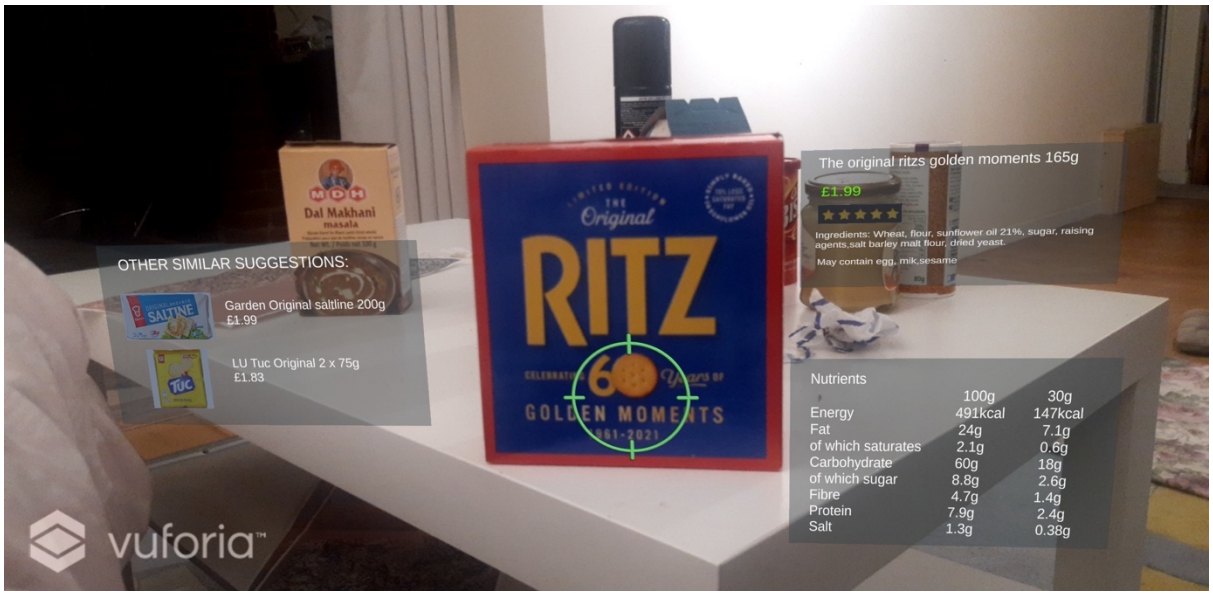
DEMONSTRATION


Start
vuforia™

1.


Navigate to products
Hover on products to see details
OTHER SIMILAR SUGGESTIONS:
Shan Daal Makhani 100g
£0.99
GM Foods Daal makhani
£1.39
Learn how to make daal makhani using MDH Dal Makhani masala
MDH Daal Makhani masala 100g
Nutrients
Energy 261kcal
Fat 12.8g
of which saturates 0g
Carbohydrate 29.4g
of which sugar 0g
Protein 14g
Salt 5.5g
MDH
Dal Makhani masala
Net Wt. / Poids net 100 g
vuforia™

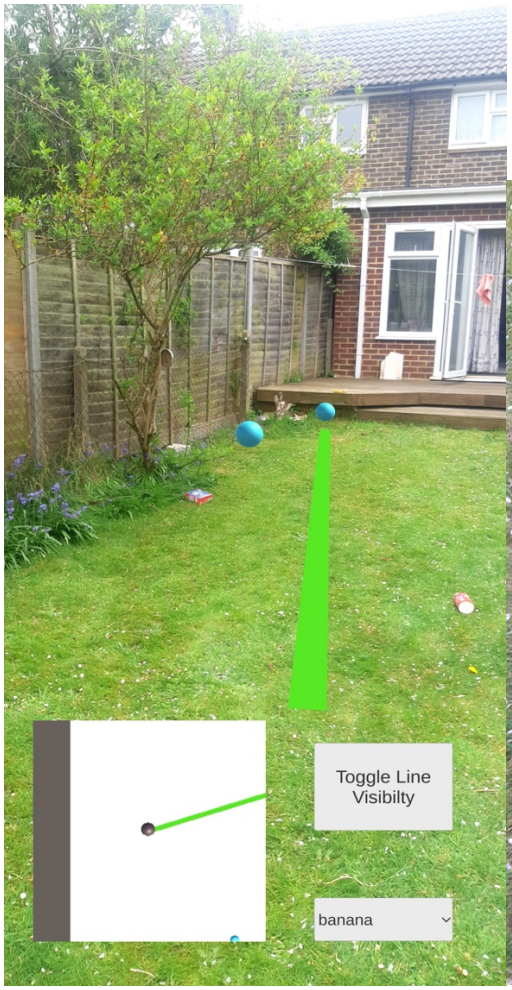
2.

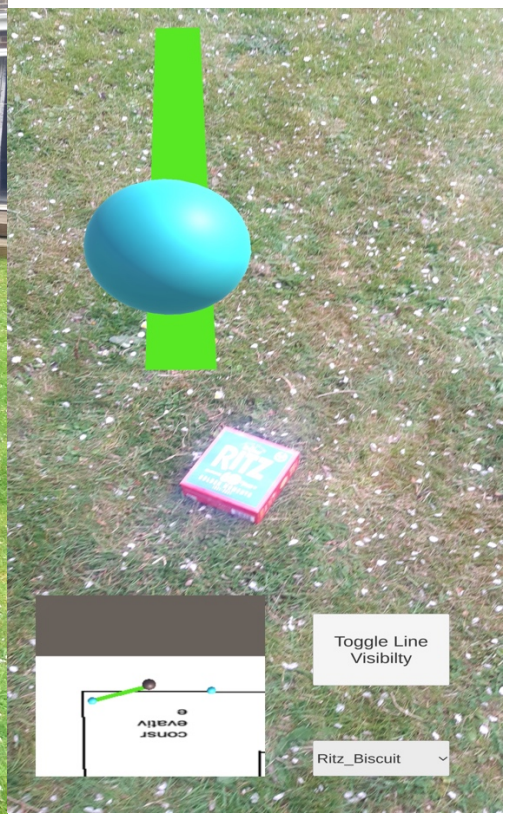

OTHER SIMILAR SUGGESTIONS:
Garden Original saltline 200g
£1.99
LU Tuc Original 2 x 75g
£1.83
MDH
Dal Makhani masala
THE Original RITZ
GOLDEN MOMENTS
1941-2021
The original ritzs golden moments 165g
£1.99
Ingredients: Wheat, flour, sunflower oil 21%, sugar, raising agents,salt barley malt flour, dried yeast.
May contain egg, milk,sesame
Nutrients
100g 30g
Energy 491kcal 147kcal
Fat 24g 7.1g
of which saturates 2.1g 0.6g
Carbohydrate 60g 18g
of which sugar 8.8g 2.6g
Fibre 4.7g 1.4g
Protein 7.9g 2.4g
Salt 1.3g 0.38g
vuforia™

3.


Navigate to products
MDH
Chicken
curry masala
MDH
Meat
curry masala
MILAR SUGGESTIONS:
MDH Chicken Curry masala100g
£1.29
Shan Meat Masala
£0.89
vuforia

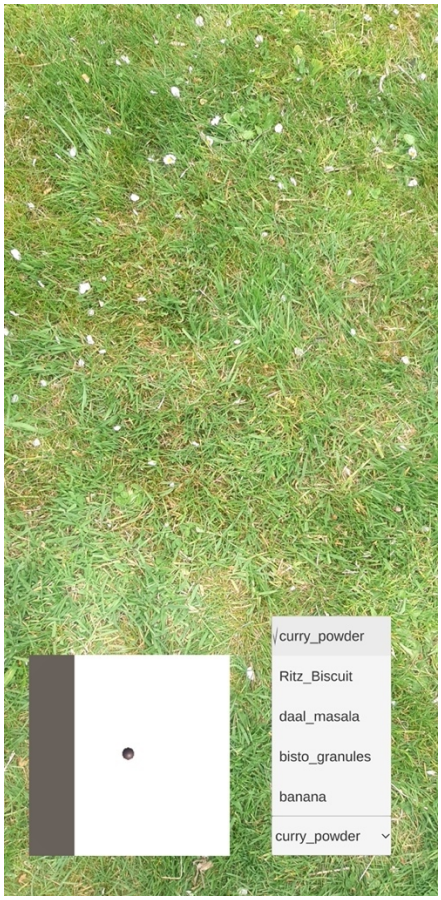
4.


Toggle Line Visibilty
banana


Toggle Line Visibilty
Ritz_Biscuit

.

5.


curry_powder
Ritz_Biscuit
daal_masala
bisto_granules
banana
curry_powder

5.TESTING AND EVALUATION

I will be conducting testing and evaluation in two separate parts. At first, I will be testing my AR application in order see if the application meets the requirements which were mentioned before. Then I will do the evaluation of the application to see how much goal it has met.

5.1 TESTING

There are many different types of methods to do a software testing, the method I am using to test my application is Black Box Testing or also known as behavioural testing. I chose it as my testing method because this testing is conducted based on software requirements and specifications.

Test	Description	Expected Result	Achieved Result
1	Click on “start” button on menu scene	A new scene “scan” should open	New scene “scan” opens
2	After changing into a new scene.	The “scan” scene should have a button and a text message for user.	The “scan” scene has a button and a text message for user.
3	When hovering around image target.	The application should show a canvas with product description over the product when hovered over it through the phone screen	The application shows a canvas with product description over the product when hovered over it through the phone screen.
4	When hovering around object target.	The application should show a canvas with product description over the product when	The application does not show a canvas with product description over the

		hovered over it through the phone screen	product when hovered around it. The object target is not working.
5	Hovering between different products.	Each product should have own different description about the product, price and ratings displayed when the user hovers between them.	Each product has their own different description about the product, price and ratings displayed when the user hovers between them.
6	Click the “YouTube” button and “Google” button	On clicking the YouTube button, it should open a YouTube video and on clicking the Google button it should open a website link.	On clicking the YouTube button it opens a YouTube video and on clicking the Google button it opens a website link.
7	Moving away the phone from the targets.	The application should only show a button and text when keeping away the phone from the target.	The application only shows a button and text when keeping away the phone from the target.
8.	Click the “Navigate to products” buttons	The application should change scene from “scan “to “navigate”	The application changes scene from “scan “to “navigate”
9.	After changing into “navigate” scene	The application should show a map with the user in it, toggle button and a dropdown box.	The application shows a map with the user in it, toggle button and a dropdown box.

10.	Click the dropdown arrow in drop box.	The dropdown button should show 5 options to choose when the arrow is clicked.	The dropdown button shows 5 options to choose when the arrow is clicked.
11.	Click the “daal_masala” option in drop down box.	The main drop drown should change from “ritz_biscuit” to “daal_masala”.	The main drop drown changes from “ritz_biscuit” to “daal_masala”.
12.	Click the “toggle visibility button"	A green line should appear which makes a path towards the product daal masala	A green line appears which makes a path towards the product daal masala, but it is not totally sharp and clear. Sometimes the lines are cut to half or starts lagging.
13.	Click the “toggle visbility button” again	The green navigation path line should disappear.	The green navigation path line disappears.
14.	Try to move from one place to another	The map shown should include indicator representing the user and move along with it.	The map shown includes indicator representing the user and move along with it.
15.	Click “Back to main” button	The scene should change from “navigation” to “scan”	The scene changes from “navigation” to “scan”

5.2 EVALUATION

General Evaluation

The main purpose of this project research was to create an application which uses Augmented Reality features and is used for shopping grocery foods which helps user to be more interactive with the product and make their shopping experience fast and reliable. The final developed application fulfils most of the product requirement from the project proposal and literature Review. Still, some of the requirements like having a login and signup before the start of the application could not happen. I believe my application is quite stable and works smoothly. All the buttons and scripts work perfectly except the navigation line renderer. For example, if I test the navigation functionality any other places than my house the navigation will start to lag and deviate. Because the navigation works according to the map, and I have given my house map the navigation functionality might not work in other places. After my research finishes, I will still try to fix this issue to make my app better.

To carry out the evaluation a research study was conducted where human participation was involved. The ethical research form was accepted by our university committee. In the study the participants had to use the application system and fill the online questionnaire form after using it. The survey was created using Qualtrics and send to the participants through the invitation. For the evaluation of the data, I will be using System Usability Scale (SUS). System Usability Scale is the easiest method to get the clear judgment about the usability of software.

Here is the given questionnaire for our software evaluation with its results.

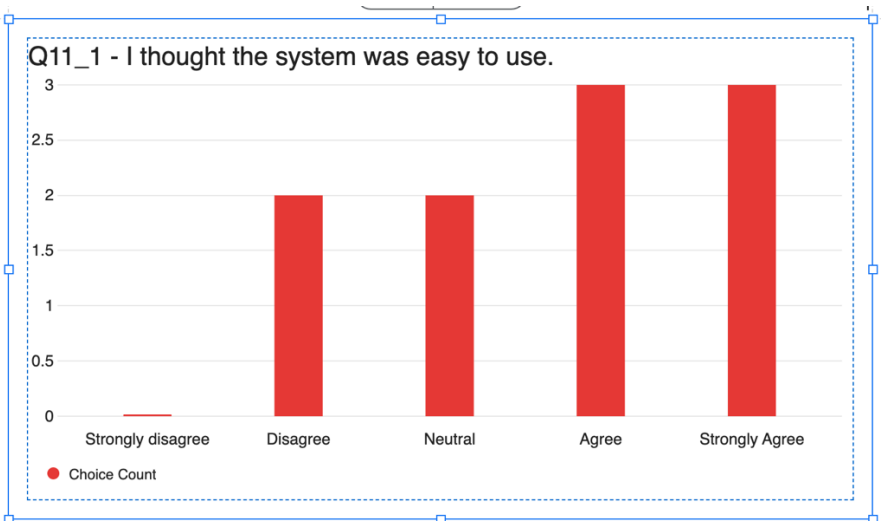


fig 5.2.1

In figure 5.2.1, according to the question 1 survey 20% of the participants chose Disagree, 20% of the other chose neutral, 30 % of them chose Agree and remaining 30% chose strongly Agree. Thus, the majority of the participants have chosen the system to be easy.

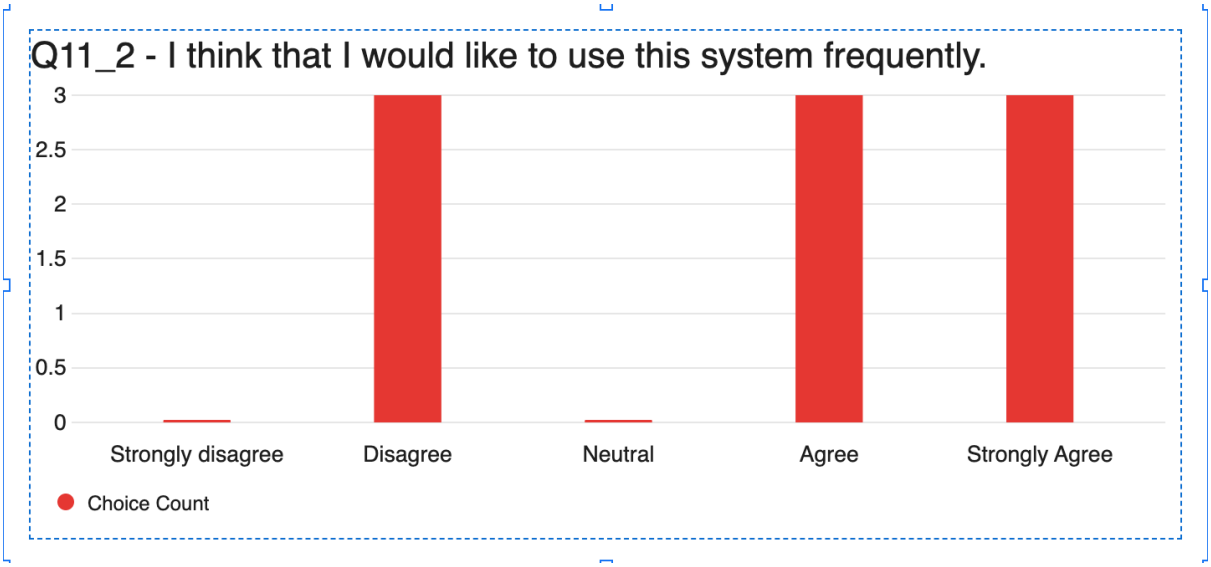


fig 5.2.2

In figure 5.2.2, according to the question 2 survey 33.33% of the participants chose Disagree, other 33.33% chose Agree and the remaining 33.33% of the participants chose Strongly Agree. Thus, it shows that majority of the participant would like to use this system frequently in future.

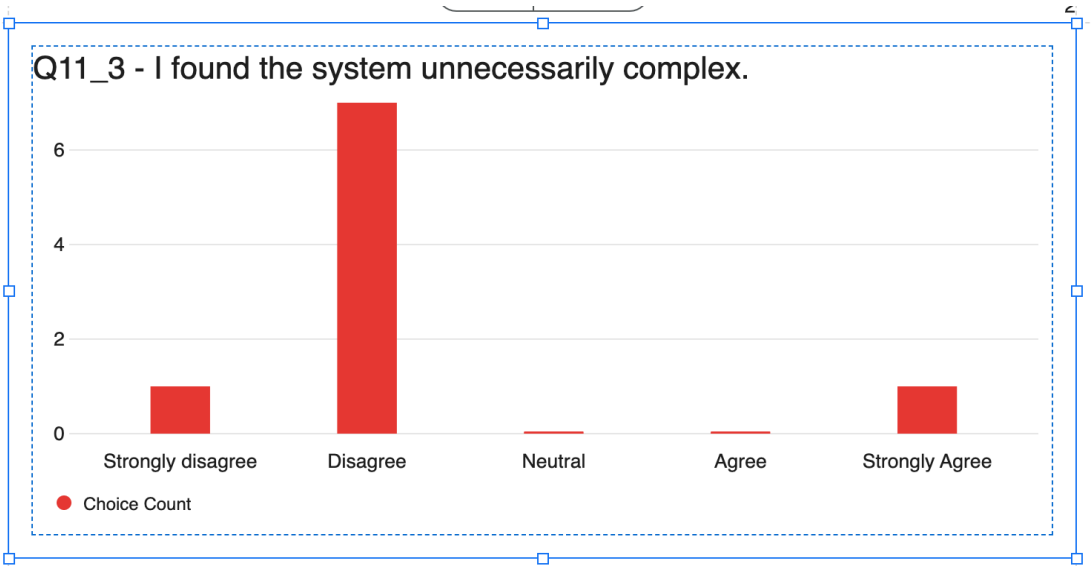


fig 5.2.3

In figure 5.2.3, according to the question 3 survey, 11.11% of the participant chose Strongly Disagree, other 11.11% of participant chose Strongly Agree, and the remaining 77.78% people chose Disagree which means majority of the participant didn't found the system complex and hard to use.

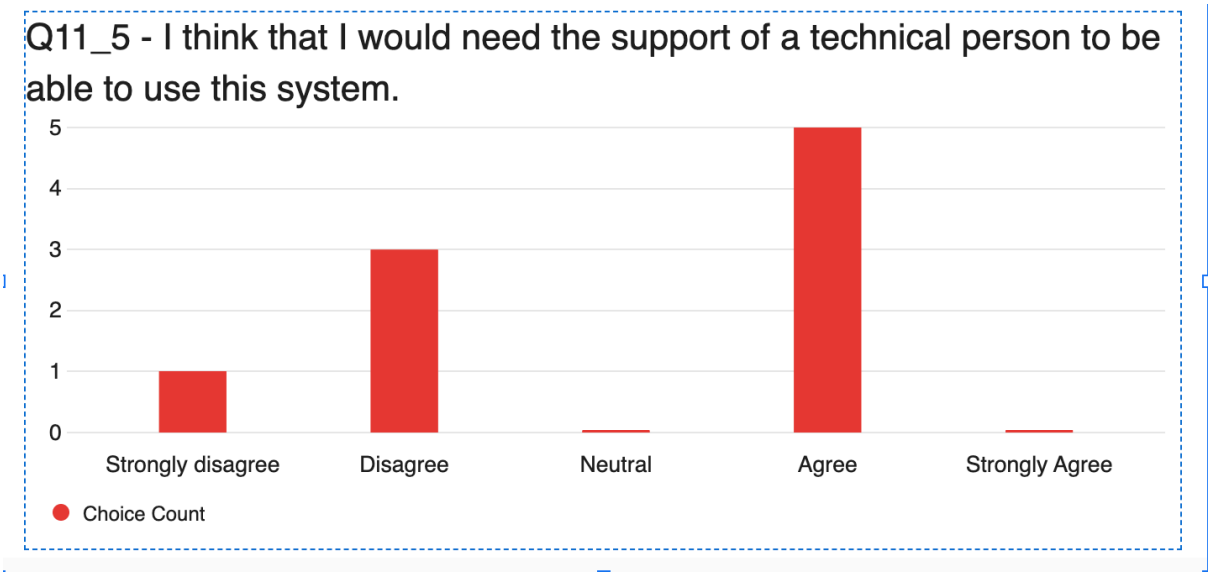


fig 5.2.4

In figure 5.2.4, according to the question 4 survey, 11.11% of the participants chose strongly disagree, 33.33% of the participants chose Disagree and remaining 55.56% chose to agree as their answer. These results might show most of them needed someone to teach them how to use the application.

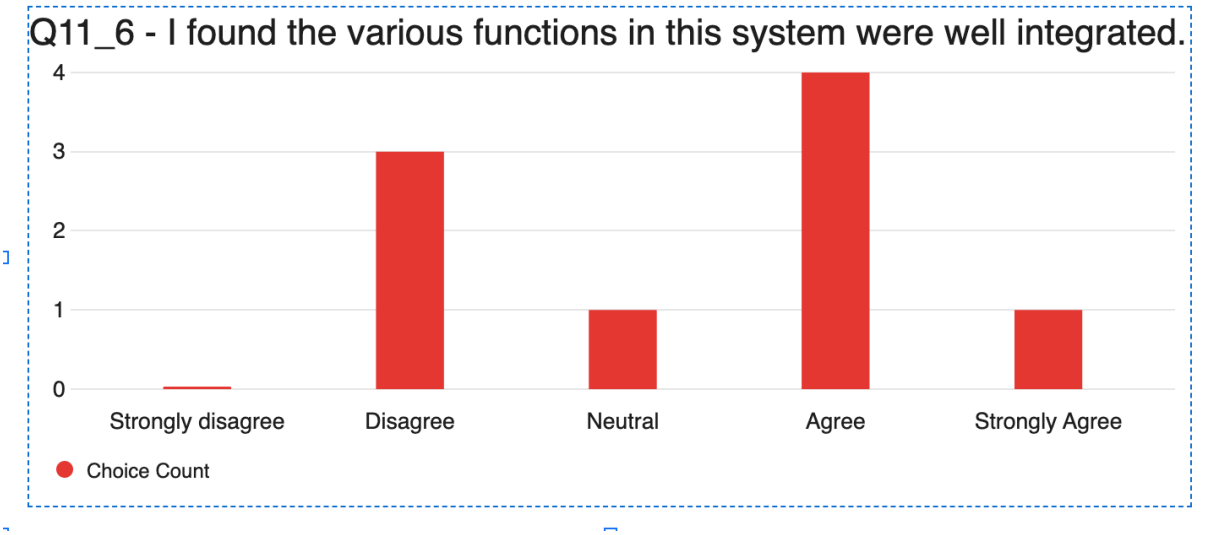


fig 5.2.5

In figure 5.2.5, according to the question 5 survey, 33.33% of the participants chose to disagree, 11.11% of them chose neutral, 44.44% of them chose Agree and remaining 11.11% of them chose strongly agree. Even though majority of the people found the system well integrated there is just little gap with disagree people that means still many participants does not believe the functions on the system were well integrated.

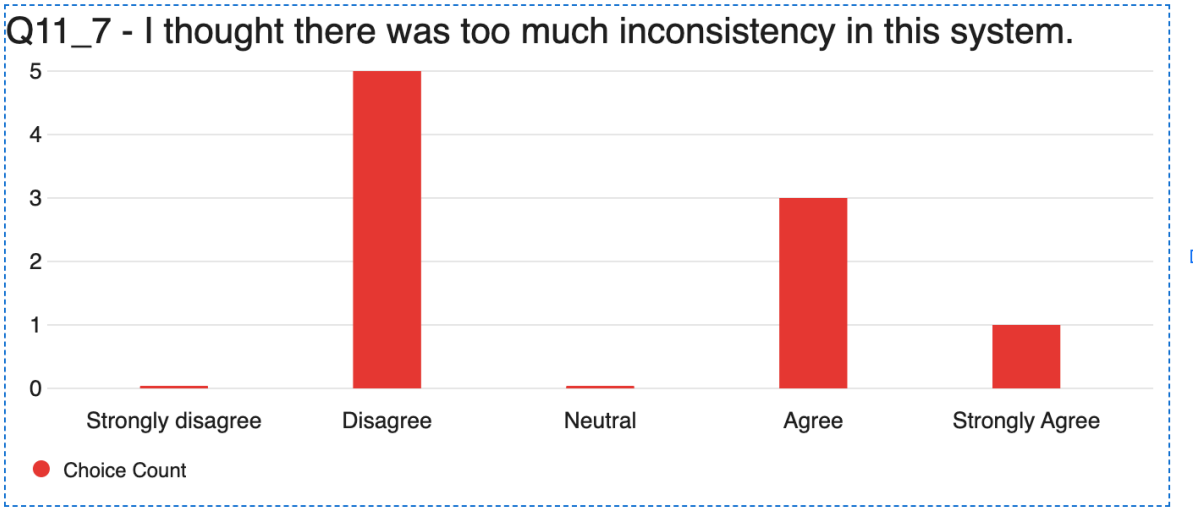


fig 5.2.6

In figure 5.2.6 according to the question 6 survey, 55.56% of the participants chose Disagree, 33.33% of them chose Agree and remaining 11.11% of them chose Strongly Agree. Thus, the given data shows that majority of the participant believes that the application is very consistence.

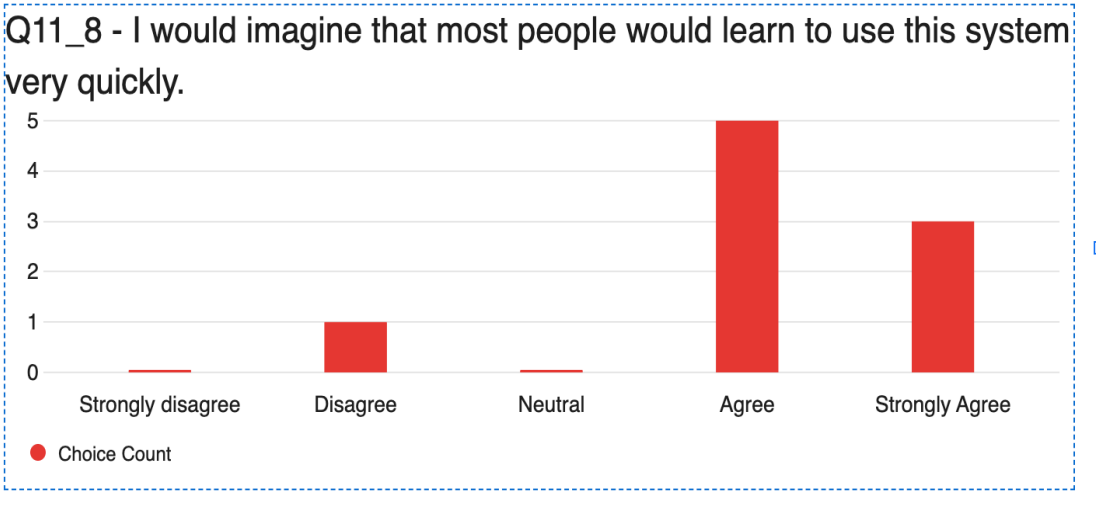


fig 5.2.7

In figure 5.2.7, according to question 7 survey, 11.11% of the participant chose Disagree, 55.56% of them chose Agree and remaining 33.33% of them chose Strongly Agree. The given data shows that many participants believe that most of the people could learn using the application very quickly.

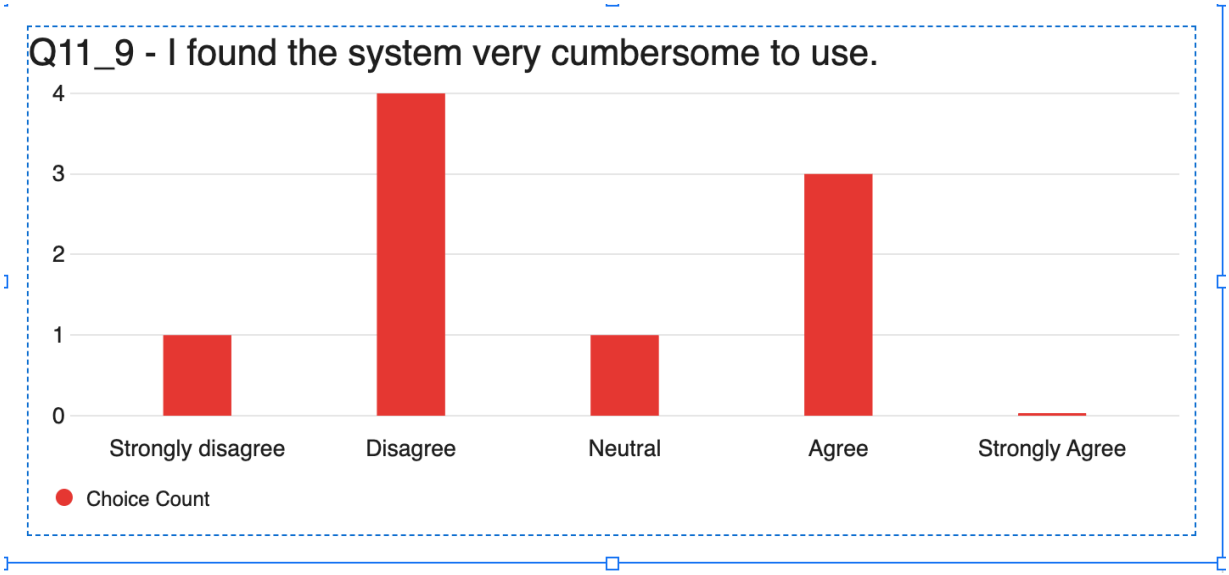
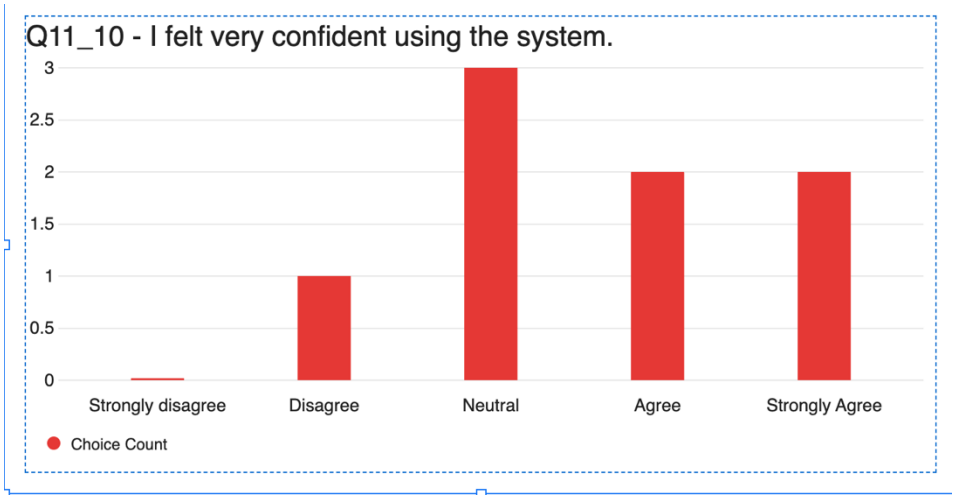


fig 5.2.8

In figure 5.2.8, according to question 8 survey, 11.11% of the participants chose Strongly Disagree, 44.44% of them chose Disagree, 11.11% of them chose Neutral and remaining 33.33% of them chose Agree. Even though majority of the data shows that the participants disagree on this but still 33.33% people still think the application was cumbersome to use.



fig, 5.2.9 according to question 9 survey, 12.50% of the participants chose Disagree, 37.50% of them chose Neutral, 25% of them Agree and remaining 25% Strongly Agree. Thus, this data shows that majority of the people were confused with themselves if they were confident using the system or not.

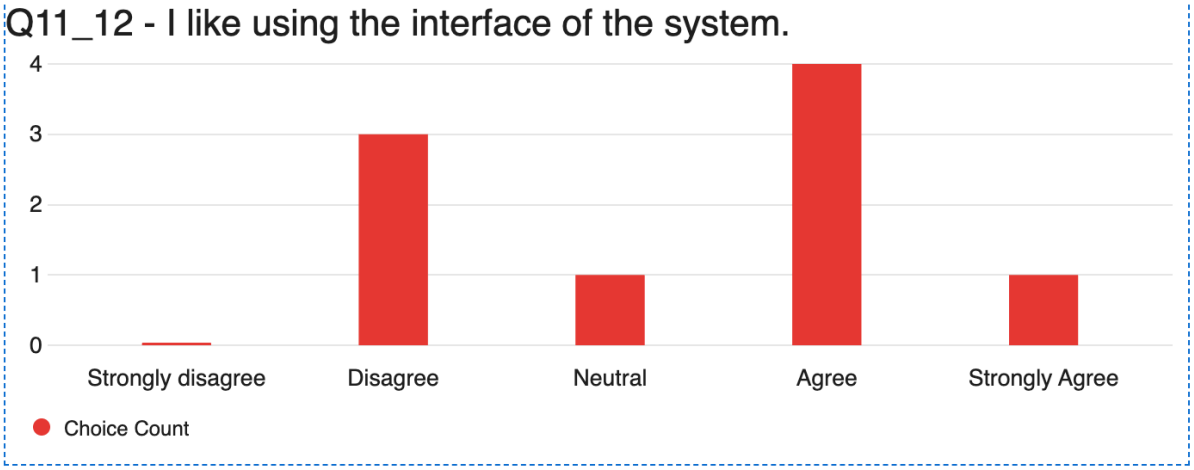
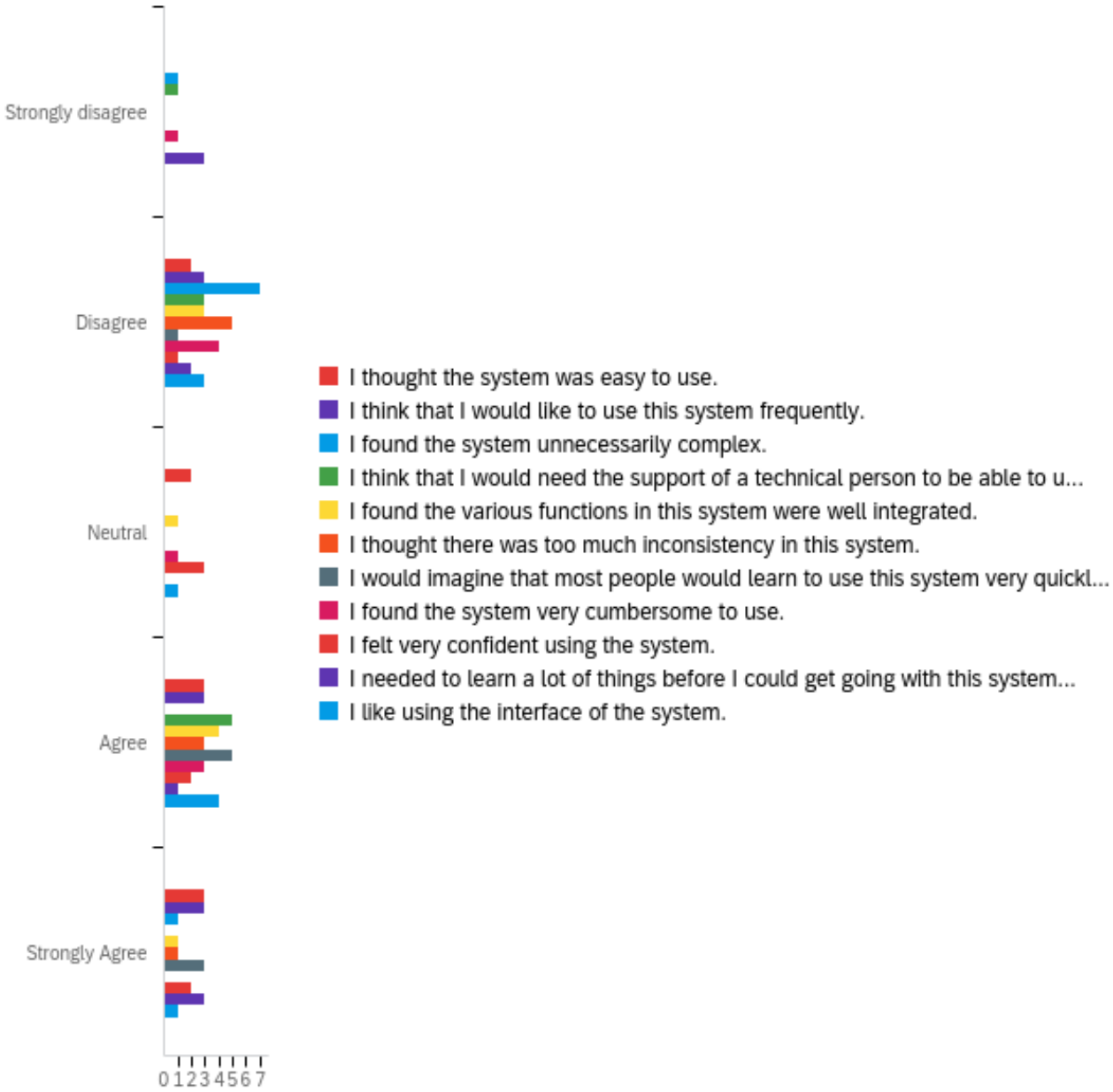


fig 5.2.10 according to question 10 survey, 33.33% of the participants chose Disagree, 11.11% of them chose neutral, 44.44% of them chose Agree and 11.11% of the remaining chose Strongly Agree. Thus, the collected data shows that majority of the people liked using the interface of the system.

Survey

Ethics



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I thought the system was easy to use.	2.00	5.00	3.70	1.10	1.21	10
2	I think that I would like to use this system frequently.	2.00	5.00	3.67	1.25	1.56	9

3	I found the system unnecessarily complex.	1.00	5.00	2.22	1.03	1.06	9
4	I think that I would need the support of a technical person to be able to use this system.	1.00	4.00	3.00	1.15	1.33	9
5	I found the various functions in this system were well integrated.	2.00	5.00	3.33	1.05	1.11	9
6	I thought there was too much inconsistency in this system.	2.00	5.00	3.00	1.15	1.33	9
7	I would imagine that most people would learn to use this system very quickly.	2.00	5.00	4.11	0.87	0.77	9
8	I found the system very cumbersome to use.	1.00	4.00	2.67	1.05	1.11	9
9	I felt very confident using the system.	2.00	5.00	3.63	0.99	0.98	8
10	I needed to learn a lot of things before I could get going with this system.	1.00	5.00	2.89	1.73	2.99	9
11	I like using the interface of the system.	2.00	5.00	3.33	1.05	1.11	9

#	Question	Strongly disagree		Disagree		Neutral		Agree		Strongly Agree		Total
1	I thought the system was easy to use.	0.00%	0	20.00%	2	20.00%	2	30.00%	3	30.00%	3	10
2	I think that I would like to use this	0.00%	0	33.33%	3	0.00%	0	33.33%	3	33.33%	3	9

	system frequently.										
3	I found the system unnecessarily complex.	11.11%	1	77.78%	7	0.00%	0	0.00%	0	11.11%	1	9
4	I think that I would need the support of a technical person to be able to use this system.	11.11%	1	33.33%	3	0.00%	0	55.56%	5	0.00%	0	9
5	I found the various functions in this system were well integrated.	0.00%	0	33.33%	3	11.11%	1	44.44%	4	11.11%	1	9
6	I thought there was too much inconsistency in this system.	0.00%	0	55.56%	5	0.00%	0	33.33%	3	11.11%	1	9
7	I would imagine that most people would learn to use this system very quickly.	0.00%	0	11.11%	1	0.00%	0	55.56%	5	33.33%	3	9
8	I found the system very cumbersome to use.	11.11%	1	44.44%	4	11.11%	1	33.33%	3	0.00%	0	9
9	I felt very confident	0.00%	0	12.50%	1	37.50%	3	25.00%	2	25.00%	2	8

	using the system.											
10	I needed to learn a lot of things before I could get going with this system.	33.33%	3	22.22%	2	0.00%	0	11.11%	1	33.33%	3	9
11	I like using the interface of the system.	0.00%	0	33.33%	3	11.11%	1	44.44%	4	11.11%	1	9

6.CONCLUSION

In this section I will give my judgements on the application developed met the requirement and specification of the research or not. The main reason to do research and develop an AR application was to show how augmented could be used in our daily lives and make it easier. Taking that in reference I took an initiation to do on research called implementation of augmented reality in grocery stores. At the beginning of the project the main requirement of the project was to develop an AR based application, could be used by the customers in grocery store, have a navigation feature in the application to locate the product places and show the product description through augmented reality. Now the application has been full developed by testing and evaluating it I can proudly say that the application has met up most of the requirement and specification which was at the beginning of the project. Even through function like navigation work properly I am still a bit unsatisfied about what my navigation can do. My current developed application can navigate the specific target only under some circumstances. Since my house layout map is used in the unity editor, the navigation can only conduct which has same layout as mine. That means my navigation feature is constricted in a house map design which makes us not be able to demonstrate how the feature works. After completion of the research also I would like to work in the navigation feature to make it better and successfully working.

6.USER GUIDE

1. “Buddha.zip” file contains the unity file which is supposed to be deployed in an android device for it to function.
2. The first will have a button called start. You need to click on the button to start your Augmented Reality Experience.
3. After opening new scene, the back phone camera will be turned on with some UI in the screens. There will a button on left top corner written navigate to products which on click will open another Augmented Reality Scene.
4. You have read the description written on the scene i.e., to hover on the respected products. We can’t just hover in any random products. It has to be the product who are set as image target or object target in the unity. If you want to print out the item picture, I have put all the images of the targeted item in texture folder in asset.
5. To try using navigation feature, you have to click the button called navigate to products which will open a new scene for you.
6. On navigation scene you will see a map in bottom left corner, a drop-down box to select the product and a toggle button.
7. First to start the route you need to choose an item from the drop box and click the toggle visibility button there. After clicking just turn around and hover around your surroundings, then you will see a green navigation line which will take you to the location of chose item. for navigation as well you can’t just hover anywhere, the navigation should be demonstrated on the area where the map design was created in unity. Therefore, I can only show the navigation feature only from my house.
8. There is a button called “back to main” which allows the user go back to previous AR scan mode.

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