Project Deliverable K:
User and Product Manual

GNG 1103 - Winter 2021
Faculty of Engineering - University of Ottawa

uOttawa

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1 Introduction

In the final stages of the design process and after completion of the final product of the GreenAR World recycling application. At the beginning of our project, we identified the misplacement of waste into the correct bins, resulting in inefficient recycling and overflow of landfills. Though most waste products are correctly disposed, there remains a fraction of products that are unclear which disposal category they fall under. This leads to cross contamination of garbage and recycled products ending up in the incorrect facility. A need exists for mobile users to have a proper recycling identification application that can be used to detect whether the identified item is recyclable or not in a simple and efficient manner. Our application was created in Unity and incorporates Vuforia toolbox.

In this user and product manual, we will be discussing how our final product operates, each subsystem, set-up and user access considerations, system organization and navigation, exiting the system, troubleshooting and support, and product documentation. The purpose of this document is to inform anyone who wishes to recreate our product such as classmates, professors, or clients. This document will give background knowledge and key components that were used in the development of our application. Troubleshooting and support will consist of error messages, special considerations, maintenance, and support. The product documentation is composed of discussions regarding the bill of materials, equipment list, and instructions for each subsystems. The C# scripts that were implemented in our subsystems will also be examined.

2 Overview

Upwards of 25% of the waste put in recycling bins is also rendered non-recyclable by food contaminants or other materials [1]. Misplacement of waste into the incorrect bins results in inefficient recycling and overflow of landfills. Many Canadians are throwing a significant amount of garbage into the incorrect bins often out of laziness, ignorance, or the lack of knowledge [2].

A need exists for the general public to develop better recycling habits in a simple and intuitive way. This can be done by creating an AR based application that provides clear and proper recycling instructions. This solution must be cost effective and follow the proper regulations according to the City of Ottawa. We also made the application free to users. Otherwise, our market is significantly decreased and that would fail the purposes of the app. To motivate use of the application, we have implemented a recycling points system where competition with other app users is possible. There are approximately 31.4 million smartphone users in Canada, so it is safe to say that there is a clear market for providing correct recycling habits nationwide [3]. Canada alone produces approximately 4.6 million metric tonnes of plastic waste each year and only 9% gets properly recycled [4]. We can slowly try to solve this issue with something as

simple as a mobile application. The more application users we have, the more potential decrease in improper recycling and overflow of landfill wastes.

When the words “recycling application” is searched in the app store on a mobile device, there are 3 categories of applications. There are collection day applications that are city specific such as Recycle BC. These applications show when what collection day is and sends a reminder to the user. Other applications such as iRecycle are applications that just show helpful and interesting information about recycling. Finally, there are recycle destination applications such as 1800Recycling.com. These applications work on a geo map system where it tells the user what location a recycle can be made for specific items. All of these categories of applications are features that we have or are planning to add to our application. Having all of these features within one application would be convenient and helpful to any user.

Our product differentiates from other competitors in the market because first, there is no recycling application that we were able to find that scans and sorts waste items through AR technology. Second, we have a rewards system that will motivate application use where users are able to compete with family, friends, co-workers, and more. A rewards system is currently non existent in other recycling applications like ours. Finally, the information we provide for our application comes from the Government of Canada website so it is accurate, reliable and helpful.

In the future if given the opportunity, we would like to start by collaborating with the City of Ottawa recycle management. We can then develop the application with the resources they have and test the compatibility with the city. Another feature we would like to try and offer is having multiple language settings. Since Canada is such a diverse and multicultural country, it would be nice if the new residents in Canada can learn to have proper recycling habits as well. With enough budget or collaboration, we would like the application to offer users with physical prize incentives. This will promote the use of the application and the city may experience an impact that application is making. Finally, it would also be nice to be able to program GreenAR World to not only be compatible with Ottawa recycling regulations but also branch off nationwide and even worldwide. With enough research, data, budget and staff, this application can be a tool for anyone in any country to fight global warming.

2.1 Final Product

Our final product has met the requirements set at the beginning of the semester. We were able to implement all subsystems we hoped for. Although we are only able to detect about 20 different items through analyzing recyclable objects, we are proud to say we achieved the first step of an application that can make a difference in improving recycling habits. Although we were not able to implement features such as geo-mapping, a full setting menu, and detect 90% of garbage, given the chance, we hope to develop this in the future. Our client, Mitch Bouchard has mentioned that he had connections with the head of City of Ottawa recycling. Given the opportunity, we would like to work with them to develop and publish this application for our city

to use. We can make a difference one user at a time and we hope that this application can help reverse some of the damage that people have caused to our planet.

Figure #1: Screenshot of Introduction Screen

Description:

In Figure #1, we have created an introduction screen on Unity. This screen includes our application logo, the application slogan, and a physical start button that the user will have to press on in order to proceed to the main screen.

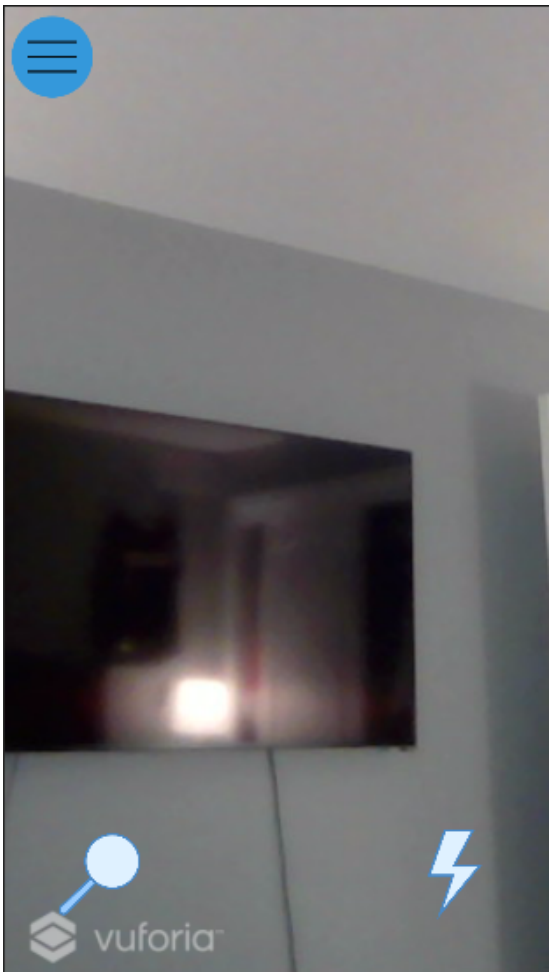

Figure #2: Screenshot of Main Screen with No Object in Camera's view

Description:

Figure #2 shows a screenshot of what the main screen looks like before any recyclable items are detected in its camera view. The bottom right features a flash toggle. If an object cannot be recognized, the flash toggle can be used to help the camera of a mobile device get a better view of an object. The bottom left of the screen has a search button. In Prototype I, when the search button is selected, the application will redirect to the City of Ottawa regular waste disposal practice website. In this prototype, it includes cosmetic improvements from prototype II.

Figure #3: Screenshot of Rice Krispies Box Image Target in Main Screen with Analyze button

Description:

Figure #3 demonstrates the Rice Krispies cereal box displayed in the camera's view before the analyze button is selected.

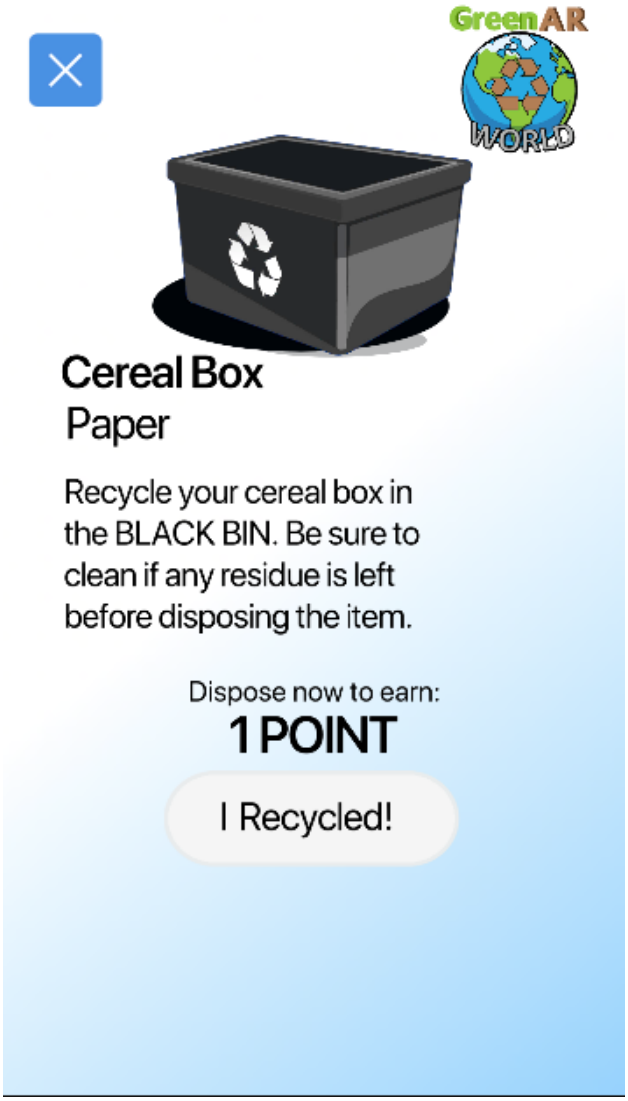

Figure #4: Screenshot of Rice Krispies Box Image Target Displaying Corresponding Recycling Information (Redirected from Main Screen)

Description:

Figure #4 demonstrates the information displayed after the analyze button is selected. In this example of the Rice Krispies Cereal Box, it displays the name of the item, disposal method, and reminding the user to rinse the item before disposal. Alongside this shows an icon that represents where to dispose of these items. In this case, the disposal method is the black bin so it shows an icon of the black bin. At the bottom of the screen, it displays how many points were earned by this recycle. We have also implemented a “I Recycled!” clickable button. Upon clicking this button, the user is redirected to the main screen.

Figure #5: Screenshot of Chunky Soup Can Image Target in Main Screen with Analyze button

Description:

Figure #5 demonstrates the Chunky Soup can displayed in the camera's view before the analyze button is selected.

Figure #6: Screenshot of Chunky Soup Can Image Target Displaying Corresponding Recycling Information
(Redirected from Main Screen)

Description:

Figure #6 demonstrates the information displayed after the analyze button is selected. In this example of the Chunky Soup Can, it displays the name of the item, disposal method, and reminding the user to rinse the item before disposal. Alongside this shows an icon that represents where to dispose of these items. In this case, the disposal method is the blue bin so it shows an icon of the blue bin. At the bottom of the screen, it displays how many points were earned by this recycle. We have also implemented a "I Recycled!" clickable button. Upon clicking this button, the user is redirected to the main screen.

Figure #7: Screenshot of Play-Doh Image Target in Main Screen with Analyze button

Description:

Figure #7 demonstrates the Play-Doh container displayed in the camera's view before the analyze button is selected.

Figure #8: Screenshot of Play-Doh Image Target Displaying Corresponding Recycling Information
(Redirected from Main Screen)

Description:

Figure #8 demonstrates the information displayed after the analyze button is selected. In this example of the Play-Doh container, it displays the name of the item, disposal method, and reminding the user to rinse the item before disposal. Alongside this shows an icon that represents where to dispose of these items. In this case, the disposal method is the garbage so it shows an icon of the garbage. At the bottom of the screen, it displays how many points were earned by this recycle. We have also implemented a “I Recycled!” clickable button. Upon clicking this button, the user is redirected to the main screen

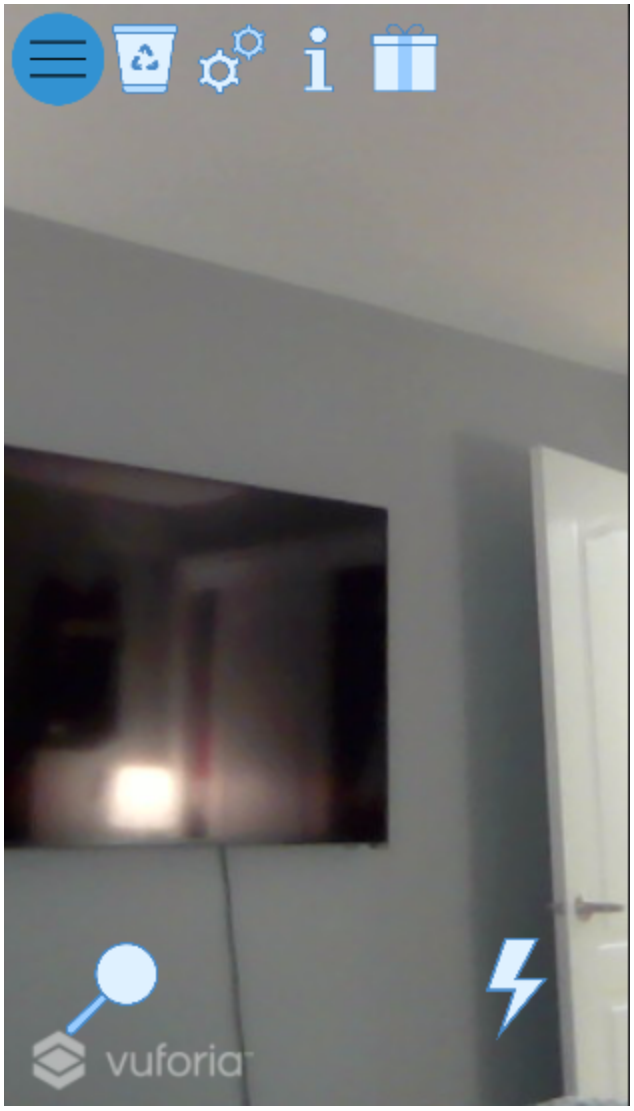

Figure #9: Screenshot of Main Screen with Collapsible Menu Opened

Description:

Figure #9 demonstrates the camera view with a collapsible menu located at the top left of the screen. These setting icons going from left to right are recycling icon, internal settings icon, information menu icon, and the reward menu icon.

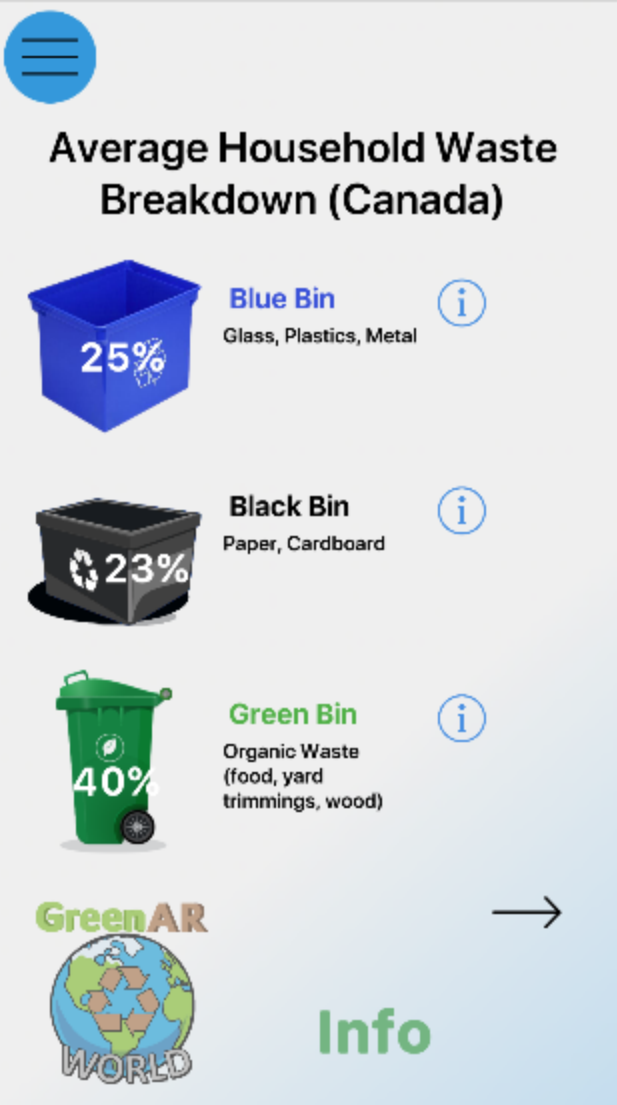

Figure #10: Screenshot of Information Menu (Page 1)

Description:

Figure #10 demonstrates the first page of the information menu. This page shows statistics about the average household waste breakdown in Canada. This page displays the percentage of blue bin waste, black bin waste and green bin waste produced by a Canadian household. Beneath each bin is a brief description of what items can be recycled in each disposal bin.

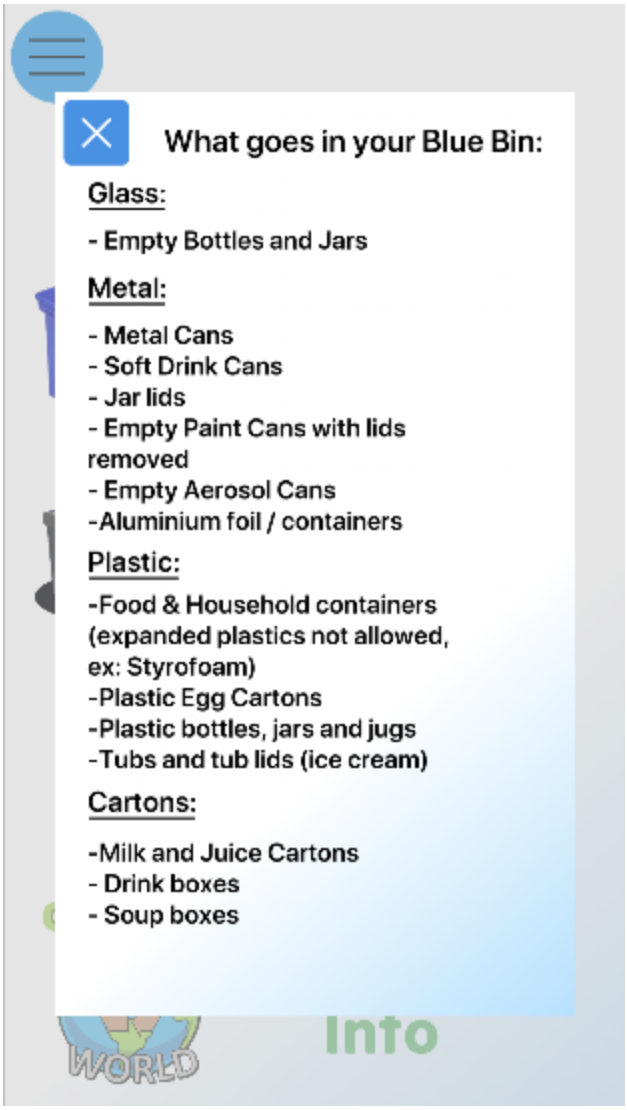

Figure #11: Screenshot of Information Menu (Page 1.1)

Description:

Figure #11 demonstrates the first page of the information menu after the “i” button is selected beside the blue bin. It expands upon some examples of items that can be disposed of in the blue bin.

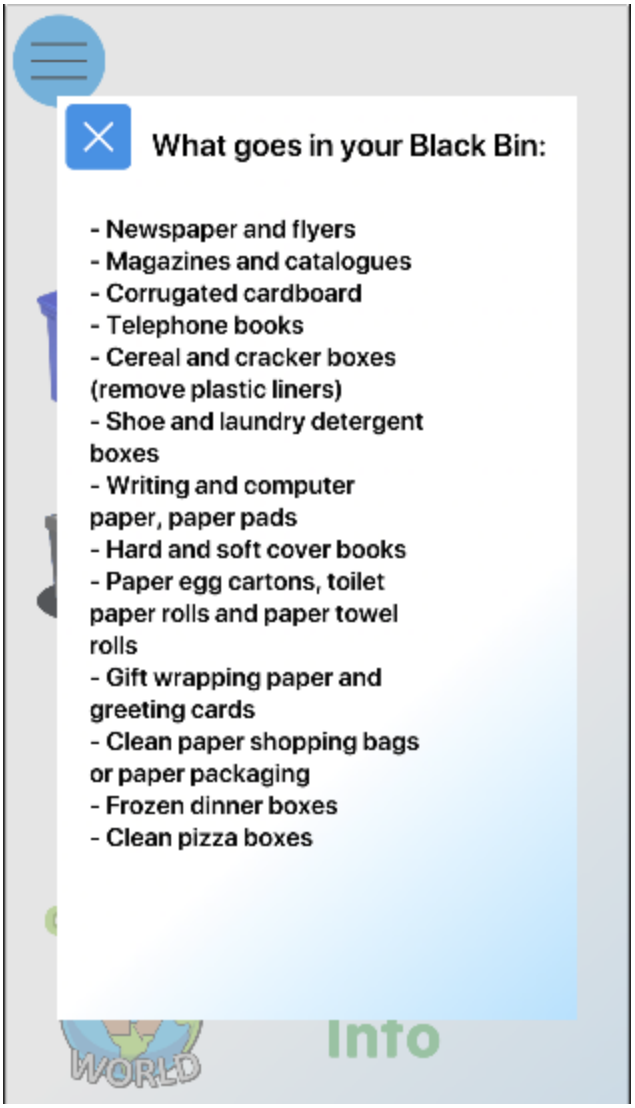

Figure #12: Screenshot of Information Menu (Page 1.2)

Description:

Figure #12 demonstrates the first page of the information menu after the “i” button is selected beside the blackbin. It expands upon some examples of items that can be disposed of in the black bin.

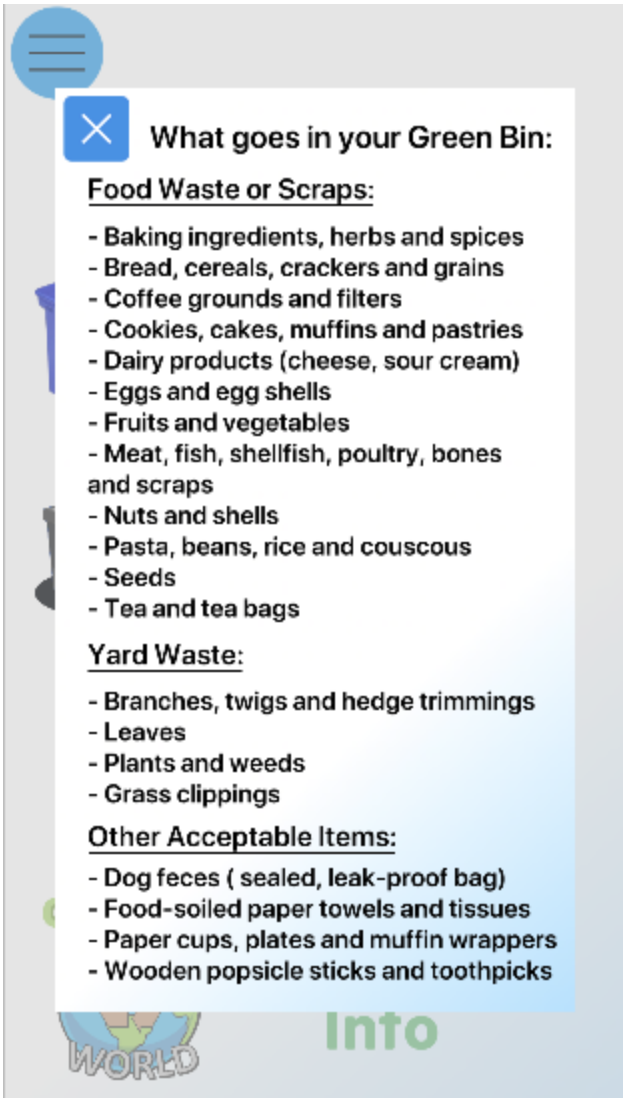

Figure #13: Screenshot of Information Menu (Page 1.3)

Description:

Figure #13 demonstrates the first page of the information menu after the "i" button is selected beside the green bin. It expands upon some examples of items that can be disposed of in the green bin.

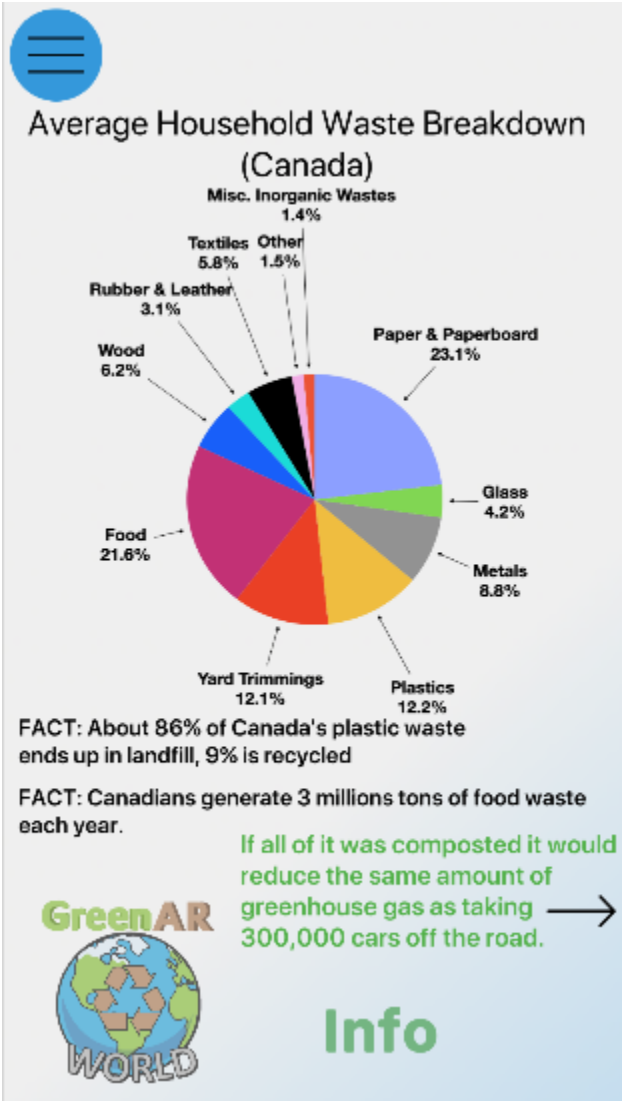

Figure #14: Screenshot of Information Menu (Page 2)

Description:

Figure #14 demonstrates the second page of the information menu. To navigate to this page from page 1, users can use a swiping motion to the left. This page shows more in depth statistics of the average household waste breakdown in Canada by utilizing a pie chart. Beneath the pie chart shows various facts about recycling. This information is included in hope of getting users to realize the importance of recycling.

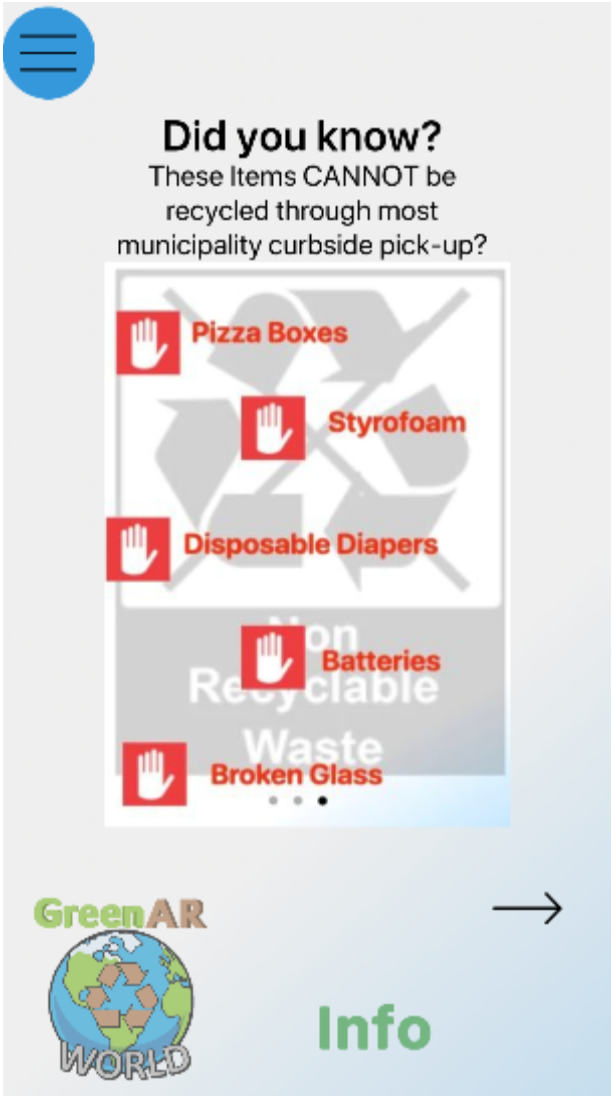

Figure #15: Screenshot of Information Menu (Page 3)

Description:

Figure #15 demonstrates the third page of the information menu. To navigate to this page from page 2, users can use a swiping motion to the left. This screen displays information about items that cannot be recycled through municipality curbside pick up. We hope to add more information or a redirect on how these items can be properly disposed of in the future prototype.

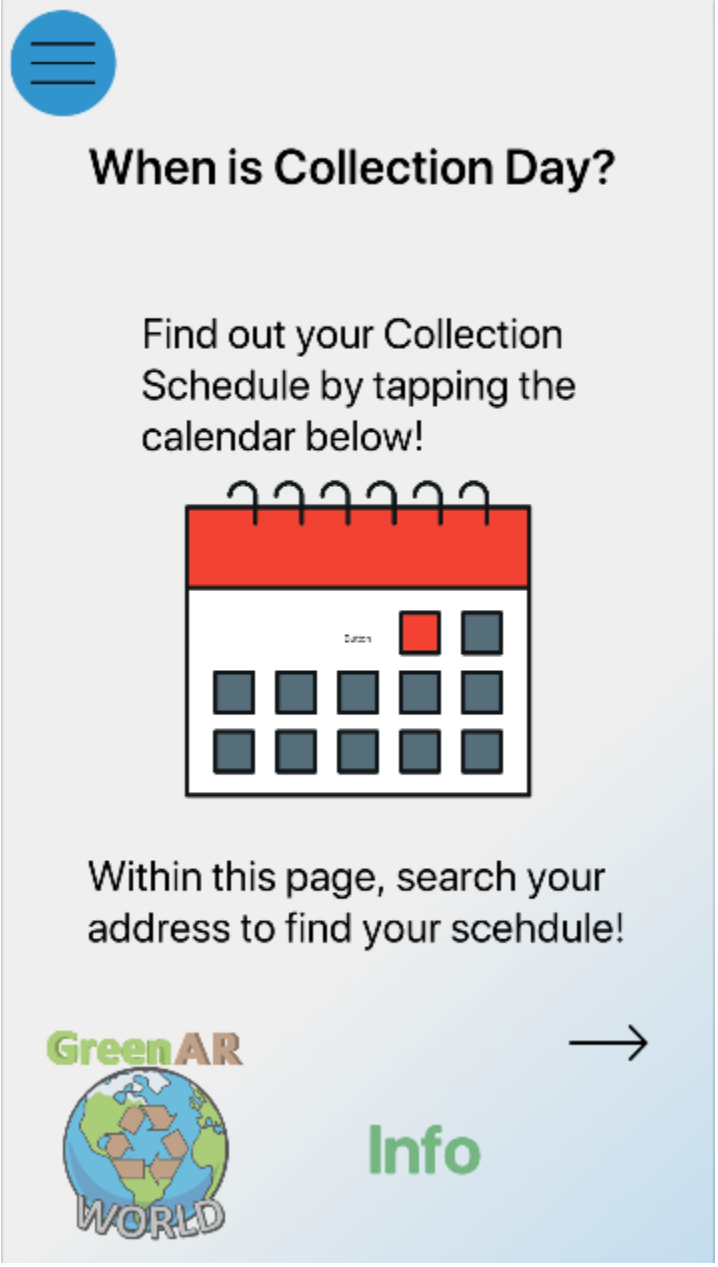

Figure #16: Screenshot of Information Menu (Page 4)

Description:

Figure #16 demonstrates the fourth page of the information menu. To navigate to this page from page 3, users can use a swiping motion to the left. This screen displays a clickable calendar where upon clicking, will redirect the user to the City of Ottawa recycle calendar website. Here, users can input their address and retrieve the correct recycling schedule for their area.

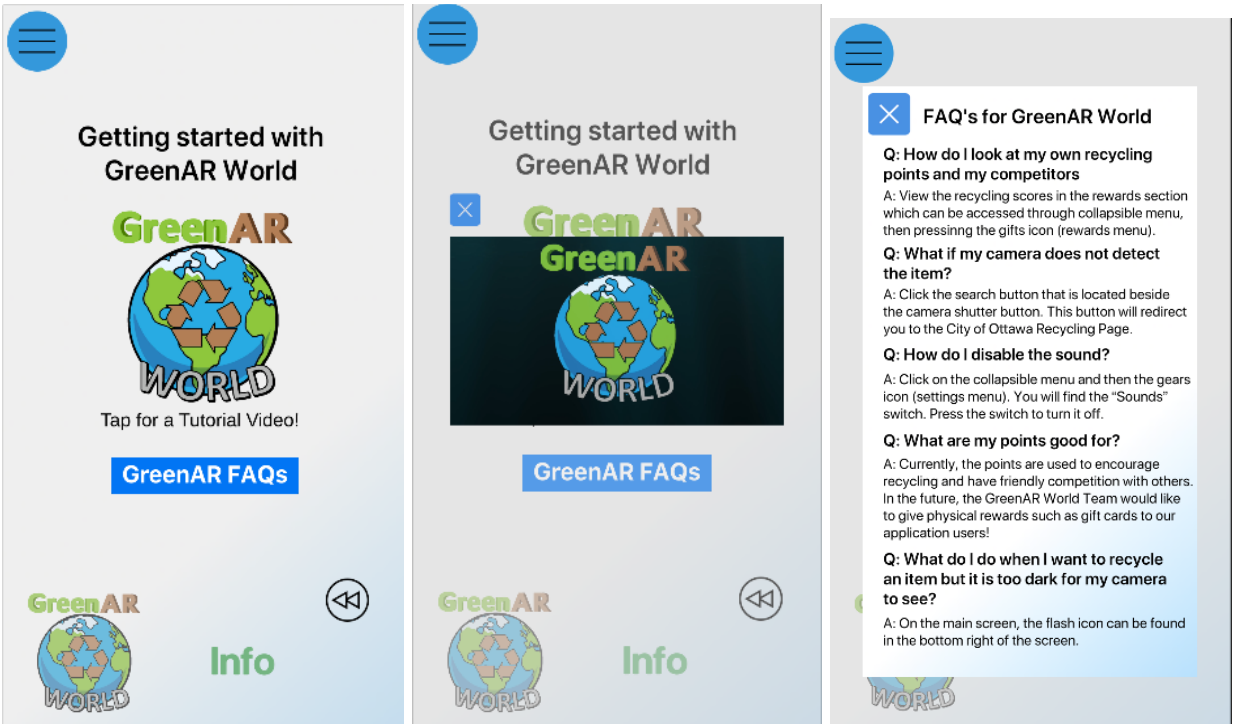

Figure #17: Screenshot of Information Menu (Page 5)

Description:

Figure #17 demonstrates the fifth page of the information menu. To navigate to this page from page 4, users can use a swiping motion to the left. This screen shows a tutorial video where users will be walked through how to utilize the GreenAR World app. To open the tutorial video, users will have to click on the GreenAR World logo in the middle of the screen. The first screenshot represents the app before the logo is selected. The second screenshot represents the app after the logo is selected. The video will begin to play. This page will also have a FAQ section where the most commonly asked questions and answers are displayed. The FAQ section is shown in the third screenshot.

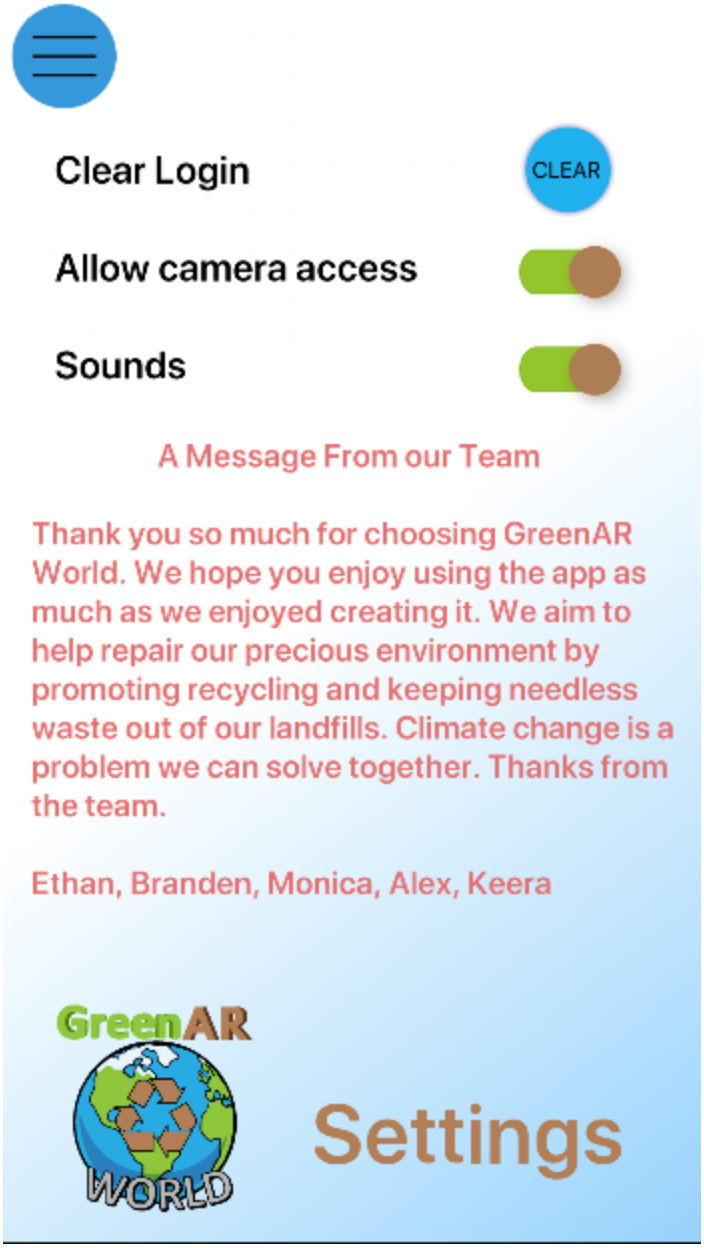

Figure #18: Screenshot of Settings Menu

Description:

Figure #18 demonstrates our settings menu. It displays 3 clickable settings menus that are fully functional. These settings are the clear track rewards option, allow camera access option, and the sound option. When these settings are selected or turned on or off, the settings should function accordingly. At the bottom of the settings menu, there is a brief message from our team. This message describes why we created this application and that we appreciate the user for helping us reach our goal or better recycling habits.

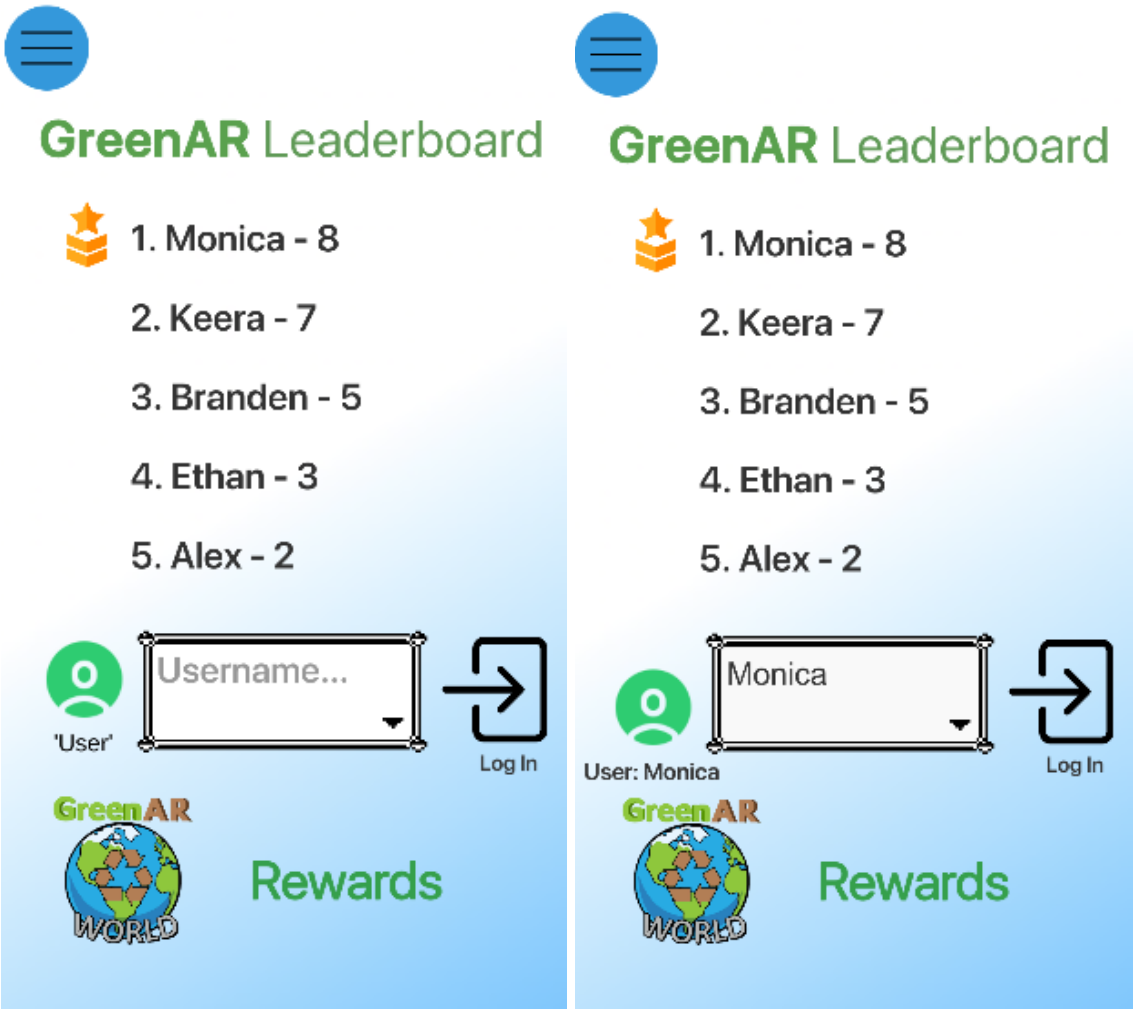

Figure #19: Screenshot of Rewards Menu

Description:

Figure #19 demonstrates our GreenAR Leaderboard which will be used to track the user's scores and their competitors. Once a user logs in and starts scanning items, their points will accumulate accordingly. To sign in, enter your user name into the username section then click the login button. You will know that you are in the correct profile when under the green user button, your username appears. The other competitors will be organized and ranked based on their scores. The difference between both screenshots is entering the username.

2.2 Cautions and Warnings

Since this is a mobile application in its early stages, there are no cautions or warnings to provide at this time. However, there are some limitations to the application. In its current state, the application follows the City of Ottawa recycling practices and may not be applicable in other cities, provinces, and countries. Also, our application is only capable of detecting 25 image

targets. If we do decide to further develop the application, we would like to improve the object recognition portion to about 90%-95%. For the rewards section, all we have at the moment is a points collection system as well as a leaderboard. Although the points are more for the fun game/competition aspect, we would like to potentially have physical prize incentives such as gift cards or possibly collaborate with businesses for coupons.

3 Getting Started

When first loading up the application the user will be brought to the screen that contains our team's logo, our slogan and a start button as seen above in figure #1. To advance to the next screen where the main functionalities are, the user can click the “start” button seen below in figure #20.

Figure #20: Start button present in application

After advancing from the start-up screen the user will be redirected to the main screen where their front-viewed camera will be used. Here, on the screen will appear what your front-viewing camera sees, along with a drop down menu in the top left, a search button in the bottom left, and a flash toggle in the bottom right. This screen along with these functionalities can be seen in figure #2. If users are unsure on how to use the application, they can access a tutorial video which goes through the entirety of the application and all of its functions. This is accessed within the application under the information menu which is seen in figure #14.

3.1 Set-up Considerations

In order to use the application users must have a smart-device which is able to download android applications, as well as have a minimum available space of 39 megabytes. Alternatively, if the user wanted to download the full version that includes the tutorial video which walks you through how to use the application, 129 megabytes of available space must be free on the device.

In order to get maximum use out of this application, the mobile device that is being used for the application must also have a functional front-viewing camera. Although there is a search feature, the main features are based around scanning items with a camera. Another feature that’s integrated in the application is the ability to check when your neighbourhood garbage days are. To do this, the application directs the user to the City of Ottawa website, which will only function if the device is connected to an internet connection.

3.2 User Access Considerations

This application is made for anyone that owns a mobile device and is old enough to understand the difference between throwing something in the garbage and recycling it. Being a very simplistic application that is easy to use and understand, anyone that has access to a mobile device and can benefit from this app. The intended audience would be specifically smart device users that have access to the internet, as well as a front-viewing camera within their device, however other basic features can also be used if these specifications don't match your accessibility. As of now some features are specified towards users in the city of Ottawa Ontario, however this will not impact the main functionalities of the application if a user is located outside of this area.

3.3 Accessing the System

When starting up the application, the user will come across the startup screen which is seen in figure 1, and can click the start button to proceed. From here the user will get a view of their front-viewed camera along with a button in the top left corner of the screen. This button can be clicked to view 4 other options that you can access within the application. This can be seen in figure 22.

Figure #21: Collapsable menu screen

Description:

Figure #21 demonstrates the collapsable menu that is located in the top left corner of the main screen. Here four new options are given, and are represented by icons that correlate to each of their functionalities. The first icon is of a recycling bin and is used to access the main screen where the user can scan items. The second icon of the two gears are used to access the settings menu, the third icon of the (i) leads the user to the information screen, and finally the last icon of the gift will lead the user to the leaderboards menu. Here, in the leaderboards menu, the user will have the option to sign in to an account user his or her name. This can be seen in figure #19.

After the user is signed in with his or her name, they will then be eligible to collect points on every item that they scan and recycle. To do this, users just have to be logged in, and scan a recyclable item. From here the application will ask you if the item was recycled, and if yes one point will be rewarded to that account.

If the user is signed in and wishes to sign out, they can do so by accessing the settings menu that is in the collapsable menu. In this tab, users will have access to sound settings, allowing camera access and also the ability to sign out/clear your account.

3.4 System Organization and Navigation

The main screen that is shown in figure #2 is the screen that will appear after opening the application and clicking the start button. From here there are multiple screens that can be accessed which all allow different features. When the front-view camera on your device comes across a recyclable item that is recognized, a circular button will appear in the bottom center of the screen indicating that the item can be scanned for further information. This can be seen in the following figure.

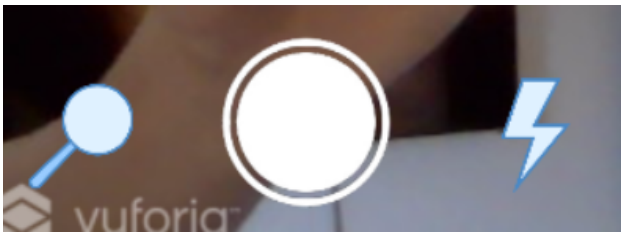

Figure #22: Analyze button

Description:

Figure #22 represents the analyze button which appears on the users screen after the users camera recognizes an item within its database.

If an item is not scanning, the user can click the magnifying glass icon located in the bottom left of the screen, which will direct them to a page where items can be manually searched. Another feature that is accessed here is to the right of the scan button which is indicated by a lightning symbol. This feature can be used in case you are ever in a dark room and the camera is not able to properly scan the item. Using this flash will turn on your device's flashlight (if your device has such a feature) and make it easier for the camera to identify which item is being scanned.

From here the other features that can be used are all located in the drop down menu displayed in the top left corner of the main screen. The drop down menu with all of its features can be seen in figure #21.

3.4.1 Settings Screen

Upon clicking the settings icon, the user will be directed to the settings screen which can be viewed in figure #18.

3.4.2 Information Screen

Upon clicking the information icon (i), users will be directed to the information screen which can be viewed in figure #10. On this screen users will be able to view the different type of recycling bins that are available in the region, as well as have the option to view information regarding each one. Users can scroll to the next page by dragging their finger/stylus across the screen from

right to left. The next screen that will be displayed is a pie chart displaying the average household waste in Canada which can be viewed in figure #14. If you continue to slide your finger across the screen the user will have access to three more screens. These screens include “did you know” facts about recycling in Canada, the collection schedule in your region, and a question/answer section which is accompanied by a tutorial video. These screen can be seen in figures #15, #16, and #17 respectively.

3.4.3 Rewards Screen

Upon clicking the rewards screen the user will be directed to the rewards screen which can be viewed in figure #19.

3.5 Exiting the System

To exit the system the application can simply be closed by returning to your devices main screen. In order to ensure the application is not running in the background it is recommended to completely close the application within your devices task manager. This varies depending on which smart device is being used. Another precaution that is recommended to users in order to fully exit the application is to make sure you are on the main screen upon closing the application. This is a precaution to ensure the next time the application is used, it starts up properly.

4 Using the System

In this section, we will provide a step-by-step outline of the user features within the app, and their corresponding system outputs.

4.1 Introduction Screen

Upon opening the app, you will be greeted by an introductory screen. Simply press the large blue 'Start' button to enter the app and access the cutting-edge garbage sorting technology. Once you press this button, the app will automatically redirect you to the main screen.

4.2 Main Screen

The main screen is your home base. You will be able to easily employ the AR sorting scanner from this screen, while also enjoying quick access to the other supplementary features of the app.

4.2.1 Analyze Button

The analyze button is the cornerstone of this application. You will use this button to initiate the AR software that analyzes and designates the appropriate disposal bin for your waste. To sort your refuse, point your camera at the item you wish to dispose of, once the app recognizes the item in question a large circular button will appear at the bottom centre of your screen, this is the

analyze button. Pressing this button will prompt the app's sorting functionality and will subsequently redirect you to the results panel.

4.2.1.1 Information Panel (Redirect)

Once the app has identified the item in question, it will redirect you to the results panel, where it will plainly display the proper bin in which you should dispose of your item. At the bottom of the page, you will see the potential points you can earn from properly disposing of the waste in question. Underneath the point allocation, you will observe a large button which states; 'I recycled'. Press this button once you discard your waste in the bin displayed on the results page. In doing so, you will collect the displayed points.

4.2.2 Search Button

To the left of the analyze button on the bottom of the main screen, you will see a magnifying glass icon, this is the search button. Use this button in the unlikely case that the app is unable to identify the item you wish to analyze. Upon pressing this button you will be redirected to the city of Ottawa website, where you can manually input your item and the website will display the proper bin for disposal.

4.2.3 Flash Toggle

To the right of the analyze button on the bottom of the main screen, you will see a flash toggle icon. Use this button if you are attempting to analyze your waste item in low lighting situations. Upon pressing this button the flash function on your camera phone will be activated.

4.3 Collapsable Menu

To navigate to other areas of the app, press the blue circular button with three horizontal lines located at the top left corner of the main screen. Once selected, a collapsable menu will appear across the top of the screen. In this menu, you will see various icons which will redirect you to the supplementary features of this page. In order, from left to right, you will first see a recycling icon which represents the main screen, then the gears icon which represents the settings menu, then the 'i' icon which represents the information menu, and lastly a gift icon which represents the rewards menu. By selecting any of these icons, you will be redirected to the correlated page within the app. This collapsable menu can be found at the top left of each page and is used to navigate throughout the entire application.

4.4 Information Menu

Upon selecting the 'i' icon, you will be redirected to the information pages consisting of five pages that include further recycling instructions, facts and advice, as well as a collection calendar and a step-by-step tutorial video instructing how to use the GreenAR World app

4.4.1 Categories of Bins

The first page you will see once selecting the 'i' icon from the collapsable menu is the average household waste breakdown. You will see the three recycling options on this page; the blue bin, the black bin and the green bin as well as their respective percentage of household waste. Beside each of the bins, you will see a blue 'i' button to the right. Select this button to view a comprehensive list of all acceptable items which can be disposed of in that specific bin.

4.4.2 City of Ottawa Calendar (Redirect)

As you scroll through the information section, you will reach the collection calendar on the fourth page. To access the collection calendar, press on the large calendar icon located in the middle of the screen. Upon pressing the icon, you will be redirected to the city of Ottawa Collection Calendar. There, you can manually input your home address to view your tailored collection schedule for garbage, blue bin, black bin and green bin.

4.4.3 Tutorial Video & FAQs

Scroll one more page to the right to access the tutorial page. Here you will find a step-by-step tutorial video where users will be walked through how to utilize the GreenAR World app. To begin this video, press on the large GreenAR World logo located in the middle of the screen. Once you press the logo, the video will begin momentarily. Below this logo, you will see a blue square button that states 'GreenAR FAQS'. By selecting this button, you will be redirected to the FAQ page in which the GreenAR team answers your most frequently asked questions.

4.5 Rewards Menu

Upon selecting the gift icon in the collapsable main menu, you will be redirected to the rewards page. On this page, you will find a leaderboard displaying the users with the highest points and ranked accordingly. You will also be able to view all the points you've collected thus far in the app

4.5.1 Log in Functionality

To begin accumulating points, you must first set up a profile within the app. To do so, select the white rectangular box at the bottom of the screen, once selected enter your username and then press the black arrow login icon to right. Once you have logged in, you will see your username appear in the bottom left corner. You can now collect points for properly disposing of your waste.

5 Troubleshooting and Support

5.1 Error Messages or Behaviours

The GreenAR World application has a few error messages or behaviours that will occur upon different interactions with the application. The following below will explain these error messages and behaviours.

Once logged into the rewards system, repeatedly pressing the “Log In” button will display the message “ERROR SAME”, as the same request is being processed in short periods of time. No corrective action is needed, as the rewards leaderboard will return to normal functionality after a second.

An error behaviour that will occur is when the application is having issues recognizing the image target. The analyze button will repeatedly blip in and out, as it does not have a clear focus on the image target. This may render the analyze button difficult to interact with. A workaround would be to utilize the flash toggle to increase visibility of the object and allow the application to clearly identify the image target.

When the application is unable to recognize a target, no indication will be given and the scanning feature is rendered useless. This could be corrected by allowing user uploads of image targets using Vuforia Web API services to expand the user database for better recognition. The search feature would be a present-moment correction of this fault.

The toggles in the settings menu may appear triggered, though the toggle may display the opposite representation. For example, if sound were to be disabled, leaving and re-entering the settings menu may display sounds as active, though it is disabled. This can be corrected by modifying the C# script associated with the toggle.

5.2 Special Considerations

A special consideration to consider is the lack of passwords to the login for the rewards system. This would mean any individual would be able to login as anyone on the app. This shortcoming is due to the use of the dreamlo leaderboard. Though the leaderboard was more feasible to implement, the tradeoff is the ability to create a proper secure account to keep your score in the application.

5.3 Maintenance

In terms of maintenance for this application, the only forms of maintenance needed is to make sure the leaderboard database does not get overly populated, and to constantly update the image database to increase the accuracy of the application.

5.4 Support

If ever any issues arise with the application, the user may contact the GreenAR World developers through email, depending on the type of issue arising. For any concerns or questions regarding the informational menus, the user may contact Keera Moretti, at kmore034@uottawa.ca. Any questions or concerns regarding the main, rewards, and settings menu may contact Ethan Leung, at eleun037@uottawa.ca. Sending emails regarding the users problems and concerns will suffice. If this application gets further developed in the future, we would look into creating a customer service email or phone option for users to get support. If given the opportunity and the City of Ottawa collaborates with GreenAR World, the city may be able to handle any support issues through their existing resources.

6 Product Documentation

Since the GNG 1103 Course is being taught online, we are creating a mobile application and not a physical product. All of the softwares and materials we are using for this project are offered for free. The softwares we plan to use is either free to users or we get special access/trial periods because we are university students.

As a result, we have not spent anything from our $100 budget. All softwares used has been accessed for free. This includes Unity and Vuforia. Unity was chosen as the development software due to the simplicity of creating different UI elements, without having to hard-code them. Also, Unity is a more popular development software, which in turn provides lots of online tutorials to help the team out, since we all have never developed applications before. Vuforia was chosen as the method of augmented reality due to the ease of use of the software. First introduced by the TA's, Vuforia proved to be the easiest augmented reality to incorporate into Unity. In future iterations of this product, we may need some funding to implement a better AR system, improve aesthetics, and incorporate other features such as games.

This section of the user manual will explain how each subsystem of our application was developed and which C# scripts were associated with each component. Each subsystem provided a critical aspect that was essential for our final design. Our 5 final subsystems include an introduction screen, main screen, settings menu, information menu, and rewards menu.

6.1 Introduction Screen

6.1.1 BOM (Bill of Materials)

Table #1: Bill of Materials (Introduction Screen)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
			Total	$0

6.1.2 Equipment List

Table #2: Equipment List (Introduction Screen)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
Laptop	Portable Personal Computer	1	$2000	$0
			Total	$0

6.1.3 Instructions

All C# scripts may be found in the Design Files.

To build the introduction screen, a new canvas was created. Within this canvas, the GreenAR World logo was put big and center of the screen, as well as the team slogan “Recycling made simple” below and to the right. Along the bottom portion of the screen, a “Start” button was implemented in blue. A C# script using the UnityEngine.SceneManagement package was used with the SceneManager.LoadScene function attached to the button. Upon clicking the button, the user will be advanced to the main screen. Attached below is the script to advance to the next screen.

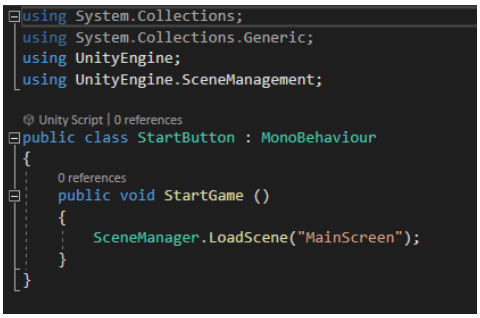

Figure #23: C# script using the UnityEngine.SceneManagement package

6.2 Main Screen

6.2.1 BOM (Bill of Materials)

Table #3: Bill of Materials (Main Screen)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
Vuforia Package	Model target generator, scanner support, and area target software that will be used in Unity	1	$0	$0
DOTween Package	Provides animations for the general menu	1	$0	$0
Recyclable items	Items that will test the application's functionality. Properly label and give instructions of disposal method.	1-10	$0	$0
			Total	$0

6.2.2 Equipment List

Table #4:Equipment List (Main Screen)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
Laptop	Portable Personal Computer	1	$2000	$0
			Total	$0

6.2.3 Instructions

All C# scripts may be found in the Design Files.

The main screen consists of numerous hidden panels associated with the recognition of specific image targets, as well as the search, flash, and expandable menu.

To begin, each individual image target is associated with its own analyze button that will appear upon recognition. This is also an indication to the user when an image is recognized. A C# script associated with the button with the command to enable and disable the panel with the function Panel.SetActive. Once the button is clicked, the informational panel associated with each image target will be set visible. The user will be able to read all the information and be able to press the X button to exit, or the “I Recycled!” button to earn a point towards the leaderboard. Both of these buttons use the Panel.SetActive button to disable the panel and return to the main screen, though the “I Recycled!” button has a second function to add a point to the points total. The second C# script for the “I Recycled!” button will add one point to the global score variable and call the leaderboard script which will upload the username and score to the dreamlo database. Attached below are each respective scripts.

```
public GameObject Panel;

0 references
public void OpenPanel()
{
    if (Panel != null)
    {
        bool isActive = Panel.activeSelf;

        Panel.SetActive(!isActive);
    }
```

Figure #24: C# script associated with the button with the command to enable and disable the panel

```
0 references
public void AddPoint()
{
    Globals.score = Globals.score + 1;
    Highscores.AddNewHighscore(Globals.player2, Globals.score);
}
```

Figure #25: C# script for the "I Recycled!" button that will add one point to the global score variable

The second component of the main screen consists of the search button and flash button. The search button has an attached C# script that will open a dedicated URL in a browser using the Application.OpenURL function in Unity. The flash button has an attached C# script that will toggle the devices flash. It does so by using the Vuforia package with the .SetFlashTorchMode function. The attached scripts are below.

```
public void Open()
{
    Application.OpenURL(Url);
}
```

Figure #26: C# script that will open a dedicated URL in a browser

```
public void FlashTourch()
{

    //CameraDevice.Instance.SetFlashTorchMode(ON); //Phone flash
    if (ON)
    {
        CameraDevice.Instance.SetFlashTorchMode(true); //Phone flash
        ON = false;
    }
    else
    {
        CameraDevice.Instance.SetFlashTorchMode(false);
        ON = true;
    }
```

Figure #27: C# script that will toggle the devices flash

Upon pressing the analyze button, a soft shutter noise will play, this was done with the SoundPress.cs script found in the Design Files. This script uses the PlayOneShot function and is attached to the analyze button to play on actuation.

The last component of the main screen is the expandable menu, with animations from the DOTween asset. The menu will expand upon clicking the options icon, with buttons that give access to the settings, informational, and rewards screen, all with the SceneManager.LoadScene function seen with the introduction screen. The animations were implemented and given specific coordinates to expand up to, as well as the rotations the icons experience as they are expanded. Two scripts were used, a general settings menu script to control animations, and a settings menu

item script to control individual icons. The scripts will be attached to the manual, SettingsMenu and SettingsMenuItem.

6.3 Settings Menu

6.3.1 BOM (Bill of Materials)

Table #5: Bill of Materials (Settings Menu)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
DOTween Package	Provides animations for the general menu	1	$0	$0
			Total	$0

6.3.2 Equipment List

Table #6: Equipment List (Settings Menu)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
Laptop	Portable Personal Computer	1	$2000	$0
			Total	$0

6.3.3 Instructions

All C# scripts may be found in the Design Files.

To construct the settings menu, a new canvas was created with a gradient blue image set as the background, with the GreenAR World logo and a “Settings” title. A short team message is included as well.

To create the “Clear Login” button, a C# script was attached to the button which sets the user login and uploads as NULL, meaning a blank username. The score will no longer be tracked as an invalid username is used. Attached is the script.

```
public void ToggleScore()
{
    //score = Random.Range(0, 10);
    Globals.score = 0;
    username = "";
    // Debug.Log(username);
    Debug.Log(Globals.player2);

    Highscores.AddNewHighscore(username, Globals.score);
}
```

Figure #28: C# script for button which sets the user login and uploads as NULL

To create the sounds toggle, the DOTween animation was implemented upon toggling the sound to create the smooth transition from enabled to disabled. Attached to the toggle, is a C# script that will mute and unmute sounds upon toggle. Attached is the script.

```
// Start is called before the first frame update
0 references
public void Mutee()
{
    AudioListener.pause = !AudioListener.pause;
}
```

Figure #29: C# script that will mute and unmute sounds

6.4 Information Menu

6.4.1 BOM (Bill of Materials)

Table #7: Bill of Materials (Information Menu)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
DOTween Package	Provides animations for the general menu	1	$0	$0
			Total	$0

6.4.2 Equipment List

Table #8: Equipment List (Information Menu)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
Laptop	Portable Personal Computer	1	$2000	$0
			Total	$0

6.4.3 Instructions

All C# scripts may be found in the Design Files.

To construct the information screen, a new canvas was created with a gradient blue background with the GreenAR World logo and “Info” title along the bottom. 5 panels are created side by side, each containing different information. In order to swipe between pages, an empty game object was created with a C# script attached that will allow swiping between the 5 panels within the empty game object. The C# script will be attached, PageSwiper.

Within the first panel, the average household breakdown for Canada was described with Black, Blue, and Green bins. Beside each bin, is an information button, which will set visible a panel with further information. This is done with the same script PanelOpener earlier described in the main screen construction. An exit button with the same PanelOpener script was used to close the panel. The logos and texts were added with simple UI elements.

Within the second panel, an image with the average household waste breakdown in form of pie chart was added with UI elements, along with facts regarding waste disposal.

Within the third panel, an image with “Did you know” facts was added with UI elements, along with a text description.

Within the fourth panel, a button in the form of a calendar was added. Upon clicking the button, the script URLOpener, previously described in the main screen, will open the City of Ottawa recycling schedule.

Within the fifth panel, a button in the form of the GreenAR World logo will activate a panel using the PanelOpener script. The attached panel holds a tutorial video that will play once the panel is activated. This is done with the Video Player feature within Unity. Just below this, a

button labelled “GreenAR FAQs” will activate a panel that displays frequently asked questions. This panel is activated and deactivated with the PanelOpener script.

The same general settings menu is added. The method to build is previously described in the main screen.

6.5 Rewards Menu

6.5.1 BOM (Bill of Materials)

Table #9: Bill of Materials (Rewards Menu)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
DOTween Package	Provides animations for the general menu	1	$0	$0
			Total	$0

6.5.2 Equipment List

Table #10 Equipment of Materials (Rewards Menu)

Bill of Materials				
Item	**Item Description**	**Quantity**	**Unit Price**	**Amount**
Unity	Augmented Reality Software	1	$0	$0
Laptop	Portable Personal Computer	1	$2000	$0
			Total	$0

6.5.3 Instructions

All C# scripts may be found in the Design Files.

To construct the rewards screen, a new canvas was created with the gradient blue background set. Along with the GreenAR World logo and the “Rewards” title.

To set up the scoring system, a dreamlo database was created. Dreamlo is a free online scoring database. Attached will be the script used to add new and receive scores to the database. An

input field UI element was added to accept character input to login into the system. A C# script attached that will take the input from the input field and upload to the database. Alongside this user input, is the score that is continuously added when the “I Recycled!” button is pressed on the main screen. A similar void in the same script is used to display the input into the user field, so it clearly presents which user is currently logged in. Five texts were set up and associated with the script to update as scores are received by the application. A “Log In” button was created with two actions performed on click, one to upload and receive scores from the dreamlo database, and the second to update the user display name to confirm which user is currently logged in. Attached will be the scripts Game, NameTransfer, Highscores.

The same general menu construct is being used in this menu as well.

6.6 Testing and Validation

Prototype I: The tests done on prototype were the tests of overall ease of use as well as the testing the overall usability of the application by the members of the team. It was determined that in prototype I, the format of the informational screen was not visually appealing, as well as the necessity to keep the camera on the object to keep the information visible. Also, the overall aesthetics of the prototype were in need of improvement. Along with these faults determined, plans for the informational, settings, and rewards screens were expected to be included in prototype II.

Prototype II: With all additional screens added to the application, the aesthetics updated, and the information panel upon analyzing much improved, the team ran tests regarding the usability and aesthetics of the prototype. It was determined that the new method of analyzing image targets was much more effective, and as well looked much better visually along with the updated icons. Further testing concluded that the implementation of the information and settings menu were visually appealing, though full functionality still needed to be implemented. For the rewards screen, further completion was needed to test this subsystem.

Prototype III: The app is majorly complete, with subtle tweaks determined through testing needed to be done. As per the previous two prototypes, the tests regarding usability and aesthetics of the prototype were done. It was determined that the application was up to standard as to what the team expected the app to be, in terms of functionality, aesthetics, and performance. Some issues identified were the abundance of settings options, where some were deemed redundant. Also, the correction of the fluidity of the information displayed when scanning an object belonging to the black bin. These issues were corrected in the final product by reducing the number of setting options and only keeping the necessary ones, and correcting the sentence structure for the information displayed in the black bin panel to have more continuity when reading.

7 Conclusions and Recommendations for Future Work

To conclude our waste management project, we believe that our GreenAR World recycling application is a user friendly application that promotes proper recycling habits. The result of proper recycling leads to reduced landfill waste. Our application also raises awareness about the consequences of improper recycling.

While conducting this project, we learned many lessons regarding the process of developing our application and the Unity software. The first lesson we learned was utilizing Unity. Unity allowed us to create our app while implementing Vuforia development kit.

The second lesson our team learned was having effective communication. In order to communicate with each other, we used Facebook Messenger and Microsoft Teams. For common questions and organizing our deliverables, we used Facebook Messenger. During our meetings on Microsoft Teams, we would discuss the parts assigned to each team member for each deliverable. We communicated with each other to ensure what was expected in all the deliverables. We noticed that having good and constant communication with each other would improve our team dynamic and workflow.

The third lesson learned was the importance of project planning. In order to complete each deliverable, we would constantly update the Wrike. Wrike is a project management tool that was utilized by our team. that For each deliverable, there were sub-tasks that needed to be completed. Each person was given sub-task(s). Wrike allowed us to stay organized and plan ahead. Some tasks required for another task to be completed first, Wrike allowed us to add precedent tasks and succeeding tasks. Since we followed the Wrike task planner, our team was able to stay on schedule and complete all deliverables before the assigned deadline.

The fourth lesson we learned was the importance of having a simple and clean user interface. Having a user friendly interface would make it more appealing to customers and be used more frequently if the application was simple to use. We realized that paying attention to every small detail would help improve customer satisfaction. Based on the customer feedback we received for each prototype, they liked the fact that our application has a simple design layout and buttons were clear and descriptive. Also, the tutorial video really helped users to understand how our application worked.

The fifth lesson we learned was the design process. We learned how to go from an abstract idea to creating a functional final product. In order to do this, we determine the Client's needs and what he wanted in his final product. We then identified the problem statement based on what the Client discussed. Next, we developed design criteria which included technical benchmarking, target specifications, functional requirements, and non-functional requirements. Furthermore, we created our conceptual design by each member creating their own individual design on what they

envisioned the final application would look like and how it would operate. After, we developed the project plan and cost estimate. We planned the time required to complete each subsystem of our application and the duration required for all three prototypes. During our first prototype, we created our introduction screen and AR recognition capabilities. During our second prototype, we implemented all our subsystems (introduction screen, main camera view, settings menu, information menu, and rewards menu) and added more image targets. In our third prototype, we made full implementations of all of our subsystems and inserted additional image targets. We also improved the overall aesthetics and the usability of our GreenAR Leaderboard rewards menu. For our final product, we made minor adjustments to prototype III. We learned that this design process will not only be useful in this class, but in real life applications as well.

The final lesson learned from completing this project was learning how to perform prototype testing. We found this is extremely important as we discovered flaws in our application that we did not know that existed. We would find certain bugs that did not allow our app to be used to its full potential. We developed the prototype test plan chart and utilized the stopping criteria method to determine if the testing was satisfied and successful.

For our future works, we hope to publish our application so it can be downloaded from the Apple's app store or the Google Playstore. Also, we would like to implement physical prize incentives to our rewards system. Furthermore, we would like our application to detect 90% of image targets. Lastly, we would like to collaborate with the City of Ottawa to implement the GreenAR World recycling application to improve recycling habits of Ottawa citizens.

If our team had more time to complete this project, we would include the implementation of a geo-map to identify the locations of different recycle bins within Ottawa. Also, we would have added more image targets so our app can identify more recyclable items.

8 Bibliography

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9 APPENDIX I: Design Files

Doc ID	Document Name	Document Location and/or URL	Issuance Date
1	All Project Files (Deliverable B,C,D,E,F,G,H,I,J,K)	https://makerepo.com/bleun011/798.gng1103c6greenar-world	2021-04-13
2	StartButton.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
3	PanelOpener2.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
4	Game.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
5	URLOpen.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
6	FlashToggle.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
7	SettingsMenu.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
8	SettingsMenuItem.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
9	Mute.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
10	SwitchToggle.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
11	PageSwiper.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
12	Highscores.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
13	NameTransfer.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13
14	SoundPress.cs	Maker Repo (Refer to Doc ID 1 link) GreenARWorldV1/Assets/Scripts	2021-04-13