

# Deliverable K – User and Product Manual



## Group 5

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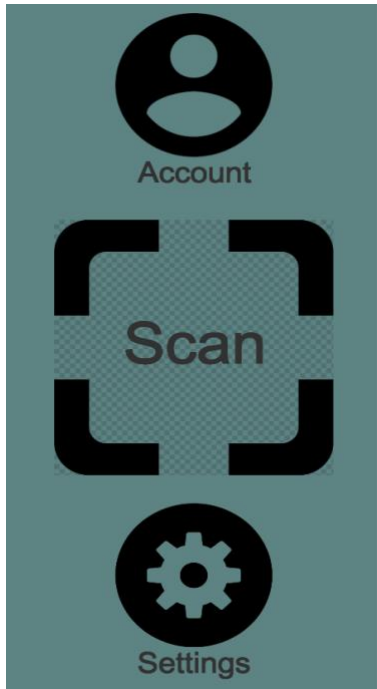
# **1 Introduction**

This User and Product Manual is intended for those who wish to expand or update the project, or for those who want to understand how to effectively use the application. Information on how to update, modify, use and support the application will be provided.

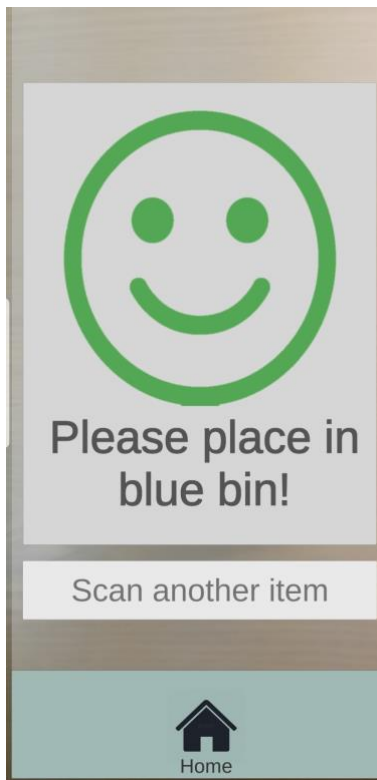
## **2 Overview**

Local municipalities and counties across the world have implemented such recycling programs to help reduce landfill waste as well as the need for new raw and synthetic materials, such as plastics. Unfortunately, modern recycling programs, specifically in Ontario, are not as efficient as they could be. Recyclable materials are being contaminated which leads to their disposal in landfills, thus invalidating the entire recycling process. To help combat this issue, the problem of contamination should be addressed at its source: the sorting of items in individual households. The recycling process starts at each individual's home, where members of the household must choose whether the item they wish to dispose of is recyclable and in which bin they should deposit it into. Regrettably, this task is not always done successfully which leads to items being sorted into its incorrect bin. This in turn leads to contamination of the recyclable material at the processing plant, which can then cause the material to be diverted to landfills.

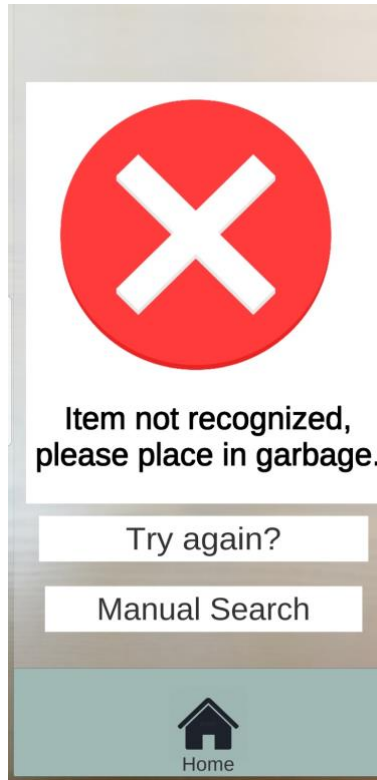
To combat this issue, users need a simple, effective and user-friendly solution to help them sort their recycling at home. Thus, a phone application using AR scanning technology was created. This app will let users scan items and then indicate to them which recycling bin it should be deposited in. This application is better than other solutions to this problem as it is extremely simplistic and user-friendly, which will avoid any learning curve or confusion on the users part. Below are a couple screenshots of the application in use:



*Figure 1 - Home Screen*



*Figure 2 - Scanner Screen once a Recyclable Item has been Recognized*



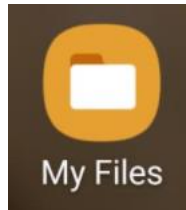
*Figure 3 - Scanner Screen once a Non-Recyclable Item has been Recognized*

The application works by comparing what the scanner is seeing with a database of images. Every image has a condition set to it (i.e. whether the item is blue bin or black bin), so once the scanner recognizes an item, that condition can be displayed to the users. If the item is not recognized, then a pop-up will tell the user to place it in the garbage (as seen in figure 3). The application will also incorporate a rewards system to encourage users to properly recycle and their will also be the option to setup an account.

### **3 Getting started**

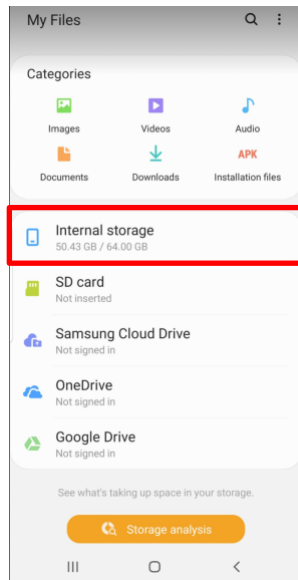
There are only two systems that used to create the application. The first is the image database which uses *Vuforia*. The second is the structure of the app itself, which was created by *Unity*. The current version of the prototype is fully functional and be downloaded to any android phone with the following steps:

1. Download the latest *apk* file, in this case *DemoTest\_11.apk*, from MakerRepo directly from your android phone;
2. Open the *My Files* application (as seen below):



**Figure 4 - My Files App Icon**

3. Click on the *Internal Storage* option (as seen below):



**Figure 5 - My Files Application**

4. Click on *Download*;
5. Click on the file (as seen below):



**Figure 6 - Location of App File**

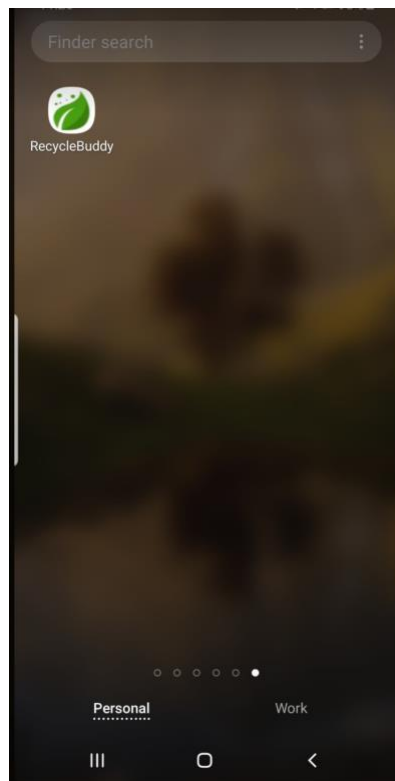


6. Click on *Install* (as seen below):



**Figure 7 - RecycleBuddy Installation**

7. Find the app in your list of apps and open it (as seen below):



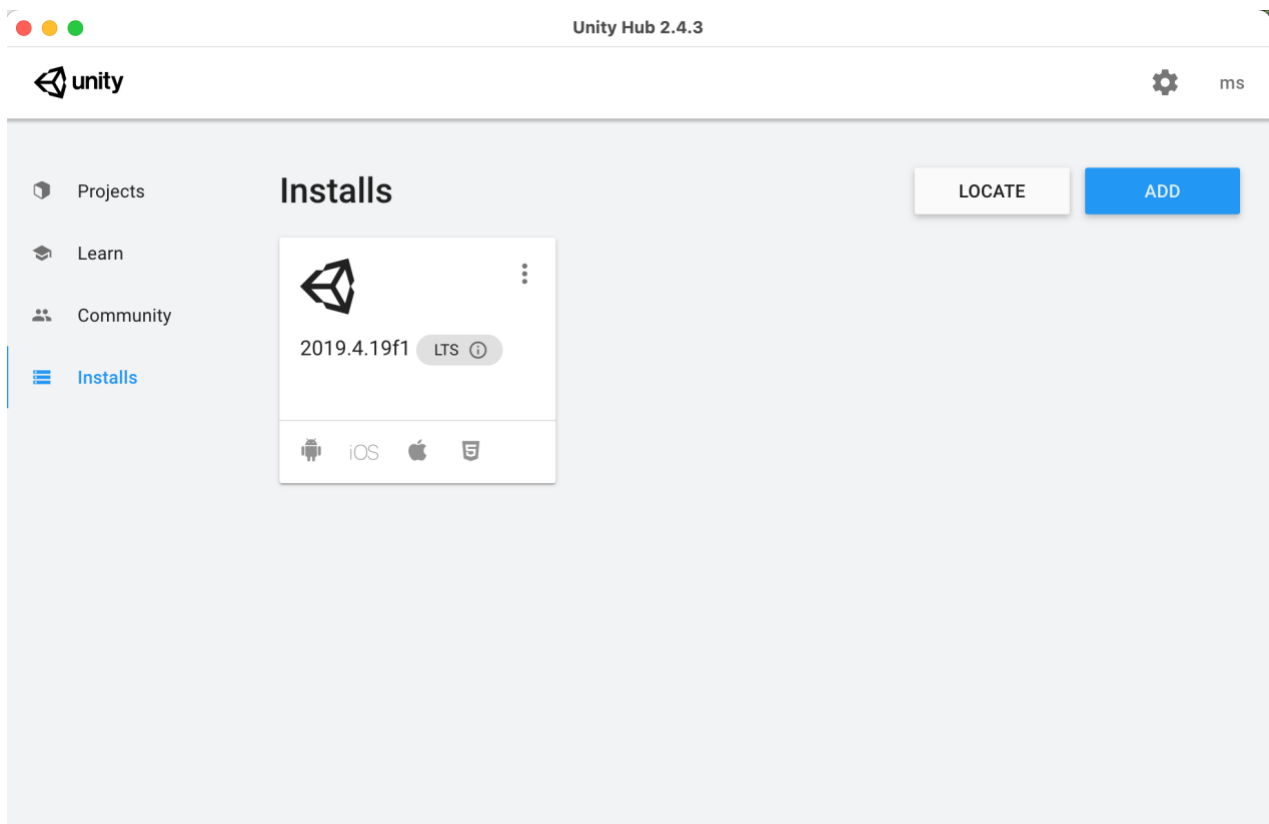
**Figure 8 - RecycleBuddy App**

Until the application is added into the *Play Store*, this is the only way to get RecycleBuddy on your phone. Implementing it on Apple phones would be the next step of this project as currently it is only supported on Android phones.

### 3.1 Set-up Considerations

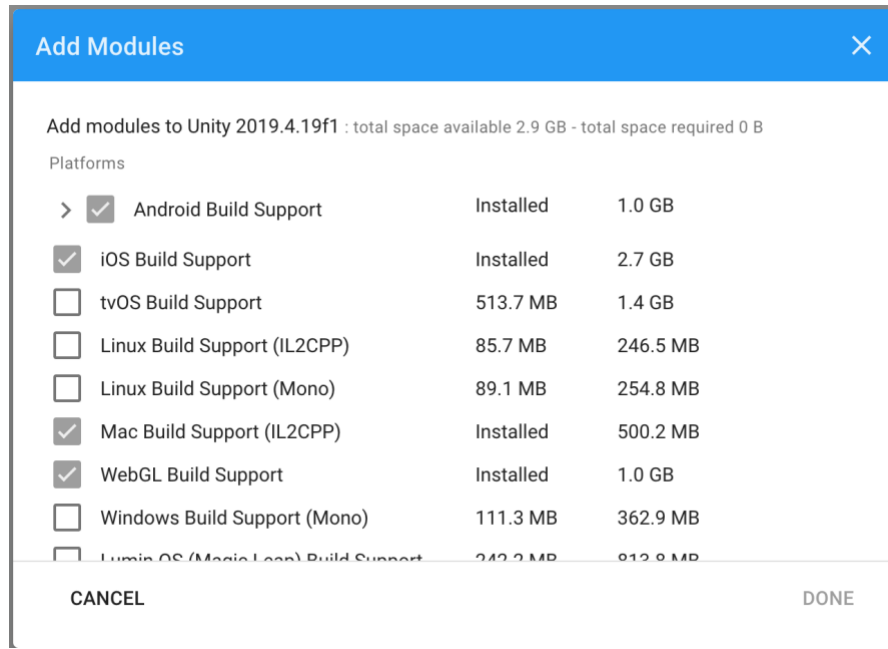
To modify the application, the first step is to download Unity which can be done at the following [link](#). Select the “Personal” option which allows anyone to use Unity for free if yearly revenue is less than \$100,000. Since this application will be used to help and inform people on recycling, no profits or revenues will be generated. As such, using Unity for the purpose of this app will always be free of charge.

Once Unity Hub has been downloaded, the next step is to make sure the right version is installed. Click on the *Installs* tab on the left (as seen below) and make sure the version you are using is 2019.4.19f1.



*Figure 9 – “Installs” Section of Unity Hub*

Then, click the 3 little dots and select *Add Modules*. Once that pop-up is open, check *Android Build Supports*, *iOS Build Support* and either *Mac Build Support* or *Windows Build Support* (it depends on the computer you are currently using).



*Figure 10 - Adding Modules in Unity Hub*

Now download the project from the Maker Repo page, which is called *GNG Project.zip*. Once downloaded, extract it and open it with Unity Hub.

For the image targeting database, it can be accessed at the following [link](#). To have access to the database for this project, hit login in the top right corner. The account information will be presented in section 3.3.

### 3.2 User Access Considerations

There is no restricted access to the application in Unity. Once one has downloaded and imported the file, they will have full access to the back-end. However Vuforia is restricted to an account and will require login information to modify the image database.

### 3.3 Accessing the System

Here is the account information for the Vuforia database:

**Email address:** aberasenathi9@gmail.com

**Password:** Prototype1

Please feel free to change the email address or password attached to the database account.

### **3.4 System Organization & Navigation**

Once the app is open, it shows the home page. The home page has buttons to 3 other pages: account, scanner and settings. The account page leads to 4 pages: add an account, user account, reward info and claim reward. The settings page leads to 2 pages: step-by-step tutorial and the send us a message pages. The scanning page leads to no other page. If an item is not recognized, it will ask the user if they want to do a manual search. Once clicked, this will open the City of Ottawa *Waste Explorer* page, where users can manually type in their item for recycling information on it. All these pages will be demonstrated and further explained in section 4 of this document.

Each page also contains a home button at the bottom, which when clicked leads users back to the home page.

### **3.5 Exiting the System**

There are no special instructions to exit the system while using it on your phone or modifying the app on your computer. Remember to save the application in Unity before closing if modifications were made to the app.

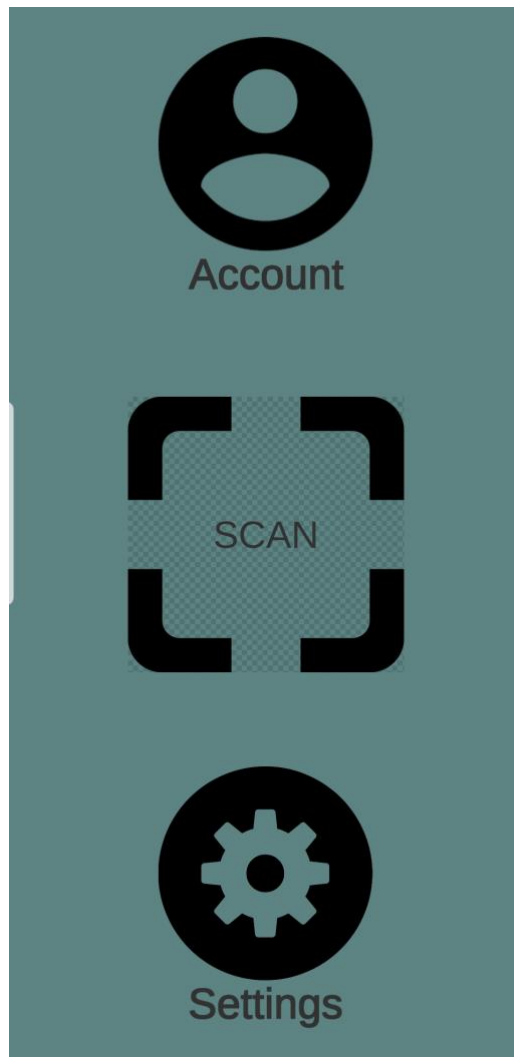
## **4 Using the System**

The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the RecycleBuddy app.

## 4.1 Home Page

When the app is opened, the user is taken to the home page. This page contains 3 buttons, which lead to the account page, scanner and settings page. The accounts button is on the top, and is an image of a person. The scan button is in the middle, and is an image of a scanner target. The settings page is on the bottom, and is an image of a gear.

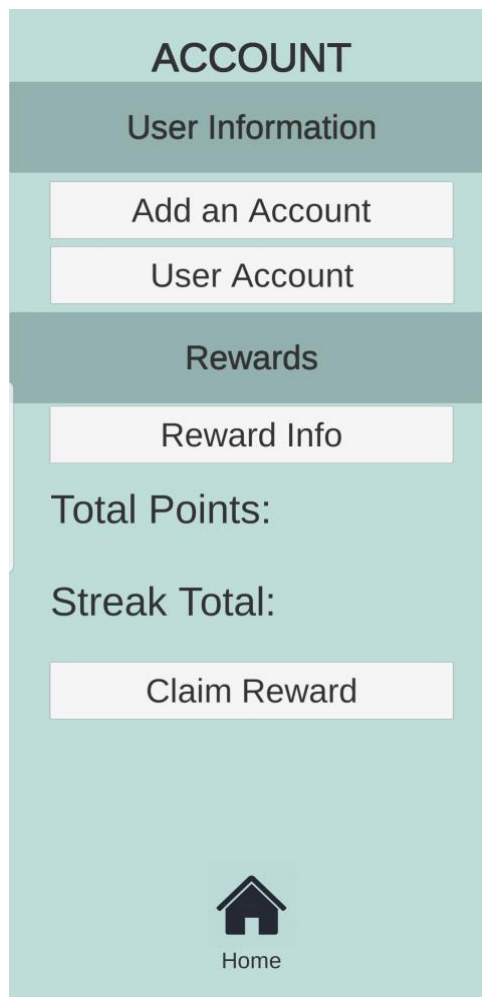
Every page in the app will have a home button at the bottom, which will allow users to navigate back to the home page.



*Figure 11 - Home Page*

## 4.2 Account Page

The account page has two sections: *User Information* and *Rewards*. The *User Information* section is on top and is made up of two buttons which lead to the page they are named after, which are the *Add an Account* page and the *User Account* page. This section is where users can access and manage their personal account. The *Rewards* section is below and contains all the information about the user's rewards. The reward system is streak based, which means every day users get awarded a certain amount of points for using the app. If they use the app on consecutive days (i.e. streak), they get more points per day. The user's streak (i.e. amount of days they have used the app consecutively) and total points are displayed in this section. There are also two buttons which lead to the pages they are named after, which are the *Rewards Info* page and the *Claim Reward* page. The reward system will be implemented in a future update.



*Figure 12 - Account Page*

#### 4.2.1 Add an Account Page

This page allows users to create an account that will be stored in a cloud. Accounts are comprised of a user's name, email address and phone number. The account system will be implemented in a future update.

**ACCOUNT**


Add an Account

Name:

Email Address:

Phone Number:

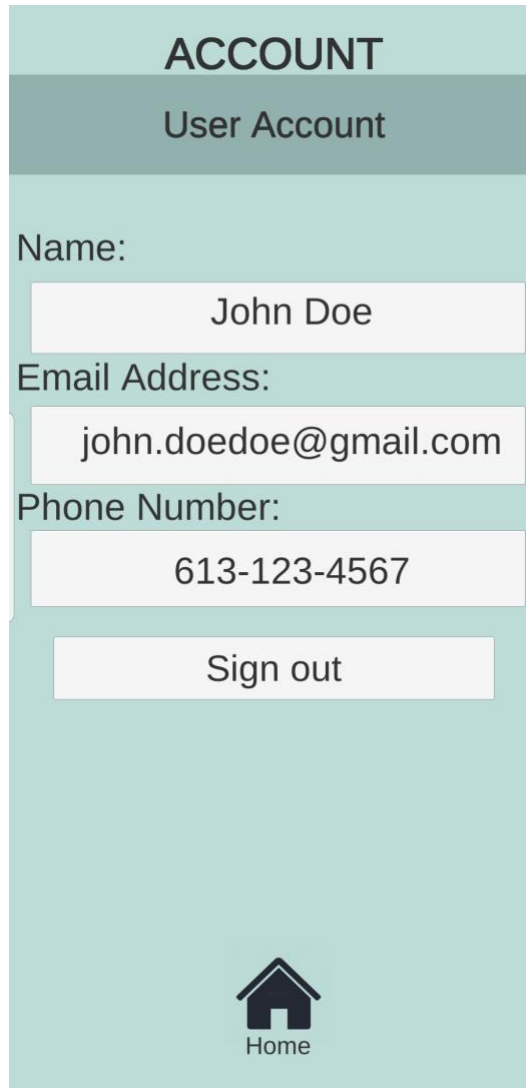
Create Account

  
Home

*Figure 13 - Add an Account Page*

## 4.2.2 User Account Page

This page allows users to see the account that is currently signed into the app, as well as make modifications to its information. It will also allow users to sign out of the current account. The account system will be implemented in a future update.



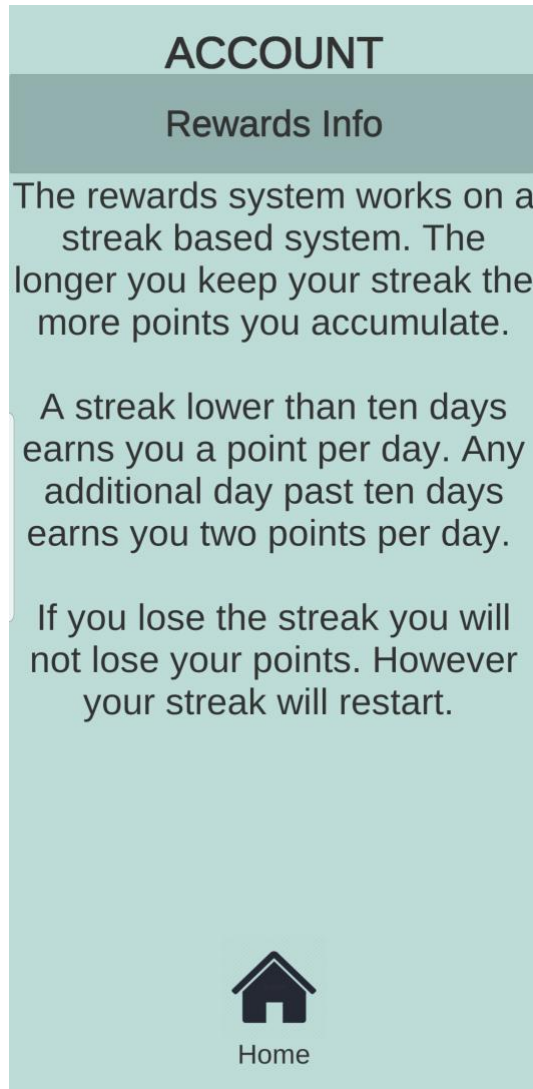
The image shows a mobile application interface for a user account page. At the top, there is a header with the word "ACCOUNT" in a light teal box, and below it, a darker teal box containing the text "User Account". The main content area is light teal and contains three input fields: "Name:" with the value "John Doe", "Email Address:" with the value "john.doedoe@gmail.com", and "Phone Number:" with the value "613-123-4567". Below these fields is a "Sign out" button. At the bottom center, there is a house icon with the word "Home" underneath it.

*Figure 14 - User Account Page*



### 4.2.3 Rewards Info Page

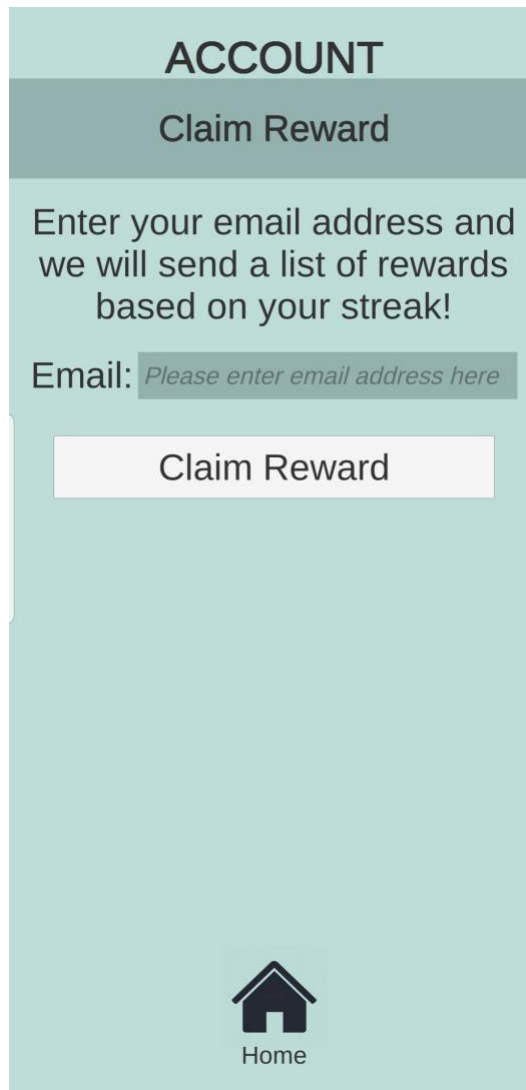
This page will explain to users how the reward system works. The reward system will be implemented in a future update.



*Figure 15 - Rewards Info Page*

#### 4.2.4 Claim Reward Page

This page allows users to claim a reward based off their total points. Once users have accumulated enough points, they can access this page and enter their email address to be sent a list of rewards to choose from (sent to their email account). These rewards will most likely be gift cards from local retailers such as Tim Hortons and Starbucks. The rewards system will be implemented in a future update.

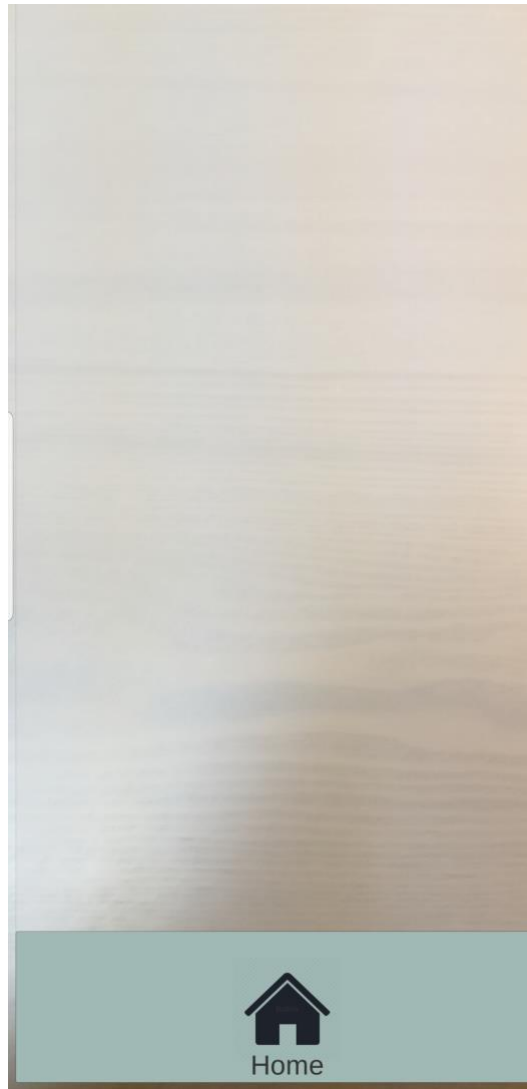


The screenshot shows a mobile application interface for claiming a reward. At the top, there is a header with the word "ACCOUNT" in a light teal bar. Below this is a dark teal bar with the text "Claim Reward". The main content area has a light teal background and contains the text: "Enter your email address and we will send a list of rewards based on your streak!". Below this text is a label "Email:" followed by a text input field containing the placeholder text "Please enter email address here". Underneath the input field is a white button with the text "Claim Reward". At the bottom of the screen, there is a dark teal bar with a white house icon and the text "Home" below it.

*Figure 16 - Claim Reward Page*

### 4.3 Scan Page

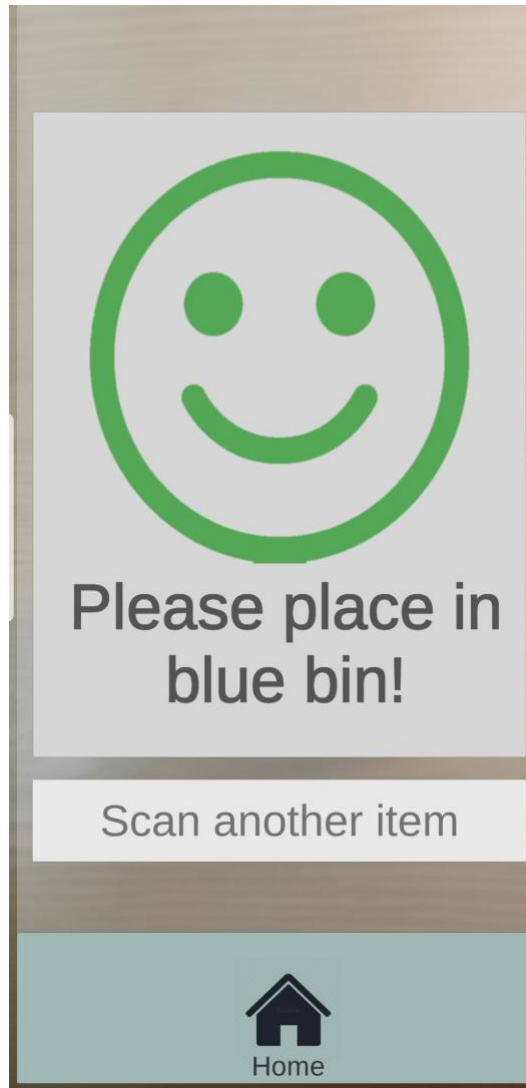
This page is the scanner portion of the app. This scanner uses AR technology to identify items and determine whether or not they are recyclable in the users local municipality. The user must grant the app access to their cameras as it will use the phone's camera to scan items.



*Figure 17 - Scan Page*

### 4.3.1 Recyclable Item Pop-up

When a recyclable item has been placed in the phone's field of vision, the scanner will identify it as recyclable and this pop-up will appear. The pop-up is a large green smiley face, thus indicating the item is recyclable, with text below it indicating which bin to place the item in.



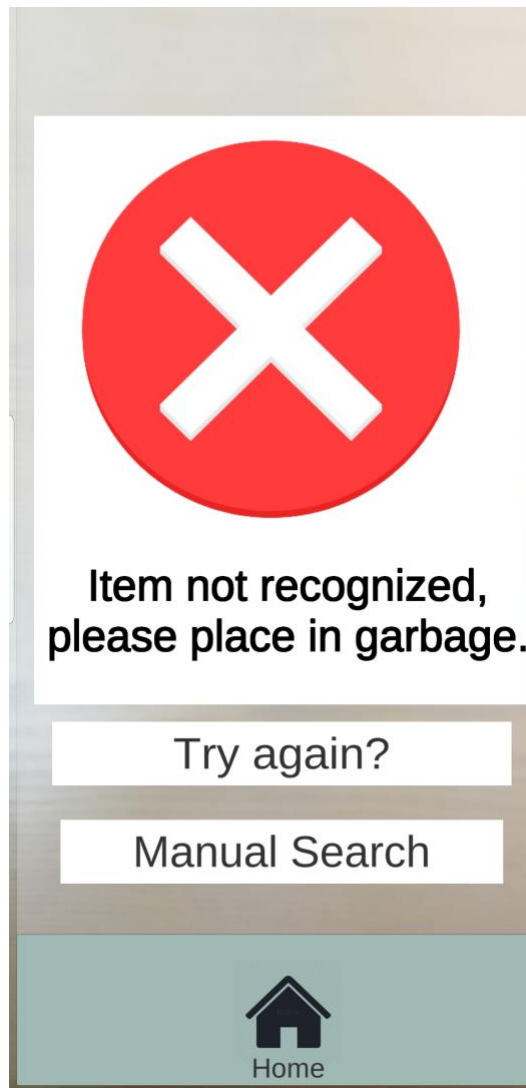
*Figure 18 - Recyclable Item Pop-up*

#### 4.3.1.1 Scan Another Item Button

Below the pop-up is a button which will allow users to scan another item (it will wipe the screen of the pop-up).

### 4.3.2 Non-Recyclable Item Pop-up

When a non-recyclable item has been placed in the phone's field of vision, the scanner will identify it as garbage and this pop-up will appear. The pop-up is a large red "X", thus indicating the item is not recyclable, with text below it indicating to place it in the trash.



*Figure 19 - Non-Recyclable Item Pop-up*

#### 4.3.2.1 Try Again Button

If the user is not satisfied with the result, they can click on the *Try again?* button below the pop-up. This button which will allow users to scan the item again (it will wipe the screen of the pop-up).

#### 4.3.2.2 Manual Search Button

Another option the user has if they are dissatisfied with the scanner's result is to click on the *Manual Search* button which will bring the user to the City of Ottawa *Waste Explorer* webpage (it will automatically open in the users default web application). The *Waste Explorer* is a manual search engine where users can type their item and then search for it in the City of Ottawa's database. It will then provide users with information and instruction on to properly dispose of their item.

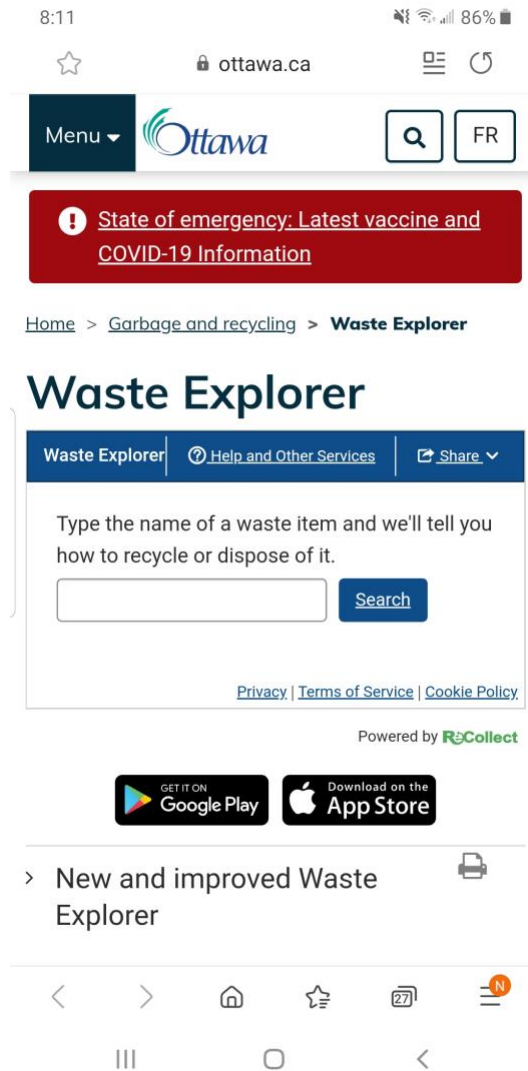
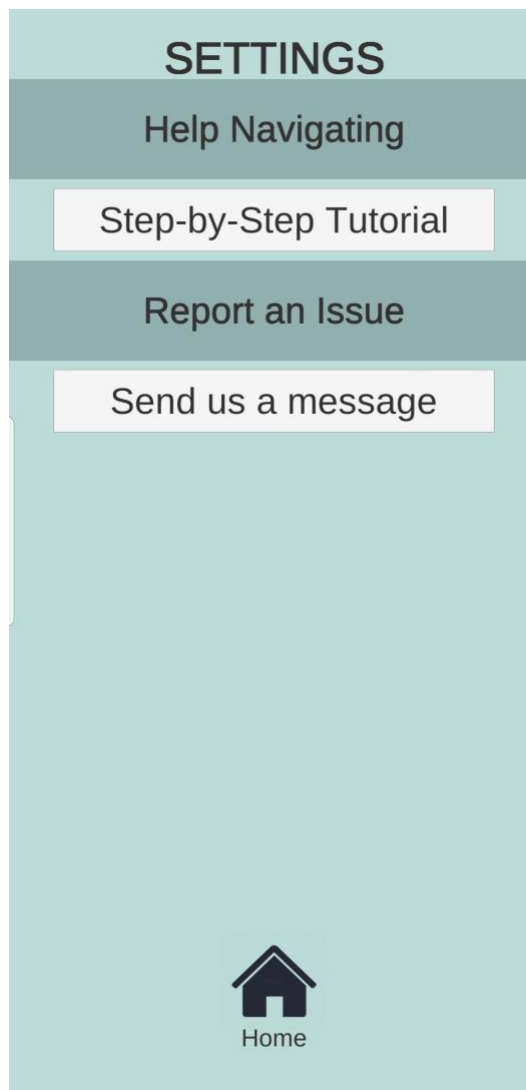


Figure 20 - Waste Explorer Page

## 4.4 Settings Page

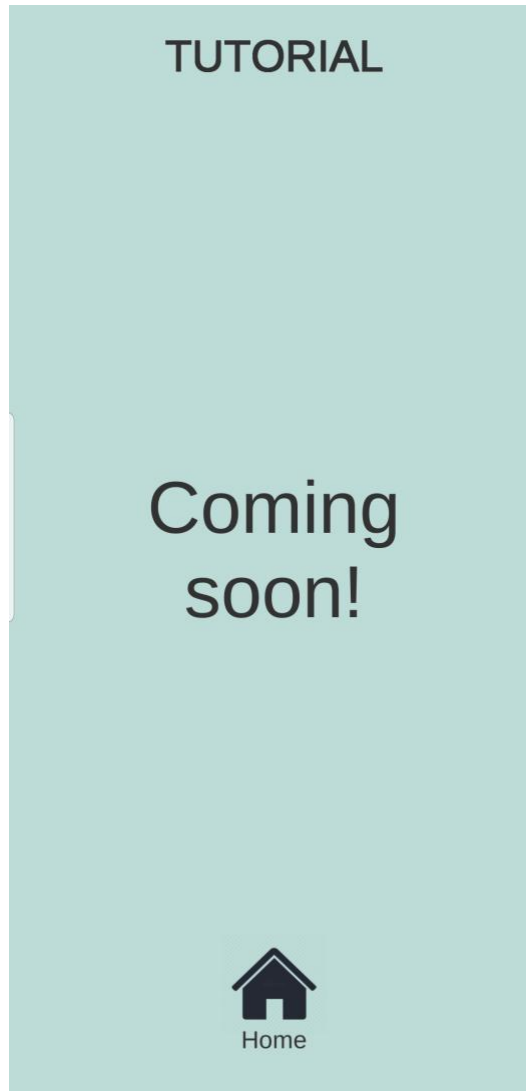
The settings page has two sections: *Help Navigating* and *Report an Issue*. The *Help Navigating* section is on top on is where users can seek help on how to use and navigate the app. It has a button which lead to the page named after, which is the *Step-by-Step Tutorial* page. The *Report an Issue* section is below and is a tool for users to use if they notice any bug with the app, or if the app is not working properly for them. Also, if the user is dissatisfied with the classification of a item, they may voice their concern in this section. There is one button which lead to the page it is named after, which is the *Send us a message* page.



*Figure 21 - Settings Page*

#### 4.4.1 Step-by-Step Tutorial Page

This page will contain step-by-step instructions on to use and navigate the app. It will be implemented in a future update.



*Figure 22 - Step-by-Step Tutorial Page*



#### 4.4.2 Send us a message Page

This page allows users to directly send a message to the developers of the app. If the user has a complaint, a question, has noticed a bug or is dissatisfied with the identification of a certain item, they can fill out the required information and describe their issue. This feature will be fully implemented in a future update.

**SETTINGS**

**Send us a message**


Name:

Email:

Phone Number:

Describe the Issue:

**Send**

  
Home

*Figure 23 - Send us a message Page*

## **5 Product Documentation**

The most important element of the prototype was the image scanner. This scanner uses AR technology to recognize an item with the phones camera. The *Vuforia* database is composed of multiple images, so once the scanner is launched the application will try to find these images. If it finds one of the images in its database, the application was designed to show a pop-up explaining whether or not the item is recyclable and where to dispose of it.

The application was created using *Unity*, a simple to use game building program. However *Unity* can also effectively be used to create phone applications. The *Vuforia* image database was downloaded into *Unity* and then image targets were created, linking the pop-ups to the known images. Several UI screens were then created with different functionalities and buttons were added to transition between screens. These buttons are made functional by scripts, which are small bits of code written in C#.

### **5.1 Vuforia Image Database**

#### **5.1.1 BOM (Bill of Materials)**

*Vuforia* allows up to 1,000 image recognitions per month, so the cost to use it for this prototype is free. However, if the application were to become popular and supers that number, the Basic package would need to be purchased at a cost of \$42 per month. Please see [Vuforia's pricing guide](#) for more info.

#### **5.1.2 Equipment list**

As this is a digital database, the equipment needed is an account with *Vuforia* and pictures of all the recyclable items.

### 5.1.3 Instructions

The database storing the images can be found under “Target Manager”. The screen will appear as so after clicking it:

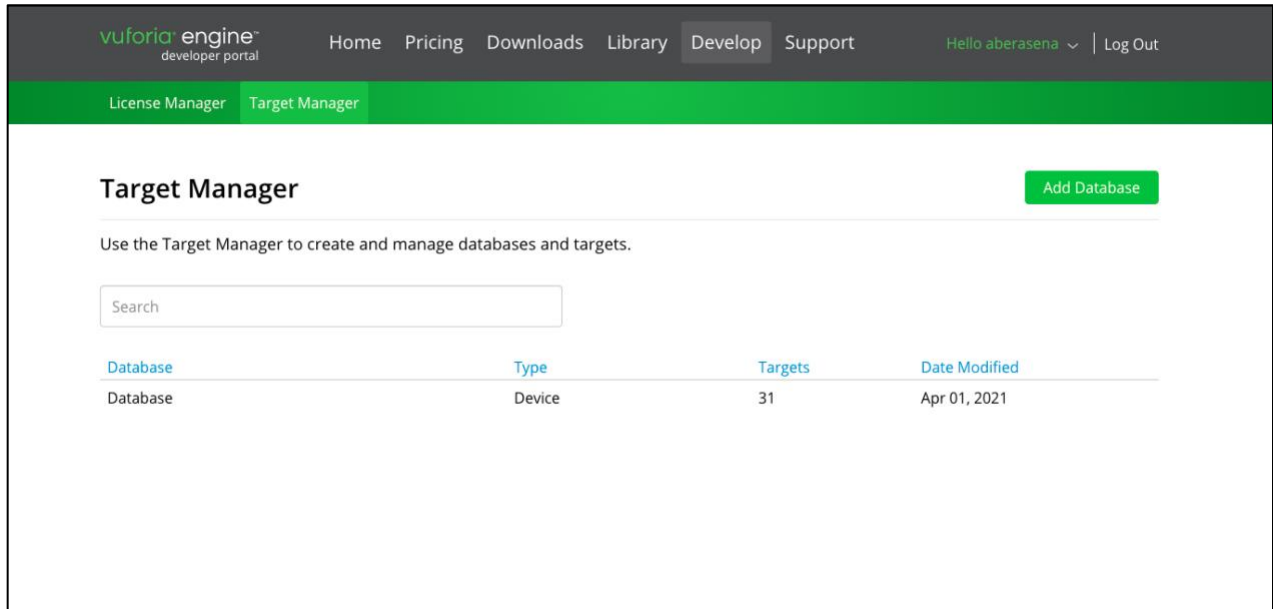


Figure 24 - Vuforia Target Manager

Then by clicking on the database, all the images that have been previously uploaded can be found. To add a new target/image, click on the “Add Target” button.

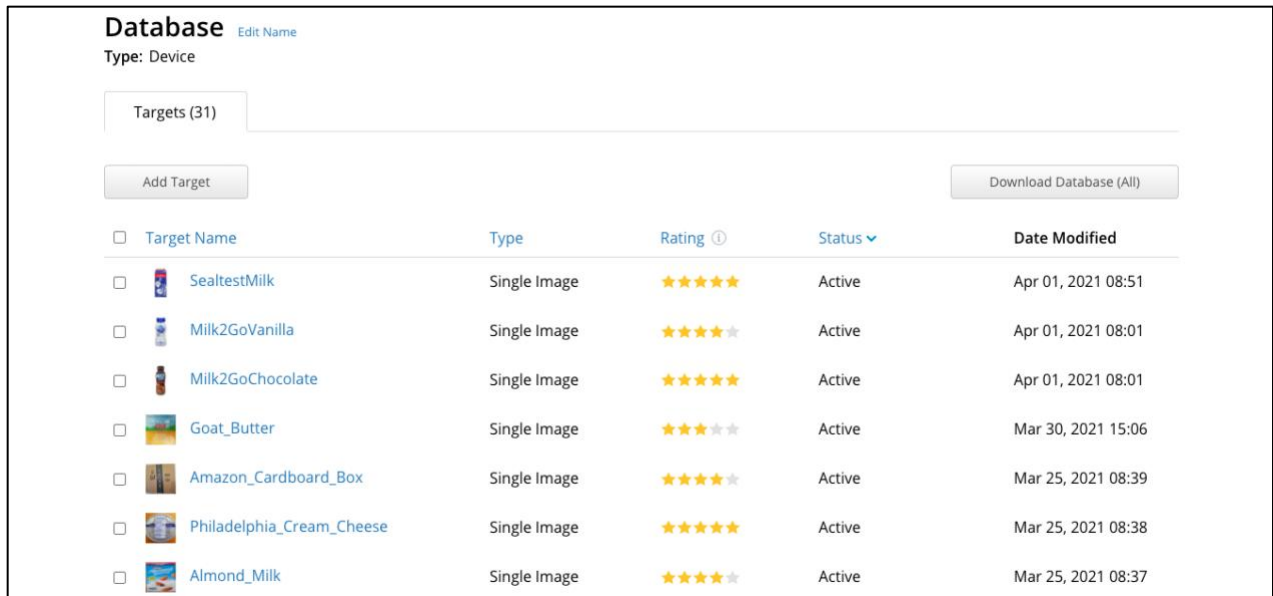


















Figure 25 - Vuforia Database

Finally, upload an image of the target either in JPG format or PNG. The dimensions of the item must also be included, and they must be in metres. A portion of the current database appears as such:

<input type="checkbox"/>	 SealtestMilk	Single Image	★★★★★	Active	Apr 01, 2021 08:51
<input type="checkbox"/>	 Milk2GoVanilla	Single Image	★★★★☆	Active	Apr 01, 2021 08:01
<input type="checkbox"/>	 Milk2GoChocolate	Single Image	★★★★★	Active	Apr 01, 2021 08:01
<input type="checkbox"/>	 Goat_Butter	Single Image	★★★★☆	Active	Mar 30, 2021 15:06
<input type="checkbox"/>	 Amazon_Cardboard_Box	Single Image	★★★★☆	Active	Mar 25, 2021 08:39
<input type="checkbox"/>	 Philadelphia_Cream_Cheese	Single Image	★★★★★	Active	Mar 25, 2021 08:38
<input type="checkbox"/>	 Almond_Milk	Single Image	★★★★☆	Active	Mar 25, 2021 08:37
<input type="checkbox"/>	 FrenchsMustard	Single Image	★★★☆☆	Active	Mar 18, 2021 15:00
<input type="checkbox"/>	 HeinzKetchup	Single Image	★★★★★	Active	Mar 18, 2021 15:00
<input type="checkbox"/>	 SaladDressing	Single Image	★★★★★	Active	Mar 18, 2021 14:59
<input type="checkbox"/>	 ActiviaYogurtSmall	Single Image	★★★★☆	Active	Mar 18, 2021 14:58
<input type="checkbox"/>	 AstrosYogurtSmall	Single Image	★★★★★	Active	Mar 18, 2021 14:58
<input type="checkbox"/>	 OikosYogurtSmall	Single Image	★★★☆☆	Active	Mar 18, 2021 14:57
<input type="checkbox"/>	 AstrosYogurtBig	Single Image	★★★★★	Active	Mar 18, 2021 14:57
<input type="checkbox"/>	 TidePods	Single Image	★★★★★	Active	Mar 18, 2021 14:54
<input type="checkbox"/>	 TideDetergent	Single Image	★★★★★	Active	Mar 18, 2021 14:53

**Figure 26 - Modifying the Vuforia Database**

Vuforia’s ability to recognize each target is based on the star ratings. Items with 5 or 4 stars can be easily identified, whereas items with 3 or less stars will be more difficult. Items with higher star ratings must be very detailed; there must be a contrast of colours, designs, and logos present. Generic items with no labels, variety in colour, or design tend to be given 0 stars, as seen below:



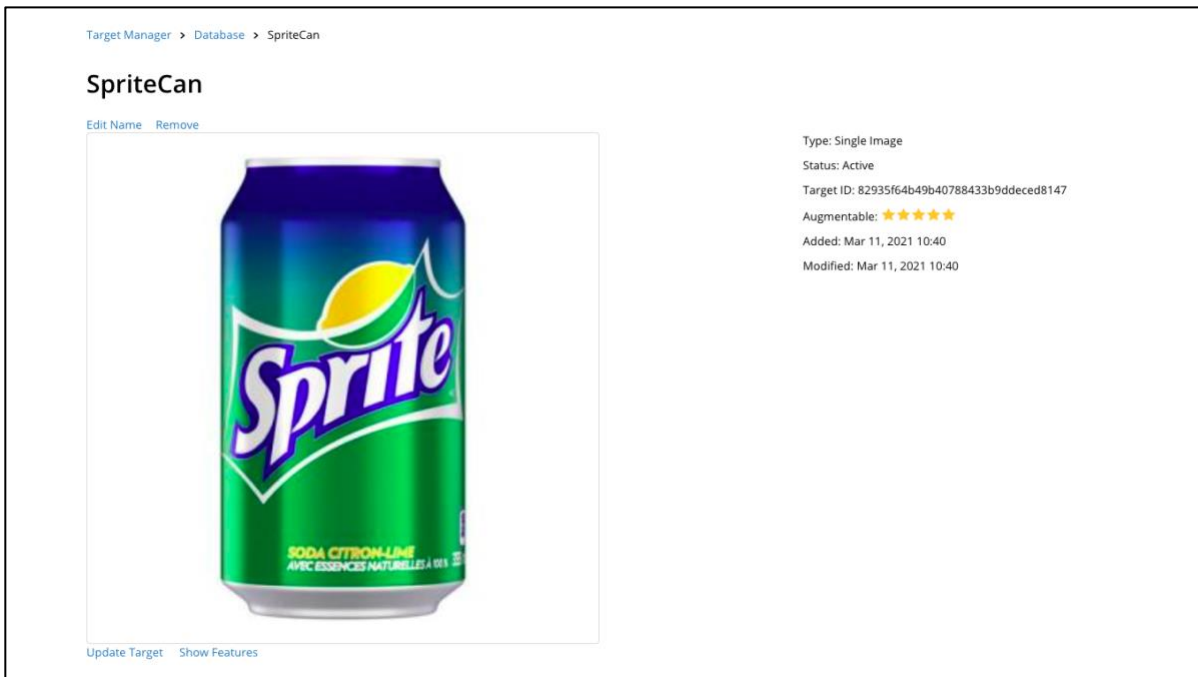
***Figure 27 - Item with a 0 Star Rating***

The glass bottle has a rating of 0 stars due to the lack of detail on the item. Since this is a generic bottle without any specific labels, images, or logos, the Vuforia does not have any special features to identify the item.



***Figure 28 - Glass Bottle Recognition***

Items that are more rich in detail have more features, which makes them more recognizable by the scanner since they have higher star ratings.



*Figure 29 - Item with a 5 Star Rating*



*Figure 30 - Sprite Can Recognition*

## **5.2 Unity**

### **5.2.1 BOM (Bill of Materials)**

*Unity* is free to use as long as yearly revenues are less than \$100,000. Since the purpose of this app is to help and inform users, it does not generate any revenues and will never hit this limit. As such, *Unity* can always be used for this application.

### **5.2.2 Equipment list**

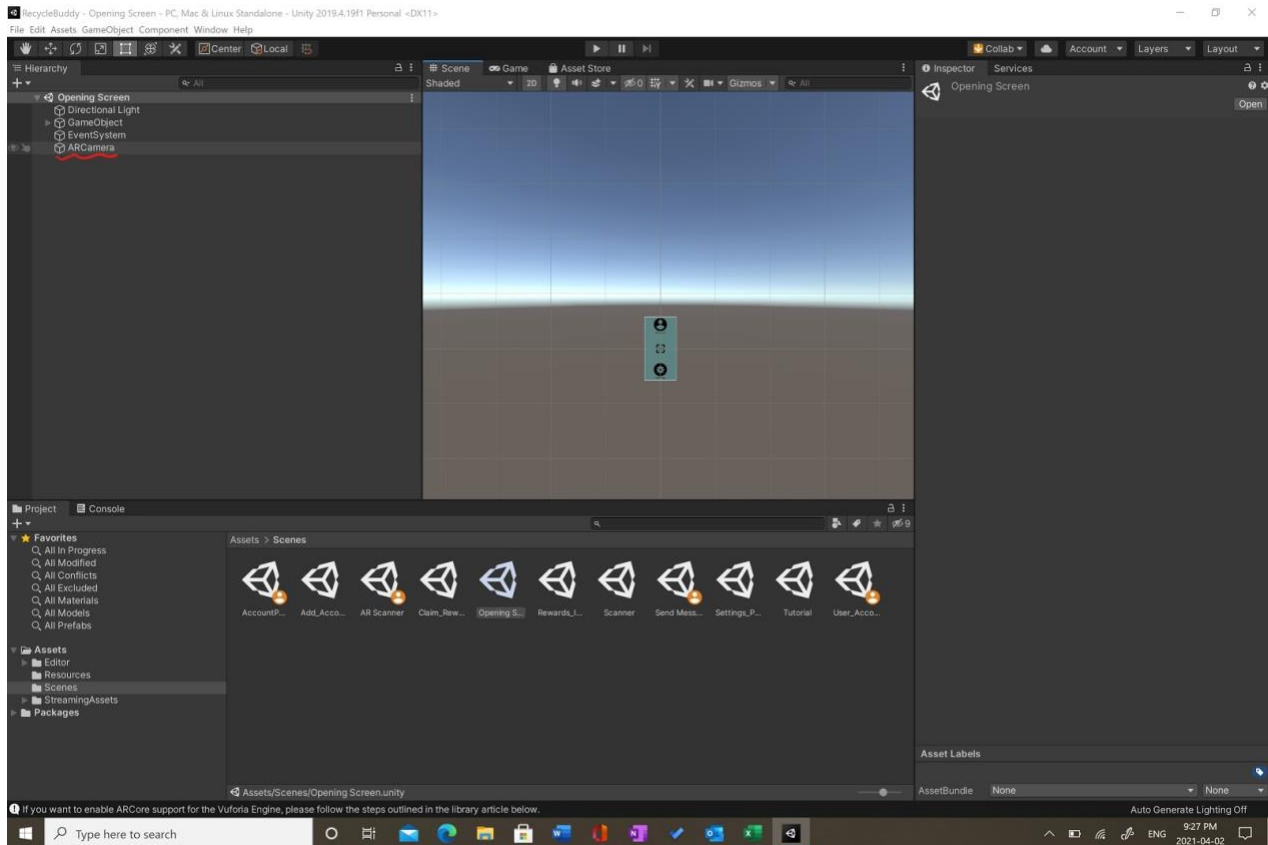
The only equipment needed are the softwares [\*Unity Hub and Unity\*](#).

### **5.2.3 Instructions**

To create the interface there are numerous steps and factors to consider. The dimension of the interface/scene, the images, the addition of different pages/scenes and other factors are all necessary in the creation, use and maintenance of the UI.

The dimension of the canvas is important since depending on the intended use the app may not appear as it appears while in *Unity*. Since the app was being created for smartphones and similar platforms, the scenes needed to fit on a smartphone screen. Consequently creating a canvas with objects and pieces everywhere will not function. The canvas must be in portrait mode and it must have the dimensions of 2160\*1080 (height\*width).

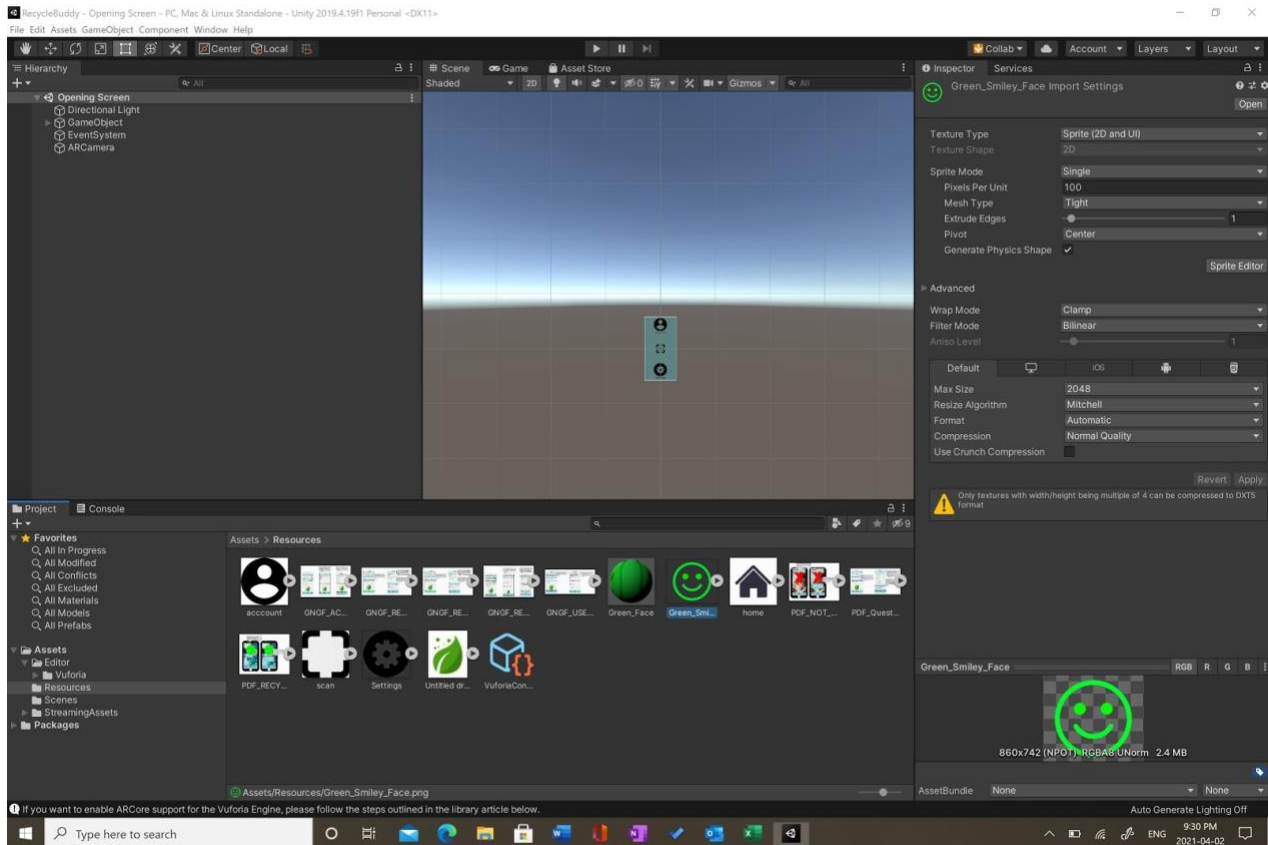
In order for the scene to function the camera must also be changed. The camera must be changed from the set “Main camera” to “AR camera”. Otherwise the app will not function as intended. This must be done for every scene. It is important to note that changing the camera on one scene will not apply to the other scenes therefore it must be done individually.



***Figure 31 - AR camera has been selected. Denoted with red underline.***

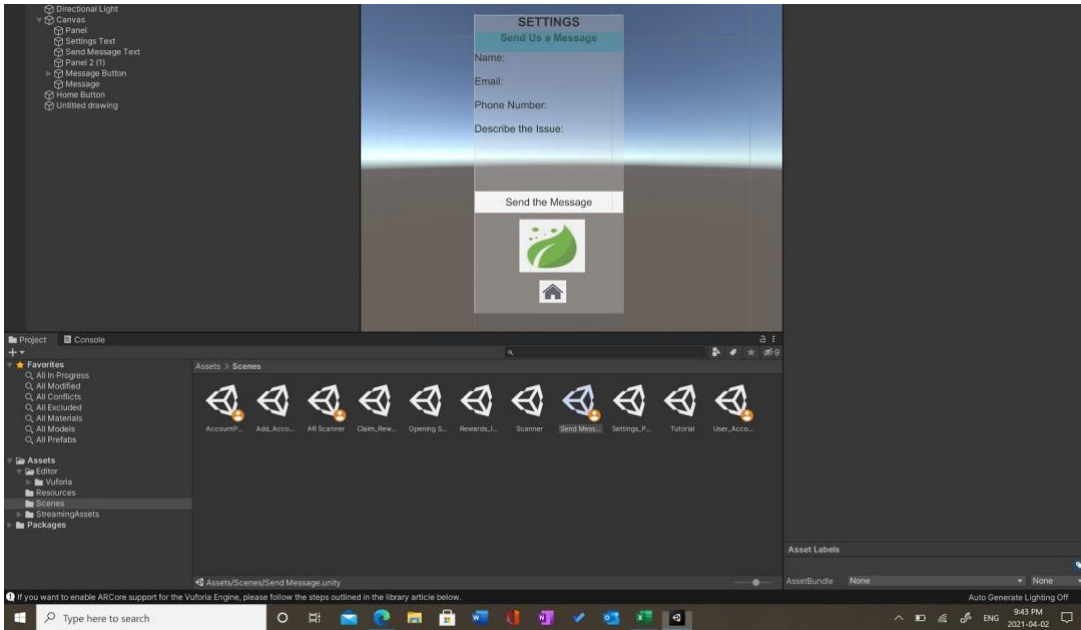
To add images, the image must first be downloaded. From there one must go to assets and under assets click on “resources”. One must then right click on their mouse and click “Import new asset”. Then one can select the image they downloaded to upload it into *Unity*. It is to be noted that images without backgrounds are ideal and if possible backgrounds should be removed. This creates a smoother result. To drag and drop into new scenes one must change the texture to “Sprite Editor”. Otherwise the process is cumbersome and inefficient.





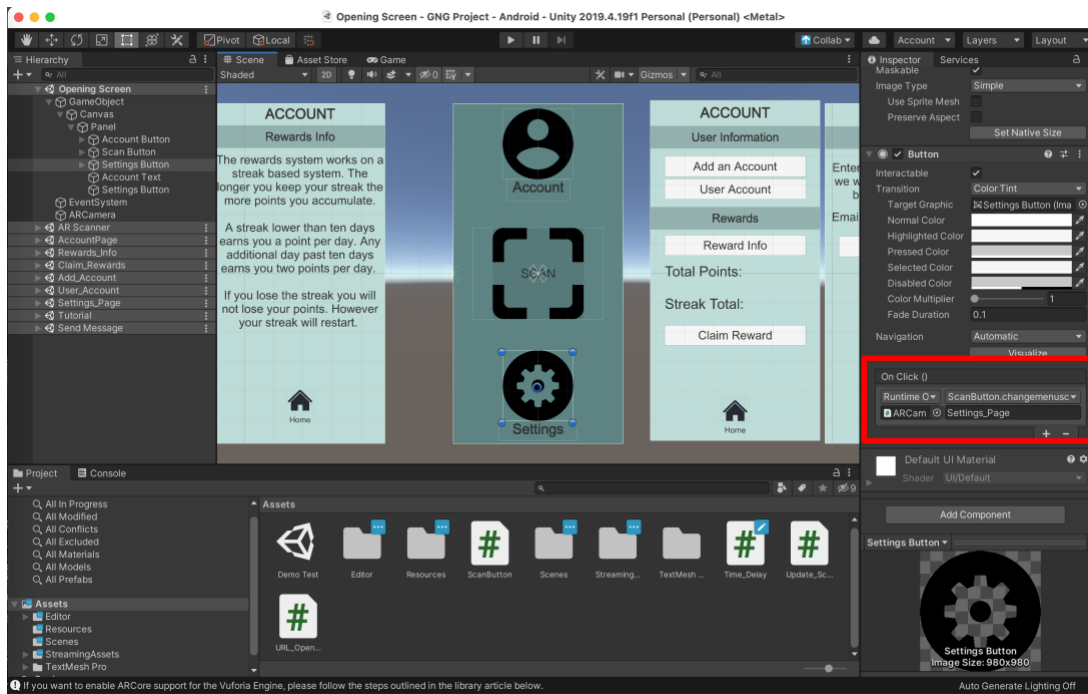
*Figure 32 - Sprite Editor has been selected meaning the image can be dragged and dropped into a new scene easily.*

Lastly to create new scenes one must go under assets to the scenes subsection. Then one must create a new scene by right clicking the mouse and selecting the appropriate button that says “Create new scene”. From there a new scene has been created. A canvas must be created as well since the canvas is what the user sees when using the application. This is why the canvas must be of a specific dimension as discussed above. The canvas acts as a boundary of sorts where all the functions are placed inside. To add features or function one must right click on the canvas button and add the features they wish. These features include other canvases and text boxes.



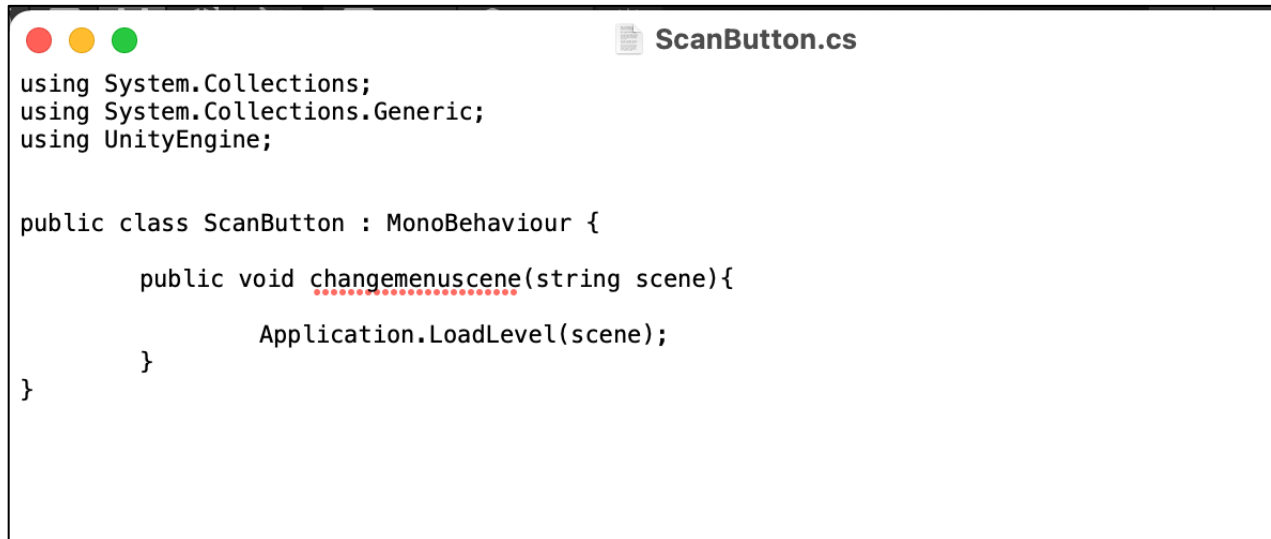
**Figure 33 - UI scenes and functions**

Now that the UI screens have been created, buttons can be added. In *Unity*, buttons can be dragged and dropped onto the UI screens. To add a functionality to the buttons, “Scripts” have to be created. These scripts are written in C# and are attached to buttons as an “On Click” function as seen in the following figure:



**Figure 34 - Attaching a Script to a Button**

This project contains four scripts, each with different purposes. The first script, “ScanButton”, as seen below, is typically attached to a button and transitions the user to a new scene. For example, this script is attached to the home button on every screen and brings the user back to the home page when activated.



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

public class ScanButton : MonoBehaviour {

    public void changemenuscene(string scene){

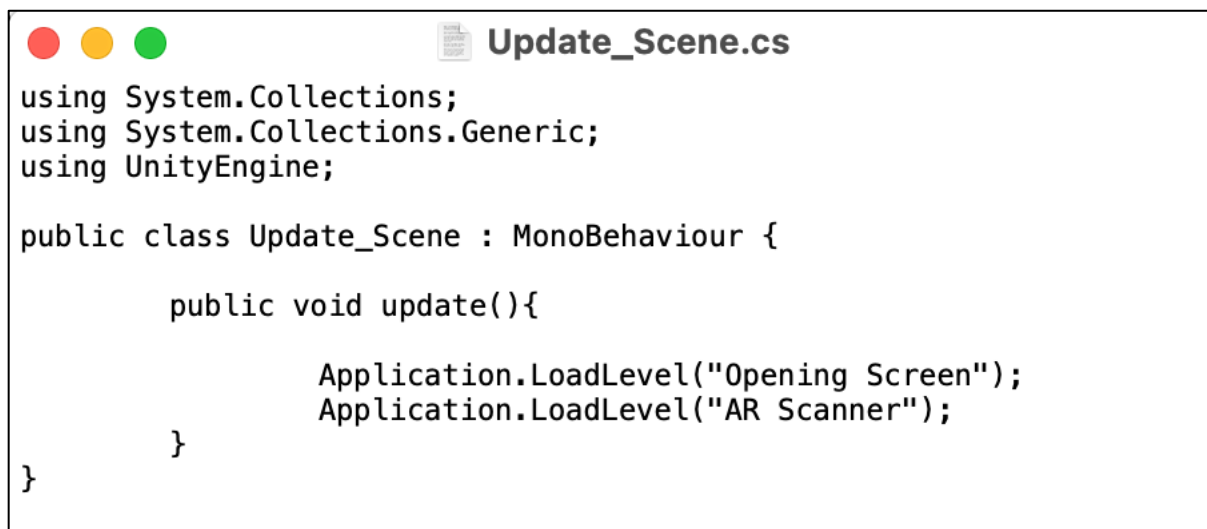
        Application.LoadLevel(scene);

    }

}
```

*Figure 35 - ScanButton C# Script*

The second script, “Update\_Scene”, as seen below, re-uploads the scene in question. This script is attached to the “Scan another item” button in the recyclable item pop-up (*Figure 18*) and the “Try again?” button in the non-recyclable button pop-up (*Figure 19*). Once clicked, it’ll erase the respective pop-up and restart the scanner.



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

public class Update_Scene : MonoBehaviour {

    public void update(){

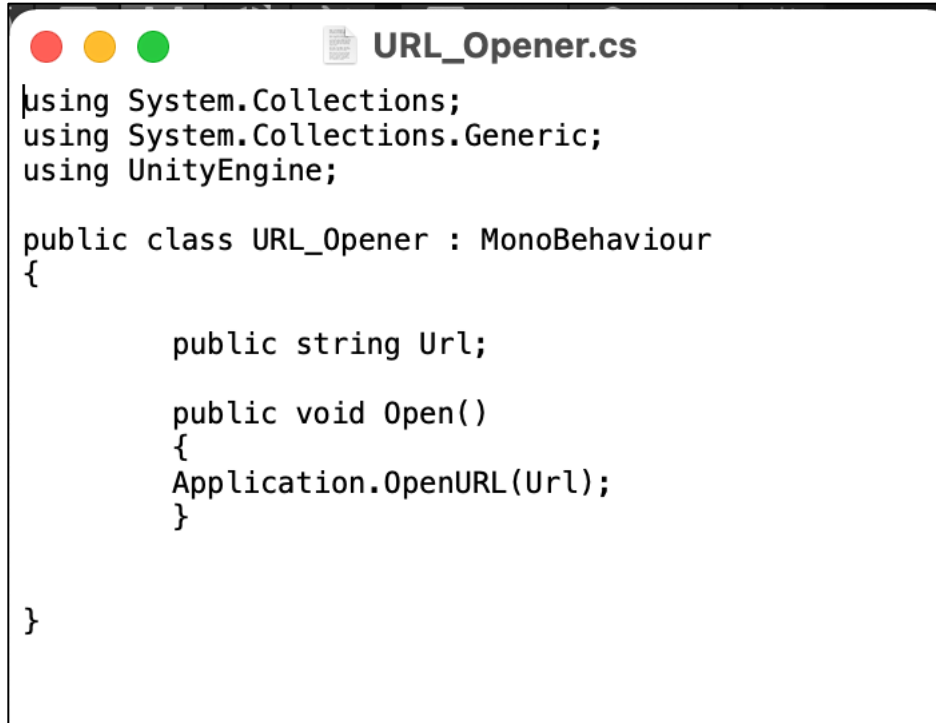
        Application.LoadLevel("Opening Screen");
        Application.LoadLevel("AR Scanner");

    }

}
```

*Figure 36 - Update\_Scene C# Script*

The third script, “URL\_Opener”, as seen below, automatically opens the desired website in the default web browser on the users phone. This script is attached to the “Manual Search” button in the non-recyclable button pop-up (*Figure 19*). In this case, once it is activated it will open up the City of Ottawa *Waste Explorer* manual search engine (*Figure 20*) to help users determine if the items are recyclable in jurisdiction of the City of Ottawa.



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

public class URL_Opener : MonoBehaviour
{
    public string Url;

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

*Figure 37 - URL\_Opener C# Script*

The last script, “Time\_Delay”, as seen below, is the mechanism that controls the non-recyclable item pop-up (*Figure 19*). Once the scanner is open, the non-recyclable item pop-up will show up in 10 seconds (this value can be changed in future prototypes if needed). The *Vuforia* image scanner is very quick to recognize items so after several tests, the team determined that if the scanner does not identify the item within 10 seconds of the scanner being activated, the item will never be identified. As such, this script will activate the non-recyclable item pop-up for future action by the user.

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

public class Time_Delay : MonoBehaviour
{
    public GameObject current_canvas;
    public GameObject item_1;
    public GameObject item_2;
    public GameObject item_3;
    public GameObject item_4;

    void Start()
    {
        current_canvas.SetActive(false);

        Invoke("Panel_Appear", 10);
    }

    public void Panel_Appear()
    {
        current_canvas.SetActive(true);
    }
}
```

*Figure 38 - Time\_Delay C# Script*

## 5.3 Testing & Validation

The final prototype was tested against four different criteria : size, performance time, complexity and efficiency.

### 5.3.1 Size

In the case of a phone application, the size criterion is measured by the size of the app. The app in its current form is 31.7 megabytes, which is well below the ideal metric set of 100 megabytes.

### **5.3.2 Performance Time**

Performance time is the total time the entire process takes, so it starts when the user identifies they need further clarification on their item and finishes when they get their answer. As such, it includes the times it takes for the user to take out their phone, launch the app and scan the item. After running several tests with individuals of different technological comfort, the average time to complete the process was 17 seconds, which is well below the ideal time which was set at 30 seconds. Thus, using the app is quick and respects the performance time criterion.

### **5.3.3 Complexity**

Any prototype must be very simple for users to use, it should have a low learning curve, it should be intuitive to use, and it should not require a lot of energy to use. Since recycling items (i.e., sorting items in their respective recycling bins) can happen multiple times a day for individual households, a complicated-to-use system would discourage potential users from utilizing this system to help them recycle better. To evaluate this, two metrics were used: number of decisions required, and number of interactions required. For this project, an acceptable range would be 5 decisions and 8 interactions required, while the ideal would be below 3 decisions and 5 interactions. Several different scenarios were tested and the majority of them were under the ideal amount of decision and interactions desired, while all of the fell within the acceptable range.

### **5.3.4 Efficiency**

The effectiveness of the prototype can be determined based on its performance. The product can be considered effective if the process is efficient; the app should recognize the item being scanned at ease and should provide the correct bin without any hesitation. The app can be considered ineffective if the image library does not recognize the item. A metric that can be utilized to measure the product's efficiency is its accuracy. The client has stated that the product should reach at least a 90% score for accuracy. However, due to the variety of recyclable materials that cannot be accounted for because of time constraints, an accuracy rate of 70-80% is a more reasonable goal. When comparing the product to the metric, it can be rated as 75% effective. This score was achieved after conducting 20 tests on the app. Out of the 20 tests, the *Vuforia* Image Library could only successfully identify 15 of the 20 items. The items that were not identified had 3-4 star ratings, which could be why the *Vuforia* Image Library could not recognize the item. An item with 3 star

ratings means that the item is too generic and that there is nothing distinct about it. Another reason for the unrecognizable items could be the angle at which the item was scanned. The scanner only recognizes an item if it is in the same position as that of the item in the photo, so any small variation could result in an error.

## **6 Conclusions and Recommendations for Future Work**

Numerous lessons were learnt throughout the prototyping course and through the client feedback. First and foremost, the solution to the recycling and waste management issue needs to be simple. The solution's goal is to divert as much recyclable material as possible from ending up in landfills thus reducing the amount of waste produced. To achieve this goal the solution must be simple enough that everyone can use it. This project also focused on the individual or consumer level rather than corporate level recycling. Ultimately, this led us to choose the app as the solution. People are becoming more and more technologically literate and the number of smartphone users is increasing. Instead of creating a physical scanner or solution that the user would have to go out and buy and then install an app can simply be downloaded. Thus the chosen solution was simple. Next, it must be obvious to the user whether the item is recyclable and where to place it. After presenting the first prototype, the client brought to the team's attention that the current model may not be obvious enough. Initially, the plan was to have "scanner guides" that would help the user place the item in the appropriate place so that the camera could scan it. These scanning guides would change based on whether the item was recyclable or not. A message would then appear. The client also raised the concern that the message was not large enough and the font was too small. The team went back to the drawing board and decided to have a large green smiley face for when the item is recyclable and a large red "X" for when it isn't. The message that appears now is also much larger and more obvious. Now there is no doubt where to place the item. Through the prototyping process, it also became evident that the efficiency was directly linked to the database. When a very small database was tested with the second prototype the efficiency was 100% because the test was very small and had selected items. When more items were added to the test the efficiency decreased because these images were not in the database. Therefore it was learned that to be more effective a larger database is necessary. It is also important since generic items are harder to detect with the image tracking technology therefore having more images of various pieces of cardboard for example would allow the app to detect generic cardboard more easily. Lastly, we learned that the user must be engaged. Without an incentive, people may not want to use a recycling app when they could

simply throw the object into the garbage and be done. Consequently, in the future a rewards system based on a streak system will be implemented so that the user is forced to use the app every day to maintain the streak. The user also benefits by collecting points and claiming rewards.

If the team had more time, the reward and account system would have been fully implemented. Additionally, the step-by-step user manual would have been added to the app the image database would have been expanded.



# APPENDICES

## 7 APPENDIX I: Design Files

*Table 1. Referenced Documents*

<b>Document Name</b>	<b>Document Location and/or URL</b>	<b>Issuance Date</b>
DemoTest_11.apk	<a href="https://makerepo.com/DavidTodd/811.recyclebuddy">https://makerepo.com/DavidTodd/811.recyclebuddy</a>	18/04/21
GNG Project.zip	<a href="https://makerepo.com/DavidTodd/811.recyclebuddy">https://makerepo.com/DavidTodd/811.recyclebuddy</a>	18/04/21