MOBILE AUGMENTED REALITY FOR SMART PET

By

OOI SHION YEING

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

Faculty of Information and Communication Technology
(Kampar Campus)

JAN 2019

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ACKNOWLEDGEMENTS

I would like to thanks and express my appreciation to my supervisor, Ms Saw Seow Hui and my moderator Dr. Cheng Wai Khuen who have gave me a lot of advices in order to complete this project. Besides that, they have given me a lot encouragement and motivation during the development of project. This is important to me when I feel stressful or loss direction, they are the one who always support me and guide me to the correct direction.

In addition, I would like to thanks my groupmate, Lee Yen Long who gives me his patient when I asked him some question that I cannot solved. Besides that, I would like to thanks my family who always give me unconditional support and love throughout the degree life.

ABSTRACT

Mobile Augmented Reality (AR) for Smart Pet is an augmented reality virtual pet simulation game application. The name of this game application is called Sorumeito, which is translate from the word "soulmate" to Japanese word. The pet in Sorumeito called Soru. The application named like this because people who loneliness or depression can have companion with them and overcome the hard time together. The companion is like a soulmate that can heal their soul and heart or even can just play for fun. Especially for the students which include primary students, secondary students, and university students are facing the same problems which are easy get stress from their academic study. The main purpose of this application is some of people are not effort to buy a real pet thus this application can stimulate a virtual pet for them to play. Thus, user can save a lot of money, time and space when they want to have a real pet compared to virtual pet. Virtual pet no need fed by real food, would not get ill, no need bath for them and even not occupied the space of owner houses, it just occupied the space of the phone. In order to let the pet can be more reality, this game application is developed by using unity game engine and combine with AR technique which is Vuforia. Vuforia is an augmented reality software development kit (SDK) for mobile devices thus author can bring virtual object to real world. Furthermore, artificial intelligent part includes voice recognition and face detection will be added into this game so that owner can speak with the pet and the pet can detect their own owner face expression, then the virtual pet can make some animation based on the expression.

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LIST OF ABBREVIATIONS

AR	Mobile Augmented Reality
VRC	Virtual Reality Company
GUI	Graphical User Interface
ASR	Automatic Speech Recognition
NLP	Natural Language Processing
Mobile SDLC	Mobile Software Development Lifecycle
SDLC	Software Development Lifecycle
UX	User Experience
UI	User Interface
3D	three-dimensional
IDE	integrated development environment
APK	Android Package Kit
SDK	Software Development Kit
JDK	Java Development Kit
FYP	Final Year Project
ML - Agents	Machine Learning Agents Toolkit

Chapter 1: Introduction

1.1 Introduction

Mobile Augmented Reality (AR) for Smart Pet is an augmented reality virtual pet simulation game application. Virtual pet has become popular nowadays in the worldwide from 90s. When the virtual pet begins to be popular? The first virtual pet which is Tamagotchi, a Japanese toy which size of key ring, had a small black and white screen, a speaker, a motion sensor, three buttons, and a microphone (Bloch and Lemish 1999). User can feed and play with their Tamagotchi. Thus, from that era, virtual pet game is started to be popular. In the new era, most of the people are having a phone, there are some of the mobile application game which is virtual pet stimulation game. They can bring their virtual pet to work anywhere and anytime if they have downloaded those game. If it is a real pet, people cannot bring them to the office, it only can just stay at home. However, no matter it is virtual or real pet, it has healing purpose for many people.

According to (Novotney 2014), more than 30 percent of students who seek counselling for mental health issues. Some students have serious mental problem and have attempt suicide before. College or university students are mostly the age where seeking help for counselling because they are not fully developed yet (Annie 2017). Most of the college students are very stressful in their college life because this is the age for them to fight for their future. They have the heavy responsibility on their academic study. By the way, not only college students, all students from different academic level will feel stressful when their academic performance is not good and may cause them have depression. Apart from this, some of the students are feel loneliness because may boycott from the others or they are always stay at home without make friend with others. Another reason is parent are always busy with their work, ignore their child and leave them alone in the home.

In order to reduce students who loneliness and depression, the authors will create a mobile application virtual pet game for students so that they can release stress and not feel lonely because they have companion which is virtual pet are always beside them. The authors will combine augmented reality technique and artificial intelligent technique into this application so that the virtual pet become more reality.

1.2 Background Information

The main focus of this project is using augmented reality technique to develop pet game stimulation application. Augmented reality is a technology that using the existing environment and overlay the virtual things on top of the real environment. There are four types of augmented reality nowadays which is markerless AR, marker-based AR, projection-based AR, recognition-based AR and etc . By the way, markerless AR is used in this project(Work 2018).

Markerless AR

It includes location-based or position-based augmented reality which use GPS to provide virtual data based on user's location. User can choose certain area place the virtual object without tracking any specific marker and launch the virtual object.

Marker-based AR

It is image recognition which is requires a specific marker and launch the virtual object on to the special marker after the camera have scan on it.

Projection-based AR

It is projecting synthetic light to physical surfaces which allow user interact with it. This technique mostly used by industry-leading manufacturers and suppliers to simplify the complex work includes manufacturing and assembly operation.

Recognition-based AR

It recognizes the objects and provide user more information about that object when use mobile phone to scan a OR code or barcode.

AR can be displayed on various type of devices such as cameras and sensors. In this project, AR will be displayed by using mobile phone's camera when the application is started. After the application is started, owners can spawn their pets after have clicked on the camera button while scanning the surfaces.

1.3 Problem Statement and Motivation

Real pet is a burden compared to virtual pet

Not everyone is able to keep a pet for themselves due to their affordability and limitation. Thus, they will prefer to download virtual pet game in order to satisfy their desire to keep pets. Furthermore, the responsibility towards the real pet is higher than the virtual one. Owner need to take care of their real pet on many aspects such as owner need to feed them at least three meal per day, bath them, play with them and take them to the doctor when they are ill. On the other hand, a virtual pet does not require a lot of commitment and responsibility from the owner. When people are keeping a pet, they have to make sure that they are able to provide a proper shelter for their pet.

On the other hand, virtual pet does not take up any physical space, but the space in the phone. The owner does not have to worry about the cleanliness of their home especially the furs of dogs or cats. In addition, pet can be dangerous especially they bite and scratch other people which may cause infections compared to virtual pet. Next, the pet can be nuisance. For example, dogs may bark or make noises that irritate the owner and mood. However, virtual pet will not have this problem and user is able to control the sound effects.

Overall, it is very costly to take good care of the real pet especially when the owner goes for a vocation in a long period, they have to send their pets to some shelters that cost a lot. There are a lots of pet shelters in Malaysia, most of them are in Kuala Lumpur and Selangor, the price for small, medium and large cats or dogs is around RM 50, RM 60 and RM 70 respectively per night (Yong 2017). Therefore, mobile apps for pets are becoming popular due to everyone owns a mobile phone. For some people losing a pet, which has been part of the family for many years, is almost like losing a family member or a well-loved friend. The loss of that pet will leave a hole in the owner's heart and may experience real grief. In order to avoid these feelings, the virtual is another alternative.

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Real pet cannot talk to people

The real pet cannot understand what we talk to them. Human are easy to feel loneliness or get stress on their work or study. But some of the people do not know how to express their feelings to their friend or family. Thus, they can express their feelings through communicating with their pets although it's only one-way communication. Therefore, this is crucial reason to implement the proposed system that consist of a virtual pet that can talk to people, speak out their mind, release their emotion and stress through this application.

Virtual pet game does not let the virtual pet look realistic

Lastly, the existing virtual pet game in the market is not attractive enough, people may feel bored easily. Thus, this project is proposed to create an attractive virtual pet and games on a mobile device using augmented reality technology.

Virtual pet does not detect owner facial expression

The virtual pet in the existing virtual pet game does not detect the owner facial expression. With the face detection method, virtual pet can detect owner facial expression and based on the expression, virtual pet can make some reaction to interact with the user. For example, if sad expression has been detected, the virtual pet will do some animation and try to make the owner happy.

Table 1.1 Comparison between real pet and virtual pet

Real Pet	Virtual Pet
Costly	Cheaper
Occupied physical space	Only occupied space in the phone
Make dirty of owner's house	Would not make dirty of owner's house
May harm people	Not harm people
Cannot long lived	Can long lived
Cannot talk to people	Can talk to people
Real	Partially real
Partially know the owner expression	Can detect the owner face expression

1.4 Project Objective

Affordability

To develop an AR application in mobile device to stimulate a virtual pet. This is because take care of a real pet is costly which is around RM3,000 to RM 4,000 per year. This cost includes grooming, health check-up, vaccinations, shelter, food. Some people would like to buy pets rather than adopt especially dogs and cats, it is cost RM50 to RM280 for a dog and RM50 to RM100 for a cat but depending on their age (May 2018). So, not everyone is afforded to buy a real pet for themselves. With this pet game application, user can save a lot of money but at the same time can fulfill their wish to have a pet.

Dual communication

To create a platform for the user to speak out their mind when they have met some problems or having stress in their life. Nowadays, students will get stress easily when their academic performance is not good. They are young people thus not much experience in controlling their emotion and they do not know how to release their stress (Beiter et al. 2015). According to (Tuncay 2008), they found that 60.2% of the university students in a university are experienced loneliness which there are 721 students participated in this survey. Thus, in order to reduce loneliness, people will find a companion especially pets to stay with them. According to (Robinson n.d.), pets are the best friend of human and pets always remind their owner he or she is not alone. But the real pet cannot speak with them, thus the application will be designed dual communication to let user can communicate with the virtual pets. So that the virtual pets can comfort the user by chatting with them. Therefore, the authors will combine the element of artificial intelligent part which is ASR with the virtual pet stimulation application so that the user can speak out their mind to their pets in order to reduce the loneliness and depression (Robinson n.d.).

Reality

To enhance the realism of virtual pet. It will look more real and feel like it is totally stay in the house if AR technique is applied to the virtual pet. Thus, the depression of victim may recover more faster because they feel love, comfort, and companionship from their virtual pets.

Interaction

To increase the interaction between owner and virtual pet. A real pet could detect their owner facial expression. Thus, when the application has detected the owner having sad emotion, then the virtual pet can make some animation to make the owner happy. So, the face detection method is added into this application in order for the virtual pet to reduce the depression of the owner.

1.5 Project Scope

The proposed app is a smart pet game based on android platform. It is a pet simulation game using Augmented Reality (AR) technology that allows the interaction between user and the virtual pet. There are two parts in the proposed app:

1. Front-end and back-end of mobile application part which include the Graphical User Interface (GUI) of game design, game features, and create the virtual pet game by using augmented reality technique.

2. Artificial Intelligence (AI) engine includes conversation component using Automatic Speech Recognition (ASR) to let the virtual pet able to communicate with its owners, face recognition component using Baidu Cloud face recognition SDK to let the virtual pet can recognize its owner and facial expression recognition component using Affectiva SDK to let the virtual pet can detect the owner emotion and based on the face expression to make some animation.

Responsibility of Team Member

1. Ooi Shion Yeing

   i) Graphical User Interface (GUI)

   ii) AR technology

   iii) Face Detection

2. Lee Yen Long

   i) Artificial Intelligent (AI) engine

      - Smart Chat Component

      - Face Recognition

Deliverables

1. An AR smart pet game android application
2. Markerless AR application

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1.6 Impact, Significance and Contribution

The author has proposed this project for student is to let them have fun in this game, they will release stress when they are playing this game. This is because all students may have met some problems in their academic study, some of them want to speak out their mind to someone so that others can help them to solve their problems, but nobody want to become the listener. They may feel loneliness due to not much of true friends. So, they can talk to their virtual pet so that they have a companion which always stay beside them which can overcome bad situation together.

Furthermore, not everyone is able to keep a pet for themselves due to the cost of raising a real pet is costly compared to virtual pet. With this game application, user can raise their virtual pet and at the same time they can save a lot of money, time and space. Virtual pet no need fed by real food, would not get ill, no need bath for them and even not occupied the space of owner houses, it just occupied the space of the phone. Thus, user can get a lot of benefit from raising a virtual pet compared to real pet. Besides that, interactivity is important in this application. AR technique, voice recognition and face detection are applied in this application so that the virtual pet can be looked more reality and the owner even can talk to the pet. Then, the virtual pet can detect owner's facial expression so that the virtual pet can make some action in order to make owner happy when they feel sad. Based on the functions that have stated, owner can get happiness and get comfort from their virtual pet.

1.7 Target Audience

The target audiences for this mobile AR smart pet game are mainly for students including primary students, secondary students, and university students. The rate of getting depression is increasing almost every year among students as mentioned in section 1.1. Most of the students feel stressful because they want to get a good result in their academic. Thus, they may not know how to release their stress through a proper way. Some of them will keep all this stress in their heart because they do not know who to trust and share with consequently, they will get depression and commit suicide. Therefore, if there is a mobile app game that can help the students to release their stress by not only talking to an artificial intelligent pet but at the same time the virtual pet can make them happy when they have emotional. Thus, they will be able to overcome the hard time.
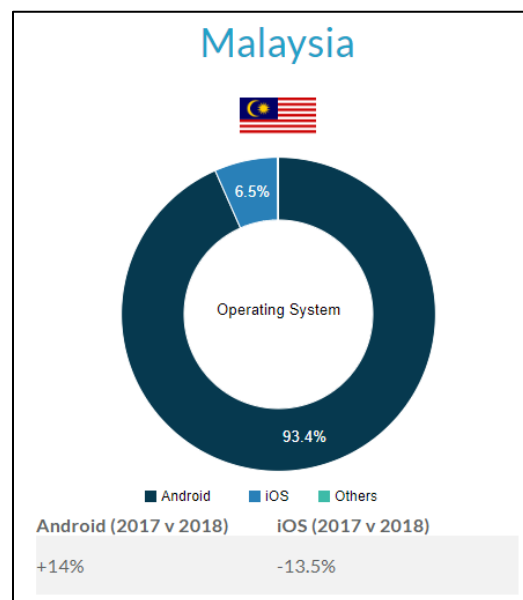
Figure 1.1 Statistic of Android user compare to iOS user in 2018

In addition, the author is targeting android user. Based on the statistic shown in Figure 1.1, the number of android users (93.4%) is more than the iOS users (6.5%) in the year of 2018. The statistic also compares the number of users in both operating system in 2017 and 2018. In this years, android user has increased to 14% and iOS user has reduced to 13.5% (Kirk 2012). Therefore, the android platform is chosen in the proposed app.

1.8 Report Organization

The report is divided into 7 chapters. The first chapter is the introduction of the project background, problem statement and motivation, project scope and objective, impact and target audience.

The second chapter of this report will review on the similar system and make comparison between the proposed system and reviewed system.

In third chapter, describe the overall design of the proposed system include system design diagram, mobile SDLC, use case diagram, swimlane activity diagram and system requirements.

In fourth chapter, have describe the preliminary work before implementation of important features such as design the UI interface and 3D models.

The fifth chapter has explained about the whole development process of the system in the Unity platform.

The sixth chapter is described about the evaluation part of the system such as system testing and objectives evaluation.

The seventh chapter is described about project review, challenges that have faced and future work.

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Chapter 2: Literature Review

2.1 Review on similar application

2.1.1 AR Dino Pet Game

Figure 2.1 The AR Dino Pet

AR Dino Pet is created by VKIDS VIETNAME LIMITED COMPANY and released on 29 September 2017. This app is available for Apple user only. It is a mobile augmented reality pet apps which bring a cute dinosaur into the real world and adopt it as our own pet. This dino pet can become human's life companion and share the happiness together. Furthermore, the owner can bring this dino pet to wherever their pet parents go (AR Critic 2017a).

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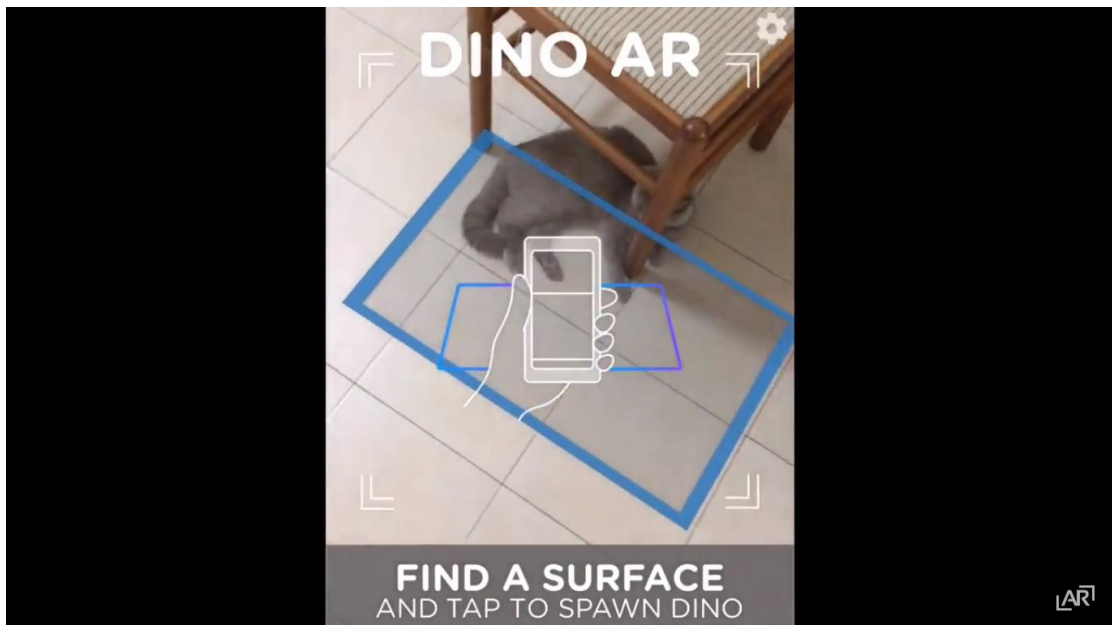
Figure 2.2 Interface of finding a surface to spawn Dino
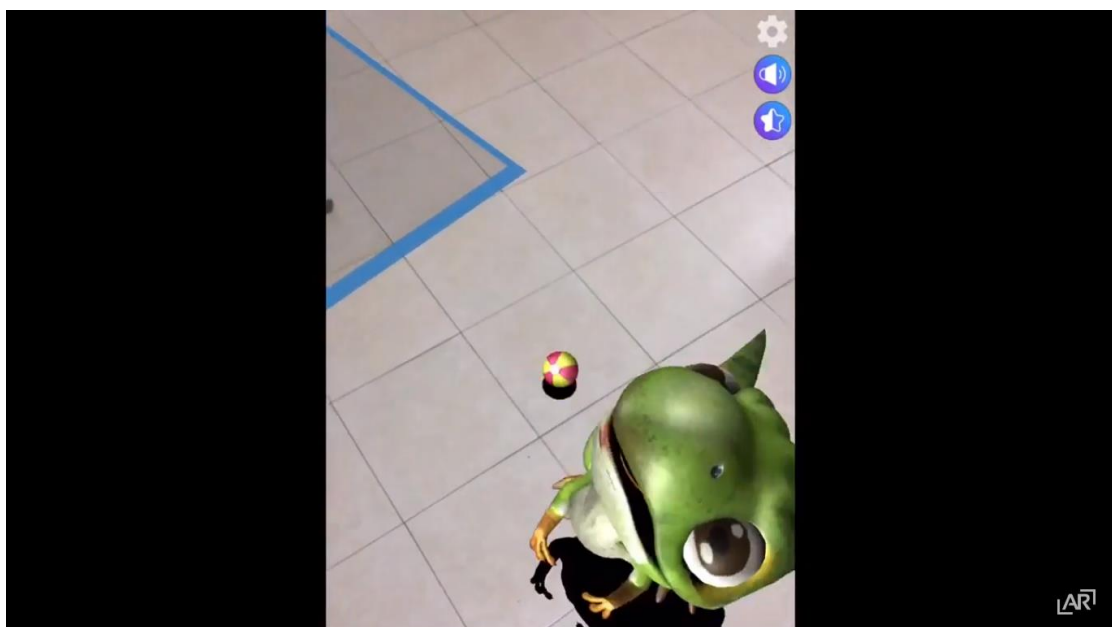
Figure 2.3 The Dino is playing the ball with user

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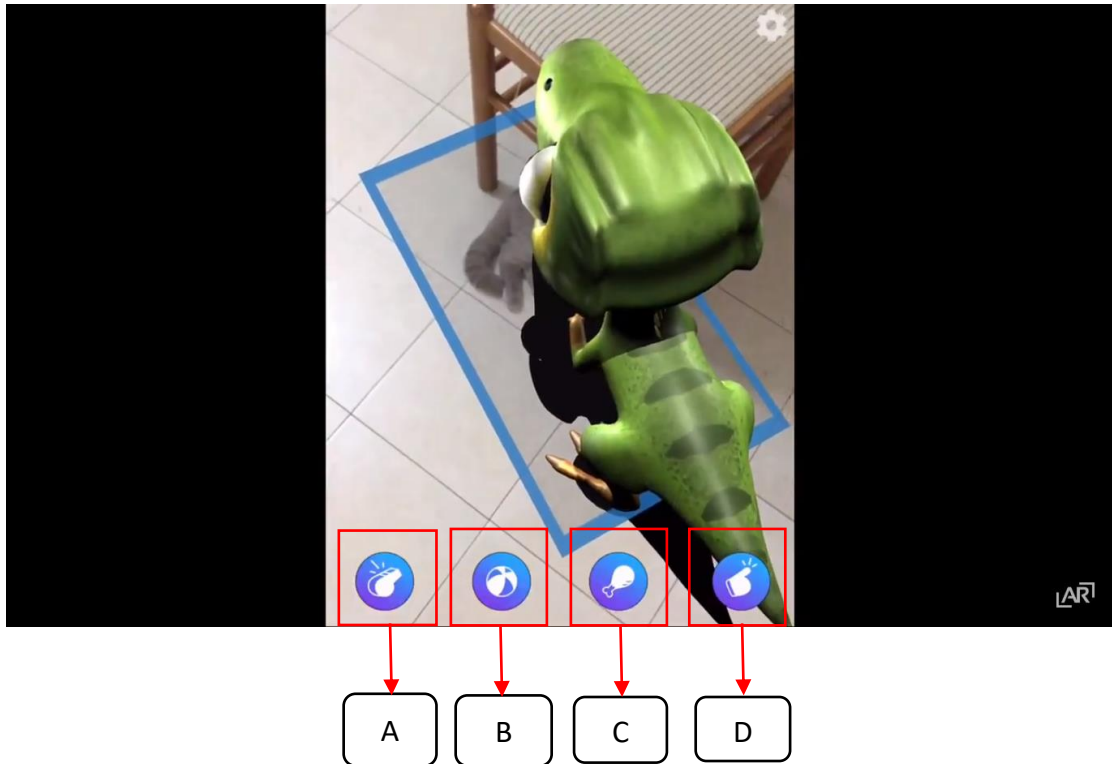
Figure 2.4 Interface after Dino has been spawned

Table 2.1 Function of the Dino game features

Label	Name	Function
A	Whistle icon	Call little Dino come to owner.
B	Ball icon	Play ball with Dino.
C	Drumstick icon	Feed the little dinosaur.
D	Finger icon	Tickle the Dino and its reaction are so cute and adorable.

When the application is started, the first step that user has to do is to adjust the phone camera around a surface find a suitable surface and tap on it to spawn the cute dinosaur Dino as shown in Figure 2.2.

Once the Dino pet has spawned on the surface, several provided features are shown so that user can use to interact with their dinosaur pet as shown in Figure 2.4. The first icon is a whistle icon which call little Dino come to them. After the first icon have been clicked, even the Dino is far away from the user, it will move forward and backward for them. Next, the second icon is a ball icon which use to play ball with it. After the second icon have been clicked, a ball will appear to the screen for the user to throw to any area. Dino will go pick up the ball and bring back for them (Figure 2.4). The third icon is a drumstick icon which use to feed the little dinosaur. After user have clicked the icon, a small drumstick will appear to the screen and they need to move the drumstick near to its mouth and feed it. The fourth icon is a finger icon which use to tickle the Dino and its reaction is so cute and adorable (AR Critic 2017a).

Strengths

1. User first spawn the little dinosaur to a surface that have chosen, the detected surface stayed on the screen only visible for the surface detection phase, there is no need to make it visible after the game starts.

2. The dinosaur character is looks so cute and people will get attraction from this little cute thing.

Weakness

1. The dinosaur character's shadows have no transparency and the shadow is just solid black. This is just making the character are disconnected from the real-world scene and there is no reason to adjust it in the settings.

2. The Dino character looks cute, but the animations are not too exciting. The animations are probably the most important part in this type of game. Thus, the interaction in this game are quite boring.

3. Skin color of the Dino cannot make changes on it. The whole appearance is by default set by the system, user cannot change clothes or appearance for it.

Comparison with proposed system

1. Pet in proposed system will have shadow but not as dark as this existing system.
2. Soru is cute and adorable.

2.1.2 Follow Me Dragon

Figure 2.5 The Follow Me Dragon

Follow Me Dragon, an augmented reality app that is created by the Virtual Reality Company. The Virtual Reality Company (VRC) is a production company that combines the best gaming and art to create powerful VR experiences for people around the world. The co-founder of VRC, Robert led the creation of Follow Me Dragon and he said that VRC is taking a leap forward into Augmented Reality with the first dragon, Drake, a cute character with unique personality that will navigate int the real-world environments with its own flair (Stromberg 2012). Follow Me Dragon is an innovative AR experience populated with an adorable new character which designed to be enjoyed by all people of all ages. The released date of this game was 19 September 2017 and the last updated was 14 January 2018 (Stromberg 2012).

Main Features

1. Not on raising a pet but enjoy watching it follow anywhere or anytime you go.
2. This cute dragon has big eyes, two cute teeth and the color of skin can be adjusted by user (Critic 2017).
3. It walks or fly after us and it is always following at user's back when turn the camera to the back of user.
4. It will fly in the air with shining particles and it is beautiful when it appears on screen.

5. Make user more comfortable and not to feel lonely when walking on the street lonely because they feel that there are always have a companion beside them.
6. It gives us have more reality and treat it as a real pet.

Figure 2.6 Drake is playing ball with the user

Figure 2.7 Drake at the outdoor which is dark

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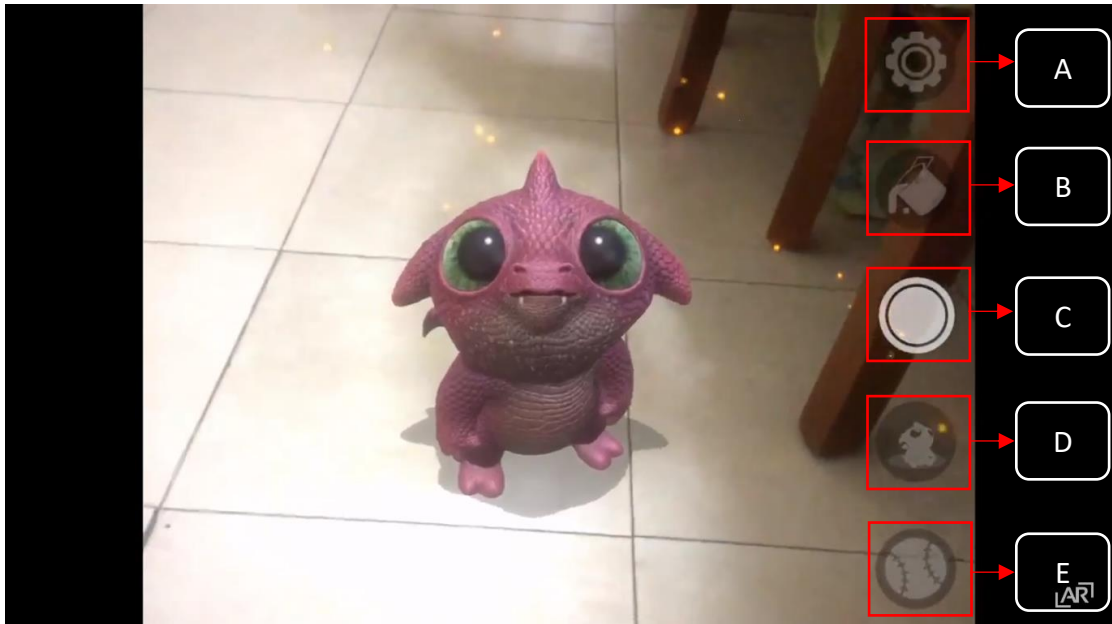
Figure 2.8 The cute dragon appears on the screen

Table 2.2 Function of Dragon game features

Label	Name	Function
A	Settings icon	Set the background music and read game tips.
B	Paint bucket icon	Change the skin color of the little dragon and there are variety of hues.
C	Camera icon	Take picture of Drake within the application.
D	Drake icon	Gives it different orders including sit, can make it stay or come to us.
E	Ball icon	Throw a multi-colored ball to Drake for it to retrieve or play with the user on screen.

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The first scene when user opened this application is a cute adorable dragon will appear in the house through their phone camera. Its name called Drake. It just stays on the floor and wait for user to make interaction with it. It looks at us so sincerely and Drake have a lots of face expression which is so adorable. There are a lot of function on the right side of the screen which can interact with the dragon pet. The top button is a settings icon which can set the background music and read game tips. The second button is paint bucket icon which can change the skin color of the little dragon and there are variety of hues. The third icon is camera icon allows us to take picture of Drake within the application. The fourth button is Drake icon which gives it different orders including sit, can make it stay or come to us. Lastly, the bottom button is a ball icon can be tapped to throw a multi-colored ball to Drake for it to retrieve or play with the user on screen (Critic 2017).

Strength

1. The interactive between the pet are more interesting. User can even pinch it become very small. When user shrink Drake down to super small, hard candies appear with the cookies for us to collect and feed to it.
2. The face expression of Drake is so expressive. Sometimes it will do stuff like looking around or even farting which have a green gas cloud behind it's back.
3. User can even double tap it to make it do pose for the camera and user also can pick it up.
4. User no need to obtain points to change its color because can just use color slider to change its skin color in real time. Thus, it is more interesting which able to change size and color of Drake.
5. This application has its own built-in camera button which can let user to take some adorable picture. This is actually essential because if user use screenshot to capture the picture, but it's going to include the user interface. So, when user have camera button in this application, it serves as a photo mode without capture the user interface.
6. The music and sound effects in this game are really good and the particles effects are looks amazing outdoors at night (Critic 2017).

Weakness

1. The game does lack content and a progression system which hurts the replay value of the game.
2. User may feel bored after they played sometime because this app does not need to collect any points to buy anything for Drake such as clothes, food and etc. User may feel no challenges because they no need to look after their pet and watch him grow.
3. It may take some time to locate an appropriate surface to spawn the dragon on. For example, it would not spawn on table in the living room which is not tiny.
4. Sometime the dragon was snatched out of the place and the ball interaction was not user-friendly.
5. This game is not free downable game and It is cost 1.99 USD.
6. Hard to feed Drake treats unless user is very far away, limited spaces inside that are lit enough to be habitable for the dragon.
7. Drake do not like dark when the user touch to a dark area, alert will be prompt out stated that "Dragons don't like dark" and it will not fly to there.

Comparison with proposed system

1. Sorumeito application will have points for user to collect it and user can watch their pet grow.
2. Soru can be spawned directly after an appropriate surface has been found.
3. Sorumeito is free download android game application.
4. Soru cannot be spawned when there is a dark environment.

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2.1.3 AR Dragon

Figure 2.9 AR Dragon

AR Dragon is created by PlaySide Studios, an Australian game development company founded in 2012 by Gerry Sakkas who is a game designer was part of Electronic Arts team in Melbourne previously. It launched at 19 September 2017 and the last updated was at 18 April 2018. Furthermore, it is available only on Apple App Store. The game is free to play but there are still have offers various in-app purchase for customizing our dragon (Tanasoiu 2018).

Main Features

1. AR Dragon is a mobile application augmented reality pet game which take care of a cute dragon.
2. The uniqueness of this game is user can raise an adorable little virtual dragon from baby dragon to adult dragon.
3. Their dragon pet is unique, it is so interesting to know that there is nobody in this world have the same dragon. Thus, everyone will have their own unique dragon. User also can collect some rare items for their dragons (Critic 2017).

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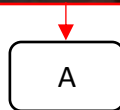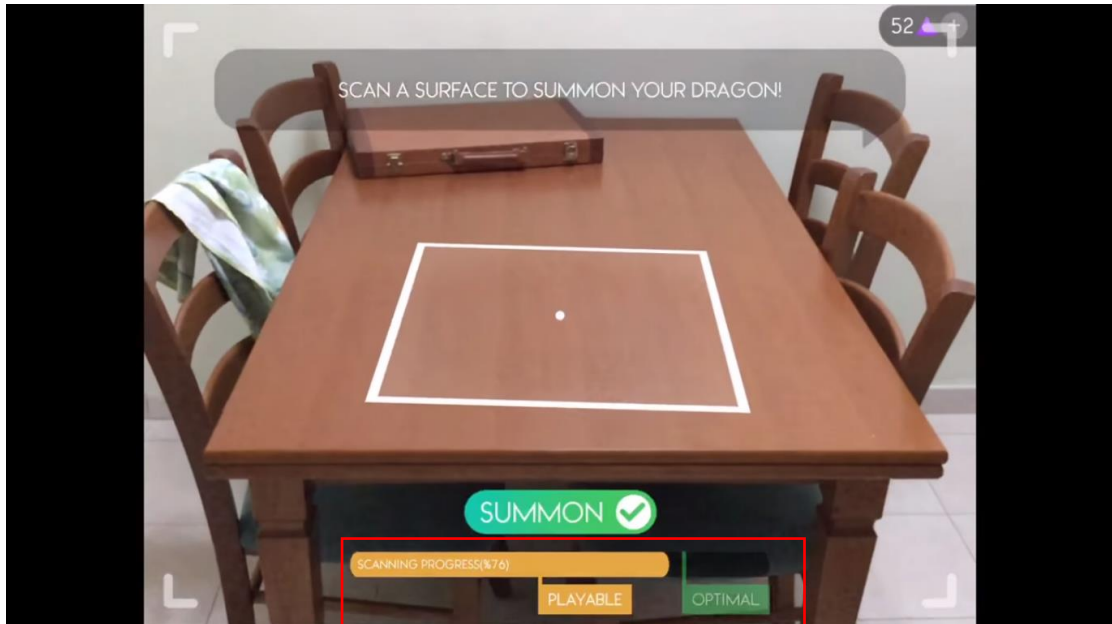
Figure 2.10 The interface of finding a surface
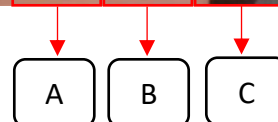
Figure 2.11 Dragon was spawned on the table

Figure 2.12 User are feeding the dragon
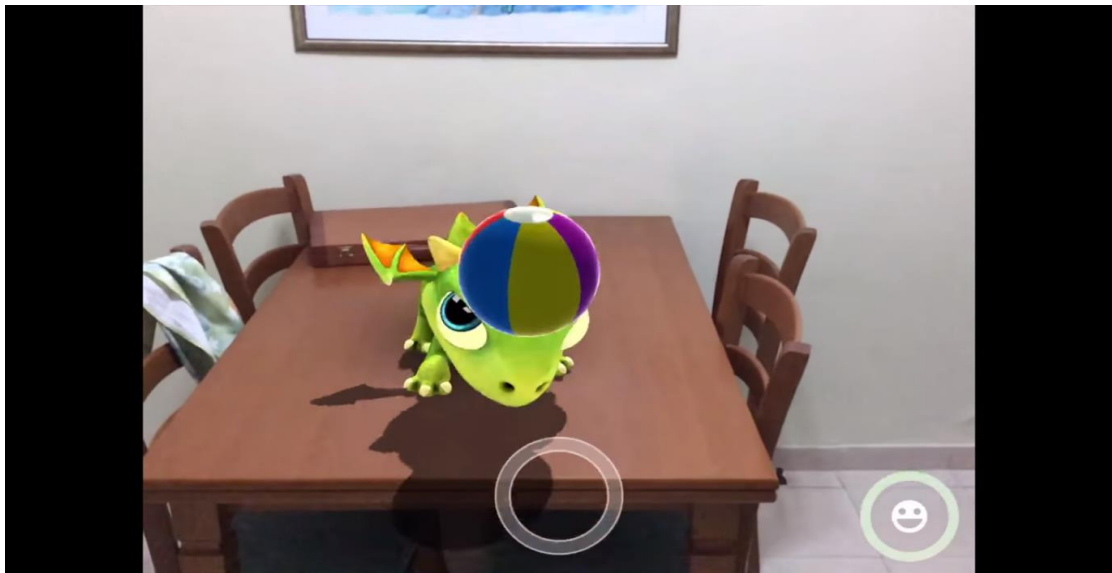
Figure 2.13 User play ball with dragon

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Figure 2.14 Change appearance of dragon by using number of diamonds
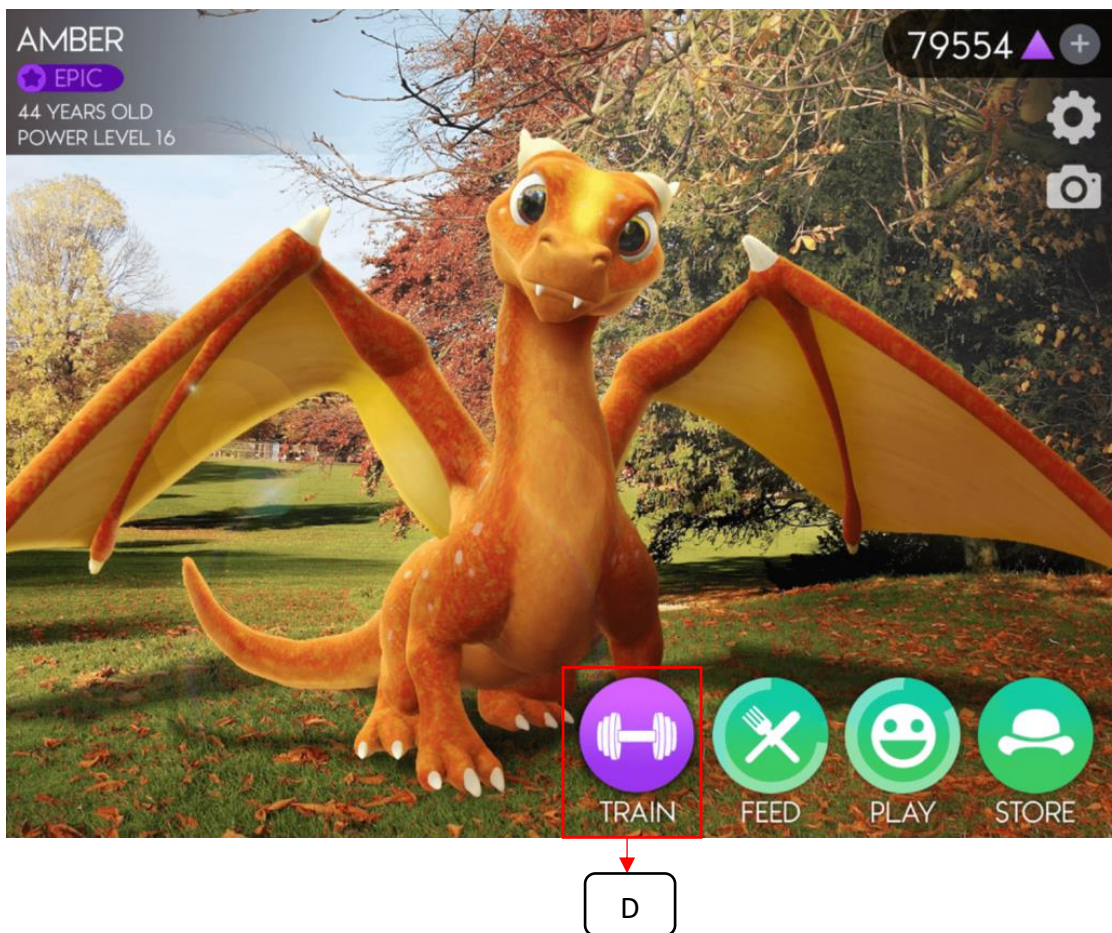
Figure 2.15 When a baby dragon become adult dragon

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When user start the AR Dragon game, user have the option to choose a dragon. The first re-rolls are easy with one press of a button, we can customize their dragon but add for each re-toll that they have made so that each one looks different than the others thus no two dragons are look the same. Once everything is set up, it's time to summon the dragon. Same as the other pet application, user need to let the game scan and locate the surfaces in order to summon the dragon on and bring it to the world. This game has a nice scan progression bar at the bottom of the game which tells user if that the surface is "optimal" or "playable" as shown as Figure 2.10 Label A. Even the surface is not optimal, they still can spawn the dragon but more prefer "optimal" condition.

Once the dragon comes to their life, this is the responsibility to take care of all its needs. User need to feed it, play game with it and always visit it so that it would not get bored and upset. Based on the Figure 2.11, there are a baby dragon which is 0 years old has been spawned on the table. It has a pair of huge eyes and by default the skin color is green.

There are few features at the bottom of the game in order to make interaction with it. The first button is used to feed the dragon as shown as Figure 2.11 Label A. After the button have been clicked, it will show the food list in order to let the user choose which food to feed the dragon as shown as Figure 2.12. Those food are need to be paid by using diamond which known as "money". The second button is a smile icon which means play game with the dragon pet as shown as Figure 2.11 Label B. After the button have been clicked, we can throw the ball to the dragon and it will throw it towards our direction. We can click on to the middle button to return back the ball to the dragon as shown as Figure 2.13. This is the interesting part when both have the interaction when playing the ball.

After user have played some game and feeding session, the game will reward them with purple triangles which is the diamonds to buy skins for their dragon to personalize it's look. As the dragon grows, user can unlock some new skin but not all, some new hats for it. But they still can preview those hats and skins without unlocking or buying it by just one tap on the store icon as shown as Figure 2.11 Label C. In order

to unlock the rest of new appearance, user must watch until 40 advertisement so that they can unlock the new appearance as shown as Figure 2.14.

After the latest updated, user can train their pets so that it grows up faster after they have clicked on the train button as shown as Figure 2.15 Label D. If the user plays game for at least 6 days their dragon pet will become a teenager. Furthermore, if they continue take care of their pet for another 14 days, they will transform their virtual pet into an adult as shown as Figure 2.15. The process is irreversible, they can't change the adult dragon to baby dragon.

Table 2.3 Function of AR dragon game features

Label	Name	Function
A	Feed icon	Feed the dragon.
B	Smile icon	Play game with the dragon pet.
C	Store icon	Buy new appearance for dragon.
D	Train icon	Train the dragon.

Strength

1. The animation and facial expression of dragon is so expressive, it really makes this game so fun because the dragon looks so adorable and it like to shake its little dragon tail.
2. The most interesting part of this game is user can watch their pet grow. User will not easy to get bored because they enjoy watching their pet grow up one day by one day.
3. They can collect purple coins to buy props and skin for their pet to create a new appearance.
4. This game is available for free on the App Store.
5. They have feature optional microtransactions if user don't have a lot of time and want to make sure their pet looks unique and cool.
6. This game also has built in camera that can capture the cute little dragon.

7. The game features a nice scan progression bar so that the pet can be spawned nicely on the surface because the unbalance surface will reduce the reality of the game environment.

8. The graphics, animation and sound effects are really well made and really help to improve the immersion.

Weakness

1. The dragon will just sit in a place will not move around. This may be losing some reality because the more active the pet are, the more real it is so that the user will not easy to get bored.

Comparison with proposed system

1. Soru can walk around and its animation is expressive.

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2.1.4 Cattery

Figure 2.16 Cattery

Cattery is a cute little virtual pet simulator app. In this game, user can deploy adorable cats into the real world. When the game begins, user start to spawn a cute little white cat and they have the option to unlock six more kittens that can join the party. In order to unlock each kitten, they have to watch a full-screen commercial so that they can get an adorable cat if they skip half way, they will not get the cat (Ar Critic 2017).
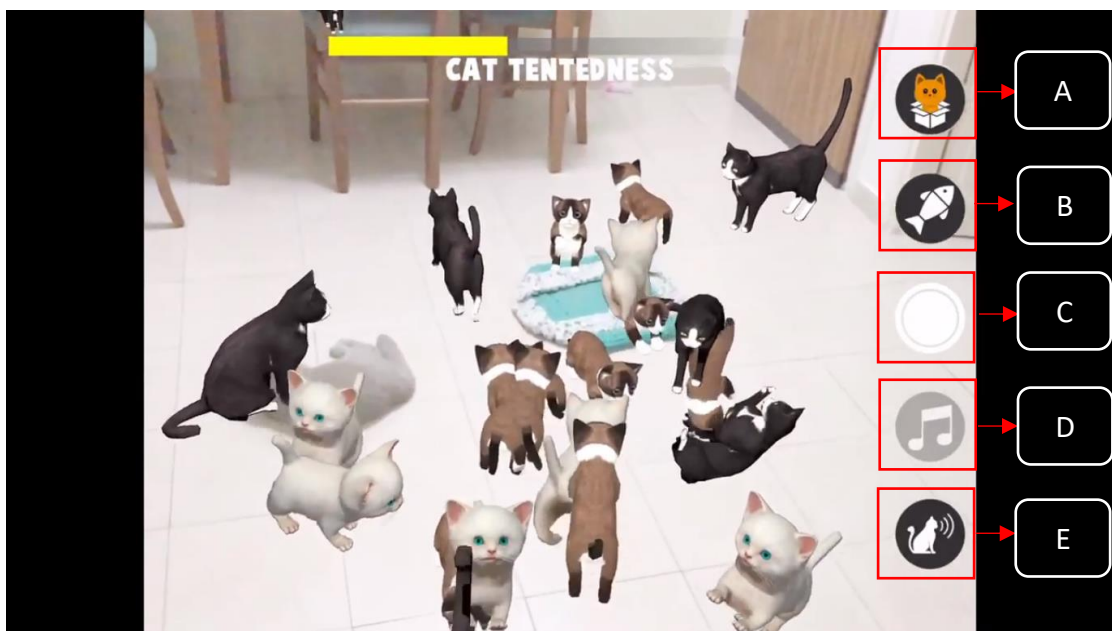
Figure 2.17 Cats have been spawned on the surface

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Figure 2.18 List of cats that can be adopted

Figure 2.19 Cat and bowl are float above the surface

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Table 2.4 Function of Cattery game features

Label	Name	Function
A	Cat icon	Prompt out some kittens are looking for a new home.
B	Fish icon	Feeding them with a bowl of fish.
C	Camera button	Capture virtual cats.
D	Music icon	Turn the background music on or off.
E	Cat calling icon	Whistle them to come near us.

This game has their own pre-defined animations but user can interact with them by feeding them with a bowl of fish when clicked on to the fish icon button as shown as Figure 2.17 Label B. Furthermore, user also can whistle to them and they will come to us eagering for some petting and attention by clicking on fourth button which is the cat calling icon as shown as Figure 2.17 Label E. Third button which is music icon ash shown as Figure 2.17 Label D is used to turn the background music on or off. Another feature is the option to press the camera button to capture virtual cats by clicking third button as shown as Figure 2.17 Label E.

When clicked on first button as shown as Figure 2.17 Label A, it will prompt out some kittens are looking for a new home. User have the option to adopt those kittens. After user have choose one of them, the new kittens will be added in our home and show to the screen.

Strength

1. The cat's look is so adorable and the textures are taken from real cat pictures.
2. The cats can make meow sounds which can get attraction from user.
3. User have the ability to deploy as many cats they want by just tapping on the screen.
4. Picture that taken from build-in camera is very nice because the developer has brightened the screen so that the environment become more childish, pure, and cute.

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Weakness

1. The graphics of this game is bad. There are some graphic glitches around the cat and the food bowl.

2. The movement of the cats are tacky, jittery and floaty. Sometime user may need to restart the app when taking photo of those cats and all of the cats are gone after restart the app.

3. The app going to crash when watching advertisement, not just once but it happened several times.

4. It also happened that the game crashed when user spawned like 20 cats. The app couldn't handle too many cats and decided to close itself.

5. There will have an issue due to the developer does not remove the user interface in the photo captured cause virtual seamlessly blends in with the real world.

6. This game quite boring because there is only little feature, no game session for the user to interact with cats.

Comparison with proposed system

1. Graphic of Soru will be better than Cattery.
2. Movement of Soru will not tacky or floaty.

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2.2 Summary of Comparison Similar System

Table 2.5 Comparison of similar system (Part 1)

Virtual Pet Simulator App Game	Game Feature				
	Pet Movable	**Game Session**	**Point Collection**	**Pet Appearance Changeable**	**Free Available**
AR Dino Pet	✓	✓			✓
Follow Me Dragon	✓	✓	✓	✓	
AR Dragon		✓	✓	✓	✓
Cattery	✓				✓
Proposed Application	✓	✓	✓	✓	✓

✓ : Yes   Blank: No

Table 2.6 Comparison of similar system (Part 2)

Virtual pet simulator app game	Game Design					Interactivity	Reality
	Graphics	Animation	Sound effects	Pet Design	Features		
AR Dino Pet	2	3	2	2	2	3	2
Follow Me Dragon	5	5	3	5	4	4	5
AR Dragon	4	4	4	5	5	5	4
Cattery	1	1	3	1	1	2	1

1: Bad   2: Poor   3: Average   4: Good   5: Excellent

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Chapter 3: System Design

3.1 Overview

In this chapter, the author is going to discuss about methodologies and procedures to develop the whole application. Furthermore, author will plan and develop the system structure according to the Mobile SDLC. Mobile SDLC usually involve 5 major phase of the process which are inception, design, development, stabilization and deployment. In addition, the author will design the draft of system flow diagram so that the whole system can be illustrated clearly. System requirements such as software and hardware tools that used to develop the application will be discussed in this chapter. Other than that, user requirements which able to download this application also will be discussed in this application. Lastly, the author will create a project timeline so that the development of the application can be planned properly.

3.2 Proposed Method
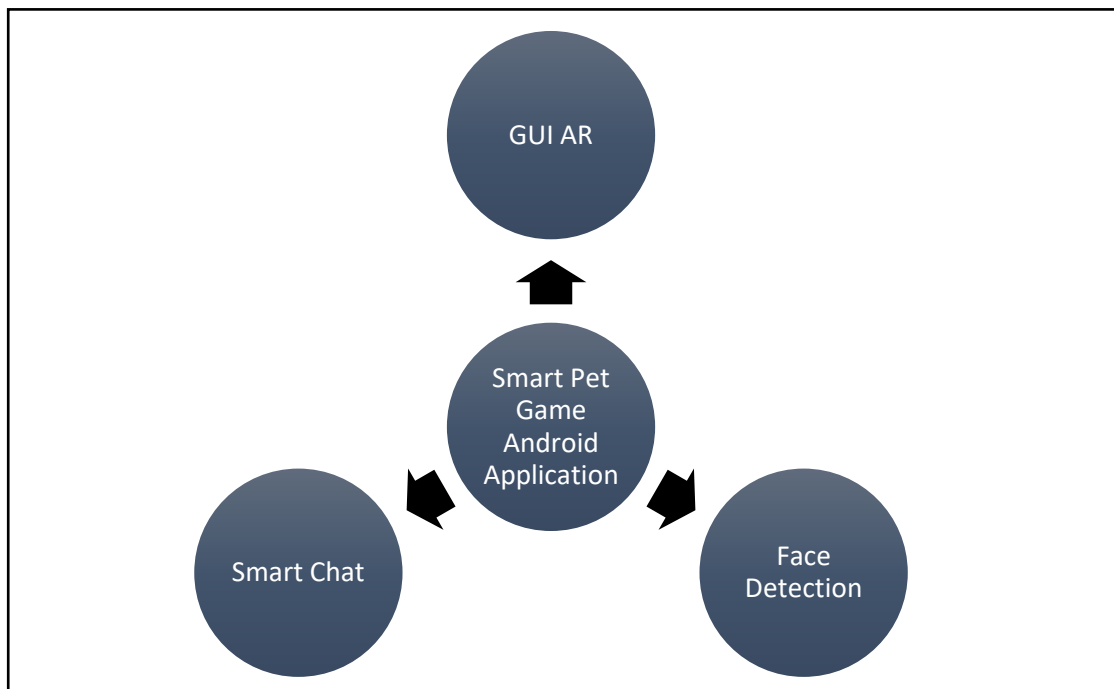
Figure 3.1 Modules of the proposed system

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Based on the problem statement that have discussed, the authors will propose a system that include two modules that shown above to solve those problems. GUI AR need to be implemented to make the virtual pet appear in the real world through phone camera. Author will do the face detection module and Smart Chat module will be done by another author.

3.3 Innovation of Project

The innovation of this proposed system is authors will combine AR technique, AI technique which include smart chat component and face detection into the virtual pet stimulation game whereas the others application in the market now only involved normal virtual pet stimulation game with AR technique only, they do not implement any AI technique into their application. Therefore, the proposed system will make the game environment more interesting and more realistic so that can help people who getting depression will become more optimistic and always happy. This is the uniqueness of proposed system mobile application virtual pet stimulation.

3.4 Mobile SDLC
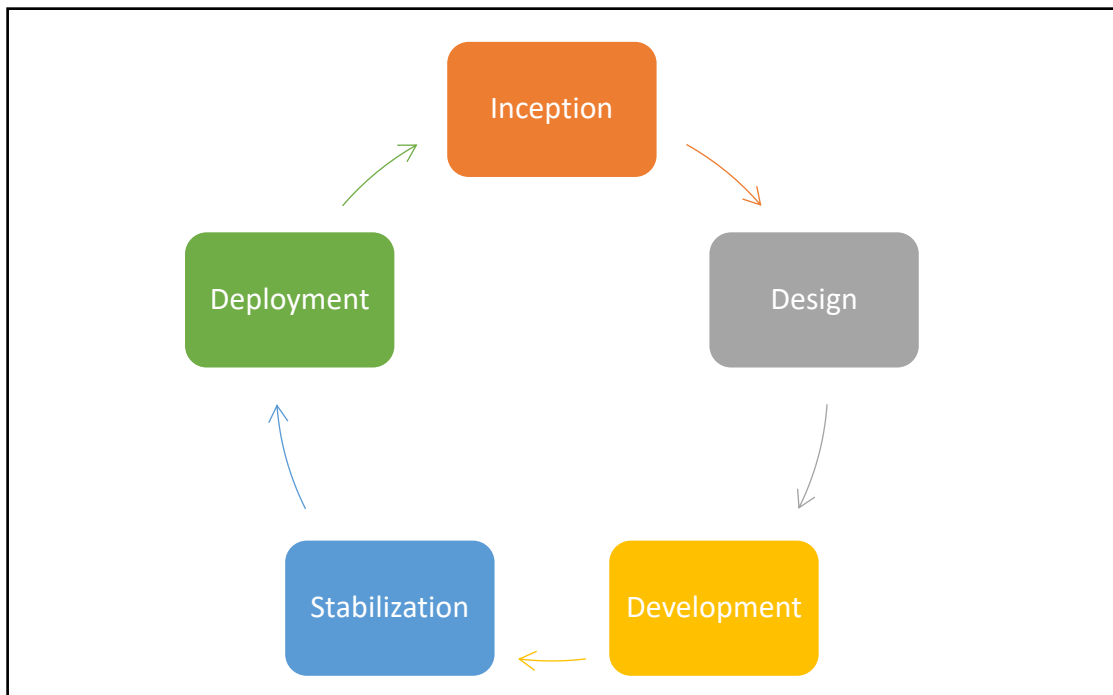
*Figure 3.2 Mobile Software Development Lifecycle (Mobile SDLC)*

Building a mobile application is very popular nowadays. Mobile application is very essential to the people especially it contributes a lot in the business world. There are statistic shows that with 2.2 million apps in the ios App Store and 2.8 million apps in Play Store which create high quality apps in the market (Josiah 2018). By the way, there are a great pre-planning during the development of mobile application. The approach that this mobile application used is Mobile Software Development Lifecycle (Mobile SDLC). The lifecycle of mobile development is not much different than the software development lifecycle (SDLC) for website or desktop application. Mobile SDLC usually involve 5 major phases of the process which are inception, design, development, stabilization and deployment (Burns 2016).

First phase: Inception

First phase of the Mobile SDLC is inception phase which means defining and refining the idea of an app. Every app starts from an idea but there is some consideration that need to be made before propose an idea. One of the considerations is competitive advantage which means there is a similar app exist in the market already? There are several similar virtual pet stimulation games in the market which are AR virtual pet game. Those existing application does not allow dual communication between owner

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and the pets. But the proposed application will combine AI technique with the application so that owner can communicate with the pet and the pet can detect owner face emotion to increase interaction between both. Thus, this is the uniqueness of this proposed application is able to attract more users.

Second phase: Design
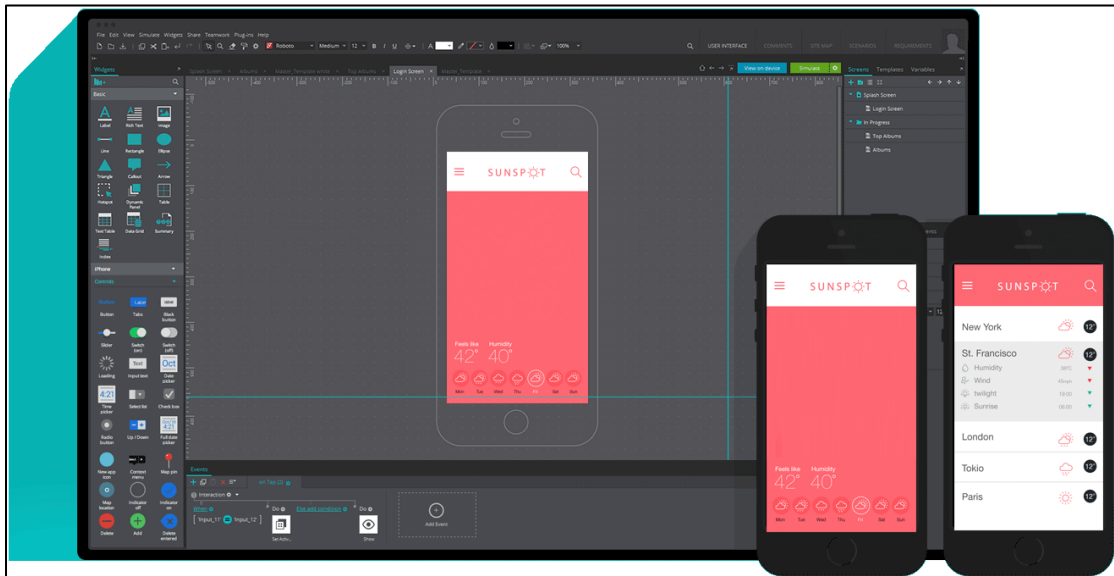
Figure 3.3 Interface of Justinmind toolkit

The second phase is design phase. Once the feature and functionality of the app have been determined, the author can start to build the User Experience (UX) design. UX is usually done via wireframes or mockups by using some design toolkits. Some of the toolkits are InVision, Justinmind, Marvel, Origami and Proto.io which allow the user to create UX design without code the actual user interface (UI) design. The author will choose Justinmind toolkit to create the prototype of UI design of mobile app (Figure 4.2). When creating UX mockups, the author needs to consider which platform to be used. The author will implement the mobile app virtual pet stimulation in android platform. A good UI design of mobile apps is important so that give people a good first impression (Burns 2016).

Third phase: Development

The third phase is development phase. The developers start to build the application in this phase. The author needs to choose the app development platform to

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develop an AR mobile app. At first, author need to design and create a three-dimensional (3D) character which is the pet of this application. Thus, author will use the 3D maker software tools to design a cute character. There is various type of 3D maker software such as blender, 3ds Max, ZBrush, SketchUp and etc. Author have chosen blender software to create the 3D pet character. The whole structure of the pet includes its appearance, skin color and all 3D objects such as ball, foods, jewelry, attires and etc will be designed by using blender.
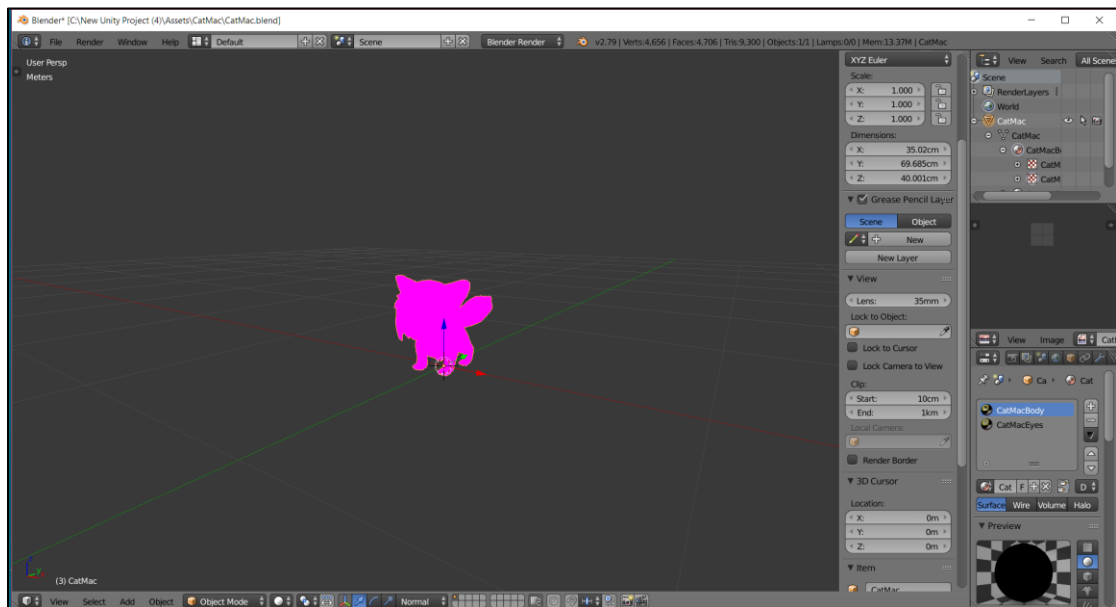
Figure 3.4 Interface of blender software

After the main 3D pet character has been designed, author sets up the whole game structures by using Unity software which is the popular game engine. Unity is the main platform to develop whole proposed application includes GUI, AR engine and AI technologies. The game engine can be used to create both three-dimensional and two-dimensional games. After that, in order to combine AR technique with pet character, Vuforia which is an augmented reality software development kit (SDK) for mobile devices is used to plug into the Unity platform so that the virtual pet can be brought to real world and become more reality. The Vuforia engine supports AR app development for Android, IOS and UWP devices.

For AR part, there are three key capabilities:
- Motion tracking: Allow the phone to understand and track its position.

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- Environment understanding: allows the phone detect the size and location of all type of surfaces which are horizontal, vertical and angled surface.
- Light estimation: allows the phone to estimate the environment's current lighting condition.

In addition, the parts of GUI such as icon button which link to the scene of face detection part and voice recognition part need to be created and its function are programmed by using Microsoft Visual Studio which is an integrated development environment (IDE) and C# programming languages is used to program it. Animation and expression of the pet will be added into application by using blender to create its animations. After the AR part and GUI part of the system have been done, the face detection method can start to implement in this application. Affectiva SDK has been used to analyzes facial expression of people. It has emotion recognition algorithms that had been trained and tested using their emotion data repository. By using this SDK, virtual pet can detect the facial expression of owner and make some animation to interact with the owner. Lastly, voice recognition part that have done by another author will be combined into this application by using open-source Unity plug-in which called ML-Agents and TensorFlowSharp to combine TensorFlow with Unity in order to integrate the voice recognition part into this application.

Fourth phase: Stabilization

*Figure 3.5 Process of testing phase*

The fourth phase is stabilization which also known as testing phase. After the application have done the implementation, the developers need to test the application before publish the Android Package Kit (APK). Actually, this phase can be started early from the second phase because if there is a major issue is found in the second phase, the UX design can still be modified until it is satisfied. There is some test case in the testing process to test about the mobile application's performances, security, usability, and compatibility.

Final phase: Distribution

The last phase is distribution phase which is the application can be published to platform for the people to download. Before publish to the store, every developer must sign their applications by using their own certificate protected by a private key. This certificate provides a chain of authenticity to tie the application with the developer. The proposed application will be placed in the play store. However, due to the publishing application in the google play will cost some money, this application is done for education purpose thus author will just output the APK and place it at the social media for people to download.

3.5 System Design Diagram

3.5.1 System Flow Chart
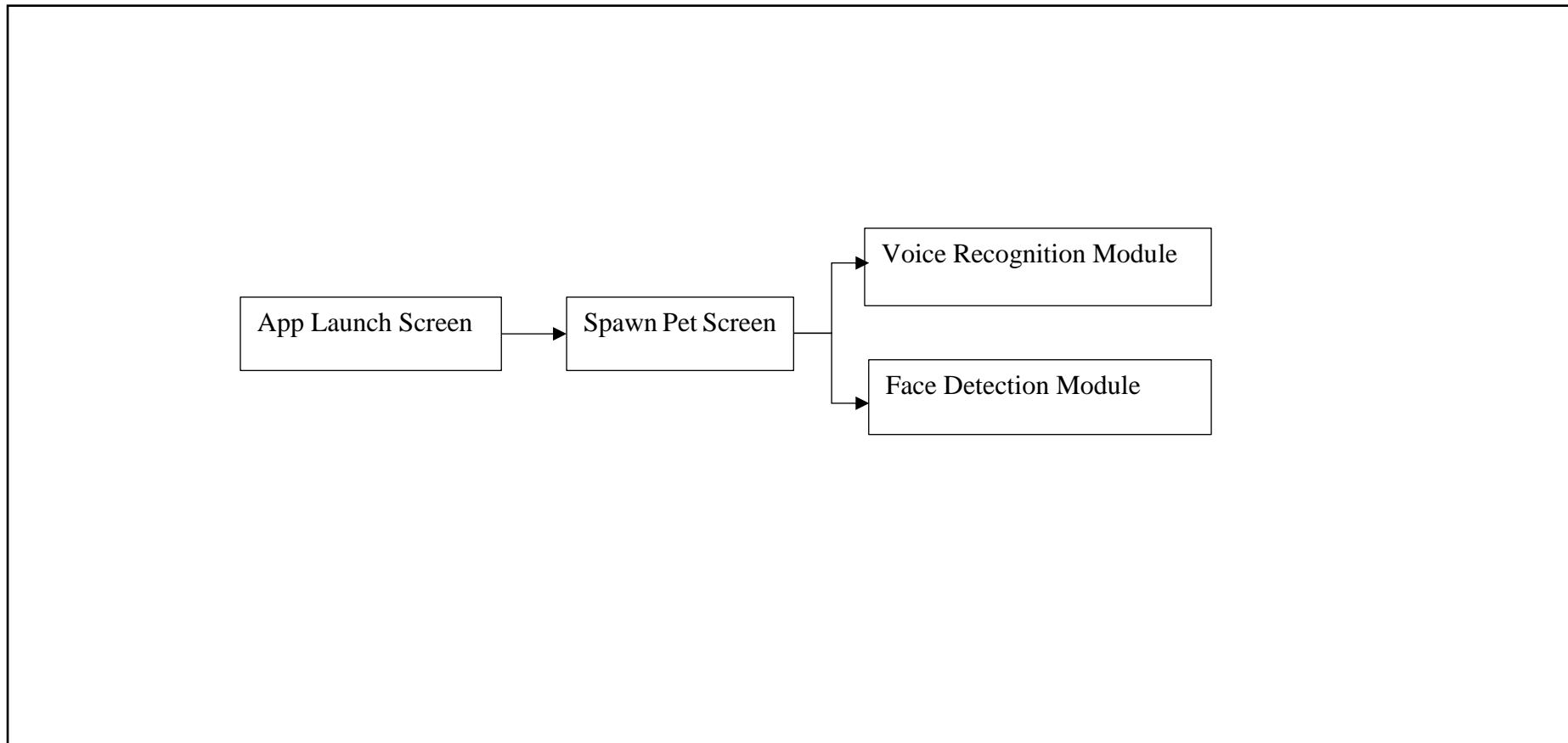
Figure 3.6 System Flow Chart of AR Smart Pet Application

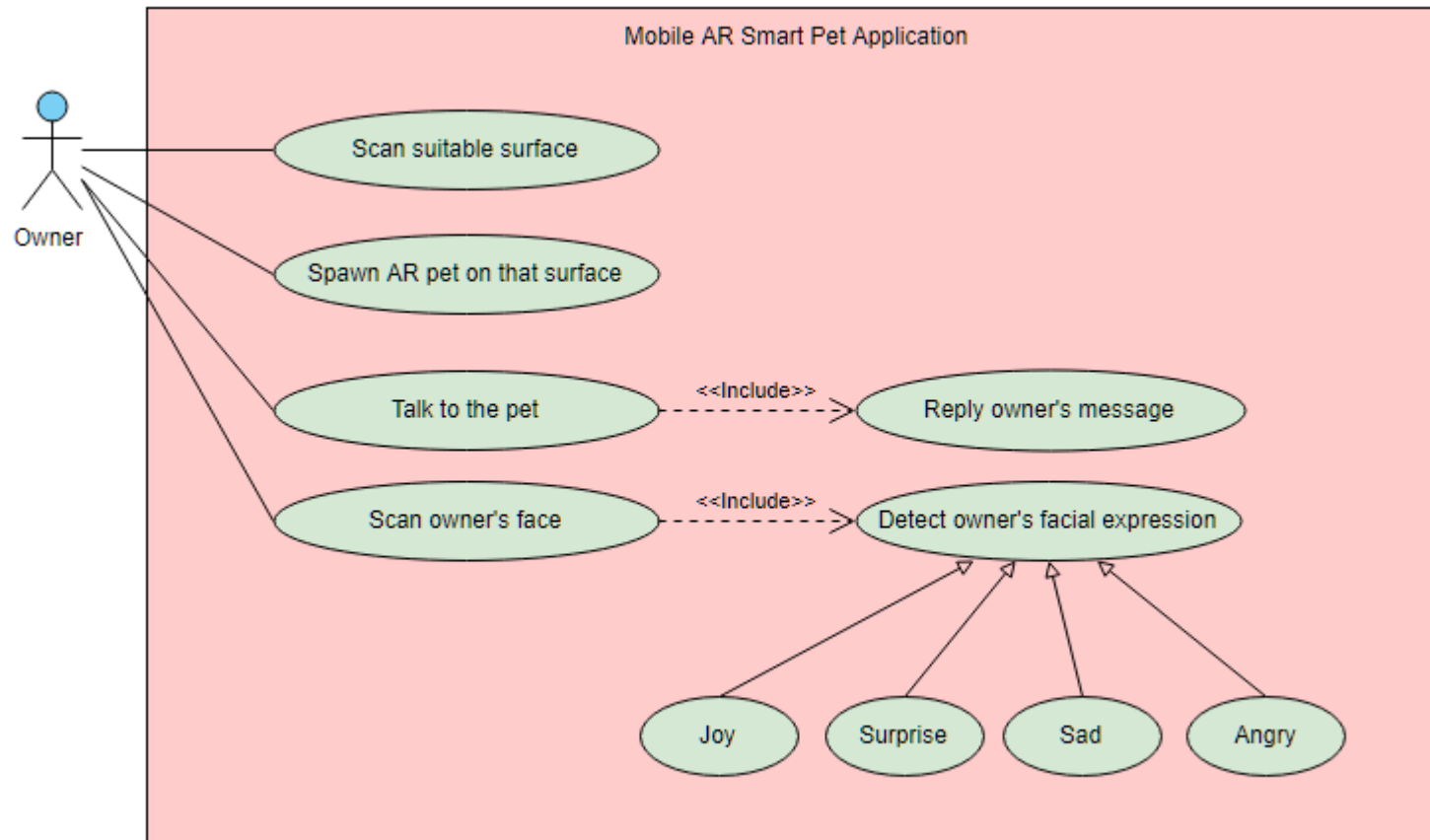**3.5.2 Use Case Diagram**

Figure 3.7 Use Case Diagram for AR Smart Pet Application

3.5.3 Swimlane Activity Diagram

3.5.3.1 Voice Recognition Module
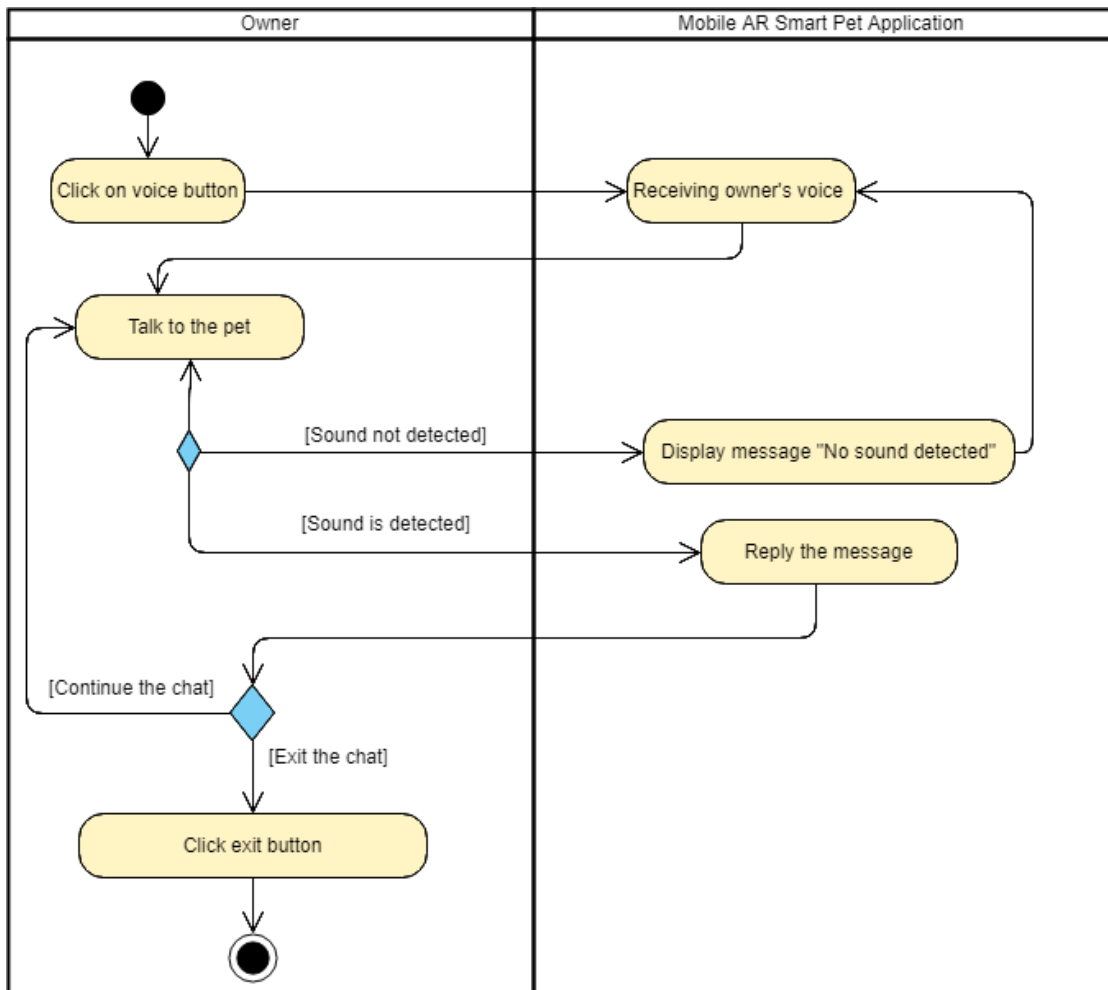
Figure 3.8 Swimlane Diagram for Voice Recognition Module

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3.5.3.2 Face Detection Module
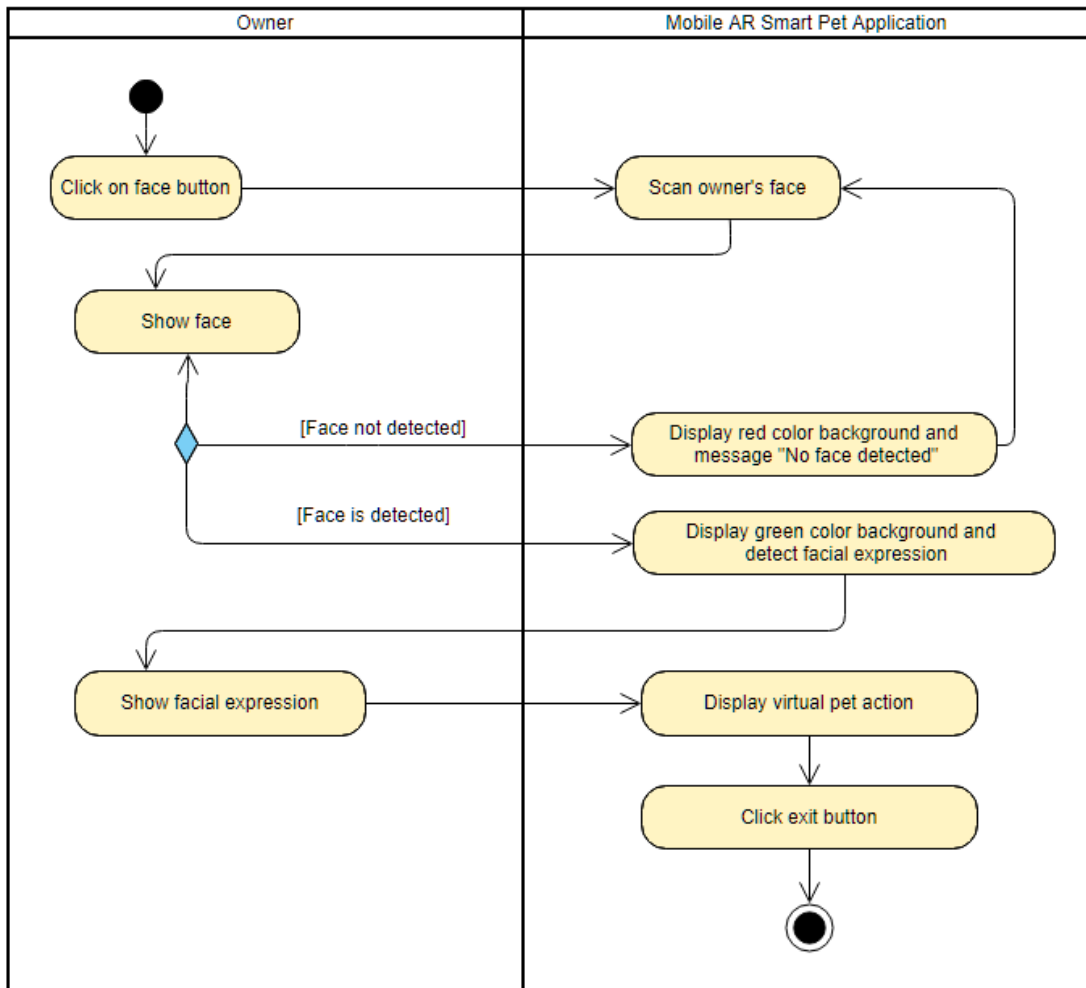
Figure 3.9 Swimlane Diagram for Face Detection Module

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3.6 System Requirements

3.6.1 Software Tools for Development

The following table shows the software tools that will be used to develop the proposed application.

Table 3.1 Software tools for development

Development Environment	Software Tools
Game engine	Unity
3D model's maker	Blender
Software Development Kit (SDK) and plugin	Vuforia SDK, Android SDK, Affectiva SDK, ML-Agents plugin
Java Development Kit (JDK)	Java JDK
Programming Languages	Microsoft Visual Studio - C# (code function of modules)

3.6.2 Hardware Tools for Development

The following table shows the hardware tools that will be used to develop the proposed application.

i)　　Computer Model: MSI GL63

Table 3.2 Computer model for development

| System	Information
Operating system	Window 10 Home(64-bit)
Processor	Intel Core i7 – 8750H
Graphic card	NVIDIA GeForce 1050 Ti
CPU	2.20 GHz
Memory (RAM)	8.00 GB

ii)   Mobile phone model: Huawei Nova 2i RNE-L22

Table 3.3 Mobile model for development

System	Information
Operating system	Android
Android version	8.0.0
Screen	2160 x 1080
CPU	Hisilicon Kirin 659
Memory RAM	4.0 GB
Phone storage	64 GB

Chapter 4 Preliminary Work
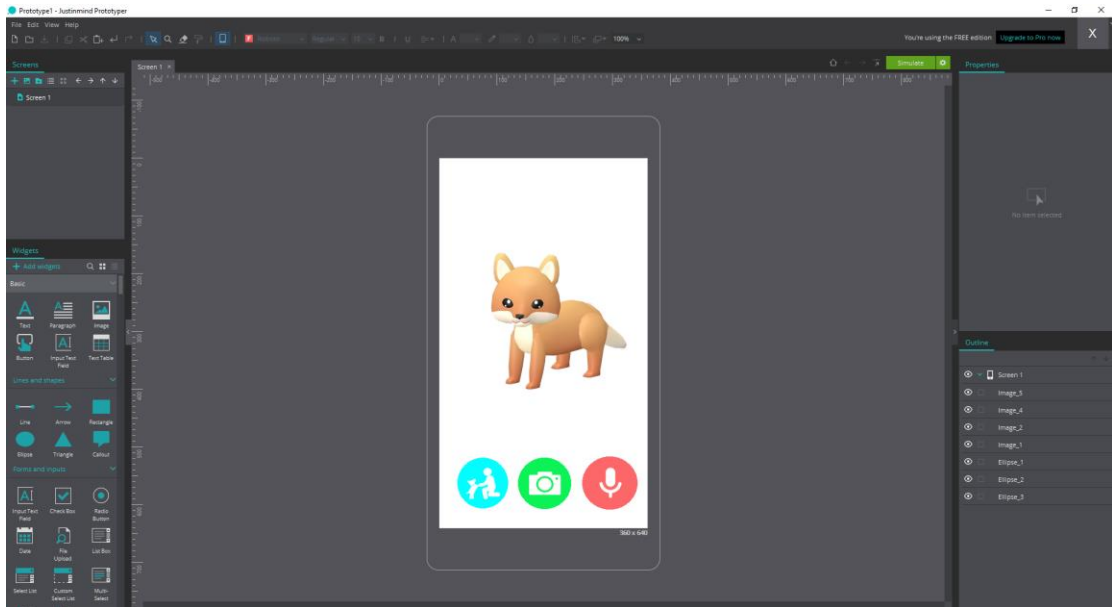
4.1 Design 3D Models
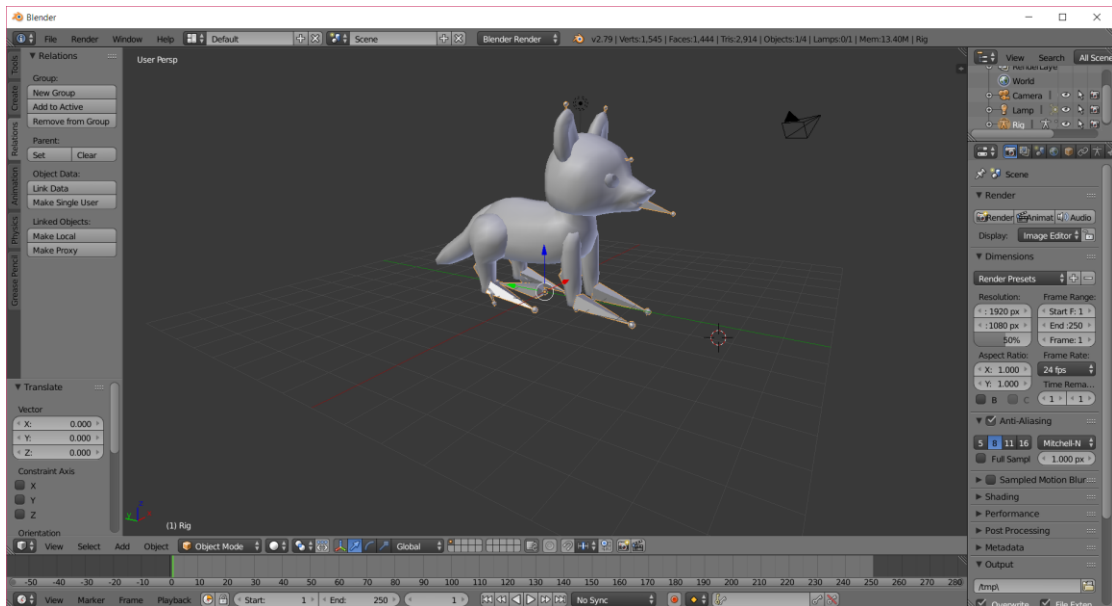
Figure 4.1 Design 3D pet model by using Blender software

Blender is a free and open source 3D creation software. It is used when modeling, animation, game creation of 3D objects. This pet is named Soru and it designed like a fox by using blender. The appearance of this pet is it has a huge black eye, middle long ear, yellowish-orange furry skin and long tail. The available animations are stand, sit, walk, run, jump, turn, eat and sleep.

Figure 4.2 The adorable Soru

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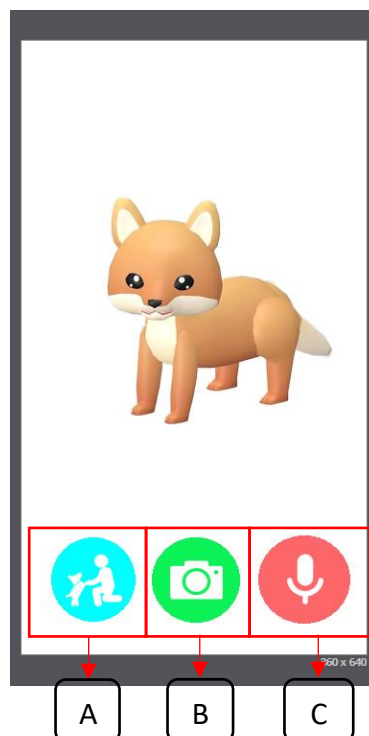Faculty of Information and Communication Technology (Kampar Campus), UTAR.

4.2 Design User Interface

Figure 4.3 Design GUI prototype by using Justinmind software

Graphic User Interface (GUI) of Sorumeito application is designed by using Justinmind software as shown as Figure 4.3. Figure 4.4 shows the menu scene when the application is started. There are total three icons which are interaction icon, camera icon and microphone icon. Each of the icon will perform different type of actions.

Scene 1 - Menu Scene with AR virtual pet

Figure 4.4 Interface of Menu scene

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Table 4.1 Function of Menu scene features

Label	Name	Function
A	Interaction icon	Link to Face Detection scene and detect owner's facial expression.
B	Camera icon	Scan surface to spawn dragon.
C	Voice recognition icon	Link to Voice Recognition scene and chat with Soru.

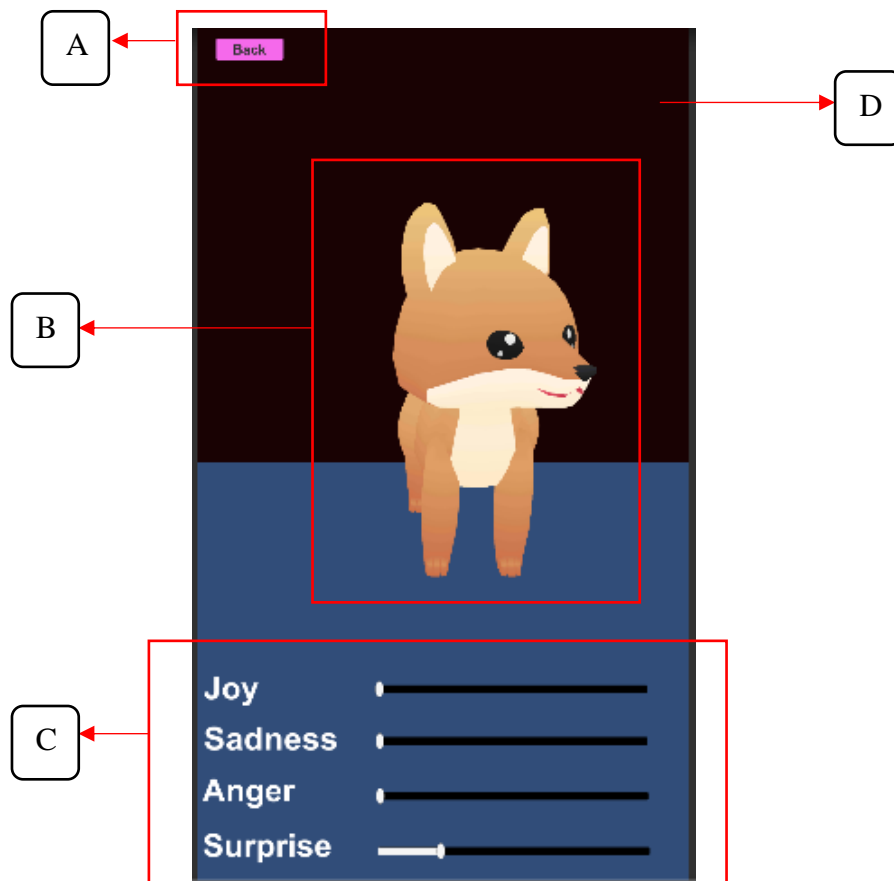**Scene 2 – Face Detection scene when Interaction icon has been clicked**

Figure 4.5 Interface of Face Detection scene

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Table 4.2 Function of Face Detection scene features

Label	Name	Function
A	Back button	Back to Menu scene when clicked this button.
B	Soru	Soru will make some animation based on owner's face expression.
C	Emotion slider	Emotion is detected and perform in the slider way.
D	Background	When the face is detected, the background will change to green color. If the face is not detected, the background will change to red color.

Scene 3 – Voice Recognition scene when microphone icon has been clicked
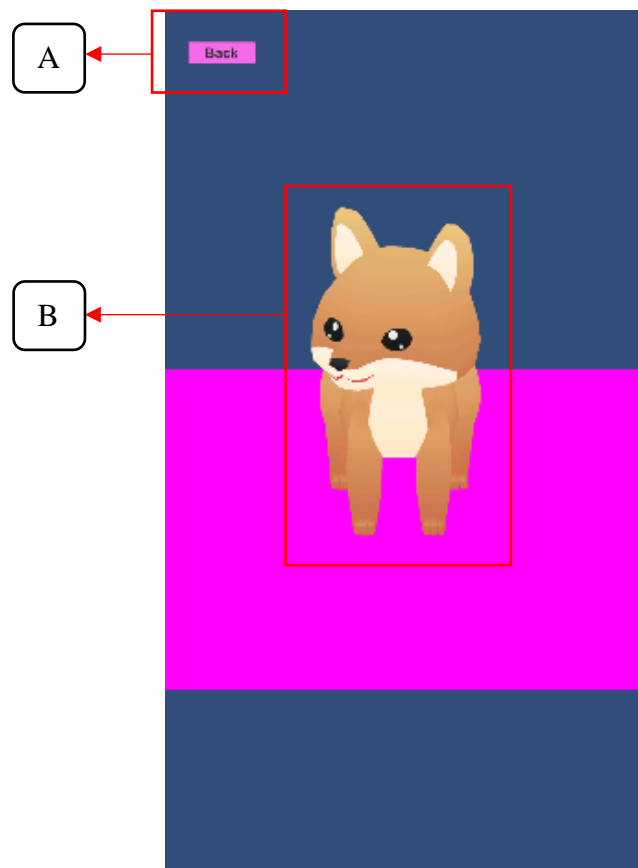
Figure 4.6 Interface of Voice Recognition scene

Table 4.3 Function of Voice Recognition scene features

Label	Name	Function
A	Back button	Back to the main scene.
B	Soru	Soru will listen to the owner and reply the message.

Chapter 5 System Implementation
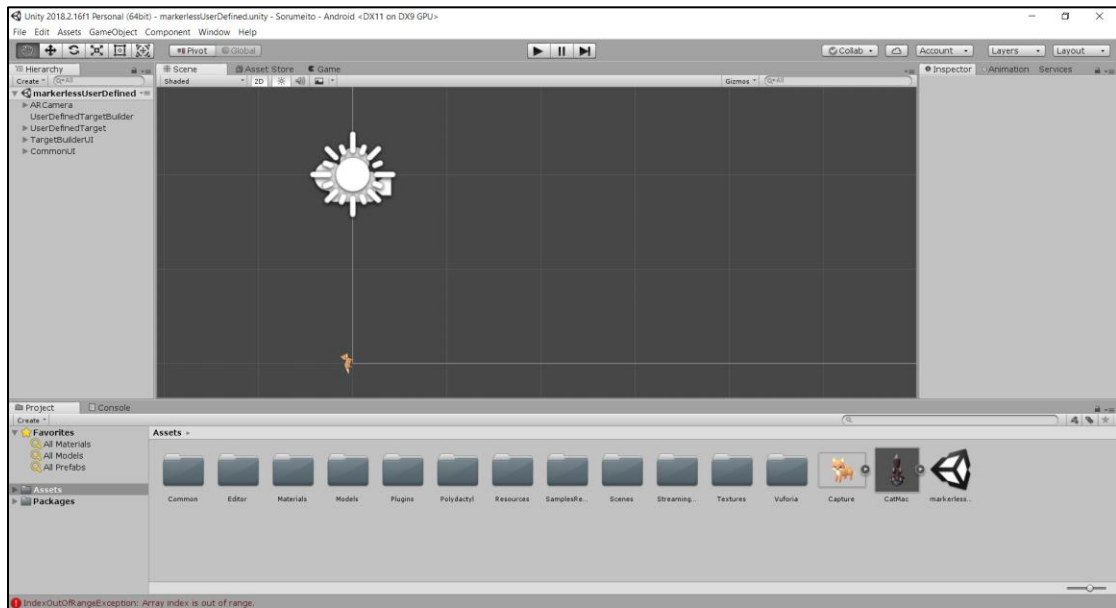
Figure 5.1 Develop the whole game by using Unity

The whole game application includes 3D pet animation, GUI, face detection module and voice recognition module are created and designed by using unity as shown as Figure 5.1.

5.1 Setup of android tools in Unity
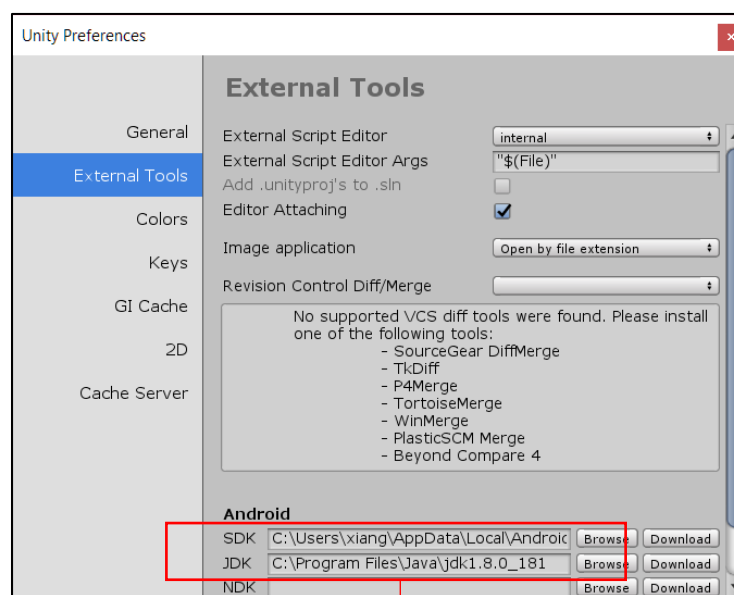
Figure 5.2 Android SDK and Java JDK are set in the Unity Preferences

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Based on Figure 5.2 Label A, Android SDK 26.1.1 and Java JDK 1.8.0 are downloaded and plug into the unity which set at Unity Preferences. So that allow this application to support android platform since this application is built into android application.

5.2 Setup of Vuforia engine in Unity

First, download the Vuforia SDK from Unity Asset Store. After that, go to file > Build Settings > Player Settings > XR Settings and tick Vuforia Augmented Reality to activate the Vuforia engine as shown as Figure 5.3.
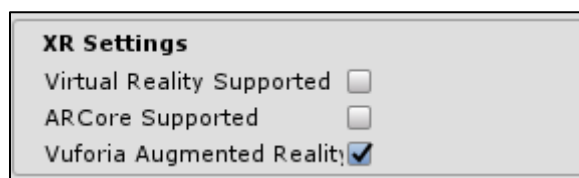

Figure 5.3 Activate Vuforia AR in Unity

5.3 Setup of Player Settings in Unity

Before proceed to game development phase, author need to set company name, product name and icon of the android application as shown as Figure 5.4.
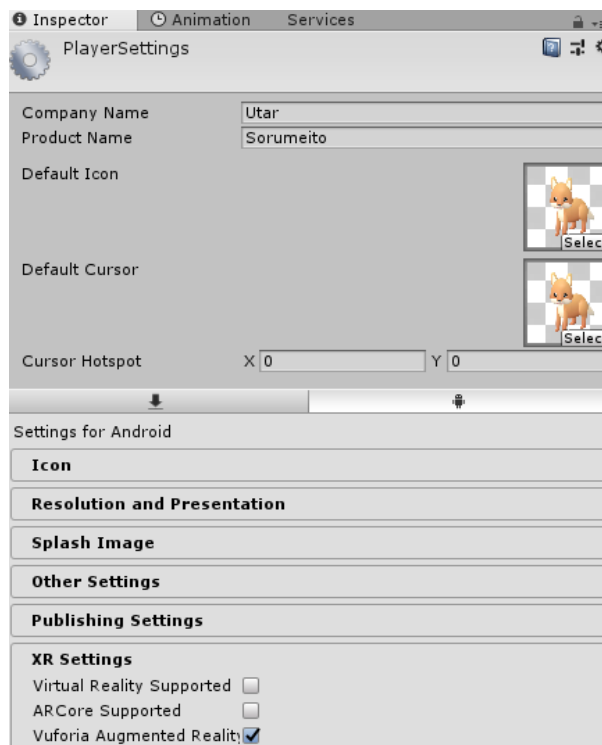

*Figure 5.4 Setup of application settings*

5.4 Setup Affectiva emotion SDK in Unity

This Affectiva SDK is used to detect the facial expression of users, their underlying emotions and appearance from facial images. This SDK can be downloaded from Affectiva website. After the plugin has been downloaded, author can use its library to detect the facial expression.

5.5 Setup ML-Agents plugin in Unity

Machine Learning Agents Toolkit (ML-Agents) is open-source Unity plugin that enable games and stimulation serve as environment for training intelligent agents. It has provided implementation based on TensorFlow to enable developers to train intelligent agents for AR games. Thus, it provides a central platform where the AI can be integrated in Unity environment. The ML-Agents plugin can be downloaded from the Unity Asset Store. After have downloaded the plugin, author can use it and integrate voice recognition module that done by another author with this application.

5.6 Development of Menu scene
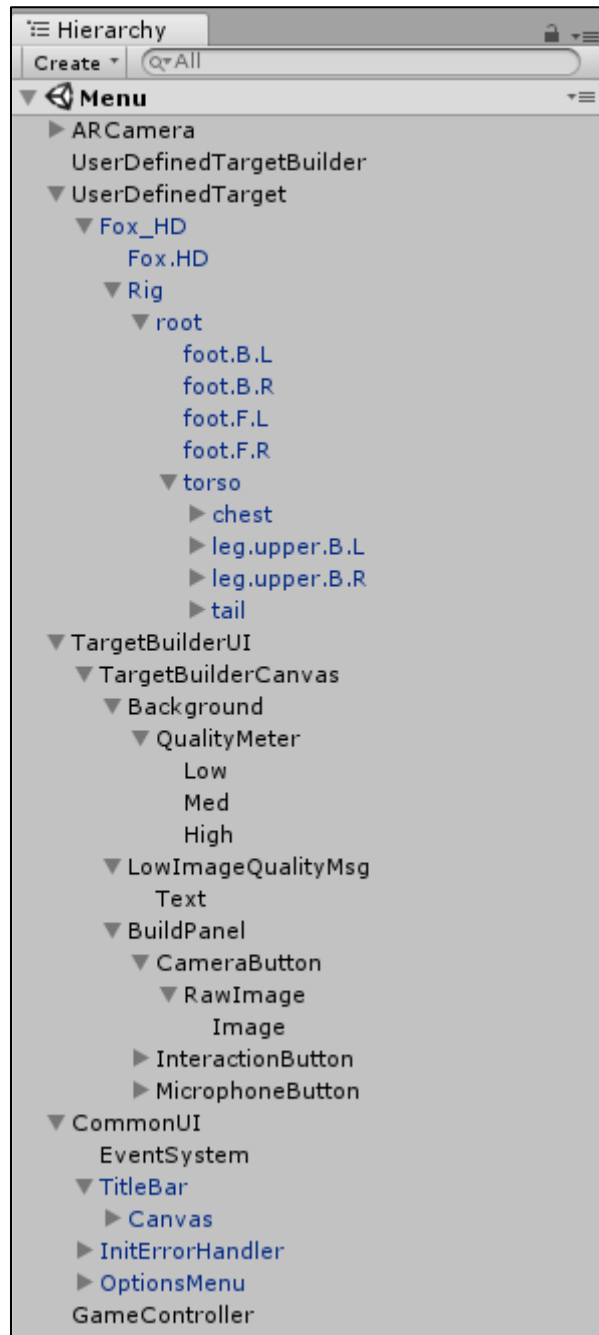
Figure 5.5 Hierarchy of Menu scene

Figure 5.5 shows the development of Menu scene which is the first scene when the application is started. This scene develop the structure of AR pet, built the menu buttons and scan a proper surface to spawn the pet. In order to build up this scene, there are some components are required to create AR pet game stimulation. Main components in this scene are stated at the table below.

Table 5.1 Main components in Menu scene

Main Components	Explanation
ARCamera	Implement Vuforia AR camera to stimulate virtual pet.
UserDefinedTarget	Target that want to be spawned.
TargetBuilderUI	Scan suitable surface to spawn the virtual pet.
CommonUI	Title bar, option menu are the common user interface.
GameController	Controller for the change scene event

5.6.1 Structure of ARCamera component
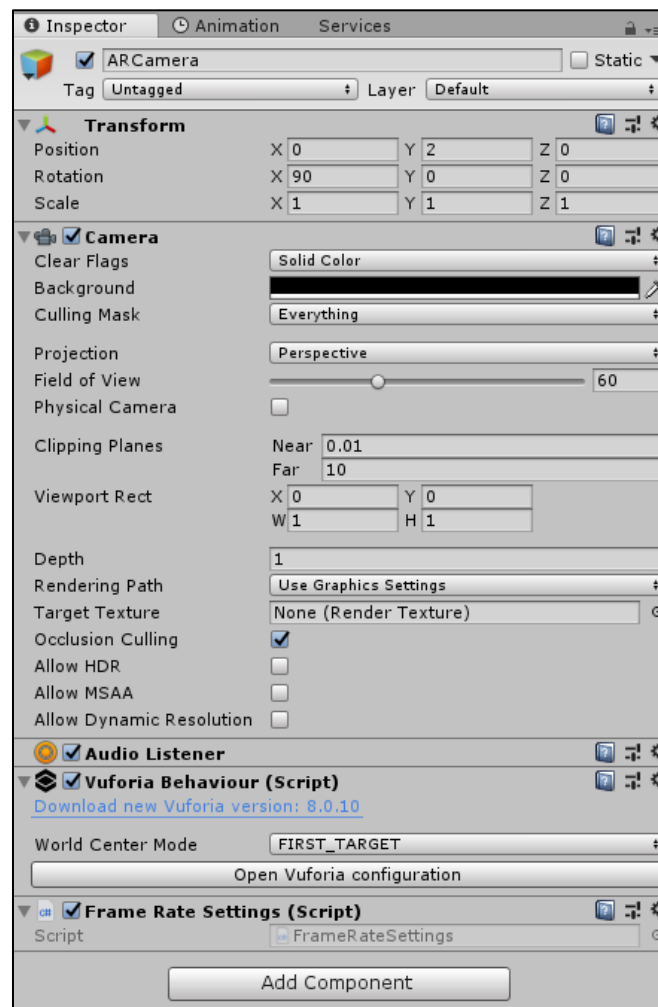
Figure 5.6 Inspector of ARCamera component

Settings of ARCamera component has been setup as shown as Figure 5.6. The important setup is Vuforia engine must be integrated into this component through the setting of Vuforia Behaviour. In the settings of Vuforia Behavior, app licence key must be included inside which need to register a developer account in the Vuforia developer portal.

5.6.2 Structure of UserDefinedTarget component

Figure 5.7 Inspector of User Defined Target component

Figure 5.7 shows that the setup of the component that used to spawn the target Fox_HD which put as sub-component of it.

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5.6.3 Structure of TargetBuilderUI component
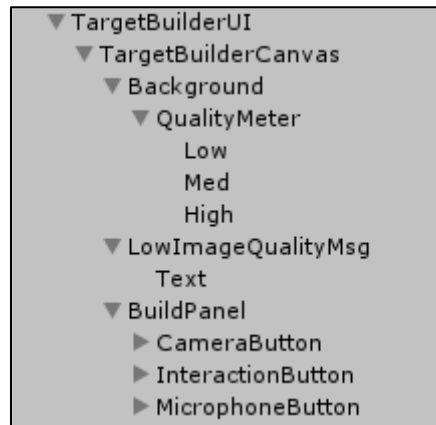
Figure 5.8 Sub-components under TargetBuilderUI component
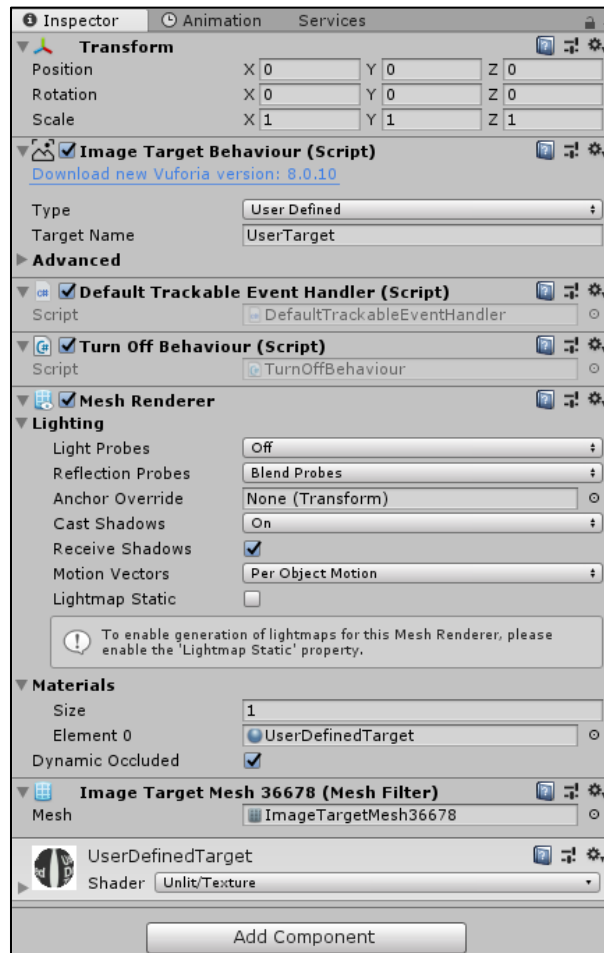
UI of this Menu scene is built by this components. The function of sub-components are stated in Table 5.2.

Table 5.2 Function of sub-components under TargetBuilderUI component

Sub-components	Function
QualityMeter	Built the surface detection bar which consist three level, low, middle and high level as indicator of the suitability for a pet to spawn in that surface.
LowImageQualityMsg	Display the message when the surface is not suitable to spawn the pet and it is indicate as low level.
BuildPanel	CameraButton, InteractionButton and MicrophoneButton are built to trigger to the certain scene when they have been clicked.

5.6.4 Structure of CommonUI component
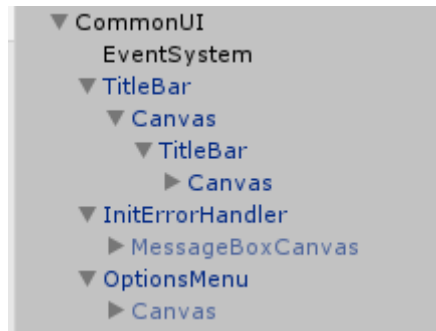

Figure 5.9 Sub-components under CommonUI component

Title bar is "User Defined Target" which place at the top of the interface. Option menu and error handler are built in this component.

5.6.5 Structure of GameController component


```csharp
changeScene.cs
C# Miscellaneous Files
1    using System.Collections;
2    using System.Collections.Generic;
3    using UnityEngine;
4    using UnityEngine.SceneManagement;
5
6    public class changeScene : MonoBehaviour {
7
8        public void ChangeFaceDetectionScene()
9        {
10           SceneManager.LoadScene("FaceDetection");
11       }
12
13       public void ChangeBackToMenuScene()
14       {
15           SceneManager.LoadScene("Menu");
16       }
17
18       public void ChangeVoiceRecognitionScene()
19       {
20           SceneManager.LoadScene("VoiceRecognition");
21       }
22   }
23
```

Figure 5.10 Change scene script that under GameController component

This component will be trigger by the UI buttons when they have been clicked. Scene will be changed based on which button have been clicked on and trigger to its function.

5.6.6 Output of the Menu scene
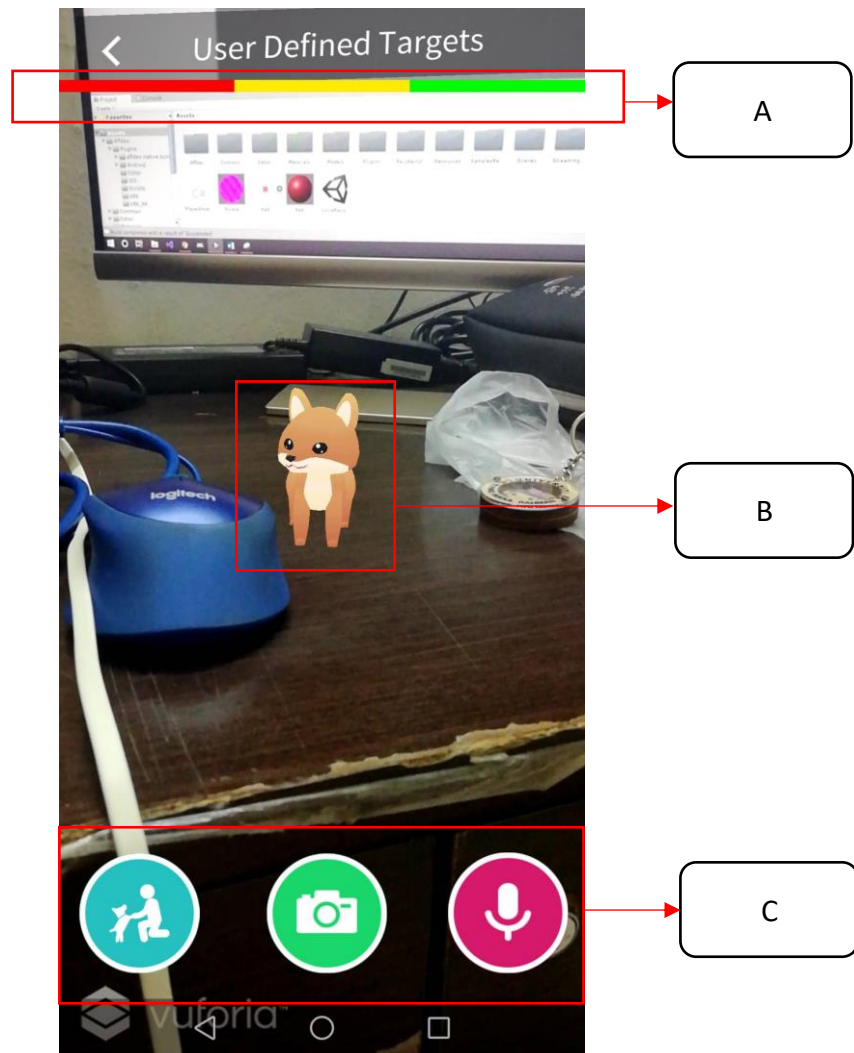
Figure 5.11 Interface of the Menu scene

Table 5.3 Function of the interface in Figure 5.11

Label	Name	Function
A	Surface detection bar	• When the surface is detected not optimal, it will show red color bar only. Pet cannot be spawned in this stage. • When the surface is detected in good condition, it will grow to yellow color bar. Pet can be spawned in this stage but not good enough.

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		• When the surface is detected in best condition, it will grow to green color bar. Pet can be spawned properly.
B	AR virtual pet	Soru are spawned in the owner's table.
C	Button panel	• First button: Trigger to face detection scene. • Second button: Spawn the AR virtual pet. • Third button: Trigger to voice recognition scene.

5.7 Development of Face Detection scene
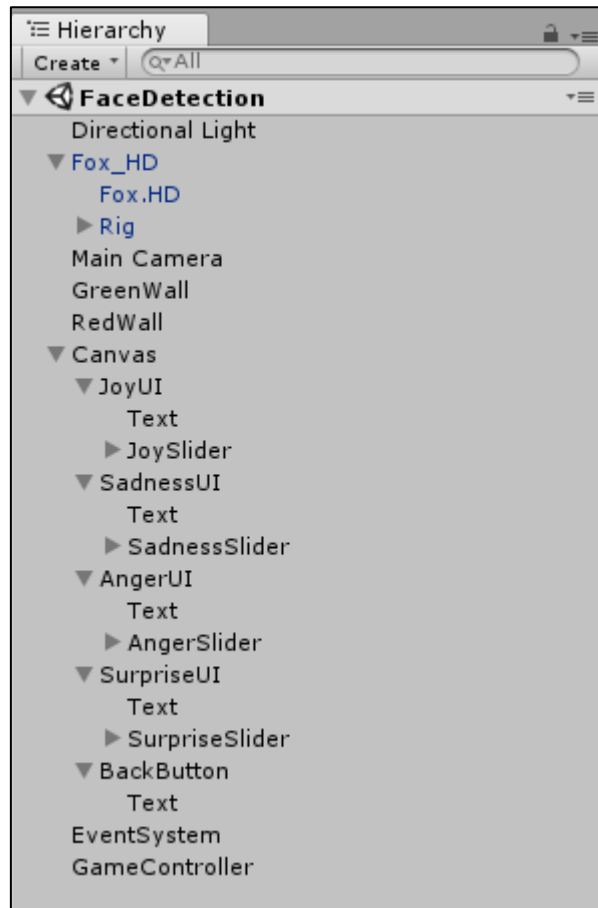
Figure 5.12 Hierarchy of Face Detection scene

Figure 5.12 shows the structure of the Face Detection scene. It is developed by main components and sub-components as shown as Figure 5.12. Function of main components are stated as Table 5.4.

Table 5.4 Function of main component in Face Detection scene

Main Components	Function
Directional Light	Create light for the scene.
Fox_HD	Virtual pet that will perform animation based on the owner's facial expression.
Main Camera	Use front camera to detect owner's face expression.
GreenWall	When the face has been detected, it will show green background.

RedWall	When the face is not been detected, it will show red background.
Canvas	Create UI such as emotion slider, back button and texts.
EventSystem	Sending events to objects in the application based on input.
GameController	Controller for the change scene event.

5.7.1 Structure of Main Camera component
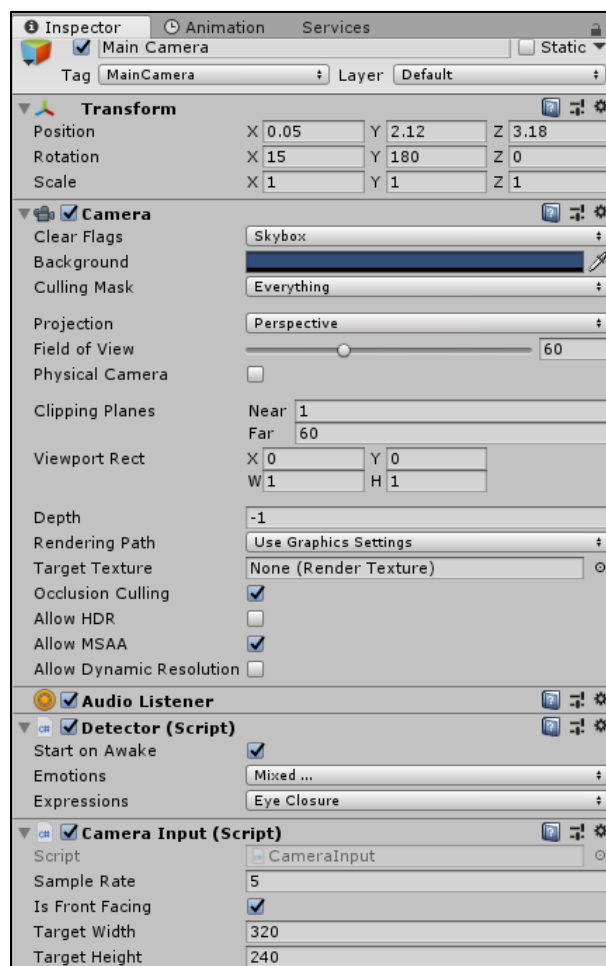
Figure 5.13 Inspector of Main Camera component

There are two important script in this component which is Detector and Camera Input script as shown as Figure 5.13. Detector script is used to detect emotions such as joy, surprise, angry and sad and it also can detect the expression such as smile, mouse open, eye closure and etc. Camera Input script is used to set the camera whether is front camera or use back camera to detect the face emotion.

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5.7.2 Structure of Fox_HD component
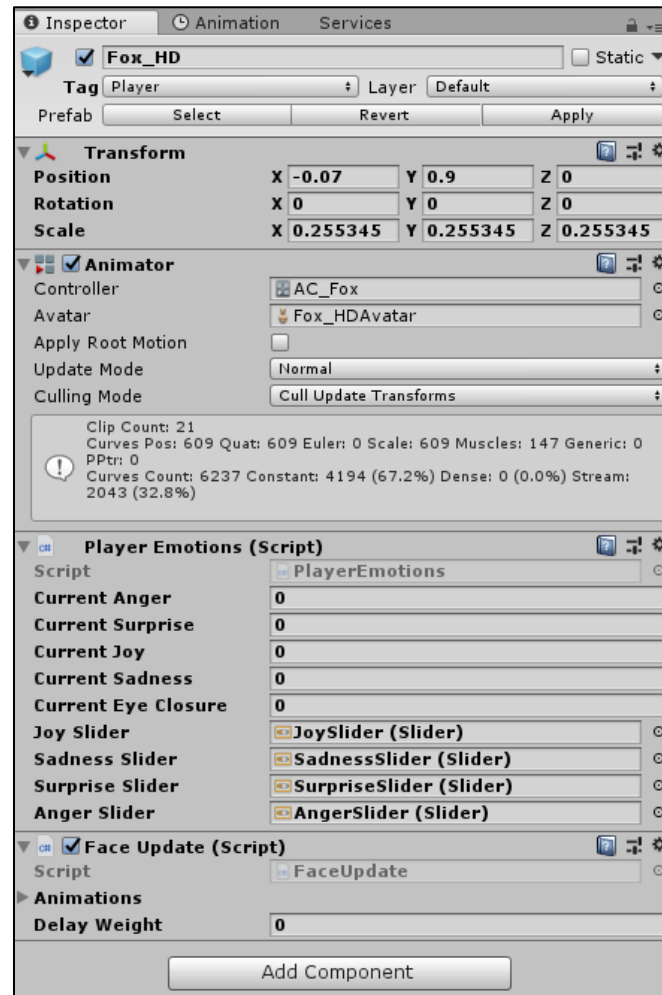
Figure 5.14 Inspector of Fox_HD component

Author has written two C# script in this component which is PlayerEmotions and FaceUpdate script as shown as Figure 5.14. For the PlayerEmotions script as shown as Figure 5.15, it will get value for the variable of current emotion such as anger, surprise, joy, sadness and eye closure. The current emotion is detected by calling the Detector script in the Main Camera component as shown as Figure 5.13. After have get the current emotion, it will output as slider's value. Furthermore, function that whether a face has detected or not also been written in this script as shown as Figure 5.15. For the FaceUpdate script, one of the functions is control the Soru to animate based on the user facial expression as shown as Figure 5.16. Final output scene is shown as Figure 4.5.

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```
    void Awake()
    {
        redWall = GameObject.FindGameObjectWithTag("RedWall");
        greenWall = GameObject.FindGameObjectWithTag("GreenWall");
    }

    public override void onFaceFound(float timestamp, int faceId)
    {
        greenWall.SetActive(true);
        redWall.SetActive(false);
        if (Debug.isDebugBuild) Debug.Log("Found the face");
    }

    public override void onFaceLost(float timestamp, int faceId)
    {
        greenWall.SetActive(false);
        redWall.SetActive(true);
        currentAnger = 0;
        currentSurprise = 0;
        currentJoy = 0;
        currentSadness = 0;
        currentEyeClosure = 0;
        if (Debug.isDebugBuild) Debug.Log("Lost the face");
    }

    public override void onImageResults(Dictionary<int, Face> faces)
    {
        if (faces.Count > 0)
        {
            faces[0].Emotions.TryGetValue(Emotions.Anger, out currentAnger);
            faces[0].Emotions.TryGetValue(Emotions.Surprise, out currentSurprise);
            faces[0].Emotions.TryGetValue(Emotions.Sadness, out currentSadness);
            faces[0].Emotions.TryGetValue(Emotions.Joy, out currentJoy);
            faces[0].Expressions.TryGetValue(Expressions.EyeClosure, out currentEyeClosure);

            joySlider.value = currentJoy;
            sadnessSlider.value = currentSadness;
            surpriseSlider.value = currentSurprise;
            angerSlider.value = currentAnger;
        }
    }
}
```

Figure 5.15 Functions in PlayerEmotions.cs

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```
void Update()
{
    if (Input.GetMouseButton(0))...
    else...

    anim.SetLayerWeight(1, 1);
    float dominantEmotion = Mathf.Max(playerEmotions.currentAnger, playerEmotions.currentSadness,
        playerEmotions.currentEyeClosure, playerEmotions.currentJoy, playerEmotions.currentSurprise);

    if (dominantEmotion <= 5)
    {
        anim.SetLayerWeight(1, current);
    }
    else if (playerEmotions.currentJoy == dominantEmotion)
    {
        if (playerEmotions.currentJoy > 60)
        {
            Debug.Log("Jump");
            anim.CrossFade("Jump", 0.1f);
        }
        else
        {
            Debug.Log("Jump_Begin");
            anim.CrossFade("Jump_Begin", 0.1f);
        }
    }
    else if (playerEmotions.currentAnger == dominantEmotion)...
    else if (playerEmotions.currentSurprise == dominantEmotion)...
    else if (playerEmotions.currentSadness == dominantEmotion)
    {
        if (playerEmotions.currentSadness > 50)...
        else...
    }
    else...
}
```

Figure 5.16 Update function in FaceUpdate.cs

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5.8 Development of Voice Recognition scene

*Figure 5.17 Hierarchy of Voice Recognition scene*

The UI component of this scene has been developed as shown as Figure 5.17. Function of the main components are stated in the Table 5.4.

Table 5.4 Function of main components in Voice Recognition scene

Main components	Function
Directional Light	Create light for the scene.
Main Camera	Display the game world.
Fox_HD	Virtual pet is listening to the owner. It will reply message to the owner.
Plane	A plane to place the virtual pet.
EventSystem	Sending events to objects in the application based on input.
Canvas	Create a back button for returning to the menu scene.
GameController	Controller for the change scene event.
NLPmodel	Learning voice recognition model.

5.8.1 Structure of NLPmodel
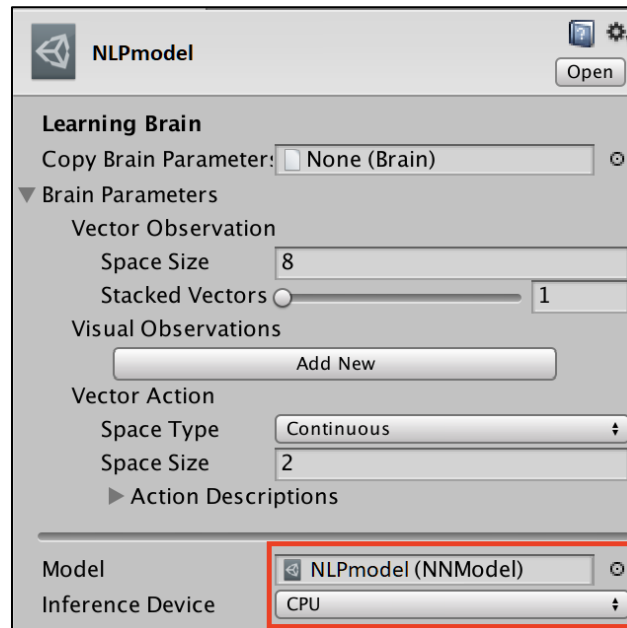
Figure 5.18 Inspector of NLPmodel

In the new version of ML-Agents Toolkit, the training process produces .nn file format. Author will use CPU for running inference due to it is small models and is faster because the data remains on the CPU while the GPU option is used for large models. Lastly, voice recognition modules can be integrated successfully with this application and the pet can chat with the owner.

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Chapter 6 Evaluation

6.1 System testing

Early testing can be made during the development phase such as test the functional of UI button and test the application whether can detect user facial expression correctly. After the whole application has developed successfully, follow the testing phase as shown as Figure 3.5. This android application is deployed to few android devices. Testing include whether the virtual pet can be spawned on the screen, functional of UI buttons, functional of face detection module and functional of voice recognition module.

In conclusion, only android device which must have android version 6.0 and above only can play this application. It is responsive to any screen size of android devices.

6.2 Objective evaluation

This proposed system has achieved objectives that stated below:

- AR application in mobile device can stimulate a virtual pet.
- Virtual pet can communicate with the owner.
- Realism of virtual pet is enhanced through the augmented reality.
- Virtual pet contains comfort effect when user in the sad emotion.

Chapter 7 Conclusion

7.1 Project Review

The aim of this mobile AR smart pet application is to let lonely people to get a companion stay beside them which can let those people communicate with the pet and speak out their mind. Besides that, everyone can have a virtual pet without spending any money but not every effort to have a real pet. Furthermore, to enhance the reality of the virtual pet, AR technique is implemented into this application so that the owner will have good visualization of this game. In addition, this application can detect the owner face emotion, virtual pet can give comfort to the owner when the owner emotion is sad such as dancing in order to make owner feel happy.

7.2 Implementation Issues and Challenges

Difficulty in designing of 3D pet and objects

Design 3D models is a big challenge for the author. This is because the author not good in drawing. Besides that, the 3D maker software is hard to use for the beginners, it is more suitable for the professional 3D designer.

Solution:
- Buy some 3D models which is hard to draw from the internet
- Ask some friend who has better drawing skill for help

Only certain phone models are support Vuforia AR SDK

There have a Vuforia supported device list at the Vuforia website. Features such as ground plane and model targets need to meet the minimum required specification for those features. The supported device must have android version 6.0 (Marshmallow) or newer, IMU w/ Gyroscope sensors and etc (Devices 2018).

Solution:

- Use another feature
- Change others phone to develop
- Use emulator without deploy in the device

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Face Detection scene can not combine with Menu scene into one scene

AR method need to use back camera to capture the environment in order to spawn the pet, whereas face detection method is using front camera to detect user facial emotion. Front camera and back camera cannot be trigger at the same time.

Solution:
- Both modules need to be separated into different scene.

7.3 Future work

Some improvements can be made in the future;
- Animation of the pet is not interesting enough, need to improve in animation part.
- The virtual pet sometimes may disappear and it is not so stable when spawned at the surface.
- Interface can be designed more nicely and interesting.

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