Department of Computer Science and Engineering

The Chinese University of Hong Kong

ESTR4998 Graduation Thesis Report

LYU1904

College War – An AR mobile game

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Abstract

In this project, we focus on designing and developing an online mobile game with augmented reality(AR) technologies and elements derived from CUHK Campus. We would apply the map of our campus as well as the college system into the game. AR games have certain advantages that they act as new ways of expression and give players the sense of interaction in the real world. Moreover, unlike virtual reality(VR) games which need players wear equipment, AR games have effects that can be shown in mobile phones very well. So that we integrate our game with AR technologies. In this term, we only implement an offline version of the game with the framework. However, we hope that after the full implementation in next semester, the game may encourage students and stuffs of CUHK to explore the beautiful campus more.

Acknowledgements

We would like to express our greatest gratitude to our supervisor Prof. Michael Lyu and advisor Mr. Edward Yau for providing guidance, feedback and resources in this interesting project.

Besides, we are also very appreciated to everyone who has supported us in the project or read this report.

1. Introduction

1.1. Motivation

> *"One day, we believe this kind of immersive, augmented reality will become a part of daily life for billions of people."*
>
> ——*Mark Zuckerberg, Founder and CEO of Facebook Inc.*

During the recent few years, mobile technologies have diffused into all consumer segment (1). AR provides opportunities for various industries, including those that develop interactive and engrossing game (2). For example, Goldman Sachs indicated in 2016 repot that AR has the potential to "become the next big computing platform, and as we saw with the PC and smartphone, we expect new markets to be created and existing markets to be disrupted". There is no doubt that AR will new the existing game development. We would like to design a game with the CUHK campus as the map background. Since our campus is a very beautiful campus built on the mountain, we hope our game can give players a chance to better explore our campus. Moreover, while keeping the basic design of the reference game, we would like to add elements of augmented reality to give players more novel and interesting experience. Furthermore, we want to introduce the college system of CUHK into our game by dividing players into different groups and making them fight for their own group and college which can increase the players' sense of substitution and belonging. At the same time, we hope that such a design can attract more players and that's why we named the game CollegeWar.

1.2. Background

1.2.1. Unity

Unity is a very popular and powerful game engine that supports both virtual reality and augmented reality games. While bring convenience to our game

development, unity offers packages and supports third party packages that could help us with AR technology.

1.2.2. Augmented reality

Both of virtual reality(VR) and augmented reality(AR) are becoming more and more popular. There are many VR trial spots in large spots as well as many applications in app stores. While VR allows users immerse in the three-dimensional virtual environment generated by computer and be separated from the real world, AR adds or removes real-time interactive objects and information generated by computer in real environment. One of the disadvantages of virtual reality is that users must wear the corresponding equipment. On contrary, users can use their mobile phones to experience the AR effects so that we choose to integrate augmented reality into our mobile games.

The use of AR in games is particularly popular. A very good example is Pokémon go, which have attracted the interest of worldwide players. Media named the Pokémon Go “the biggest mobile fame in U.S. history” (3). As a new way of game expression, AR game has certain advantages. It gives players the sense of interaction in the real world and fully mobilizes their enthusiasm and initiative in playing games. Moreover, using AR technology makes the game more interesting and diversified.

1.3. Objective

The goal of the entire project is to design and build a mobile game with CUHK as its background. It should be location based and contains campus system as well as elements of AR. Last but not the least, the game will be an online game. We hope, via the release of the game, both students and stuffs of CUHK will like it and get the chances to explore our campus more.

The entire project is expected to be complete in 2 terms. Here are the objectives

for the first term:

- Design the game and build the framework.
- Collect map data from the internet and render the map in Unity.
- Complete collecting system and battle system with AR using Vuforia

2. Design

2.1. Game Overview

The name of our game is College War, which is an RPG and SLG game of college battle with Android as its platform. Our target users are students and stuffs in CUHK. In general, its gameplay is that players first choose their own college and purchase weapons and defense by collecting materials. The weapons and defense are used to attack buildings occupied by other colleges or defense buildings occupied by players' colleges. There are four main modes of the game that are map mode, collect mode, attack mode, defense mode. The aim of the game is to become stronger by occupying as more buildings as they can.

2.2. Gameplay

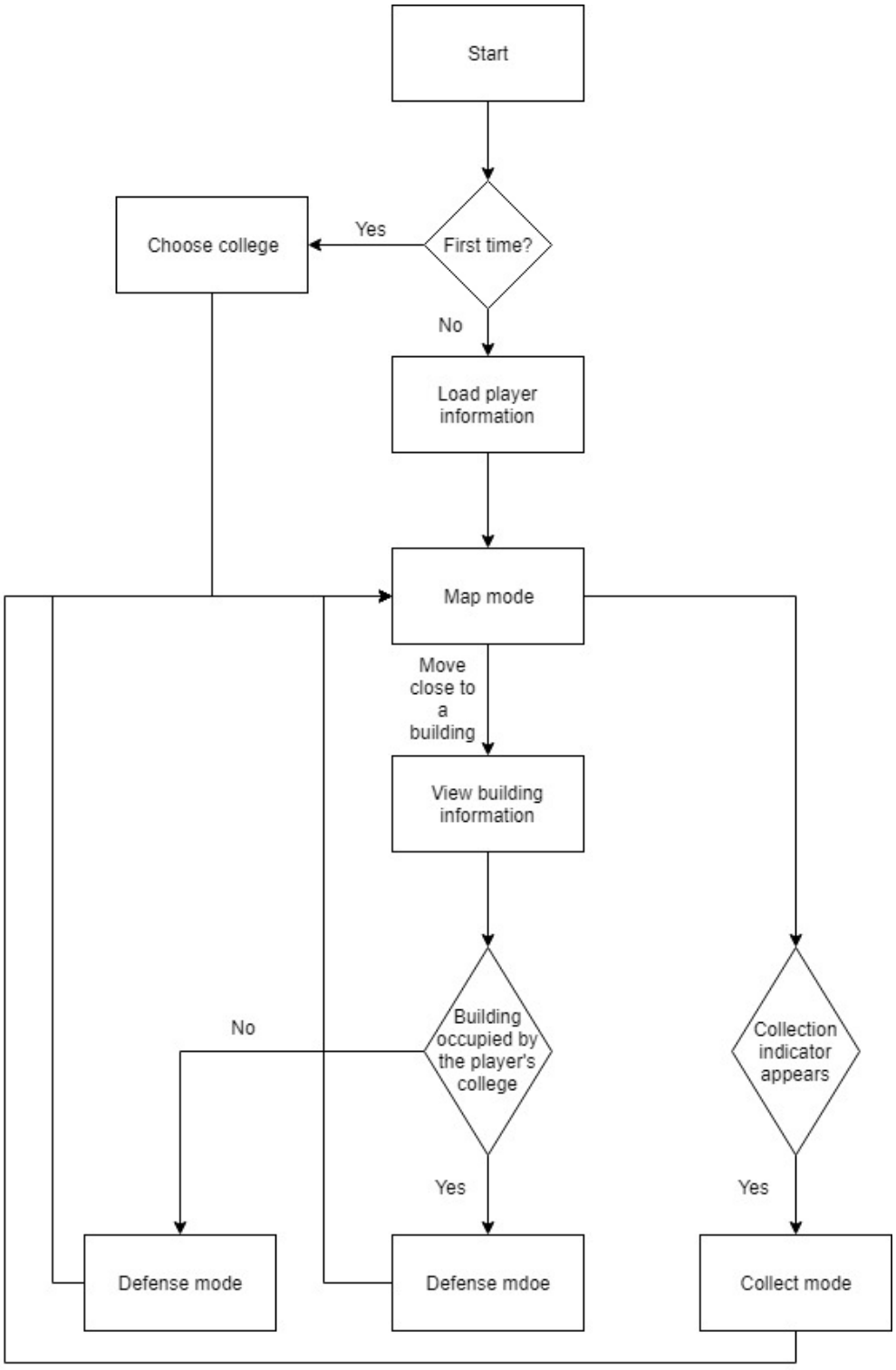

Figure 2-1 Block diagram of gameplay

The first time players start the game, they are asked to choose their own colleges. Once chosen, players don't have to choose again and they can't change it. After chosen, an avatar which indicates the player is displayed on a map based on the player's geographical location. This is called map mode.

Main features on the map are buildings include neutral ones and unneutral ones. A building is neutral means it is not occupied by any colleges. On contrast, a building is unneutral means it is currently occupied by a college. An unneutral building produces materials for players belonging the college that occupies the building. The buildings are typically the same as buildings in physical world in shapes and locations.

As players move within their real world surroundings, their avatars move within the game's map. An indicator on UI appears if there are collectible materials around players. Indicator of different color means different type of materials. Then players may enter collect mode to collect materials.

If a player wants to attack or defense a building, he/she needs to physically move to the building before entering attack or defense mode. Players are allowed to attack buildings that are not occupied by its college and defense buildings that are occupied by its college.

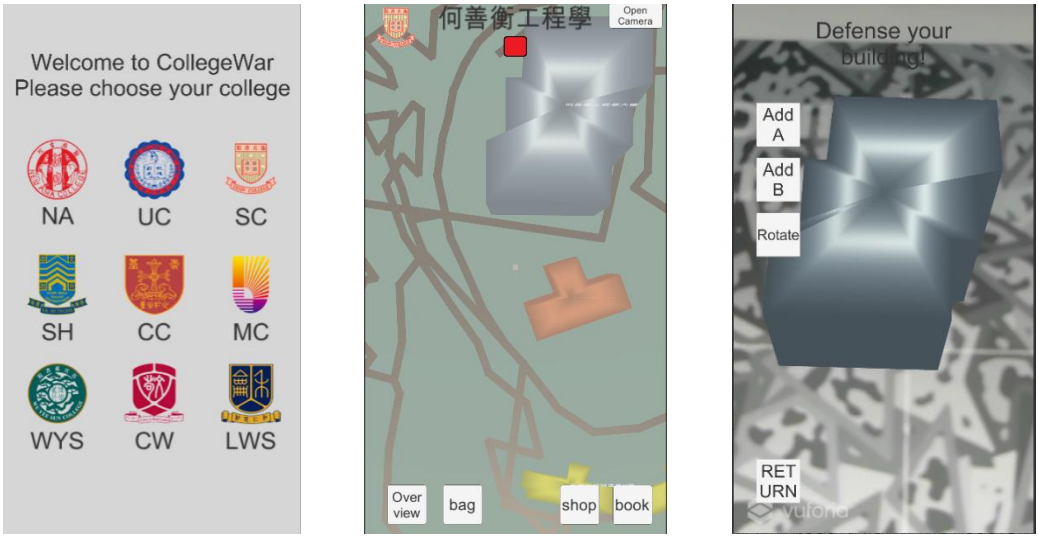

Figure 2-2 Screenshots of main scenes of the game

2.3. Game Components

2.3.1. Map

Our game is a location-based game with CUHK Campus as its map. It means that to play the game, players need to be physically at the campus. As players move within their real world surroundings, their avatars move within the game's map. Besides, the map is a 3D map that contains buildings and roads of CUHK. The buildings in the map are generally the same with the buildings in real world in names, shapes and locations.

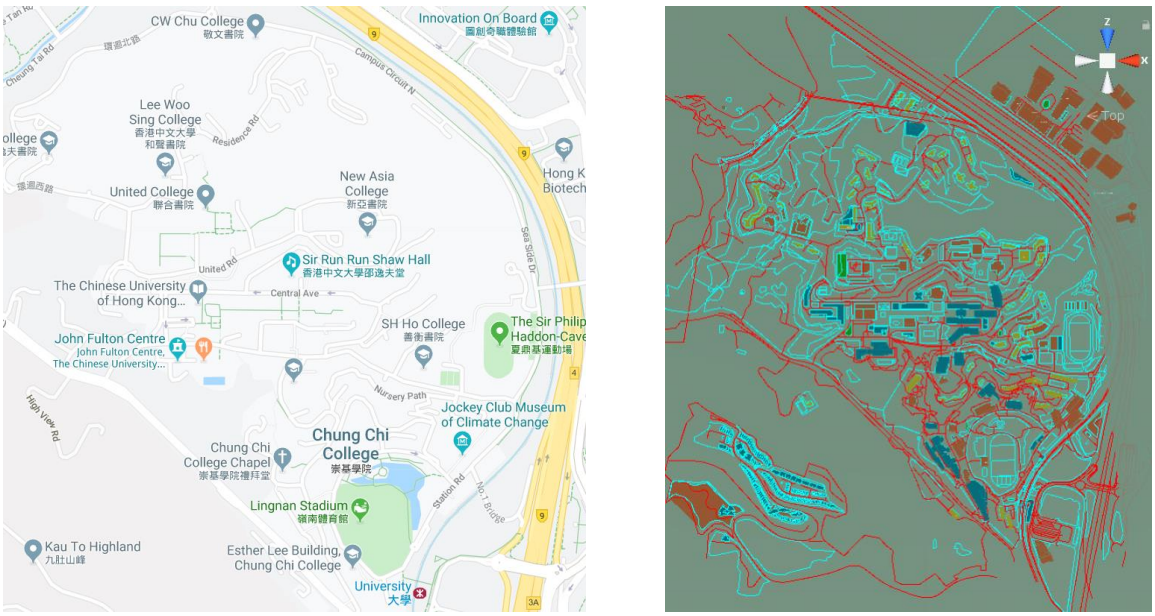

Figure 2-3 Google map and rendered map of CUHK in the game

2.3.2. College

We introduced 9 colleges in CUHK into our game. Each college has few buildings that are unattackable by other players such as its dormitory buildings. The game requires players to choose a college when they first start it. Once chosen, it's unchangeable. In this term, we don't require players to choose the college as they belong to in the real world. However, in next semester, if possible, we would like

to restrict players to choose colleges exactly they belong to in some ways. There may a problem that players of different colleges vary a lot. We have taken it into account and thought about several solutions to it, for example, give compensation to college with fewer players.

2.3.3. Collect system

To buy weapons and defense, players need to enter collect mode and collect materials. There are four kinds of materials distinguished by four colors. The indicator on UI shows which kinds of materials come out and material types are related to players' physical surroundings.

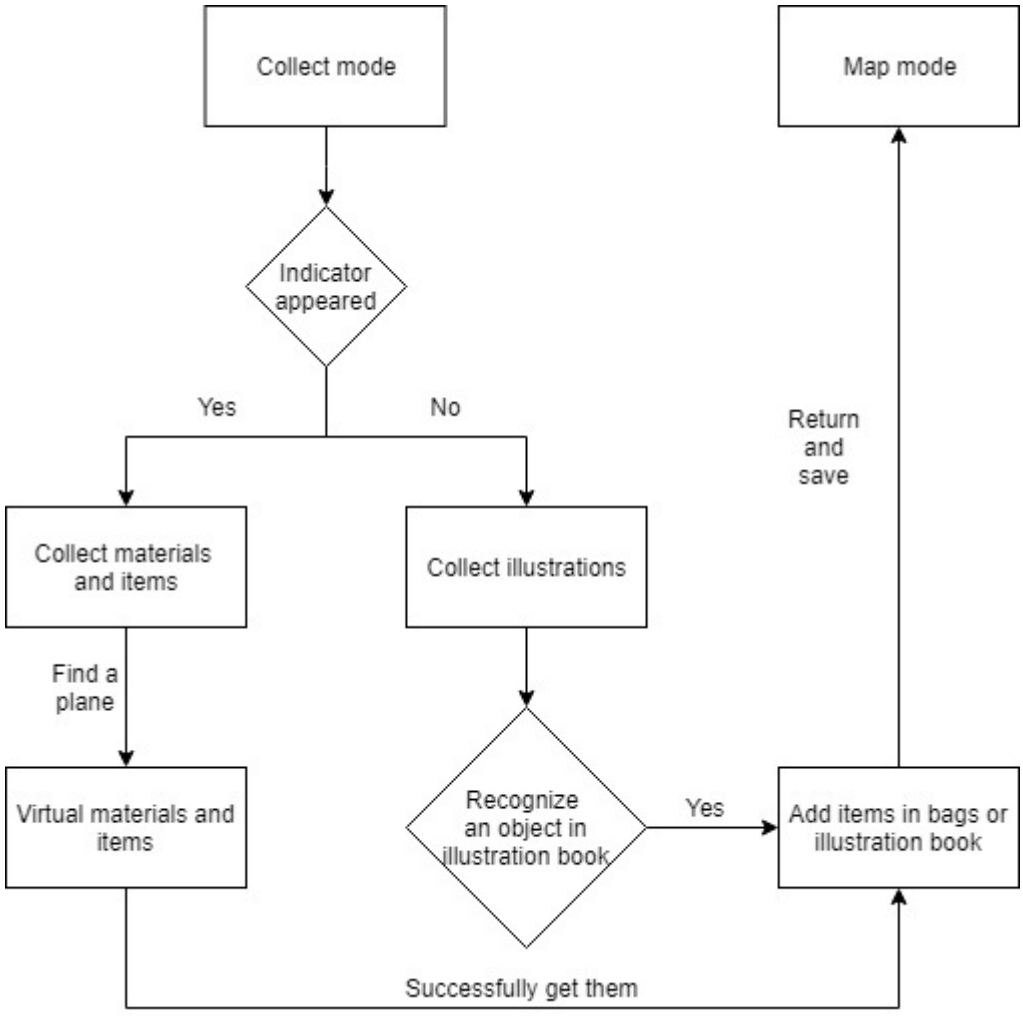

Figure 2-4 Block diagram of collect system

2.3.4. Illustrated handbook

Our game provides players with an illustrated handbook to record the collected items. The handbook contains all the materials weapons and defense. In addition, the most interesting thing is that we added popular signs of CUHK into it such as the pool in New Asia College and the female foot model in Shaw College. While some of them are well known, some are not familiar to all people.

Through this, we hope to encourage players to explore CUHK campus and know more about it. We also want to see players are surprised at finding their surroundings are shown in the game. At the same time, players are encouraged to share information with each other. Players can obtain returns according to the number of unlocking stamps of the handbook so that they will be likely to do it actively.

2.3.5. Attack system

As the main goal of players is to attack and occupy buildings, the attack system is very important. Players can buy weapons in the shop which costs materials. And materials are gained by collecting and produced by buildings that the player's college occupies. We have designed two weapons. While one has higher damage and hits single object, the other one has relatively low damage but can hit an area of objects.

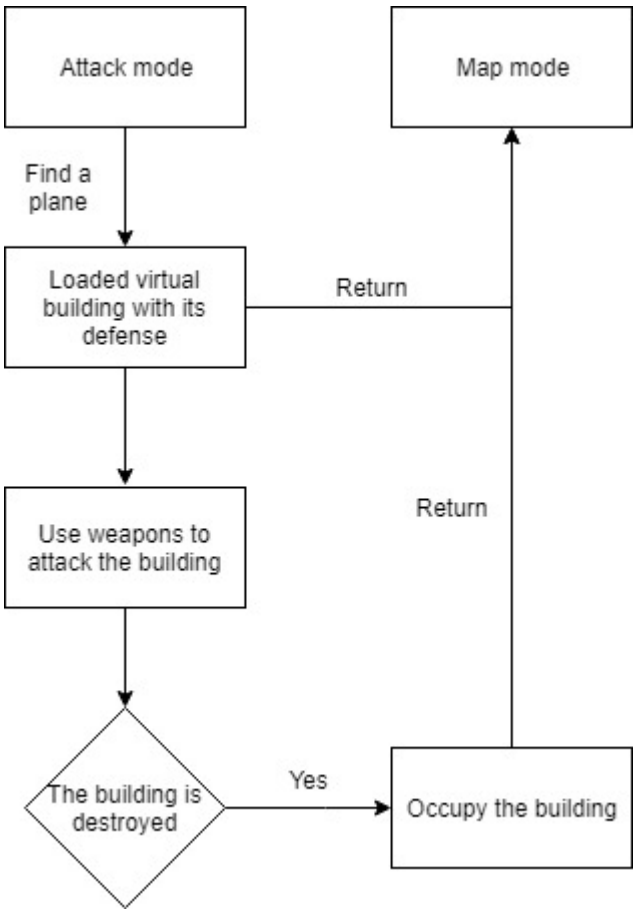

Figure 2-5 Block diagram of attack system

2.3.6. Defense system

In defense mode, players are able to build walls which can block bullets from attackers and move them freely to help to best defense the building. All the defense information will be systematically saved once players click return and go back to map mode.

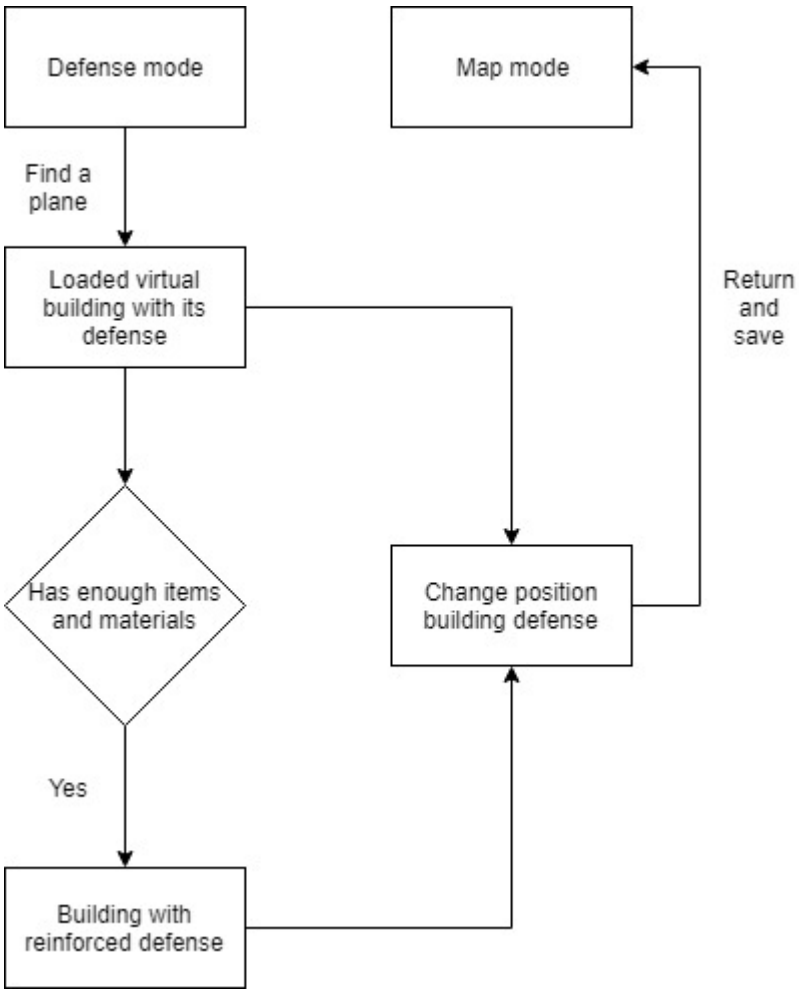

Figure 2-6 Block diagram of defense system

3. Implementation

3.1. CUHK Map Generation

In order to provide players with more reality experience, how to restore the CUHK map in our game is one of our goal. Currently we use the data from the OpenMapStreet, a open source map data website, which can translate the information of a particular area into .osm file. And what we have done is to analyze the composition of the json-type file and transform into the 3D object in Unity.

3.1.1. *.osm file analyzation

OpenMapStreet uses a series of **nodes**, which contain the latitude and longitude data, to form a **way**. The way is the basic constitution of different type of lands. With the kay-value modifier of way, it can be transformed into the real map with exact 3d information and multiple attributes. Here is an example of the modifier of SHB building.

```
<tag k="building" v="university"/>
<tag k="building:levels" v="10"/>
<tag k="name" v="何善衡工程學大樓 Ho Sin-Hang Engineering Building"/>
<tag k="name:en" v="Ho Sin-Hang Engineering Building"/>
<tag k="name:zh" v="何善衡工程學大樓"/>
<tag k="region" v="Main Campus"/>
```

Figure 3-1 An example of building data

But there exist some problems currently, because the data of OpenMapStreet resource is all depends on users' upload. Although the reality of data can be verified by the huge amount of upload data, there still exist some buildings in CUHK missing the height information. In the next semester, we decide to fulfill the database by ourselves, or do research for a better map data resource.

3.1.2. Different types of region

According to different land using, the regions are divided into water area, grass, building, bus stop, etc. We have designed abundant and attractive game rules to collect props or occupy for more manor for their own colleges in different kinds of regions. In addition, except the main campus, buildings are divided into nine colleges. To make the game more equitable, only the dormitory buildings of each college are not in public, as the base camp of each college, others can be occupied optionally. And the nearest building owned by the same college would enclose a territory, in which the owner can construct factories to yield more materials.

3.1.3. Building information interface

When player touches the building in 3D virtual map, the building information surface, currently consists of the building name, 3d preview image, and several buttons, appear in the center of screen. We use a temporary camera, keeping a proper distance from the target building, to only capture the building by setting the culling mask and then save the image into render texture, which is transformed into 2D image and shown in the interface.

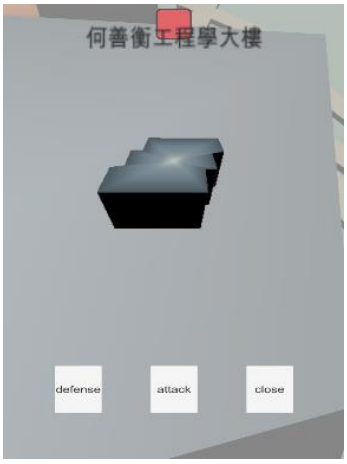

Figure 3-2 Building information interface

3.1.4. 3D objects rendering

After analyzation of OSM file, each region transforms into polygons with the coordinate of a series vertexes. In our research of mesh render principles in Unity, the basic elements forming a 3D object is a series triangle, each of which contains the normal vector, index order and 3 vectors to represent the position information. And then set multiple materials to represent different kinds of region, currently we use the basic metal material and more elegant will be used in our future plan.

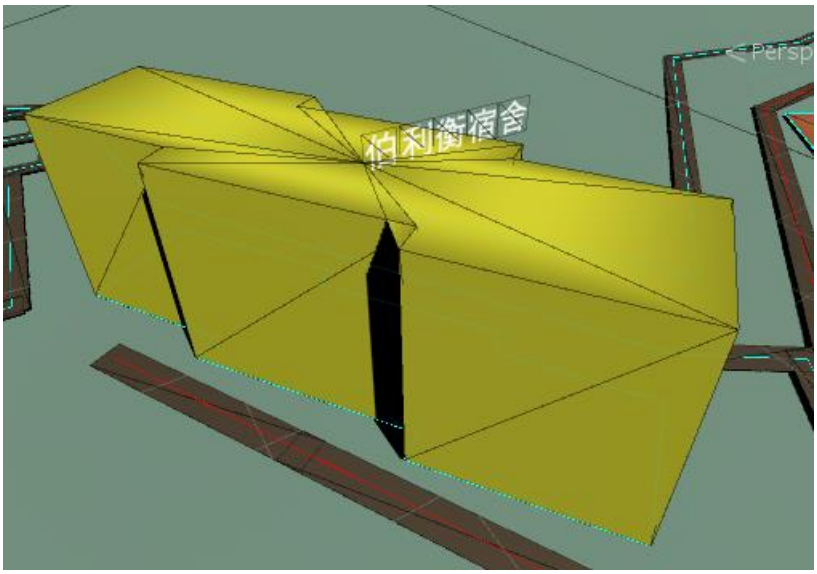

Figure 3-3 A rendered 3d building

3.2. Attack and Defense System

In our game, one of the main parts is the attack & defense system. Because players are divided into 9 colleges and everyone fights for their own college, how to occupy more buildings in CUHK is the target of players. When players walk around the building, they would be able to operate the building --- enhancing if they own the building, otherwise, attacking.

Because the time limitation, we only design 2 types of defense properties and 2

attack properties, which can be gathered or compounded by players. And the next step is to enrich the types and functions of properties and design more attractive models.

3.2.1. Defense System

When players move around the building their college occupied and touch the building in 3D map, they can equip the building with the properties in their bags. The first step is to find a plane to place the building. Here are only two kinds of barriers currently. They can touch the button to choose which type (if they own this property) and then move or rotate as their strategies.

No matter how players equip the building, all equipment will be saved as a json-type file locally which will be uploaded to public server when we finish the internet part, so that others can catch the update in real time.

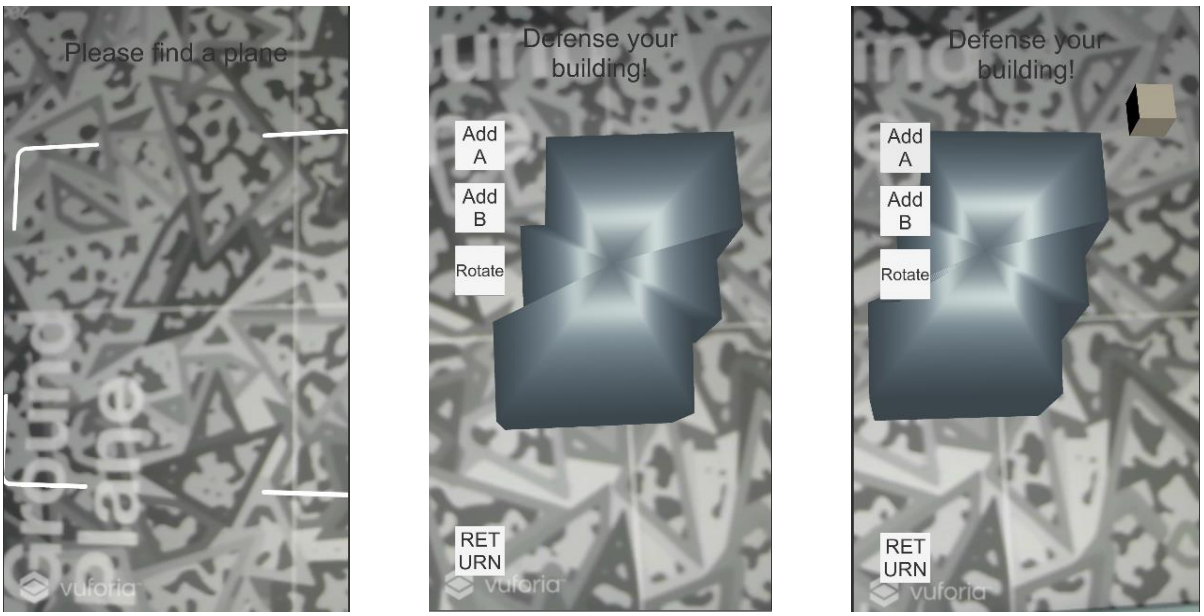

Figure 3-4 Screenshots in defense mode

3.2.2. Attack System

We have designed two kinds of attacking mode already, but, because one of them needs further technology about AR, only plane finder mode could be realized in this semester.

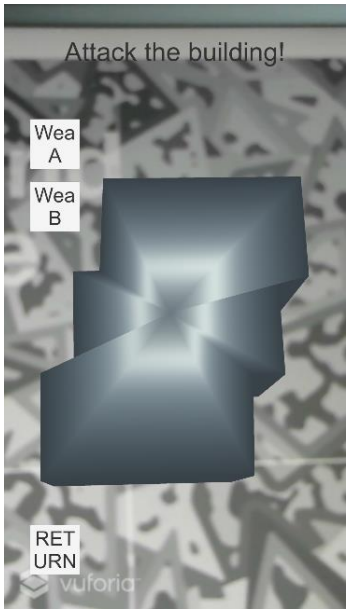

Figure 3-5 Screenshots of attack mode

3.3. Collect System

To encourage players to visit more regions in CUHK, all basic materials can be gathered in special regions. For example, the green material only appears near the grass and the blue is near the water area. When the players enter or stay in the specific regions, the materials will randomly appear and announce players. Similarly, first to find a plane and the target material will appear at the center of plane, currently players only need to rotate screen to focus and touch the target and then collect. In further plan, in order to enrich the interactions, a huge and abundant scene will be loaded, and players need to overview and observe to find the materials hidden in the scene.

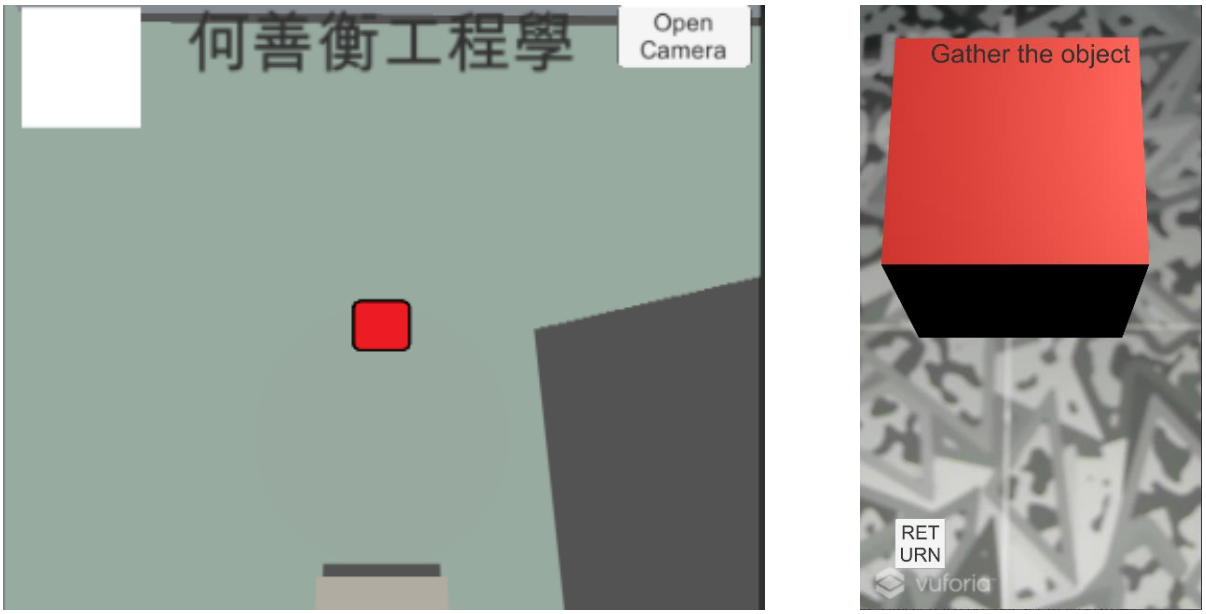

Figure 3-6 Indicator of materials and screenshots in collect mode

3.4. Other interaction

3.4.1. Camera

There are three modes of camera view. Players can switch modes by the buttons on main panel. First is follow-player mode, camera follows the player position and keep a proper distance and angel, which can be adjust by two or one finer touch. Second, overview mode, which is like the total 2D map of CUHK, can indicate the surroundings and current position of player. Last mode is gyroscope mode, combined with compass, rotating the mobile phone and the 3D scene seems like reality.

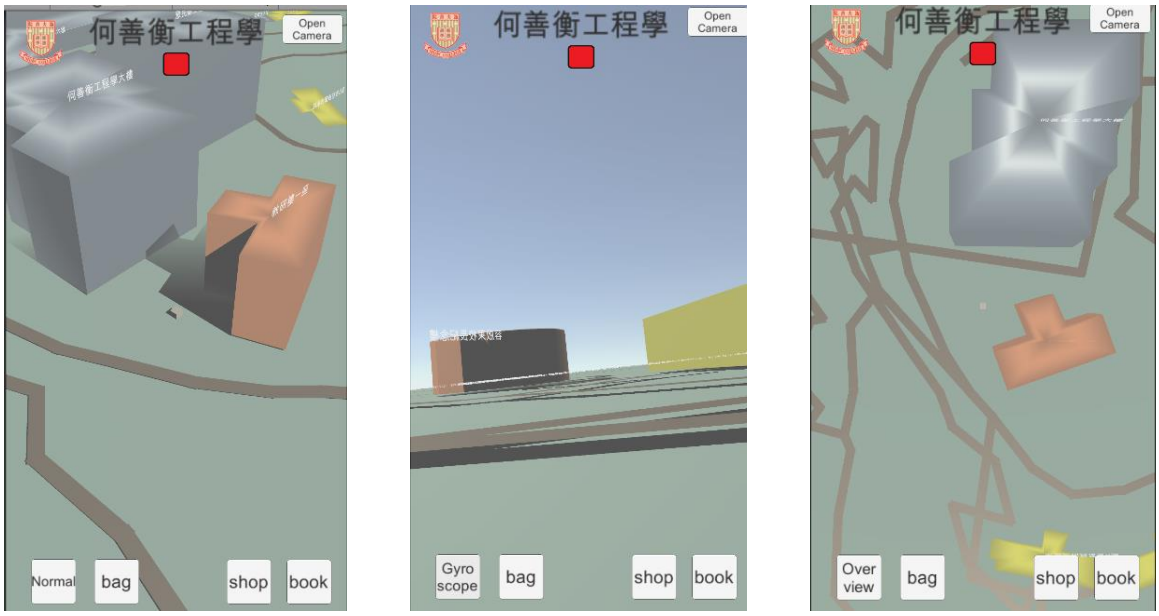

Figure 3-7 Three different perspectives of view

3.4.2. Shop and Inventory

Currently because only for function testing, only four basic materials are designed. Once player collects materials from the gathering system, the 2d icons will appear in inventory, which can be remove by touching the ‘x’ button. And if player wants to compound advanced props such as weapons or barriers, shop menu provides the choices. Only enough raw materials in the inventory can player buy advanced props from the shop.

Figure 3-8 Shop and Inventory

3.5. Archive Management

Since our game is a simulation game, all the records of players should be written down and reloaded when players open the game next time. So that we figured out a way to record player information, building information as well as college information.

First, we created two objects each time the players start the game which are used for record player information and building information. When players close the game, we transform object information to string format and write them in json files using methods offering by a third-party package. Blow are two examples of recorded json files.


```
{"college":"NA",
"material":["A":"3", "B":"1"],
"itemInfo":["WeaponA":"10"],
"bookInfo":["1", "3", "4", "7"]}
```


Figure 3-9 Player information in json format


```
{"numOfPlayers":"NA",
"occupiedBuildings":["1", "3"],
"materialProduce":["A":"2", "B":"1"]}
```


Figure 3-10 College information in json format


```
{"name":"何善衡工程大楼",
"hp":"10",
"addObjects":["wall", "tower", "wall", "tower"],
"objectsPoxX":["0.1, "0.1", "-0.1", "-0.1"],
"objectsPoxY":["0, "0", "0", "0"],
"objectsPoxZ":["0.2, "0.2", "0.2", "0.2"],
"objectsHp":["10","20","15","15"]}
```


Figure 3-11 Building information in json format

4. UI design

4.1. Start screen

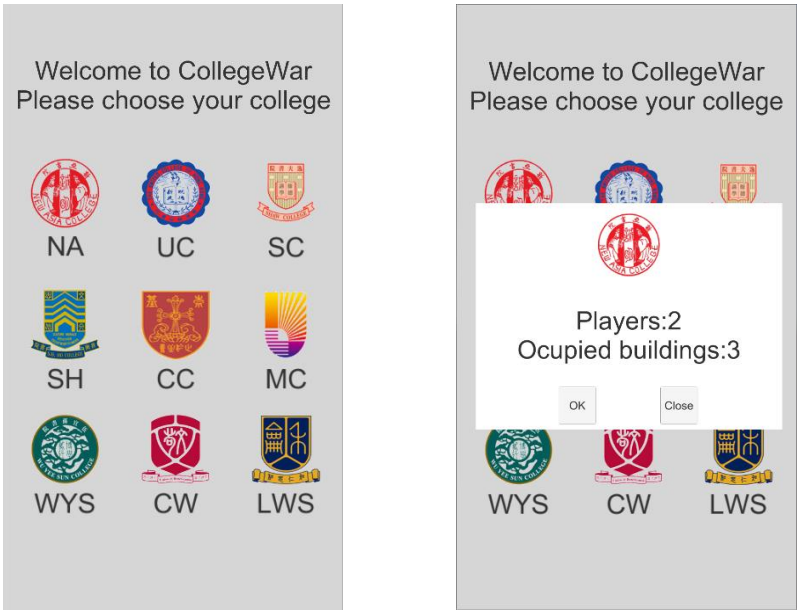

Figure 4-1 Start screen of the game

This is the UI frame when players choose their colleges. 9 colleges of CUHK are shown and players can click on logos to view detail information of the colleges including number of players and occupied buildings. They can confirm their choice by clicking ‘OK’ and will be directed to the main scene which is the map mode.

4.2. Map screen

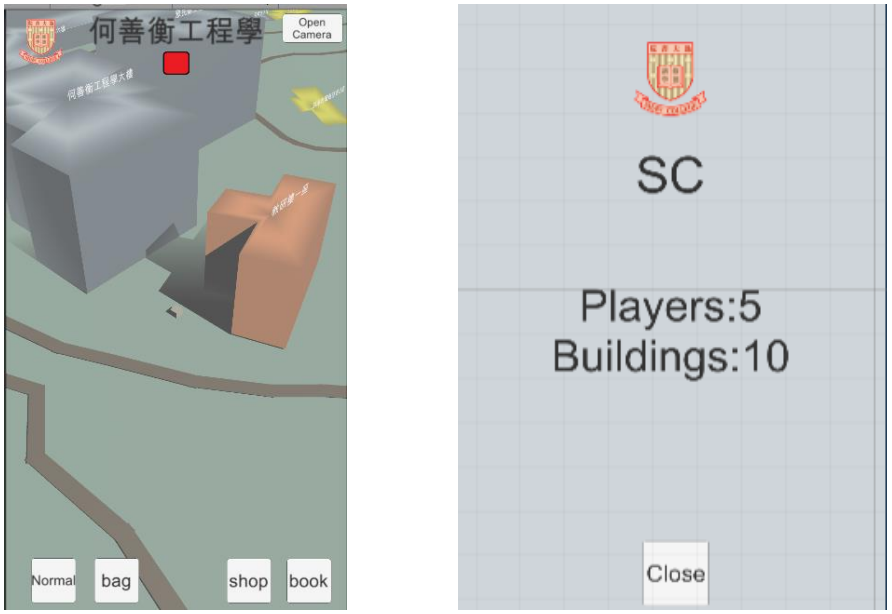

Figure 4-2 Map screen of the game

In the main scene of map mode, the image on the left-top corner is the logo of the player's college. Players can view their college information by clicking on the image.

The text on the top-middle shows the name of the building that the player is close to. Blow the text, the rectangle indicates that the player can collect materials and the color of it means different types of materials. There are four buttons in the bottom. The leftmost one is used to change view perspectives. Clicking on the last three buttons shows detail information of bag, shop and illustrated handbook respectively.

4.3. Building information and inventory screens

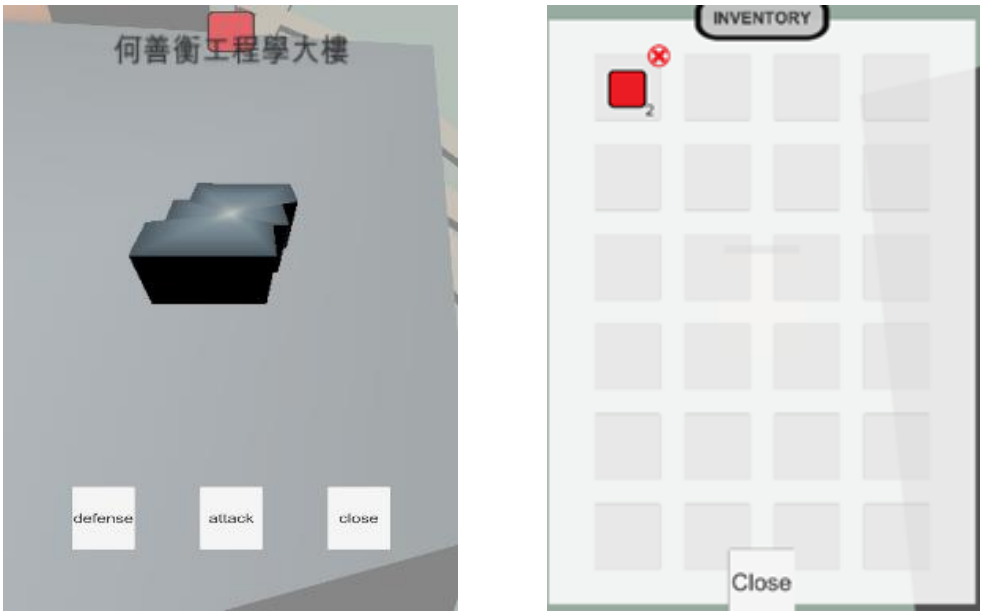

Figure 4-3 Building information and inventory screens

In building information panel, the name and type of the building will be shown on the top-middle part with the 3d object blow it. Players may choose to defense/attack this building or close this panel by clicking buttons in the bottom.

In inventory panel, all the player's items and materials will be displayed and players may view detail information by touching the image. And players can close this panel by clicking 'close' button.

4.4. Shop and illustrated handbook screens

Figure 4-4 Shop and handbook screens

This two panels show items sold in the shop and the objects or images players have unlocked in the handbook. Players may touch ‘BUY!’ button to buy items and view detail information by clicking on logos.

4.5. Collect, defense and attack screens

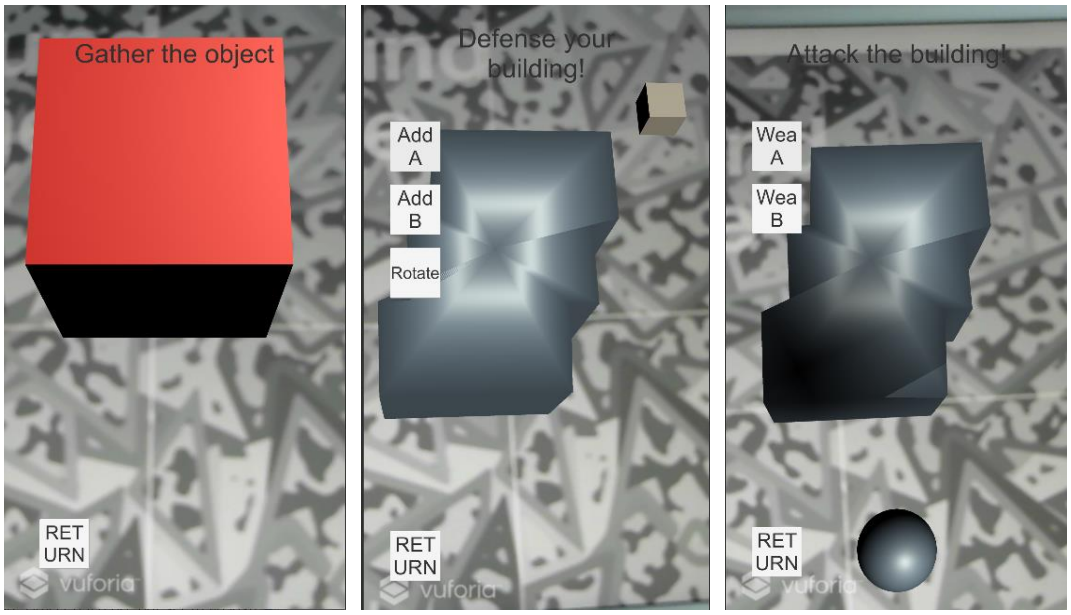

Figure 4-5 Collect, defense and attack screens

In collect mode, the text on the top-middle part shows suggestions to players. Players can go back to map mode by clicking the return button.

In defense mode, the text on the top-middle part is also advice to players. The two left upper buttons are used to add defense to the building. By clicking 'rotate' button, players can rotate the defense such as barriers. The button on left-bottom is for players to return to map mode.

In defense mode, the text on the top-middle part is also advice to players. The two buttons on the left side are used to prepare weapons. By clicking on them, corresponding weapon will be placed on bottom part of the UI. The button on left-bottom is for players to return to map mode.

5. Research in AR

5.1. Overview

The word “augmented reality” was born and first used in 1960s (4), which builds a bridge between the virtual reality and the real environment. Combined with the “Virtuality Continuum” concept introduced in 1995 by Milgram and his team, AR becomes more understandable. They used this term to construct a “road” starting from a real environment, totally ending into virtual environment and passing through augmented reality and augmented virtuality. Therefore, augmented reality is the first stage in which virtual objects are superimposed on a real scene. The main difference between augmented reality and virtual reality is that, VR application tries to replace the environment with virtual objects but without any direct connection with surroundings, while AR application adds computer-generated digital information based on surrounding environment and shows the enhanced view of environment with virtual objects to users. AR development is still in its initial stages and with the advances of technology, more user-friendly AR applications will work on mobile devices and bring AR closer to the general public.

5.2. Comparison of Frameworks for Mobile AR Development

We have do researches on the frameworks available to implement AR mobile apps on Android devices and an overview of this research is described below. The following description is captured from the characteristics and features of each framework which is out the most.

Framework	Last version found	2D recognition	3D recognition	Geo-location	Cloud Recognition	SLAM
ARCore	30 Oct,2019	√	√	√	√	√
Vuforia	1 Mar, 2018	√	√	×	√	√
EasyAR	7 July, 2019	√	√	×	√	√
ARToolKit	--	√	√	×	×	×
Maxst	2 Dec, 2019	√	√	×	√	√

And in the following we would like to summarize the features of these popular AR platforms in alphabetical order as they appear in the table.

ARToolKit (5) is an open-source AR software library providing support the following functionalities: Single-camera or stereo-camera camera position/orientation tracking, tracking code that uses simple black squares, the ability to use any square marker patterns etc. It brings in OpenCV support, OpenGl ES2.X support, integration with GPS and compass, and automatic camera calibration utilities. ARToolKit uses computer vision algorithms to solve tracking from users' viewpoint, which is extremely fast to make camera pose estimation.

ARCore (6) is Google's proprietary AR SDK. It possesses three core capabilities to link reality and virtual world: Motion tracking, environmental understanding and light estimation.

EasyAR (7) is a free AR engine developed by Visionstar Information Technology (Shanghai). Except a number of basic features, such as SLAM, 3D tracking, and screen recording, it pushed out surface tracking in the newest version 3.0.0, a new kind of tracking that is calculated by detecting arbitrary surface feature points instead of costing extra time on finding plane and will enable faster surface bonding and pose tracking.

MAXST AR SDK (8) is a cross-platform AR engine, and provides instant tracker, visual SLAM, object, image, marker and QR code tracker, QR reader and cloud recognizer. In addition, MAXST combined all the trackers into AR Fusion Tracker in the newest released version and used ARCore to track environment. Unlike other AR engine, MAXST use octagonal bounding box to compensates for user tilt between the camera and scanning object in order to make the Visual SLAM more accurate.

Vuforia (9) is the AR SDK that enables app developers to quickly get start because of the complete and detailed API. And it owns the unique tracking technology, 3D model tracking, and provided the option to train model targets using Deep Neural Networks(DNNs) for recognition in recent version, and the result of training is used to not only identify whether the object is matched, but what angle the camera viewing it from (10).

In this semester, because of time limitation, we only concentrated on two of these technologies, Vuforia and ARCore.

5.3. Vuforia Engine

Vuforia Engine is an augmented reality software development kit (SDK) for mobile devices that enables the creation of augmented reality applications. Among many of the AR software development kits, Vuforia Engine is the most popular one with the fastest recognition speed and the most stable recognition effect. There is little detailed algorithm on Vuforia official website, our researches concentrate more on the

function and effect on recognition.

Vuforia Engine's recognition and tracking capabilities can be used on a variety of images and 3D objects, but only including model pre-existing in database or the sample geometry like cylinders and cubes.

5.3.1. Image Recognition

For images, before recognition, users need to upload the target image to Vuforia database, which will analyze rating of the image(from 0 to 5) by the amount of feature points. Here are two examples with different grades.

Figure 5-1 Images of feature points with rating of 0(left) and 5(right)

By a mount of feature points, Vuforia understands the unique elements the target images own, such as curves, edges and high-contrast spots, which can help distinguish whether it is easy to recognize. After analysis of target images, Vuforia engine operate the images captured by physical camera from each frame, search the feature points, and matched if majority of reference feature points are found. The next step is calculating the relative position of all feature points and combining

the virtual game object with relevant position information. Here is an example showing how matching the reference feature points between camera captured image and preset image.

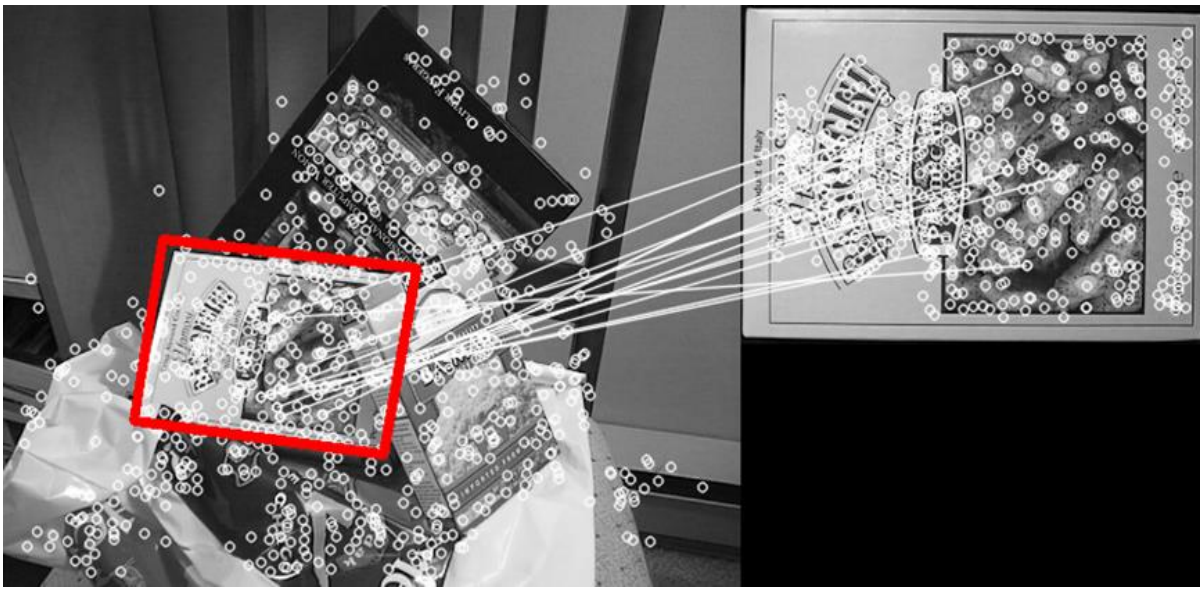

Figure 5-2 matching feature points between target image and camera capture image

5.3.2. 3D object recognition

To make a 3D model target for a particular object with high accuracy effect, Vuforia has some limitation of the object, be geometrically rigid, present stable surface features without shiny surface and be fixed with respect to the environment it is in (9). First through Model Target Generator (MTG) provided by Vuforia engine, the 3D model data representing the object users want to track would generate into a Vuforia Database, and the input data only can be accepted with 3D CAD model file, or using the Vuforia scan of the object with specific angle and distance. Currently because of lack for the digital model for each building and the difficulty of scanning each building with global angle, we do not touch this part during this semester and may try to train our database via cloud-based deep learning based on the images captured by multiple players in our future plan.

5.3.3. Advantages and disadvantages

Vuforia is the most powerful tool with the good integration into Unity, and the API is enough detailed to facilitate and simplify the development process. But the recognition with high accuracy has too much limitations, for example, when we do the plane finder, only when having contrasting coloring, or some details, the plane can be recognized. In addition, any makers with striped element will not be recognized in any case. How to avoid these disadvantages is our next step.

5.4. ARCore

ARCore is Google's platform for building and bettering AR experiences, binging information and content to life at the exact moment it's useful. Its functionality can be split into three main areas: Motion tracking, Environment understanding and light estimation (6). Light estimation allows the device to estimate the surrounding light information of environment and calculate the virtual objects texture to naturally blend into the scene, which may not be applied in our design. So, we focused more on the first two features.

5.4.1. Motion tracking

From the ARCore official API, motion tracking is implemented by a process called parallel ranging and mapping (or COM). ARCore detects visually distinct features (feature points like Vuforia) in captured camera images and uses the difference between these points to calculate their position changes and then combined with the inertial measurements of the device's IMU to estimate the pose of the camera relative to the surrounding world over time. IMU of mobile phone depends on following hardware.

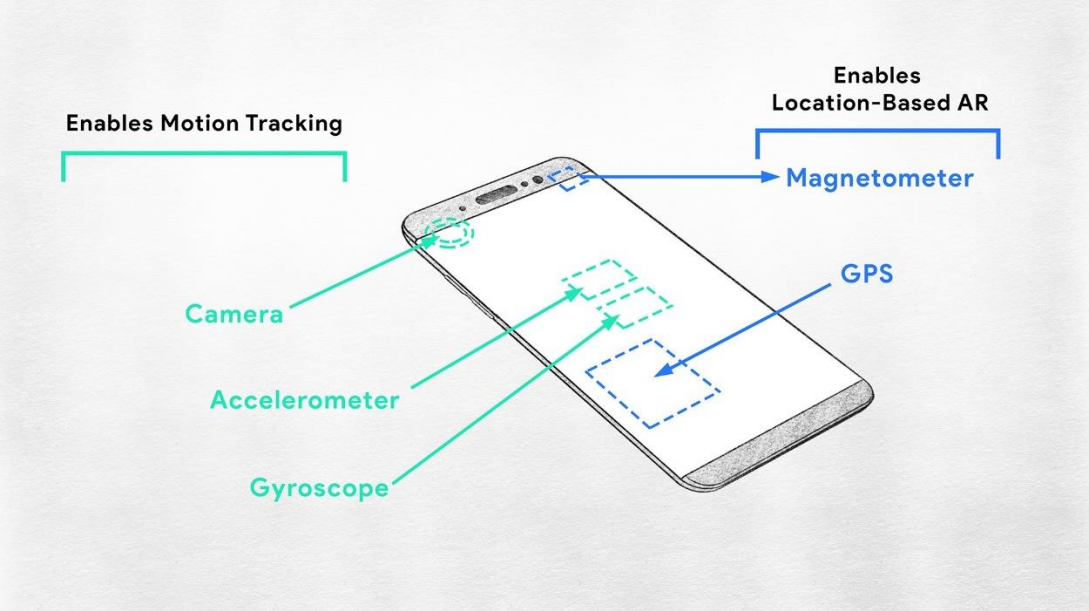

Figure 5-3 Hardware of mobile phone enhancing the motion tracking

- Accelerometer: measures proper acceleration which is felt relative to freefall by object itself.
- Gyroscope: measures and maintains orientation and angular velocity. It can calculate the rotation and ensures the virtual rotate respond correctly.
- Magnetometer: provides a simple orientation related to the Earth's magnetic field so that the virtual world map can auto-rotate depending on the physical orientation of device (11).

Only using IMU for navigation is that the tiny error will be accumulated because this system is continually integrating acceleration with respect to time to calculate velocity and position based on its last calculation without any static basis, that means, no matter how small the measurements error will be accumulated over time. This leads to "drift", an ever-increasing difference between the pose in real world and in virtual world. Due to integration a constant error in acceleration results in a linear error in velocity and a quadratic error growth in position and a constant error in attitude rate results in a quadratic error in velocity and a cubic error growth in

position (12).

Position tracking systems such as GPS can be used to continually correct drift errors.

5.4.2. Environment understanding

ARCore enhanced the understanding of surrounding real world environment by detecting feature points and planes. Because one of the shortcomings of ARCore is that it doesn't provide any visual and detailed recognition process, the feature points or planes cannot be shown either. Only a cartoon on the website may indicate the basic principle.

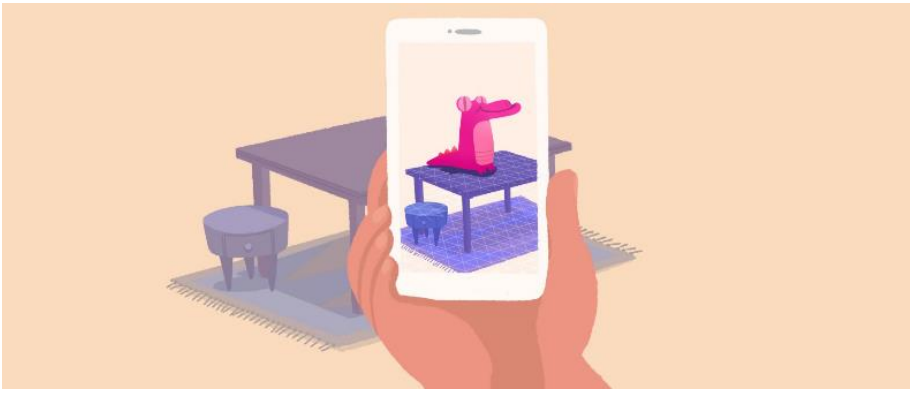

Figure 5-4 Process on how to find a plane

ARCore looks for clusters of feature points that appear to lie on common horizontal or vertical surfaces and by the position distribution from closer cluster, it can determine the plane position and edges of each plane. But similar to the Vuforia, because the flat surface without any texture cannot provide any feature points, ARCore also has no understanding on such plane.

6. Conclusion

6.1. Summary of 1st term

It's true that AR games can bring new experiences to players. But through the development of our project, we also feel the problems of AR technology. It can't recognize large objects and sometimes it recognizes wrong objects. In addition, another problem with AR games is that the size and clarity of virtual objects may not be compatible with the real world which means that the scene looks strange. We hope, if possible, we can avoid or solve some of these problems through the design and implementation.

In general, the objectives of this semester have been achieved. First of all, we got the real map data and processed them to the data we want. And then use these data to generate our virtual map that contains detail information of all the buildings in CUHK. Moreover, we have accessed the GPS of players' mobile phone and locate them in the game.

Secondly, we designed the game and developed it by learning and using unity. We successfully completed the establishment of the game framework and the implementation of all gameplays. The four main modules are map, attack, defense, collect modules. All of them were implemented with the combination of AR.

Last but not least, we have learnt the basic AR application development flow and get knowledge of some AR framework, especially in ARCore and Vuforia Engine. According to what have researched, we combined the plane finder technology using Vuforia in the fighting and gathering system.

6.2. Planned work for the 2nd term

6.2.1. Network of the game

In this term, we focused more on the implementation of an off-line version of the game. We designed and implemented the whole framework of the game. In next term, we will make this game into an online game, separating server side and the client side. There are two parts to achieve this goal.

First, for the basic information of player, building and college, for example, the equipment of building, we'd like to store the data on the centralized database instead of local device. Whenever users do any operation to the virtual world, it will update the data in server automatically. The main step for this part is to design the protocol of transformation and the data structure storing in database, and we have tried store the player information in json-type file as described before and plan to continue researching for more efficient structure.

Second, according to our simple research on AR Cloud, how to let multiple users capture the position information and update the AR pose in the shared memory is another goal of next semester. ARCore provides the cloud recognition service to make the whole virtual world become a shared spatial screen enabling multiple user engagement and collaboration by sending anchor points and nearby feature points to the cloud for hosting. Through sharing the single player AR experience with each other, our game can develop abundant gameplay, for example, players will attack the building cooperate with others from same team and their position and AR interaction are shared synchronously.

6.2.2. Numerical game design and adjustment

In order to make our game more equitable, numerical testing is important. Because teams in our game are divided by 9 of CUHK colleges, not only the

number of students has great difference between the large college (e.g. SHAW College) and the small college (e.g. SHHO College), but the geographical locations of colleges are too separately, for example, the United College locates in the center of whole campus but C.W.Chu College is far away from the other 8 colleges, we need to make a lot of numerical adjustments, including damages of weapons, possibilities of resources production, health of buildings from different regions and etc. In addition, the types of current props are not enough, and the functionality design may be plodding, how to design more attractive props is also in our plan.

6.2.3. Building model training

In our current framework, because the information of CUHK map is limited, the buildings are represented with several polygons. Vuforia Fusion provides the 3D model training process, allowing users train the target model by multiple images captured within different view frustum. Although this process can only be applied for small model, we'd like to learn the background principles to construct the building models in our database. After achieving the building model training process, it's easy to recognize and track the target building model combined with ARCore technologies, which would enhanced the player experiences in building occupied competition.

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