Research on Customized and Secure Augmented Reality

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Abstract

With the development of the AR (augmented reality), more and more information will be displayed as 3D-virtual content through the AR display devises. Nowadays, Marker-based AR system is one of the most popular AR systems in the world. By detecting the markers in user's view, marker-based AR system adds the 3D-virtual content on the marker's spatial point. However, this kind of system cannot provide the user the customized virtual content which suit the user's situation. And on the other hand, every person can easily see the 3D-virtual content just through an AR display device which means the 3D virtual-information has not been protected well in current marker-based AR (augmented reality) system.

In this research, we proposed an augmented reality system which can detect the user's situation and display customized 3D-virtual content to different user. In the other hand, the system can encrypt the 3D-virtual content. User need to unlock it by some ways (Using Password, face recognition and so on.) and finally acquire the hidden 3D-virtual content.

The system will detect the observer's identify and his context situation. the user's identify data (including the user's permission) will be provided by the user's database. And that the context data mainly acquired from the user's device (Mobile phone in this research), such as the GPS sensor, or the device system time. In our research, system also record the encryption information by database. The database will record whether the 3D-virtual content has been encrypted and what is the password (Or face ID in the face recognition method). The database will also record the user's every input. If the user input wrong password for three times, he needs to wait an hour to input again.

In our research, we also give some potential applications to show the value of the new marker-based AR (augmented reality) system. Just like the use in AR game, AR mail and so on.

Keywords: Augmented Reality, Customization, Security

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Chapter 1

Introduction

In recent years, AR (augmented reality) system has become very popular. More and more information can be displayed as 3D-virtual content by the AR system. One of the most common AR system is the marker-based AR system. Marker-based AR system detect the physical marker's spatial position as the input through the camera. Then the system will show the combination of real word and computer-generated graphics as the output through the AR display devices (such as Mobile phone or AR glasses).

With the development of the Augmented Reality, AR system need to display more diverse information and adapt to more situations. Sometimes users want to see the customized 3D-virtual content on the same physical AR marker. At the same time, the security of information also should to be considered. People should not be able to see all the additional information through a simple AR display device. There should be some methods to encrypt the 3D-virtual content which will be displayed by the AR system.

Our cure point is to research the Augmented Reality system of customization and security. we proposed an augmented reality system which has following functions.

1. Show the customized 3D-virtual content to different observers. The system will detect the observer's identity (who is the user, his permission and so on) and his context-situation (Location, time and so on). Finally, output the customized 3D virtual computer-generated graphics.

2. User can encrypt the 3D-virtual content. Our system will realize two unlock methods - Using the password or face-recognition.

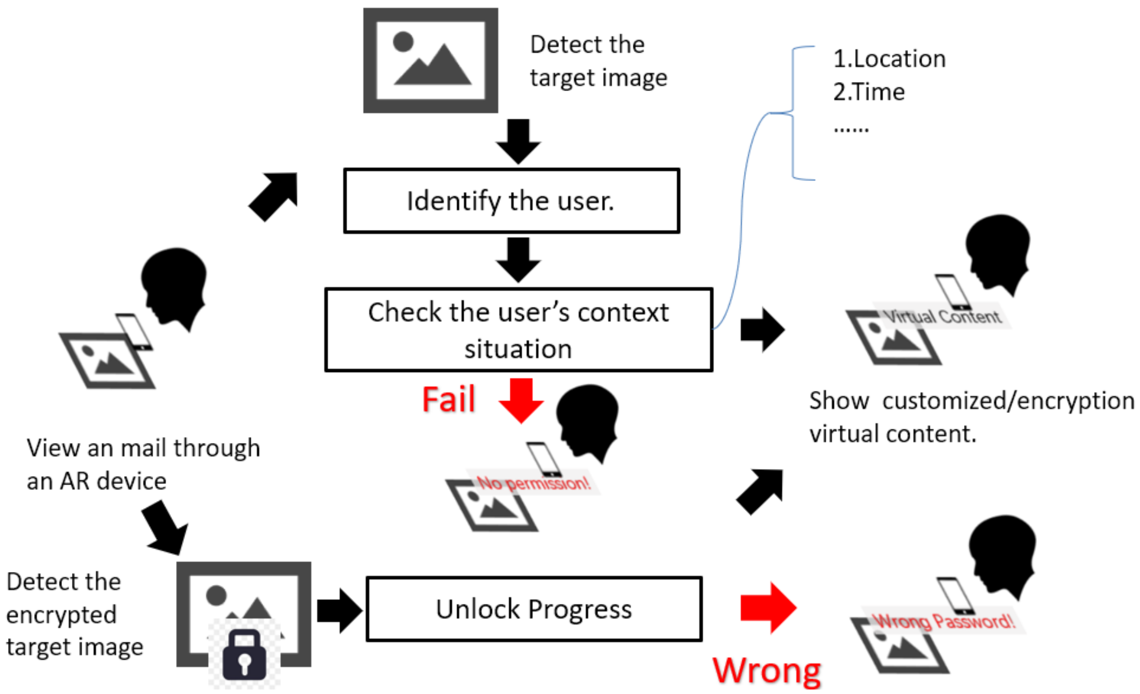


Fig. 1.1 Overview of the target system

In this research, we have realized a customized and secure augmented reality system. In practice, the system will be more complex. So, we have imagined several potential applications. Such as AR game, AR mail and so on. We have also implemented a simple AR-game. We hope that these potential applications will show the effect and meaning of the customized and secure augmented reality system.

Chapter 2

Research Background

2.1 Augmented Reality

Augmented reality (AR) is a field of computer science research that combines real world and digital data. In 1997, A researcher named Ronald T. Azuma has given precise description. In his survey, he has given three key characteristics[1]:

- Combines real and virtual content,
- Interactive in real time
- Registered in 3D.

Augmented reality overlay the 3D-virtual objects onto the real world. In the past researchers have explored the use of AR approaches to support face-to-face collaboration. Projects such as Studierstube [2], Transvision [3], and AR2 Hockey [4] allow users can see each other as well as 3D virtual objects in the space between them. Users can interact with the real world at the same time as the virtual images, bringing the benefits of VR interfaces into the real world and facilitating very natural collaboration.[5] In the research "Shared Space", the author shows that users collaborate better on a task in a face-to-face AR setting than for the same task in a fully immersive Virtual Environment [6]

A typical AR system includes a display and a motion tracker with associated software. The software reads the tracking events to know the position of the display and renders the virtual objects.[7] In order to render correctly, the virtual objects and the real world need to be registered. This registration implies that the geometry of the virtual camera where the augmentation takes place is known with respect to the real world.

Since the emergence of AR technology, it has been widely used in various fields. At least six classes of potential AR applications have been explored: medical visualization, maintenance and repair, annotation, robot path planning, entertainment, and military aircraft navigation and targeting.

At present, augmented reality hardware includes processors, displays, sensors, and input devices. The latest mobile computing devices, such as smartphones and tablets, containing cameras and MEMS sensors that includes accelerometers, GPS, solid state compasses and others, are the appropriate augmented reality platforms[8].

A head-mounted display (HMD) is a display device connected to the forehead, such as a harness or a helmet. HMD places images of the physical world and virtual objects in the user's view. Modern HMDs typically use sensors for six degrees of freedom monitoring, allowing the system to align the virtual world with the physical world and adjust based on the movement of the user's head[9].

Fig. 2.1 HMD-Microsoft HoloLens

In the aspect of the software of the augmented reality field, an important indicator of the AR system is how to truly integrate enhancement with the real world. Software must obtain real-world coordinates that are independent of the camera from the camera image. This process is called image registration and uses various computer vision methods related to video vision[10]. Many computer vision methods of augmented reality are inherited from visual odometry. Usually, these methods consist of two parts. The first step is to detect interest points, fiducial marks, or optical streams in the camera image. This step can use feature detection methods such as corner detection, spot detection, edge detection or thresholding, and other image processing methods[11]. To enable rapid development of augmented reality applications, some software development kits (SDKs) have emerged. AR SDKs are offered by Vuforia, ARToolKit, Catchoom CraftAR Mobinett AR,Wikitude, Blippar Layar, Meta and ARLab.

(a) Vuforia (b) ARToolkit (c) Blippar

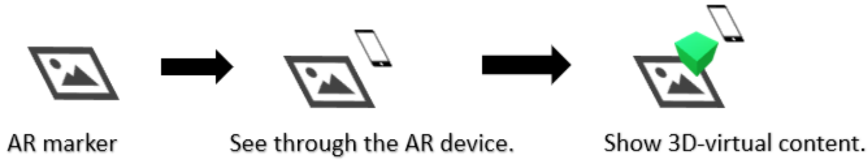
Fig. 2.2 AR SDKs

2.1.1 Marker-based Augmented Reality System

In Augmented Reality, the digital world is anchored to the real world. to add an 3D-virtual content into the realworld, we need to know that the user is pointing the camera at that particular envorniment. This can be achieved by placing a distinctive picture or shape. That picture will be recognised and the 3D display can start immediately, tracked to the appropriate place in the realworld. The user can also move the physical picture around and see the virtual world “stick” to the real surface. We call the distinctive picture that can be recognised by the device, the AR marker. [12]

AR markers are widely used in the existing AR systems. For example, ArToolKit, Auto-assembly, Outdoor tracking, CyliCon, ArLoc, and CyberCode all use visual marker based systems for motion tracking and pose estimation.[13]

Even though marker-less or feature based tracking have already been popular in recent years, AR visual markers will still be used in lots of AR applications for the forseeable future.



(a) System flow

(b) A 3D-virtual model with his AR marker

Fig. 2.3 Marker-based AR system

Maker-based AR system has been used in lots of applications. On application is used to enrich printed media. Esquire magazine published an augmented reality issue in December 2009, Süddeutche Zeitung released their first issue with AR content in August 2010 . In Esquire's case, users were able to see AR content when they showed the magazine to a PC webcam. In the case of Süddeutche Zeitung(Fig.2.4), users could see the content with a mobile phone after downloading the application. In Finland, Katso and TVSeiska magazines used AR in cooperation with VTT in advertising a new animated children series called Dibitassut in April 2010. Brazilian newspaper O estado de Sao Paulo has featured regular AR content since 2009. [14]

Unified AR is a business AR application. It can add 3D-virtual content on the carrier in reality. Such as Business Cards, Flyers, brochures, Magazines, publications, Showroom, window display cards and so on. It treats some certain images on these reality carriers as AR

(a) (b)

Fig. 2.4 Süddeutche Zeitung: An example of augmented reality in magazines and newspapers.

markers. Then these kinds of books or cards will be augmented easily - Just add the target 3D-virtual content on those markers.

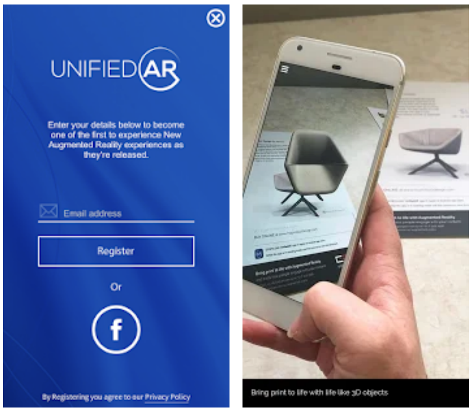


Fig. 2.5 Unified AR

Marker-based AR system can also be used in AR games. Fig.2.6 shows one example of a mobile AR game, AR Defender , which works on iPhone and Samsung platforms, for example. It uses markers for camera registration. [14]

(a) (b)

Fig. 2.6 Example of Mobile augmented reality game:AR Defender, which uses markers for pose tracking

Chapter 3

Goal and Approach

3.1 Goal

The goal of this research is to explore the customized and secure AR (augmented reality) system. According to the different situation of the observers, system will display different 3D-virtual content. On the other hand, we want to test different methods to encrypt and unlock the AR information. Finally, we will discuss the possibility of using this system for various potential applications.

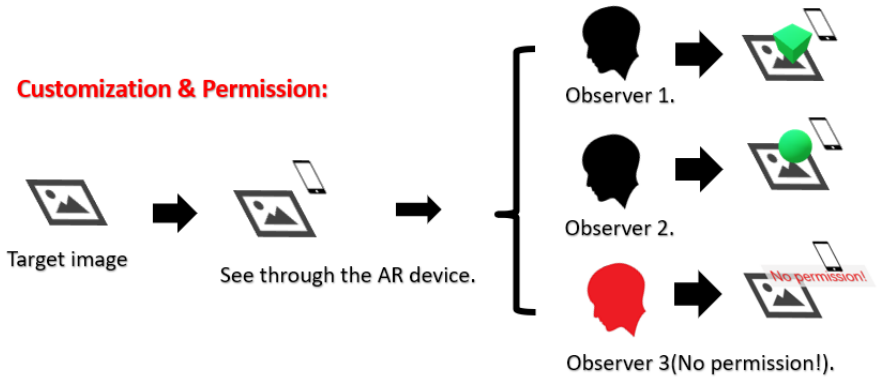
The main function of this system is:

1. Display customized 3D-virtual content according to the observer's situation. (Including identity and context situation.)

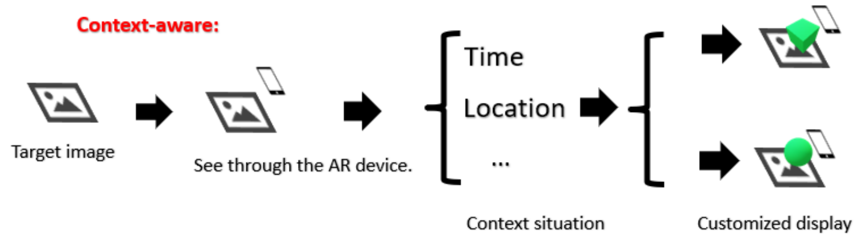
2. Encrypt the 3D-virtual content and unlock with several methods.

3.2 Approach

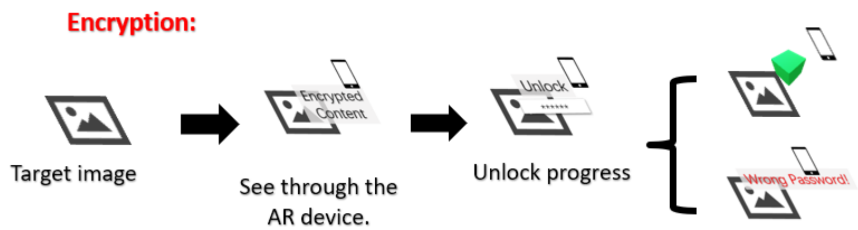
We have proposed an marker-based AR(Augmented Reality) system. Differ from the tradditional AR system, the new system will detect user's identity and his context-situation, then generate customized 3D-virtual content to different observers(or an observer in different context-situation). In encryption test part, the system will detect whether the 3D-virtual content has been encrypted and how to unlock it. An user interface of nnter password or face recognition will pop-up.



(a) User identification(Customization)



(b) Context-aware(Customization)



(c) Encryption

Fig. 3.1 Approach Overview

To show the meaning and effect of the system, we have a discussion of the potential applications in this research. We use the new system to upgrade the old AR system applications. Or design new user scenarios. Among them, we will introduce the effect of the new system in the AR-game. Compare to the AR-Defender (A mobile AR game have been introduced in chapter2), the new AR game will allow the different user see different 3D-virtual objects in their view. System also allow the plays to open some treasure box by some unlock methods. These new features add interest to AR games and increase the possibility of AR gameplay design. In addition to AR game, we also briefly introduce some other applications, such as AR mail, AR payment and so on.

Chapter 4

System Design

4.1 System Overview

The system is mainly composed of two parts. Customized 3D-virtual content generation section and information encryption section. For customization part, in addition to the camera input, the new marker-based AR (augmented reality) system will also get the data from the user-database and device sensors. These data will provide the system the observer's identity, permission, location and the system time. According to these user identification information and context information, the system finally displays different customized information.

For encryption part, we use database to support the lock and unlock progress. The database will record whether the 3D-virtual content has been encrypted and what's its password. User's input will also be recorded. If he input wrong password 3 times, he needs to wait an hour to input again. If we use the face-recognition to unlock the encrypted 3D-virtual content, the password will change to the face-ID.

Through this system, we can improve or design several potential applications. For AR (augmented reality) board game, players will have different game view. Such as, show different virtual monster-models on one creature-card or even the creature is totally unknown for some players. We can also design some treasure-box card. Player needs to input the correct password to unlock it and get some rewards. The new system can also be used to protect some private information. An obvious example is the AR (augmented reality) mail.

The main content of the AR mail can be changed to the 3D-virtual content and set permission. Only the receiver can acquire the hidden content. This way, even if the paper letter is lost, its contents will not be revealed. Customized AR (augmented reality) call-board (Or poster board for advertisements) will take care of the different needs of different observers and show more suitable 3D virtual information.

4.2 System Structure

4.2.1 For Customized Display

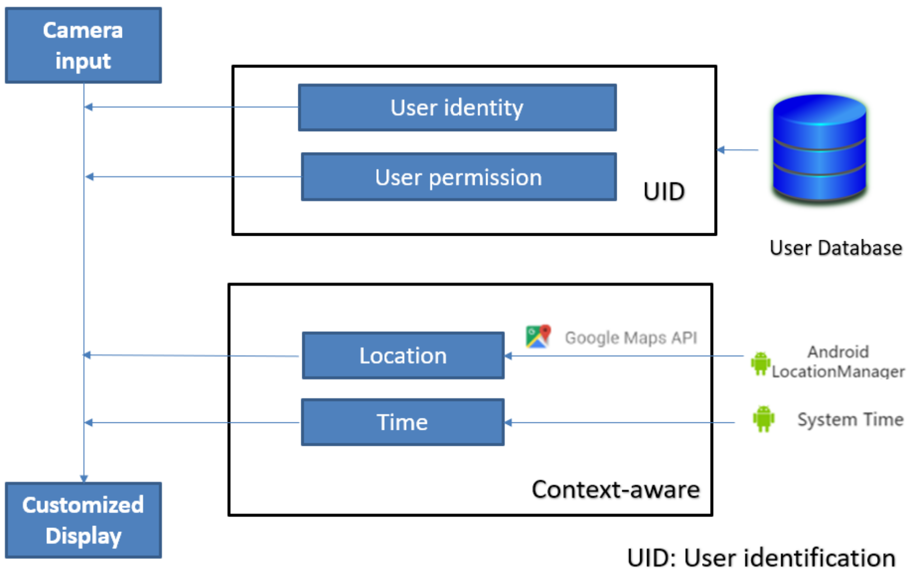


Fig. 4.1 System structure diagram for customized display

Figure 4.1 shows the structure diagram of the proposed system of the customized display part. Compare to the traditional AR (augmented reality)system, the target system also get the support of the user database and devise sensors. We record the user's identity and there permission in the user database. When the observer request to display the 3D virtual content. The user database will tell the system who is the observer and whether he has the permission to get the information. The Android LocationManager will tell the system the observer's longitude and latitude. The Google Maps API will transfer this GPS data to the location data. Then the system can judge which 3D-virtual content should be displayed here. Same thing with the time. The time data is obtained from system time. It is also one of the key elements to change the display content.

4.2.2 For Encryption

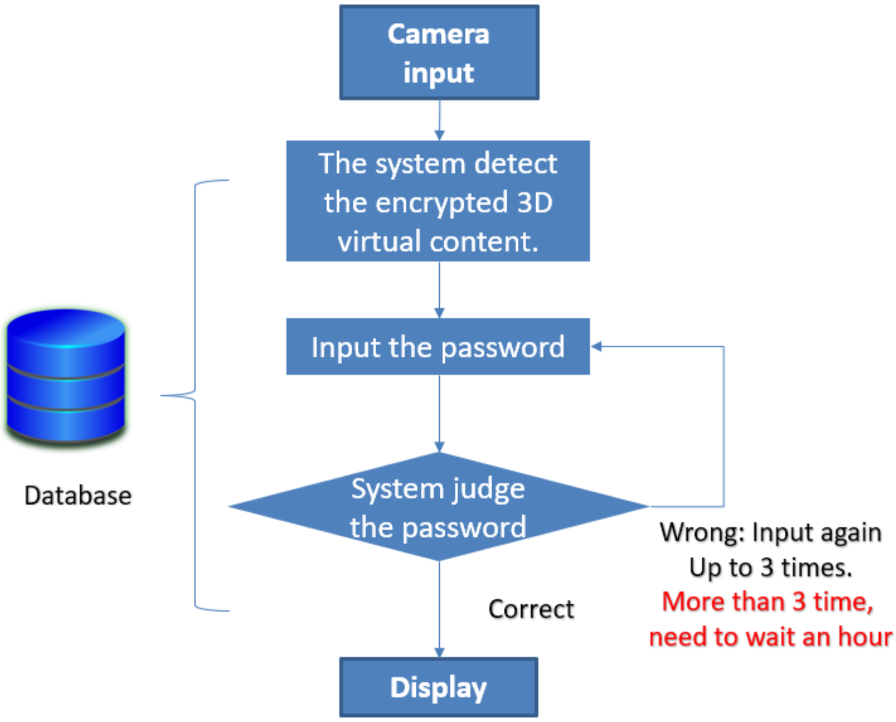


Fig. 4.2 System structure diagram for encryption section

Figure 4.2 shows the structure diagram of the proposed system of the encryption part. When system detect the encrypted 3D virtual content, it will check the database to search the target password (maybe the face-ID or something in other unlock method.). At the meantime, an UI (User database.) will pop-up to let the user input password. After the password has been submitted, the system will check if the password is correct. System record every user's input. It allows wrong input for 3 times. If the user input wrong password more than 3 times, he need to wait for an hour to input again.

4.3 Customized 3D Virtual-content Display

4.3.1 Usage Scenario

We have designed a simple usage scenario to show the system effect. We set several AR- markers in HiBiKiNo area and display customized 3D-virtual call-board according to the user's identification or context situation.

(a) AR Marker

(b) Usage-Location(HiBiKiNo)

Fig. 4.3 We set the AR Marker in HiBiKiNo area. IPS Office Restaurant and Sakura House

We designed following usage scenarios. Different usage scenarios show customized content based on different conditions.

- At IPS Office: UserA and UserB see the different information on the 3D virtual call-board with same AR marker. System detect their different identity and show the corresponding 3D virtual content. [Identity]
- At Sakura House: Only the resident of Sakura House has the permission to see the 3D virtual content on the AR Call-Board. System will check the user's permission before the display. UserA is not the Resident of the Sakura House, so he can just see the error notification "No Permission!". On the other hand, as the resident of the Sakura House, User can see the information on the 3D virtual call-board to tell him remove his old furniture. [Permission]
- At different location(IPS Office, Restaurant and Sakura House), users see different 3D-virtual call-board. [Location]
- At Restaurant: UserA see different AR 3D virtual menu at lunch time or dinner time. At other time, it will shows that "The restaurant is closed." [Time]

4.3.2 Customized Display Based on the User Identity

The identity of the user is an important condition for the customized AR display. The system to display different 3D virtual content for users with different identities is one of the core of customized Augmented Reality. In this research, we have set an AR marker at IPS Office. The fictitious UserA and UserB will receive different information on the 3D-virtual Call-board activated by this AR marker.Because that different user observer the AR marker pasted on the wall of IPS Office, the system will detect the user's identity first. Different user identities determine the ultimately display content. The virtual content and user scenarios just like the following table and diagram.

Table 4.1 The 3D-virtual content on the Call-board at IPS Office

Content Title	Fictitious Receiver	Content
Scheduled time for physical examination	UserA	2019/4/18 14:30 15:00
Scheduled time for physical examination	UserB	2019/4/19 15:30 16:00
Result of the intermedium presentation	UserA	Passed
Result of the intermedium presentation	UserB	Failed

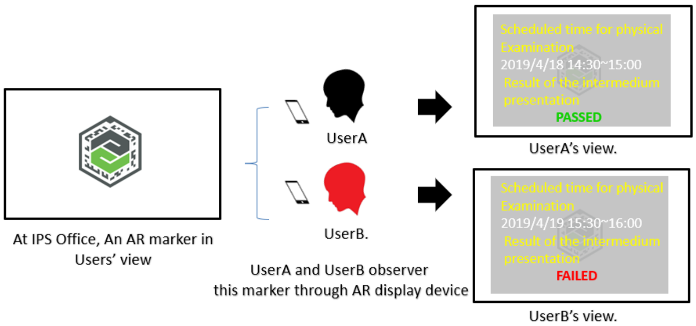


Fig. 4.4 Customized display based on user identit

4.3.3 Permission Check

User permissions are another manifestation of user identity. Permission checks prevent the system from displaying virtual information to all users. In the usage scenario of this research, the 3D virtual Call-Board at Sakura House shows the permission check function of the system. In the pre-set, UserA is not a resident of Sakura House, so he has no permission to make the hidden 3D-virtual Call-Board display. Instead, the system will give her a "No Permission!" message. In the other hand, the fictitious UserB is the resident of the Sakura House in the pre-set. So, he can see the notification from the system about the dealing with old furniture.

Table 4.2 The 3D-virtual content on the Call-board at Sakura House

Fictitious Receiver	Content
UserA	No Permission!
UserB	Notification For Sakura House Residents, the abandoned furniture will be cleared on September 10th!

4.3.4 Location

Location is one of the most important factors the for customized display. After the system scan an AR marker, the system will detect the location of the observer through the data form the GPS sensor of the AR display device. In the usage scenario, the system will detect whether the location is IPS Office, Restaurant or Sakura House, then display the 3D virtual Call-board for the corresponding location. At IPS Office, the 3D virtual Call-board will be some announcements about students' study and life. At Restaurant, it will be the menu at that time (Lunch, Dinner or just show the Restaurant is closed.). At Sakura House, the resident will get some notification from the dormitory management center.

The new system uses the device's GPS data to locate the observer. As opposed to putting different markers at different location, we just need a same AR marker. Although in this research's usage scenario, there are just three locations (IPS Office, Restaurant and Sakura House). In the real scenario, there may be thousands of locations. For example, if we want to set customized 3D virtual Call-Board at each 7-11 convenience store. For traditional AR systems, that needs thousands of AR markers. But for the new system, it just needs one.

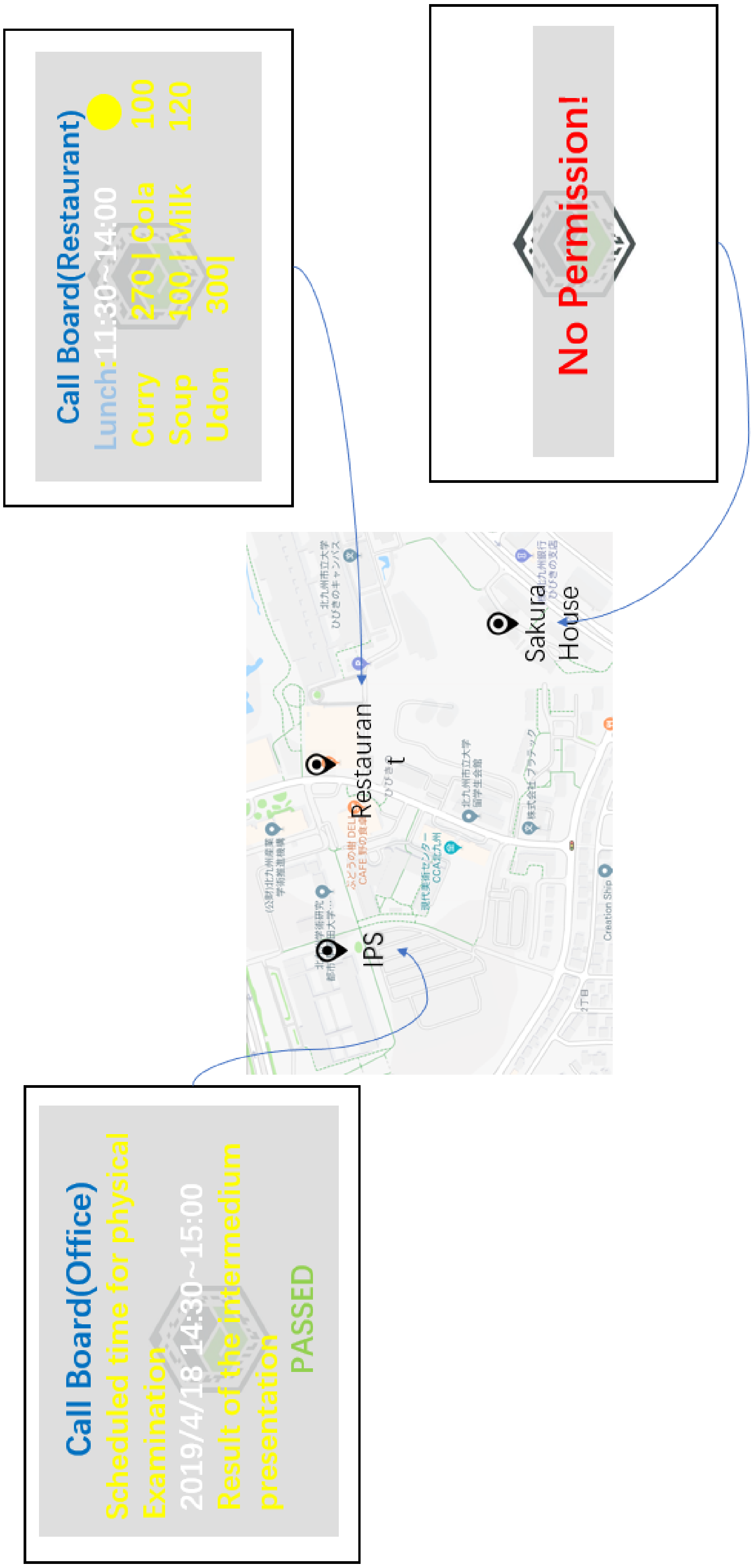


Fig. 4.5 Customized display based on user location(UserA's view)

4.3.5 Time

Another function of the system is that to display customized 3D virtual content according to the time when the user observes the AR marker. In some real situation, users may want to acquire different information at different times. The example in the usage scenario is that at the restaurant the user sees different 3D virtual menu at the lunch time (11:30 14:00) and dinner time (16:30 19:00) or a notification "Closed" at other time.

Table 4.3 The period of time

	Time period
Lunch time	11:30 14:00
Dinner time	16:30 19:00
Other time	0:00 11:30; 14:00 16:30; 19:00 24:00

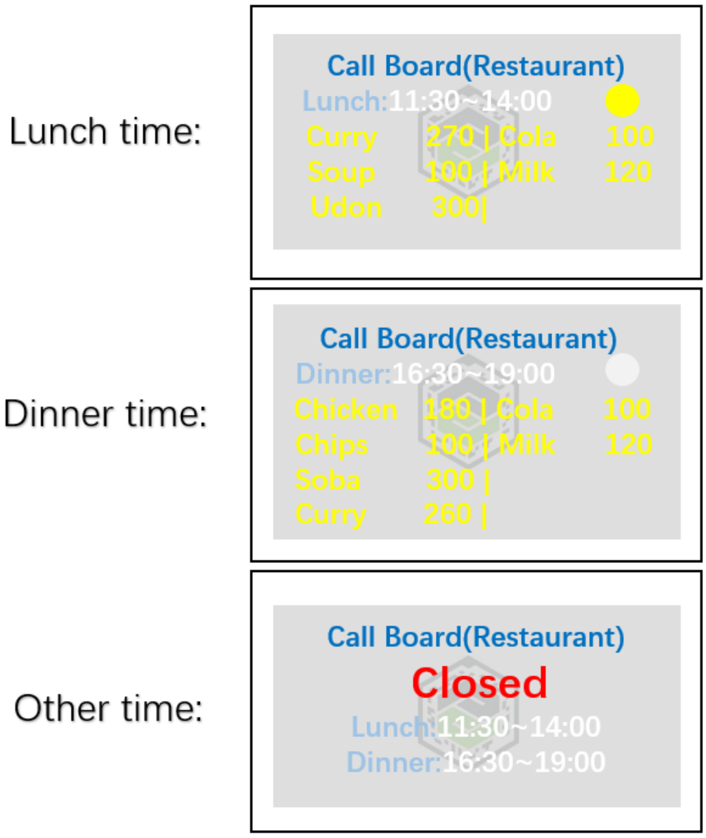


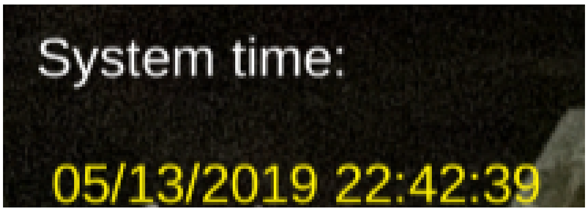
Fig. 4.6 Customized display based on the time

4.3.6 System Interface Function

In order to show the effect of the system, we add some information on the user interface of the test application, which shows the current user's identity, time, and location.

(a) User identity

(b) Location



(c) System time

(d) Virtual content name

Fig. 4.7 User identiy, location, time and the virtual content name will be displayed on interface of the test application

4.4 Encryption 3D-virtual Content

Another important part of this research is the encryption. Encryption and permission are two methods of the secure AR(Augmented Reality). Sometime the providers of 3D virtual content do not want all the users to see the hidden information. In the example of the section 4.3.3, the principal doesn't want the user who is not the resident of Sakura house acquire the information on the 3D-virtual Call-Board. So, he set permissions. But, when we set up 3D virtual content, we may not know which people can access the 3D virtual content and which people can't. At that time, setting a password becomes a good idea. We can share our passwords anytime, anywhere and let others gain the access to the content which we have set up before.

4.4.1 Encryption Content Detection

Before the user unlocks the encrypted content, the system should recognize it as encrypted content first. When the system detects AR Markers in the user's field of view, the system automatically retrieves the 3D virtual content, and it will seek the database to confirm that whether the 3D virtual content has been encrypted and how to unlock it. In this research, we use password. So, the system will check that whether the target 3D virtual content has been set password and what is the correct password.

4.4.2 Password Input

After the system detect the encrypted 3D virtual content, a interface will pop-up to let the user input his password (Showing in the Fig4.8). Each input will be recorded by the system database. System will match the user's input with the correct password which is recorded in the database.

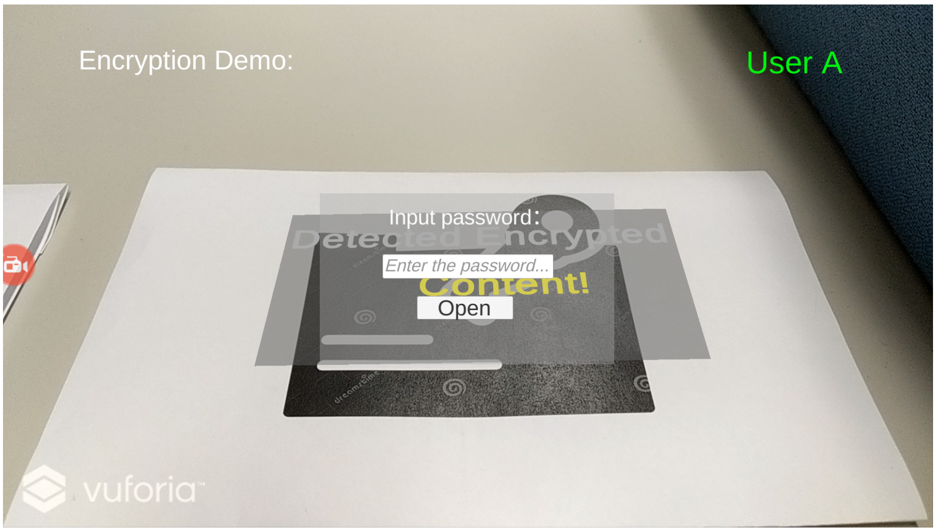


Fig. 4.8 The interface for the user to input password.

4.4.3 Wrong Input

In the real world, we can't avoid the situation that sometimes the user input wrong password. The system records the user's every input, results(enter the correct password or not) and time(when the user input the password.). The system allows the user to enter the wrong password three times. However, when the user enter the wrong password the thrid time, he will be forbidden by the system to enter password again until one hour after the last input time recorded by the system.

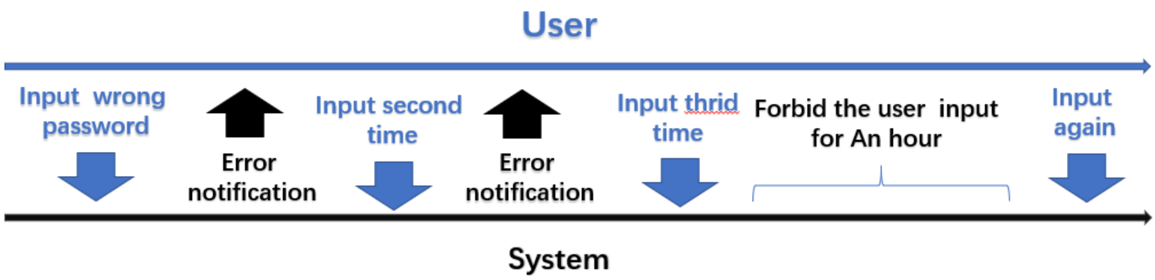


Fig. 4.9 System response for wrong input.

4.4.4 Other Potential Unlock Methods

Except password input, we also have many other ways to unlock the encrypted 3D virtual content. Such as face recognition, voice recognition and so on. But for face recognition or voice recognition, it is hard for the users to share their faces or voices. On top of that, voice recognition even has some secure issue. Because the human voice will spread in the environment, when the user uses his voice to unlock the encrypted content, it is easy to be acquired by others. Through the other method may have some defects, we still want to discuss them as a potential possibility. The Fig4.10 is our assumption system for the face recognition to unlock the 3D virtual content.

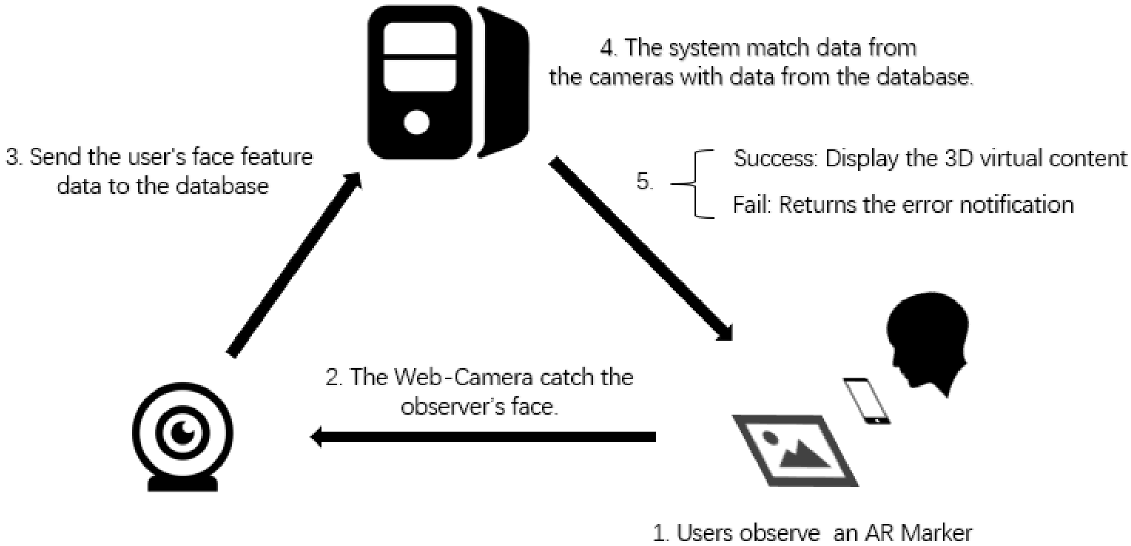


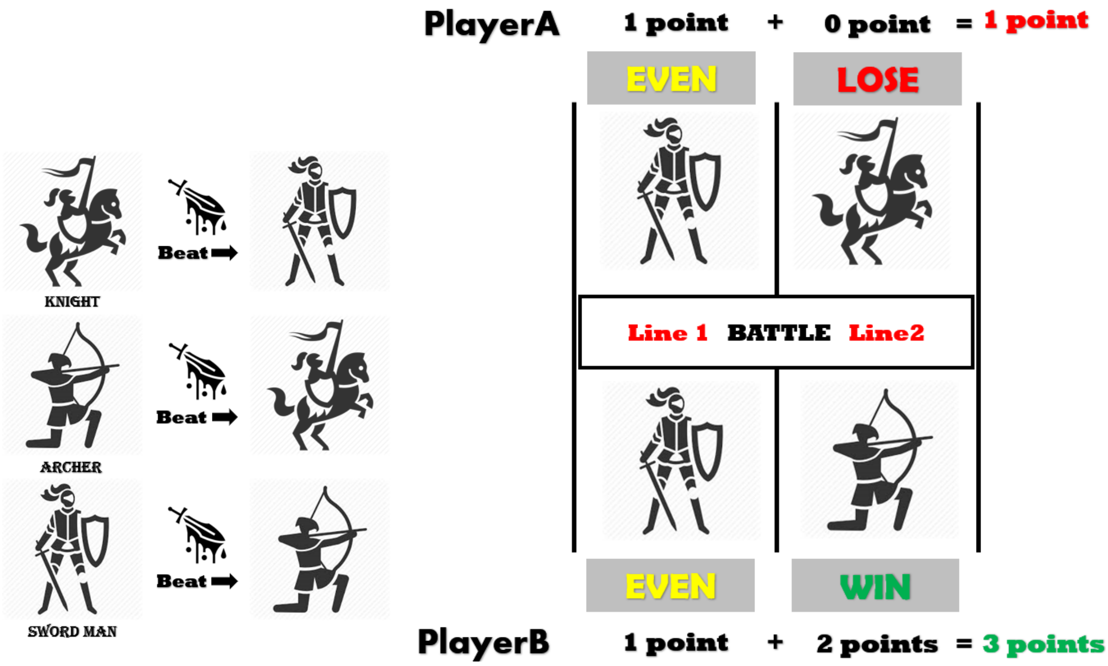
Fig. 4.10 Assumption system for the face recognition

4.5 System for Potential Applications

In this research, we also have discussed potential applications to show the effect of our system. Such as the use in AR game, AR mail, AR Call-Board and so on. We have designed a simple system for the AR game. The main function is to provide different game perspectives (Both sides see different 3D models and 3D information.) to different players and the treasure box function.

- Different game perspectives: We designed a battle board game. Players can place their creatures on the board. But from another player's point of view, the creatures are totally unknown. There are three kids of creatures: archor, swordman and knight. The restraint relationship is: archor will kill the knight; swordman wil kill the archor; knight will kill the swordman. There are two battle lines. Until the results are announced, neither player knows what creature the other has placed. The winner on each line will get 2 points, the loser will get 0 point and if the result is deuce, each player gets 1 point. The player whose point is higher will win the game.(See the Fig.4.11)

- Treasure Box:We have designed a treasure box card. The system can detect this card and show a 3D virtual treasure-box. Users can use password to unlock it and get some rewards (In this research, we set the reward is 10 coins.).



(a) Restraint relationship (b) AR battle game

Fig. 4.11 AR game schematic diagram

Chapter 5

System Implementation

5.1 Development Environment

We established the system and built the 3D module on Unity 2018 and use the C sharp as the development language. We use Vuforia-Unity SDK to detect the AR-marker and add 3D virtual content in the user's view. MySQL is used as database for data storage. PHP is used to implement the communication between the application and the server. On the user's mobile phone, we use android programming environment to establish an application for system test.The development environment used in our research is shown in the following table.

Table 5.1 Development Environment

Programming Tool	Programming Language	Purpose
Unity3D(2018)	CSharp	System Establishment; Modeling
Android SDK	Java	Front-end building on mobile phone
MySQL	SQL	Data storage
Vuforia		AR-marker detection; 3D module display

5.2 System Hardware

We have used the Google Pixel 2 as the AR display device . Google Pixel 2 is an Android smartphone with excellent camera and all the needed context-aware sensor. A PC with the windows opreation system provides a platform for the server setting-up.

(a) Google Pixel 2

(b) Personal computer with windos opreation system.

Fig. 5.1 System hardware

5.3 System Diagram

In this research, the system has two parts. One is for the customized display and the other is for the encryption.

For the customized display, the system need to acquire the user's identity (permission) and their context situation data(location and time.). The user-database will provide the user identity data which has recorded in advance. The time data will get from the Android system time of the smart mobile phone and the location data will be acquired from the GPS sensor. The server will combine all the acquired data and ultimately decide what 3D virtual content will be displayed the user.

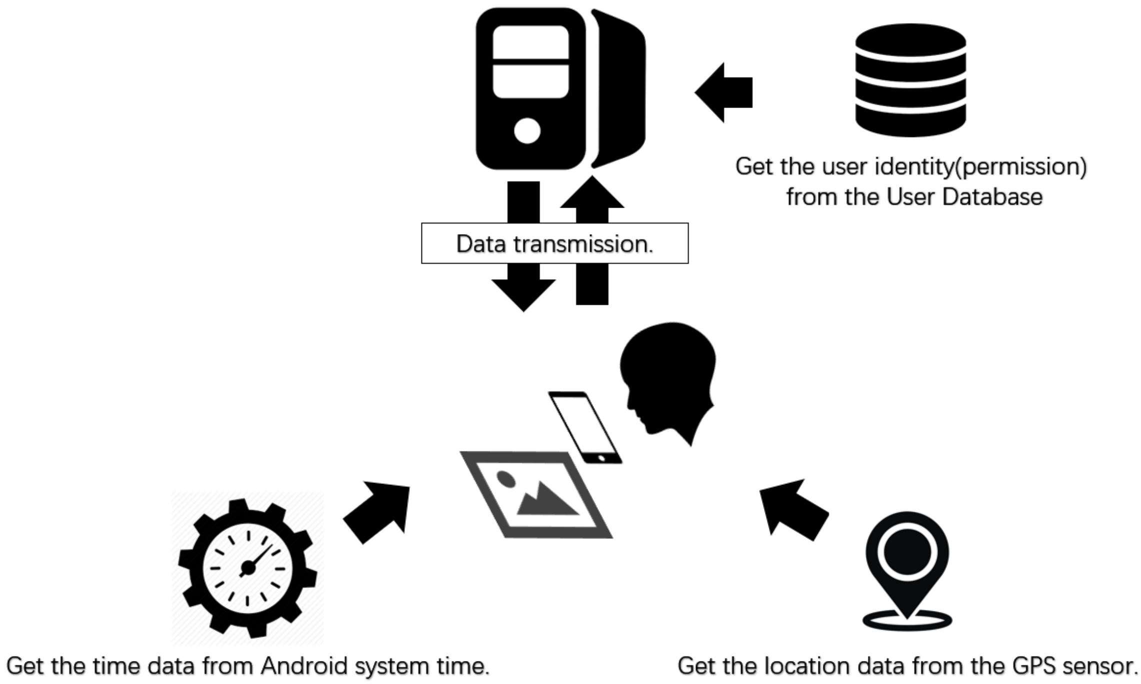


Fig. 5.2 System of customization

For the encryption part, the system gets the main support from the database. When an encryption content has been detected (The camera catches an AR-marker. The system accesses the database and finds that the content has been encrypted.), the system will ask the user to input a password and match the input password with the correct password which has been record in the database before. The system will record the user's input through the database and allow the user input wrong password for 3 times. When the user inputs wrong password at the thrid time, he will be forbidden to enter a password for an hour according to the current system time.

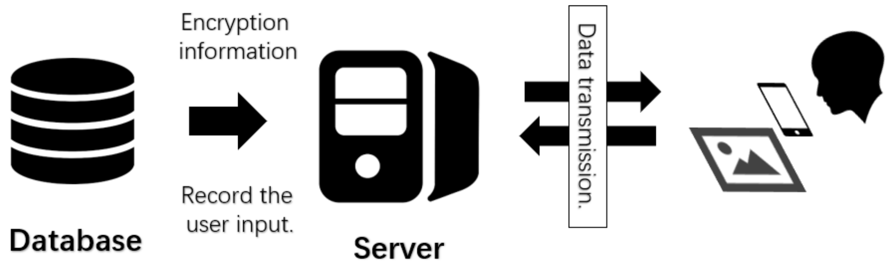


Fig. 5.3 System of encryption

5.4 Database

The database plays a very important role in this research. We have used the MySQL database and the MySQL Workbench as the visual programming software (see Fig 5.4). We have created 3 tables: user table, encrypted content table and input table.(see Fig 5.5) The user table record the users' information according to the user ID, user name and their permission. The encrypted content table and input table is for the encryption part. The encrypted content table record the encrypted content ID, name and the correct password. Input table record the user ID, input ID, input time, input result(1 for succeed, 2 for failed) and the number of wrong input times.

5.5 3D Virtual Content Modeling

In the demo, system will display these 3D virtual contents to the users. So, we need to creat those fictitious 3D virtual content in advance . We use Unity 3D to accomplish this part of work.(see Fig 5.6)

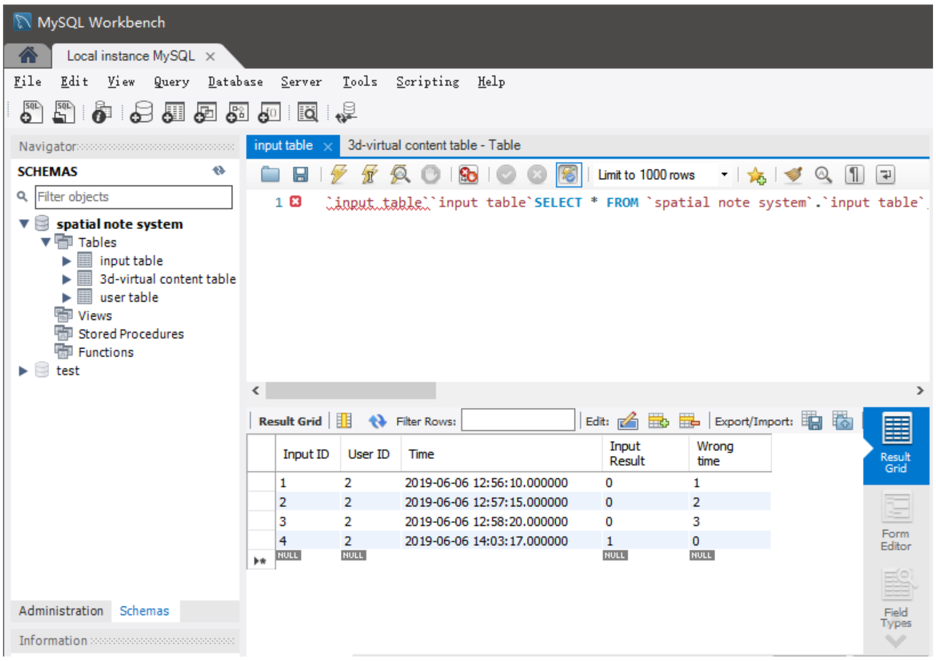


Fig. 5.4 MySQL database

User ID	User name	Permission
1	UserA	1,2
2	UserB	1,2,3

(a) user table

Virtual Content ID	Virtual Content name	Password.
1	test	123456

(b) encrypted content table

Input ID	User ID	Time	Input Result	Wrong time
1	2	2019-06-06 12:56:10.000000	0	1
2	2	2019-06-06 12:57:15.000000	0	2
3	2	2019-06-06 12:58:20.000000	0	3
4	2	2019-06-06 14:03:17.000000	1	0

(c) input table

Fig. 5.5 Database tables

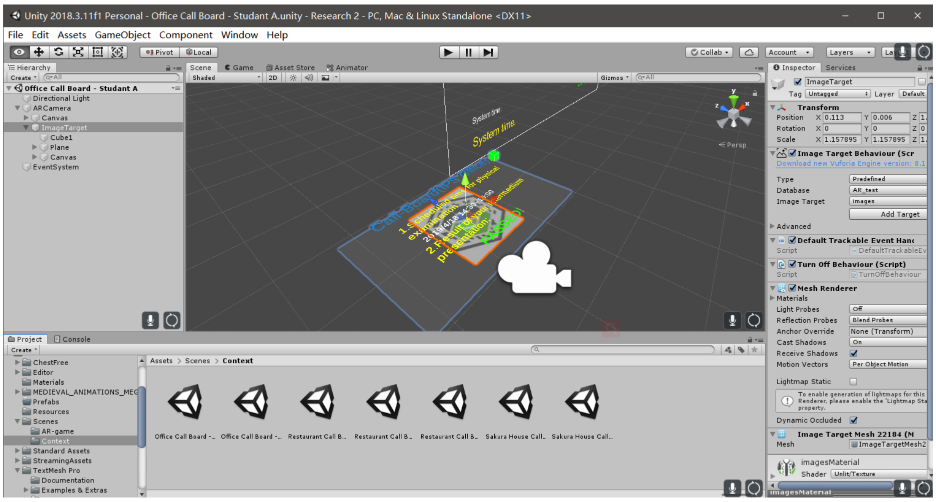
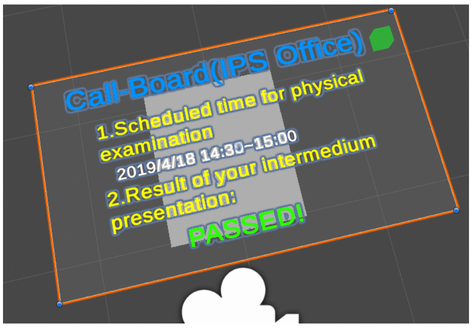
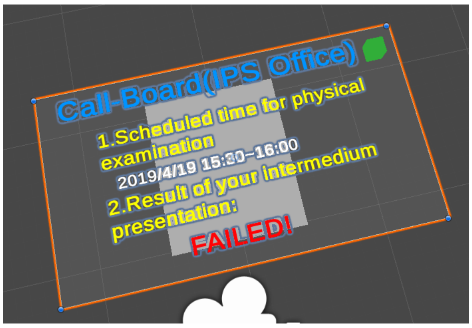


Fig. 5.6 Unity 3D

In the customized virtual content display part, we have created several 3D virtual Call-Boards. The system will display these different 3D virtual Call-Boards according to the user's identity, permission, location and time.

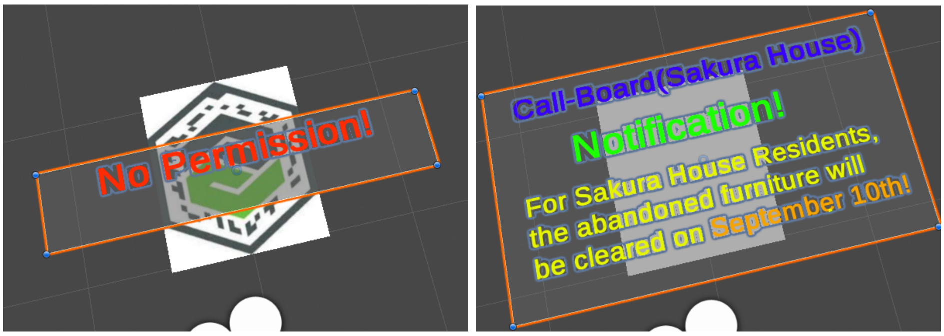


(a) 3D virtual Call-Board(Office) for UserA



(b) 3D virtual Call-Board(Office) for UserB

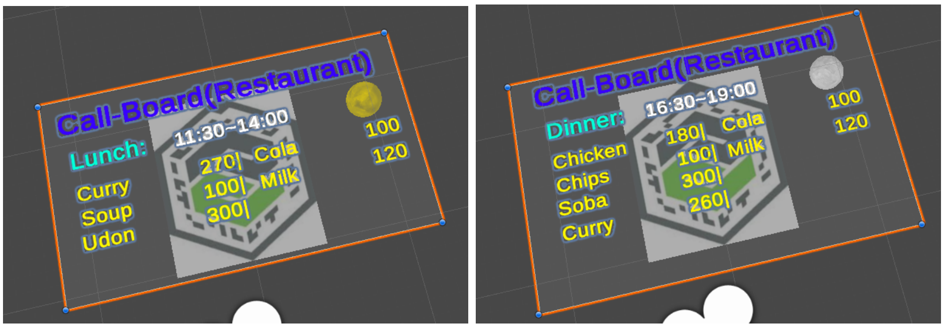
Fig. 5.7 3D virtual Call board to UserA and UserB at IPS Office



(a) 3D virtual Call-Board(Sakura House) for UserA: No permission

(b) 3D virtual Call-Board(Sakura House) for UserB

Fig. 5.8 3D virtual Call board to UserA and UserB at Sakura House



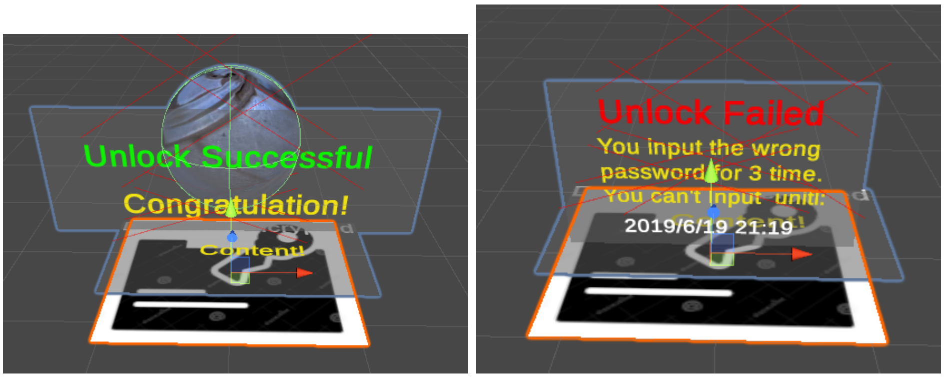
(a) 3D virtual Call-Board(Restaurant) at lunch time

(b) 3D virtual Call-Board(Restaurant) at dinner time

(c) 3D virtual Call-Board(Restaurant) at other time

Fig. 5.9 3D virtual Call board to UserA and UserB at Sakura House

In the encrypted content part, we set different 3D-virtual content as the results for unlocking successful and unlocking failed.



(a) Unlock Successful (b) Unlock Failed

Fig. 5.10 3D virtual content for encryption part

In the discussion about the potentail application, we created a simple AR game in Unity 3D. Users can add three kinds of virtual creatures: swordman, archer and kinight.

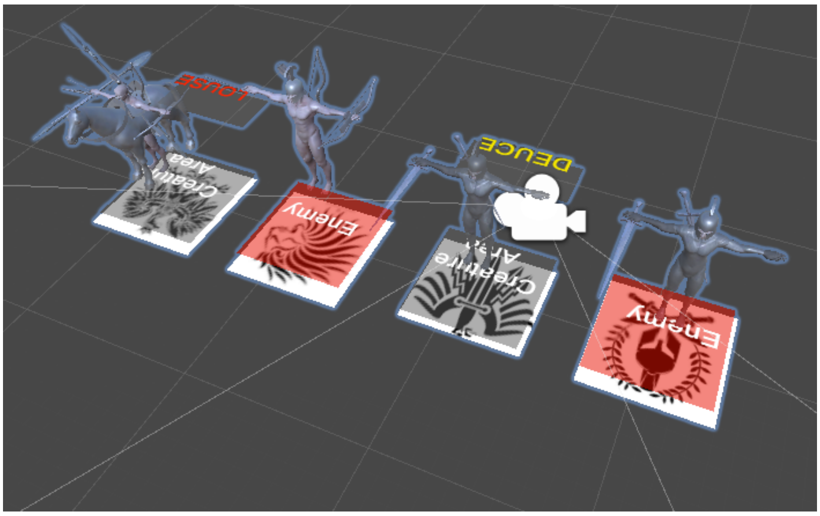
5.6 AR Marker Recognition

The system preset and identify AR markers in the user's view through Vuforia service. We apply for the license of Vuforia service on its official website. Then add the AR-markers in the Image Target database. Vuforia can help us to recognize those AR-markers in the user's view.(See Fig.5.12)

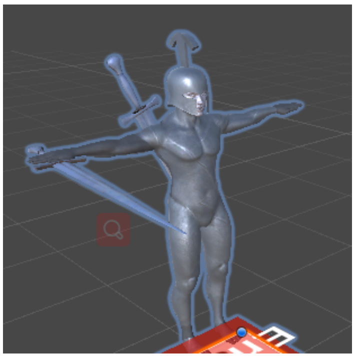
By packaging the Image Target database into the Unity 3D, we can use these AR markers in our project.

5.7 User Interfaces

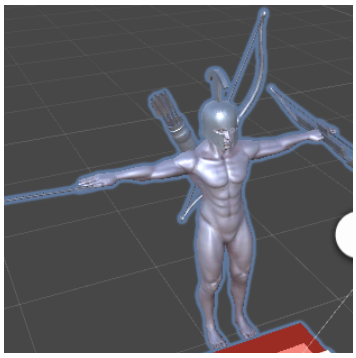
This section will show the final effect of the system. There are three parts: customized 3D-virtual content display part, encrytion part and the AR-game demo.



(a) AR-game sence



(b) Swordman



(c) Archer

(d) Knight

Fig. 5.11 AR game demo

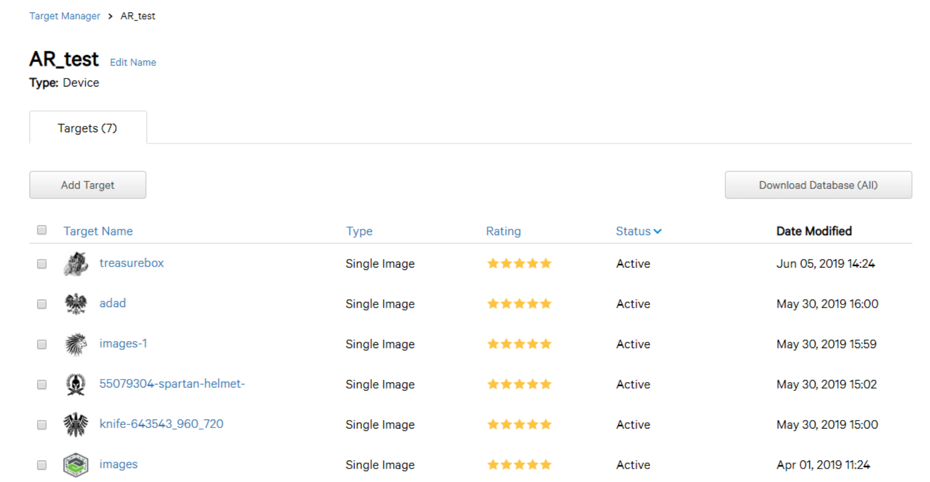


Fig. 5.12 Image Target database

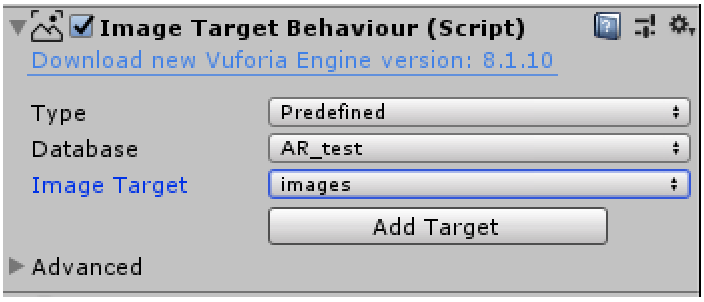
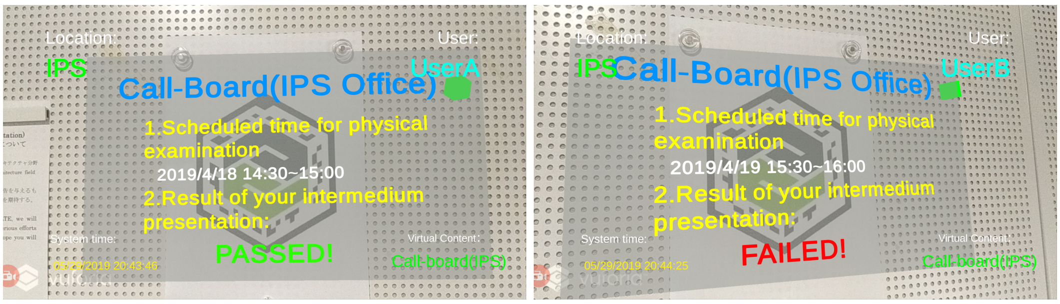


Fig. 5.13 Image Target setting in Unity 3D

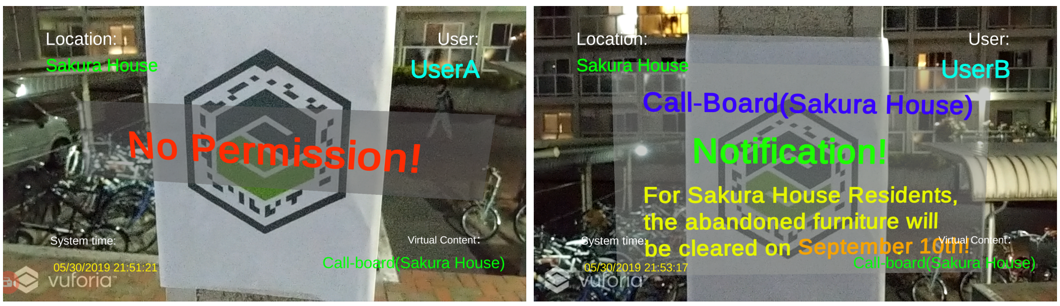
5.7.1 Customized 3D-virtual Content Display

According to the fictitious usage scenario, our system is designed to show the user customized 3D-virtual content based on their identity, permission, location and time. The final effect is shown in Fig.5.14; Fig.5.15; Fig.5.16.



(a) UserA'view(IPS Office) (b) UserB'view(IPS Office)

Fig. 5.14 Customized 3D virtual content display according to the user's identity.



(a) UserA'view(Sakura House)-No permission (b) UserB'view(Sakura House)

Fig. 5.15 Customized 3D virtual content display according to the user's permission.

(a) User'view at lunch time (Restaurant)

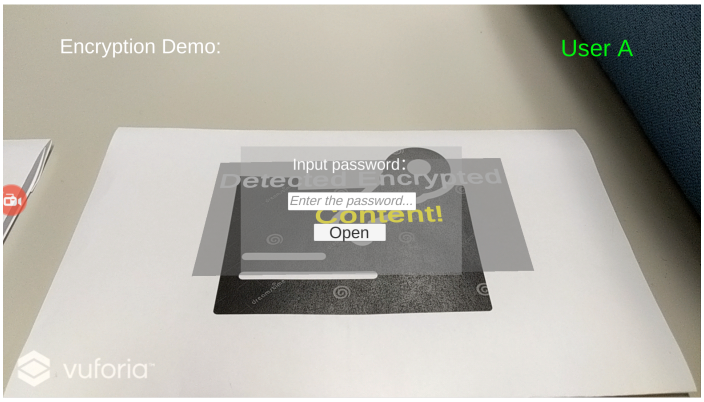
(b) User'view at dinner time (Restaurant)

(c) User'view at other time (Restaurant)

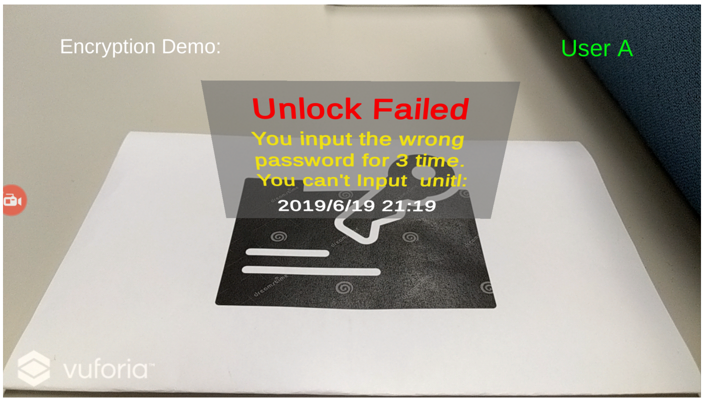
Fig. 5.16 Customized 3D virtual content display according to the time.

5.7.2 Encrypted 3D-virtual Content

When the system detect an encrypted 3D-virtual content, a user interface will pop-up to let the user input his password. If the user inputs wrong password for three times, he will be forbidden to input for an hour. See the Fig.5.18.



(a) Input interface



(b) Unclock successful

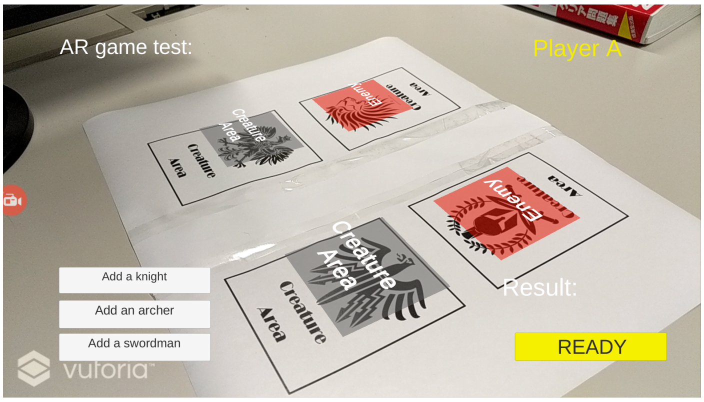
(c) Input wrong password for three times

Fig. 5.17 System effect for the encryption part

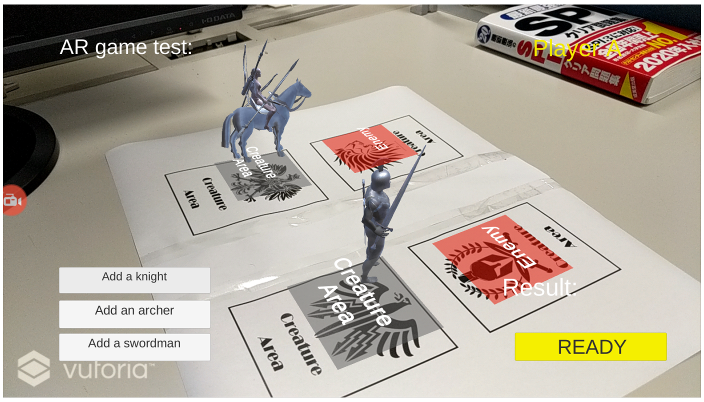
5.7.3 AR Game

In our discussion for the potentail applications, we have realized a simple AR game-demo and treasure box demo.

The user scan the real battle-board paper(with 4 AR markers) and the system will generate a 3D-virtual play board. Then the userA add two creatures, a swordman and a knight.



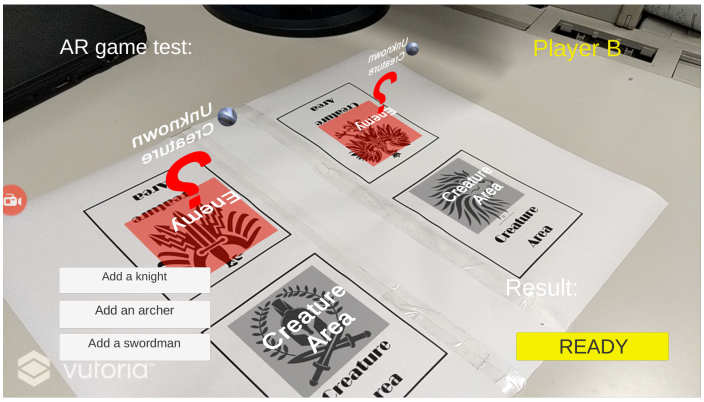
(a) 3D-virtual Battle-board generate



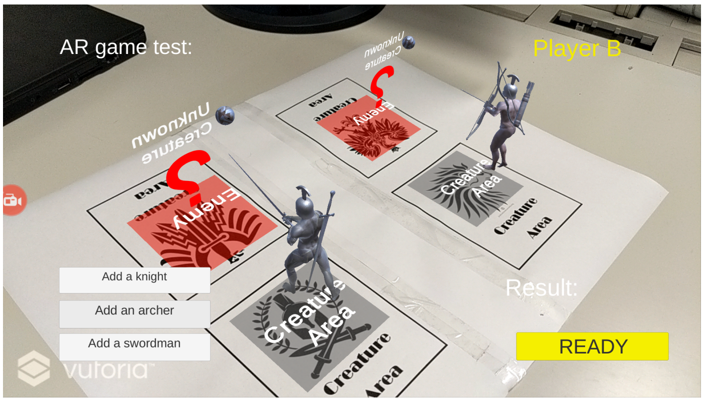
(b) UserA add a swordman and a knight

Fig. 5.18 AR Game-1

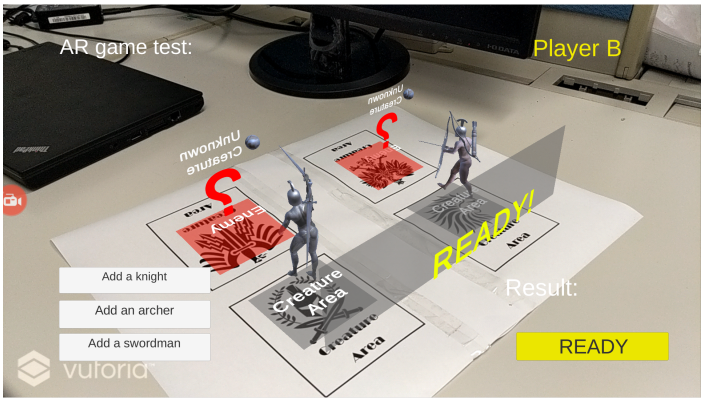
At the same time, the PlayerB will just see two "Unknown Creature"s. Then he add a swordman and an archer. Finally, he push the "Ready" button to make his situation to be "Ready".



(a) PlayerB see two "Unknown Creature"s



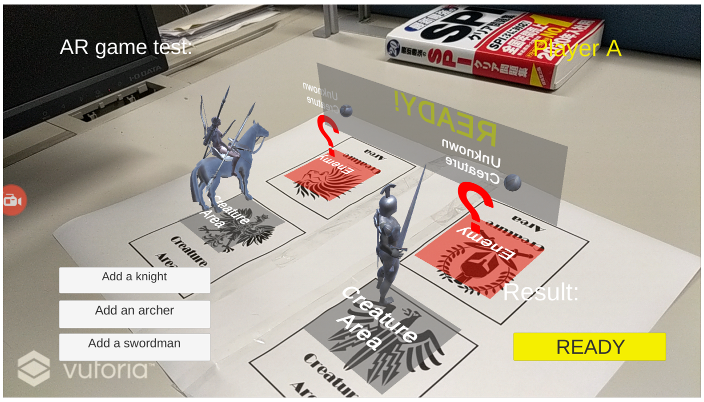
(b) PlayerB add a swordman and an archer



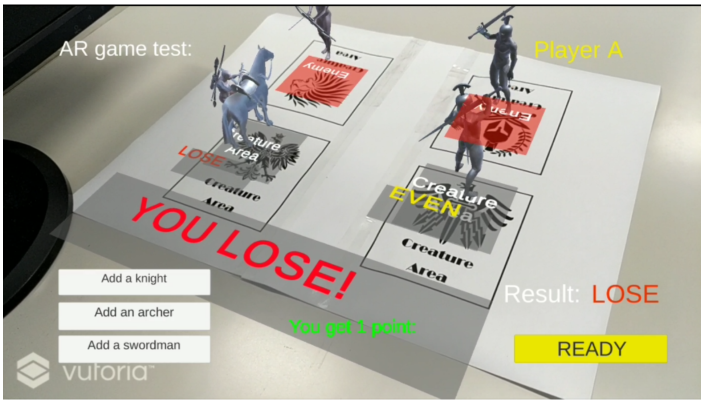
(c) PlayB push the "Ready" button

Fig. 5.19 AR Game-2

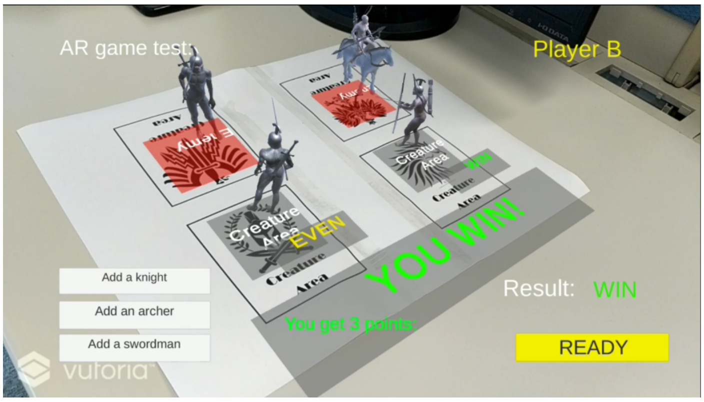
The Player will see that the PlayerB has put two "Unknown Creature" on the 3D virtual battle-Board and get ready. Then, he push the "Ready" button. Because the PlayerB's situation is "Ready". The system will show the result directly. At the same time, in the PlayerB's view, he will also see the game result.



(a) PlayerA see two "Unknown Creature"s and the "Ready" notification



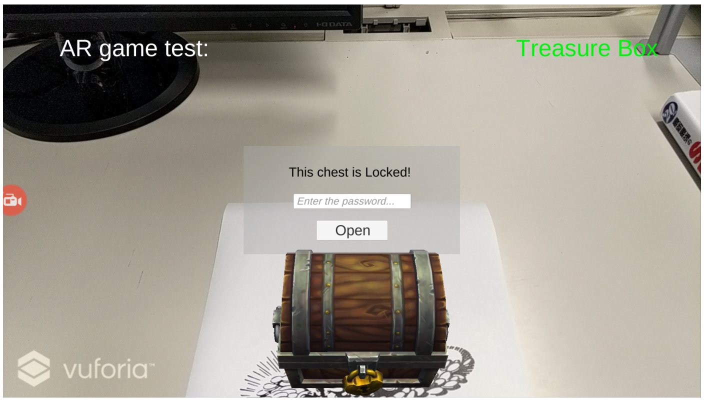
(b) PlayerA pushes the "Ready" button to see the result



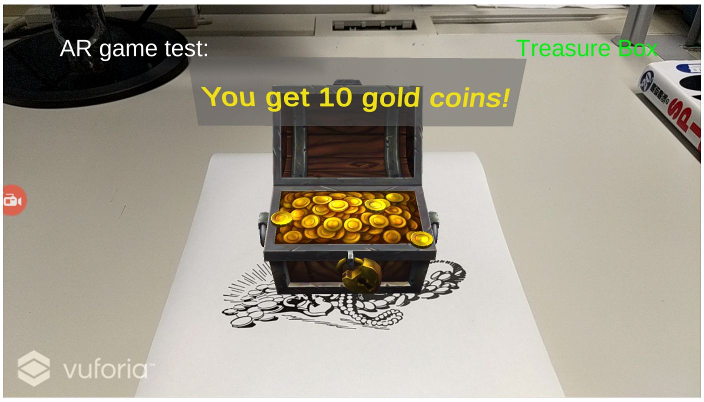
(c) Result in PlayerB's view

Fig. 5.20 AR Game-3

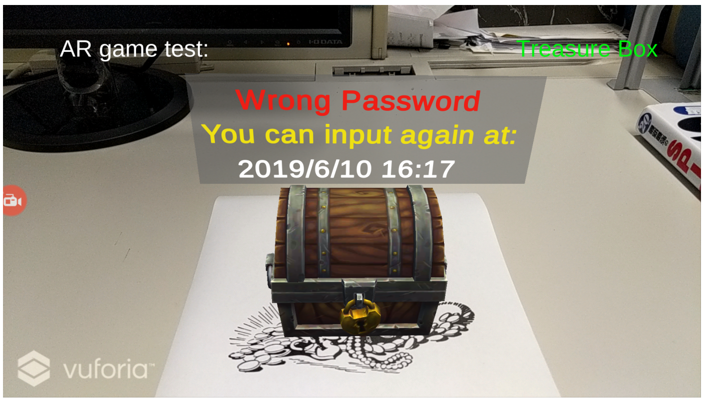
We also design a Treasure-Box card. Player can input password to unlock the 3D virtual Treasure-Box and get some reward(in that case, it is 10 gold coins.). If the Player inputs wrong passwords, he need to wait 10 minutes to input again.(See Fig.5.22)



(a) Input password



(b) Unlock Successful-Treasure Box



(c) Unlock Failed-Treasure Box

Fig. 5.21 Treasure-Box

Chapter 6

Related Work

Research on AR(augmented reality) has become increasingly popular in recent years. Augmented Reality adds the 3D virtual graphics which are agumented by the computer in the real world. The user can have the combination view with physical real environment and virtual elements. Marker-based AR system is a kind of traditional system. Marker technology is an enduring research theme in augmented reality (AR). [15] In various different researches, researchers have invented a variety of AR markers and used them for a variety of different functions.

An interesting example is the "Aero-Marker" which is described by the Hiroaki Tobita [16]: an augmented reality (AR) marker—Aero-Marker—that has both a virtual appearance and physical features. The Aero-Marker integrates a blimp with an AR marker to overcome two problems found in conventional AR applications. The first problem is mobility. While a conventional AR marker is generally paper-based and static, Aero-Marker floats in the air and moves toward the user, thereby changing the relationship between the user and the marker. The second problem is physicality. Unlike a paper-based marker, Aero-Marker has physical volume because it uses a physical blimp.

Jun Rekimoto[17] presents Cybercode. Cybercode is a kind of specific tagging system which based on a 2D-barcode technology and provides several features not provided by other tagging systems. CyberCode tags can be recognized by the low-cost CMOS or CCD cameras found in more and more mobile devices, and it can also be used to determine the 3D position of the tagged object as well as its ID number. Then Yuji Ayatsuka and Jun Rekimoto propose Active CyberCode- a directly controllable 2D code.[18] A user can give commands by putting his/her finger on a printed button beside the 2D code marker. The marker has fixed and variable parts, and the variable part is recognized as the same as the fixed part. Through this system, users can choose the customized 3D virtual content what will be displayed.

Yuan-Ping Luh[19] presents A marker-based customized AR system. A systematic framework for design customization of footwear for children and identifies three modules related to shoe styling: shoe surface, shoe bottom, and accessory. A new module, shoe cloth, is created to allow a quick change of shoe appearance. Consumers can specify various design attributes in each module, including color, texture, embroidery, and shape.

Rafaá Wojciechowski[20] has presented a system that allows museums to build and manage Virtual and Augmented Reality exhibitions based on 3D models of artifacts. For the AR part, they placed several AR markers in front of each artworks. The user scans those AR-markers to generate the corresponding 3D model. They even designed virtual buttons for users to interact with 3D models. However, they have not thought about different requirements for the different users. For example, people from different countries want to see the introduction of different languages.

AR game is also a very popular research topic. It is often used as an interesting demonstration of new attempts in the field of Augmented Reality. Some of the earliest research in AR games was conducted by Ohshima and colleagues to demonstrate advances in underlying hardware and software infrastructure, by creating, from scratch, multiplayer air hockey [21] and first-person shooter [22] games. Knoerlein and colleagues [23] implemented an AR ping-pong game with a haptic interface in which the players receive force feedback through optically tracked ping-pong racket handles attached to SensAble PHANTOM haptic devices when hitting the virtual ping-pong ball. In contrast, AR Chinese Checkers [24]utilizes optically-tracked fiducial markers (printed black and white patterns whose pose and identity can be determined automatically) as input devices, in conjunction with attached wireless physical buttons for precise selection tasks. Ohan Oda [25] described an AR racing game. In the game, the driver wears a tracked video see-through head-worn display, and controls the car with a passive tangible controller. Other players can participate by manipulating waypoints that the car must pass and obstacles with which the car can collide.

In our research, we have described a marker-based AR system to show our thinking about the customized and secure augmented reality. At the same time, we have discussed the potential applications with this system. We also use the AR game as a demo to show our system effect. So, these references have given us lots of inspiration.

Chapter 7

Potentail applications

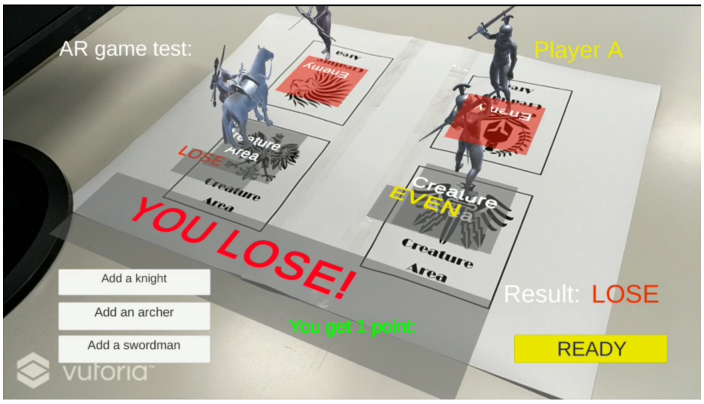
In this research, we have proposed some potentail applications. In order to show what the customized and secure Augmented Reality system can do in the future. We mainly listed some possibilities in several applications- AR game, AR mail, AR 3D-board and so on.

7.1 AR game

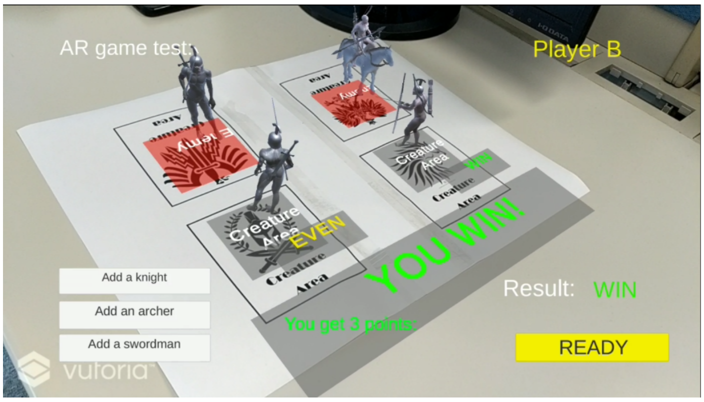
Customized and secure AR system can be used well in AR game. We have just showed the AR game demo in chapter 6. Because for the game, the customized content is very important. The players have different preferences - different game characters, different game information (Rank, damage, money, etc.). But in majority of traditional AR 3D-board game, every player can just see the same 3D virtual game objects.

Fig. 7.1 Traditional AR game

In our research, we have realized a simple AR board game which can show different game objects and information to different players. That because the AR board is consists of lots AR markers. On the same marker, system can display different 3D virtual content to different players.



(a) PlayerA's view



(b) PlayerB's view

Fig. 7.2 Different players can see different 3D-game objects

Compare with the exist AR board game, this kind of AR game that the different players will have the difference game view can improve the game experience. Because different players can get different game information. One player's information may be hidden from the other. Based on this feature, AR games with more rules can be designed. Not just show some 3D-virtual models on the cards or game boards.

With the encryption AR system, we can design some locked AR-game content. Just like the treasure-box. Players enter passwords to get hidden game hints or rewards.

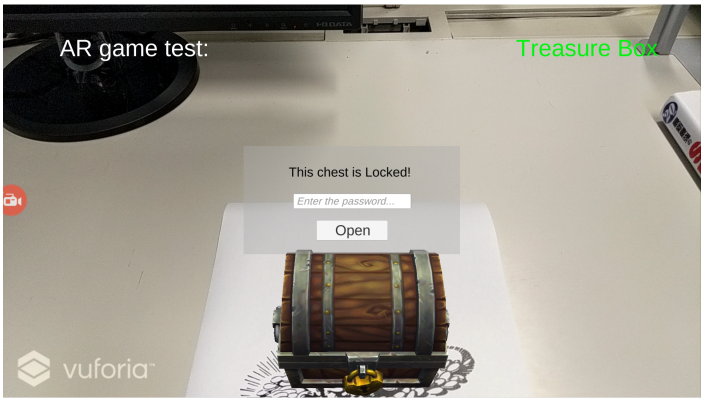


Fig. 7.3 AR treasure box

7.2 Secure AR mail

In our life, paper mail is still used. However, the paper-mail has safety issues. Paper mail has a lot of private information which is very easy to be steal. These mails are often stacked in a single iron mailbox. (just like the Fig.7.4) This kind of mail box is very easy to open by force which cannot provide good protection.

Fig. 7.4 Mail box

So, we have designed secure AR paper mail - Hide the important information and show there as 3D virtual content. The user needs to scan the AR marker on the mail. The system will detect the user's identity and decide whether to display the hidden 3D-virtual content. Secure AR mail may have two forms.

- Only the designated recipient can see this information.
- User can also use password to encrypt the virtual content.

Fig. 7.5 Secure AR mail

7.3 Customized AR display board

Customized AR display board is to show different 3D virtual content according the user's identity or context situation. Just like the usage scenario of the customized AR system in chapter 4. The new system can detect the user's identity through the user database and context-aware through the sensors on the user's device. Different user may want to see different 3D virtual content on the 3D virtual Board. We have summarized some possible scenarios.

- People of different identities want to see different information. For example, the user from different countries may want to see the football game result of their own nation team.
- On the call-board of the restaurant, the user may see different menu at different time.
- People in different countries may want to see AR call boards in different languages.
- The AR 3D virtual call-board on the same AR marker may show different 3D virtual content in different location. For example, the 711 convenience store in different area may want to show the different area limit products on their 3D virtual AR board.

Chapter 8

Conclusion

8.1 Summary

In summary, this paper has expounded the problem of the tradition AR system and design a new system to improve it in the terms of customization and security. By this way, we demonstrate the role of customization and security in the AR system. We have also discussed some possible applications based on the customized and secure AR system in the future.

For the customization part, we proposed an augmented reality system which can detect the user's situation and display customized 3D-virtual content to different user. The system will detect the observers identify and his context situation. The user's identify data (including the user's permission) will be provided by the user's database. And that the context data mainly acquired from the user's device (Mobile phone in this research), such as the GPS sensor, or the device system time.

For the encryption part, system will record the encryption information by database. The database will record whether the 3D-virtual content has been encrypted and what is the password (Or face ID in the face recognition method). If the user wants to view AR content, he must input the password. The database will also record the user's every input. If the user input wrong password for three times, he needs to wait an hour to input again.

In this research, we also give some potential applications to show the value of the new marker-based AR (augmented reality) system. We have implemented a simple AR board game, in which we can show different game objects to different players. We also discussed some other possibilities, just like the use in AR mail, AR 3D board and so on.

8.2 Future Work

There are still lots of things worth us to research on customized and secure Augmented Reality. Such as identify more user's situation in some other user scenarios, explore the better encryption methods. For the potential applications, we can do some more detailed research. For example, design more complex AR games or implement secure AR mail application in detail. Every work requires sustained effort.

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