<CAVE WORLD>

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REPORT FOR MIXED REALITY COURSEWORK 2

TECHNICAL DESCRIPTION

The Cave World is an AR project made by Unity AR Foundation on an Android environment. Due to the limitations of ARCore, some Android phones cannot use ARCore. It is developed to Honor 10 through ARCore. Unity connects to Android phones by deploying the Android environment, which consists of the JDK, NDK, and SDK, with the SDK matching the Android 10 version of the test device. There are 3 AR parts for the project: using the AR Tracked Image Manager component to identify images, the AR Plane Manager component to identify planes, and the AR Reference Point Manger and Reference Point Creator components to place the barrels in the game. In addition, the project has been designed with sound effects and background sounds, so that players can wear headphones to get a better experience of the tour.

The specific task of this project is as follows: Firstly, configure the computer's Android environment to ensure that the Android project can be packaged and delivered smoothly and find an Android phone capable of using AR tools. Secondly, build the basic framework of the game, e.g., how many scenes are needed, the components needed, and the 3D model. There are 4 scenes in the project: “HomeScene”, “IntroScene”, “GameScene” and “FinishScene”. The “HomeScene” includes the menu and settings screen, followed by the “IntroScene”, which is an introduction to the attraction by recognizing pictures of the attraction to bring up character models and a voice guide. The characters chosen for the introductory scene are the bar owner and the barmaid. The bar owner introduces the historical background to the player, while the barmaid dances alongside. Once the player has been introduced to the historical background of the attraction, they can enter the game and play the barrel-making game (as the selected attraction is the cave where the barrels are made). The barrel-making game is an AR game with a limited time of 30 seconds. It mainly generates a 3D model of a barrel on the plane by clicking the screen after identifying the plane. If one is generated, 1 point will be accumulated, and the final score will be displayed after the timing is over. Finally, enter the “FinishScene”, there are two main buttons, one is to “Play Again” to switch to the game scene, and the other is the “Menu” to return to the “HomeScene”. Finally, once the game framework and design are complete, it is time to instantiate and debug. As the development is done through Unity on the PC and the final manifestation is done on the Android phone, the game needs to be built and run through unity.

Besides, the theme of the AR project is “City of Caves” which is managed by the National Justice Museum. It offers an audio guide and supports downloads when purchasing tickets for visits. Therefore, this project makes use of this audio guide, which is relevantly designed so that the user listens to the audio guide and then plays a game related to the topic. It is worth noting that the audio tours provided by the site are narrated by a female voice, whereas this project required a male voice. Therefore, this project converts the relevant text to speech through the Axure website and adds it to the project. The 3D models for this project are from the Mixamo website and the free models and actions in the unity asset store. The background music is from the free audio uploaded by Melancholy in the unity asset store. Here are the links to UI ,3D models, and audio are the user in the project:

Barmaid: https://www.mixamo.com/#/?page=1&type=Character
Bar owner: https://www.mixamo.com/#/?page=1&type=Character
Barrel: https://assetstore.unity.com/packages/3d/props/barrels-32975
MenuUI: https://assetstore.unity.com/packages/essentials/ui-samples-25468
Button Beeps: https://assetstore.unity.com/packages/audio/sound-fx/score-and-time-59255
Background music： https://assetstore.unity.com/packages/audio/music/bard-s-tales-peaceful-harp-music-pack-lite-lite-19060.
Introduction audio:

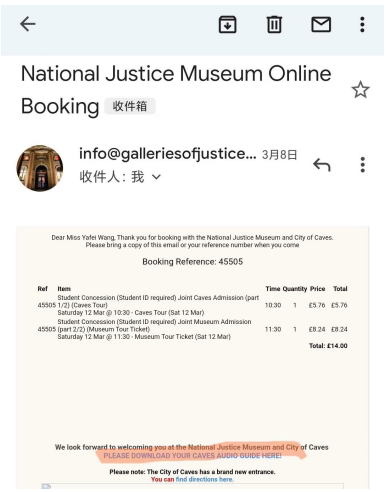

Figure 1. Introduction audio

In addition, the game is a prototype, so there are still some features that have not been developed, such as the settings function in the "HomeScene" and the switching of specific attractions. As there are many caves in the City of Cities attraction, each with its own historical context, only one specific attraction was chosen for this project.

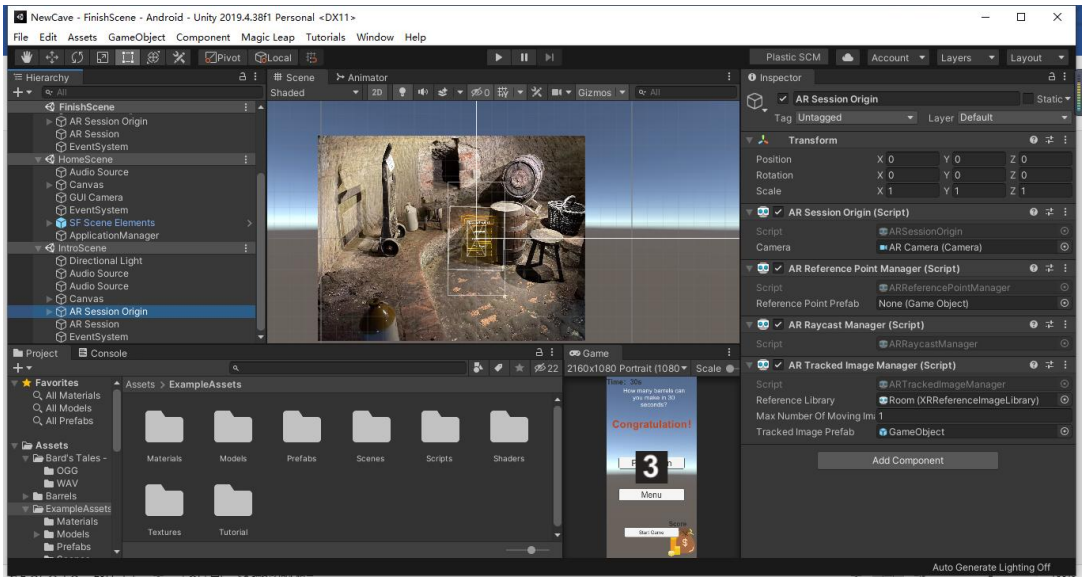

Figure 2. Unity

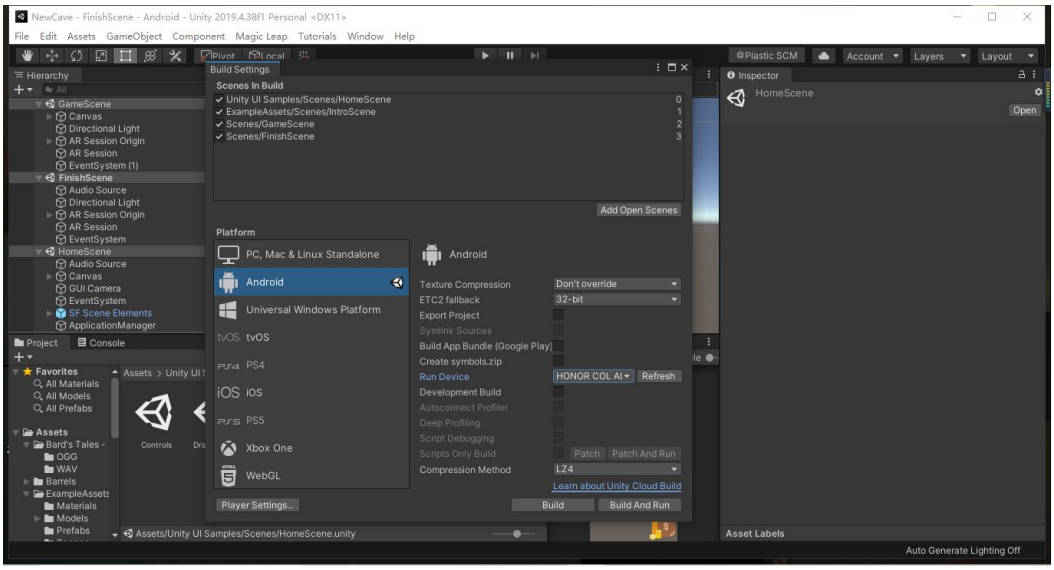

Figure 3. Unity & Android

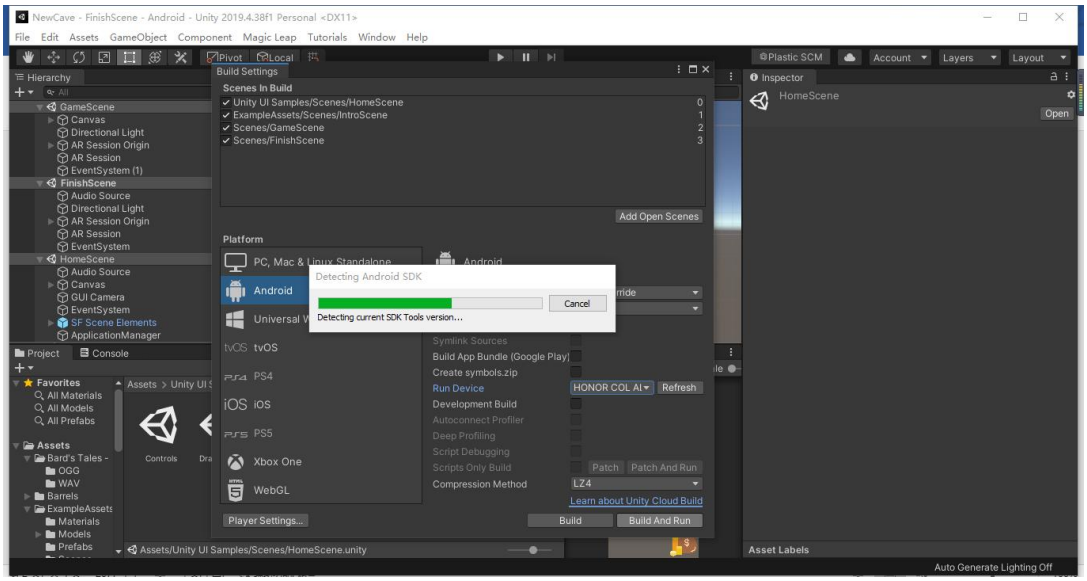

Figure 4. Build and Run

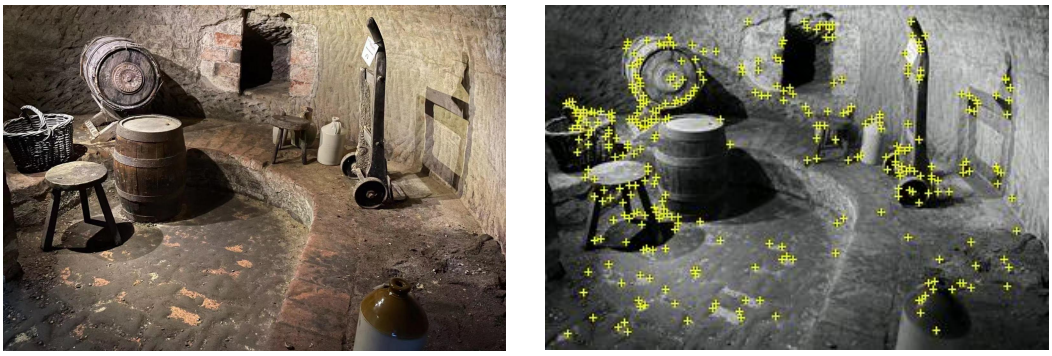

Figure 5. Track Image

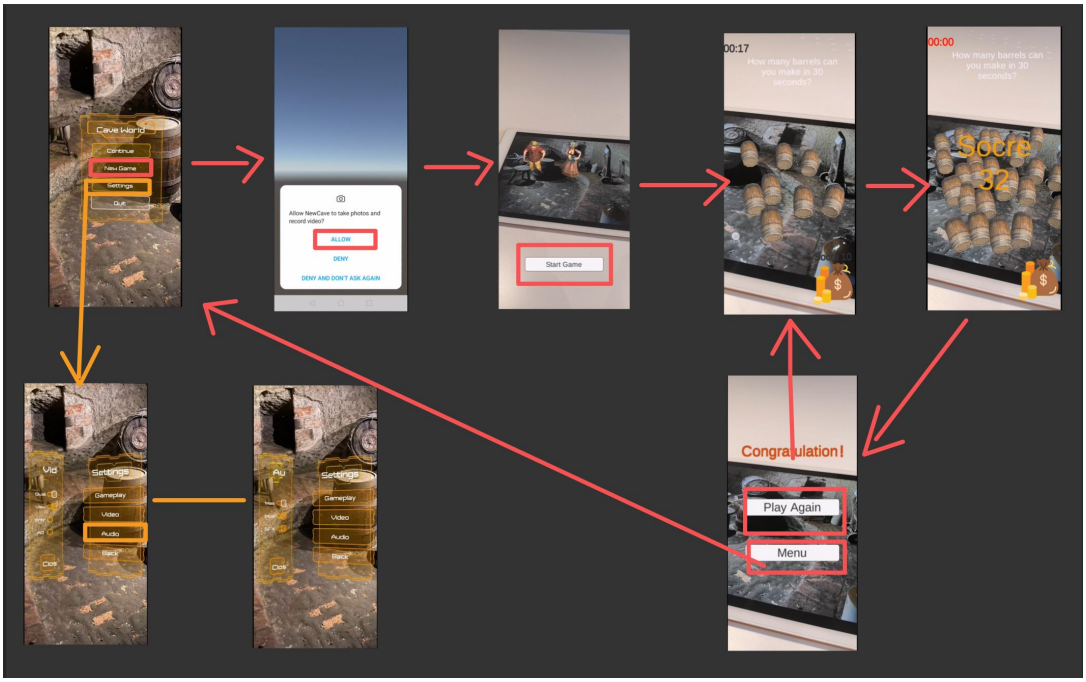

Figure 6. Process of Project

During the design phase of the project (CW1), I designed two different paths to complete the AR experience: generating a 3D model by recognizing a real view of the cave and generating a 3D model by scanning a picture in the visitor center. However, through the feedback from Coursework1, it seems that the first option will not work because changes in light, position/framing will make it not work as an image target. Thus, I chose to use a photograph of the attraction taken during my visit as a reference. Also,

an important step in ensuring that this AR project was completed was to place a photo of the attraction on the table so that this photo could be recognized using an Android phone. It allows players to complete the AR experience in a seated or standing position. In addition, an environment that is as quiet as possible is necessary to play the audio and music effects to enhance the user experience.

```
void Update()
{

    if ((Time.time - startTime) >= 1 && countdown>0 )
    {
        startTime = Time.time;
        countdown--;
        if (countdown<30)
        {
            second--;
            if (second <= 10)
        {
            mText.color = Color.red;
        }
            if(second == 0){

            fText.text =sText.text;

            while(i<100){
                i++;
            }
            if(i==100){
                SceneManager.LoadScene(3);

            }

            }
```

```
14  void Update ()
15  {
16
17  }
18  public void JumptoMenu()
19  {
20  SceneManager.LoadScene(0);
21  }
22  public void JumptoIntro()
23  {
24  SceneManager.LoadScene(1);
25  }
26  public void JumptoGame()
27  {
28      SceneManager.LoadScene(2);
29  }
30  }
```

Figure 7. Code for Timer and Switch Scene

EVALUATION/TESTING

During the evaluation phase, two main approaches are used to evaluate AR projects: the user-testing approach and the non-user-testing approach. The user-testing method is “think aloud” which is ask participants to complete a series of tasks on an AR project and discuss with them how they feel about using it. The non-user-testing method is the “technical performance test” which means I need to do some technical performance tests, such as framerates, project start-up time, scene switching time, AR image recognition time, AR plane recognition time, and successful generation rate of game objects (barrels). These two methods were chosen because they are easy to implement and get feedback on.

There are some details on the “think aloud” evaluation part: three participants were called in to take part in the evaluation and it took them an average of 3 minutes to complete the AR experience. The user tests were carried out in the kitchen of the flat where I live, as there is a large table in the kitchen to simulate the environment of the visitor center set up for the project. Identified photographs are placed on the table (I used an iPad to display the pictures) and participants can choose between sitting and standing to perform the task. Participants sign a project information sheet and an informed consent form prior to participation, and their real information is protected from being reflected in the final report, which is deleted upon completion of the project. In completing these tasks, the participants determined a few issues within the AR experience. Firstly, the gameplay is not very clear and participants felt that it would be good to have an introduction to the gameplay on the introductory page or to provide a simple animated tutorial. At present, the only introduction to the game is the "How many barrels can you make in 30 seconds?" on the game screen and the font colour should be more prominent. Secondly, the recognition of planes in the game phase is slow and sometimes requires switching angles to see the generated barrels.

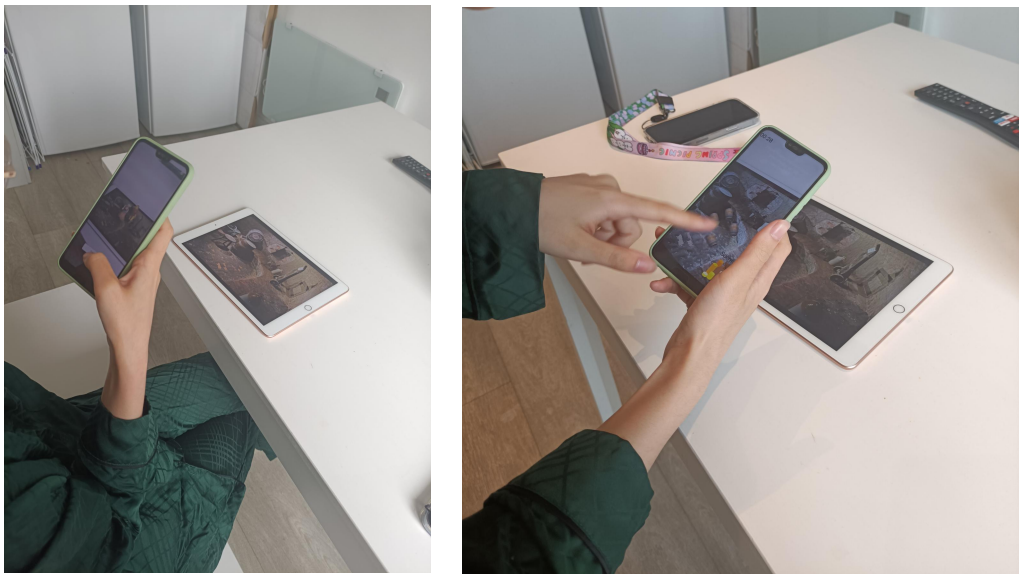

Figure 8. User Test

As for non-user-testing, I carried out five separate sets of tests and recorded the corresponding data for analysis. This evaluation test was also carried out on the kitchen table. There are 5 sections that need to be tested: project start-up time, scene switching time, AR image recognition time, AR plane recognition time, and successful generation rate of game objects (barrels).

Test content	Test 1	Test 2	Test 3	Test 4	Test 5	Average
Project start-up time(s)	03.45	02.97	03.34	03.02	03.01	3.158
AR image recognition time(s)	01.48	01.33	01.50	01.23	01.34	1.376
AR plane recognition time(s)	01.50	02.02	03.30	01.59	05.14	2.62
Generation rate of game objects (number of barrels/click number)	39/40 97.5%	24/25 96%	23/23 100%	40/40 100%	30/33 90%	96.7%

Table 1. Technical performance test-1

Scene switching time	Test 1	Test 2	Test 3	Test 4	Test 5	Average
Home->Intro	02.36	02.39	01.33	01.59	01.40	1.841
Intro->Game	01.59	01.36	01.33	01.40	01.43	1.422
Game->Finish	01.02	01.03	01.26	01.04	01.30	1.13
Finish->Game	01.39	01.34	01.77	01.40	01.50	1.48
Finish->Menu	01.30	01.22	01.34	01.10	01.19	1.23

Table 2. Technical performance test-2

The performance test session took approximately 3.158 seconds to start the project, 1.376 seconds for AR image recognition, and 2.62 seconds for AR flat recognition, but the flat recognition time varied considerably, possibly related to the content of the capture. The bucket generation rate in the game was 96.7%, with two-fifths of the test generated in full. In the scene switching session, the longest time to switch from the home page to the introduction screen was 1.841 seconds, with all other pages remaining within 1.5 seconds.

All of the issues that were evaluated above are issues that can be resolved. For the introduction of the game, I could add an introduction screen and change the font size and colour of some of them. For the plane recognition and barrel generation issues, which mainly occur when moving the camera angle, it takes time to re-recognize and some of the generated barrels disappear from view. This can be solved by marking the identified planes to help the player locate the plane area to reduce the movement of the angle.

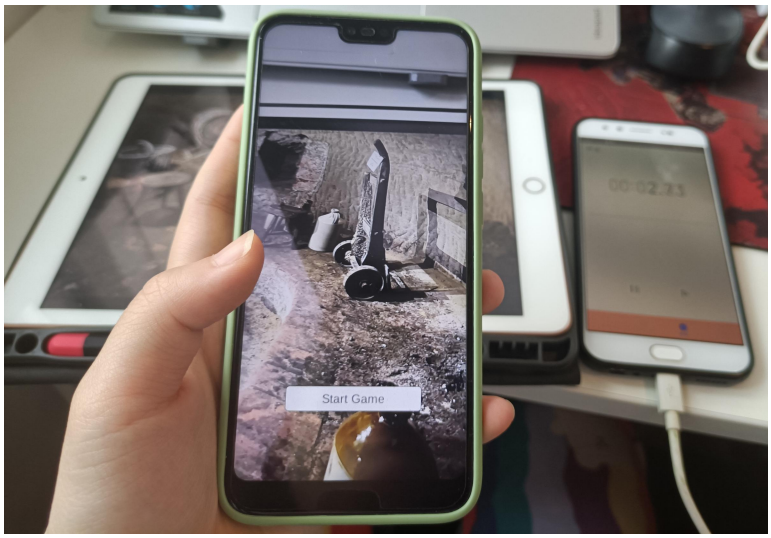

Figure 9. Technical performance test

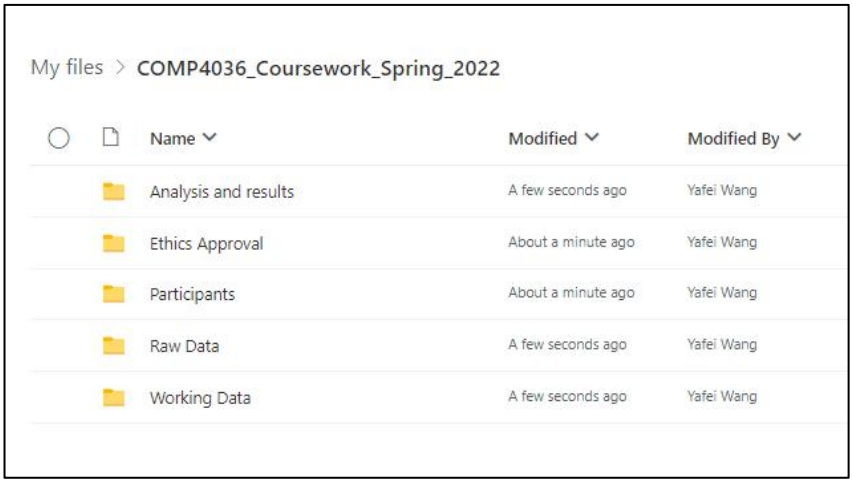

Figure 10. Coursework Ethics Procedure

REFLECTION

Compared to the design in Coursework 1, the prototype is mostly complete, but there are still some changes. Firstly, given the technical issues and the feedback from Coursework 1, the scheme design for scanning the real cave was removed by me, keeping the proposal in the visitor center. Secondly, the design of the prototype only relates to the fact that the cave was previously used as a wine cellar and there is still plenty of room for development, for example as a place to make animal skins and as a place to live. Thirdly, there is a lack of description of how to play the game in CW1, but a time-limited mini-game to create a barrel was created in the prototype. Throughout the production of the project, I identified a number of human-computer interaction issues and challenges: how do you design the game's interactions? How do you design an AR marker in the real world so that the lens of an Android phone can accurately capture the AR marker and render a 3D model? And how to give feedback to the player?

In addition, I mastered the ability to develop AR projects on Android phones using Unity and learned about mental models in the design process. In a good product, the designer's mental model and the user's mental model need to match because different people have different interpretations of the same thing which means different mental models (Carroll, J. M., & Olson, J. R.,1988). During the evaluation phase, the design problems identified by the participants were caused by a mismatch between the mental models of designers and users.

As well as, there are 2 approaches to solving “where to put things” in my project: one is markerless AR which needs to find a flat plane then put the object on the “plane” by touching the touchscreen, the other is marker-based AR which asks camera find a specific marker and place the object on the marker. The introductory scene in this project uses marker-based AR and the barrel-making game is marker-less AR. It is found in this project and previous projects that the positioning accuracy of marker-based AR methods is usually much higher than that of marker-less AR methods (Cheng, Chen et.cl.,2017). In

previous research, it was proposed that more precise positioning technologies based on RFID, Wi-Fi, or UWB can be used to set the relative positional relationship between virtual objects and the real world to improve the positioning accuracy of markerless AR (Cheng, Chen et.cl.,2017).

In my opinion, in order to improve the stability of AR games, marker-based AR can be mainly used for production. When using marker-free AR, the complexity of the model must be minimized to improve the user experience. As well as, designers should further consider the details of the game from the user's point of view. While this AR project still has a lot to improve, it still taught me a lot of knowledge and new techniques.

Words Count:1997

REFERENCES

Carroll, J. M., & Olson, J. R. (1988). Mental models in human-computer interaction. Handbook of human-computer interaction, 45-65.

Cheng, J. C., Chen, K., & Chen, W. (2017). Comparison of marker-based AR and markerless AR: A case study on indoor decoration system. In Lean and Computing in Construction Congress (LC3): Proceedings of the Joint Conference on Computing in Construction (JC3) (pp. 483-490).

APPENDIX

1.Questionaire for Participants

QUESTIONNAIRE

This questionnaire aims to study the satisfaction of users who use the Cave World AR App. Therefore, your responses are entirely voluntary, and you may refuse to complete any part or all of the questionnaire. This questionnaire is anonymous, and there is no way to connect your responses with you.
Please take your time, read each question carefully, and answer the best can.
Thank you for your time.

Section 1: Introductory details

a. Date: _____

b. What gender are you?

☐Male ☐Female ☐Prefer not to say

c. What age group do you belong to?

☐Under 20 ☐21 to 25 ☐25 to 30 ☐31 to 35 ☐ 36 to 40 ☐ over 40

Section 2: Using self-service machine details

1.

Content	Strongly Like	Like	Neutral	Dislike	Strongly dislike
1.APP Launch	5	4	3	2	1
2.Homepage design	5	4	3	2	1
3.Introducing Audio	5	4	3	2	1
4. Project background music	5	4	3	2	1
5.Project Presentation Audio	5	4	3	2	1
6.Character models on the introduction page	5	4	3	2	1
7.Game Design	5	4	3	2	1
8.Game interface model	5	4	3	2	1
9. Game sound design	5	4	3	2	1
10.Finish interface design	5	4	3	2	1

11. Setting page design	5	4	3	2	1

2. Do you have any other comments about Cave World App?

_____

_____

THANK YOU VERY MUCH FOR TAKING THE TIME TO ANSWER THE QUESTIONAIRE.

YOUR CONTRIBUTION IS GREATLY APPRECIATED.