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SpinTopAR: Multiplayer Augmented Reality Game for Smartphones

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Abstract— Multiplayer Augmented Reality (AR) games allow players to place objects in the real world with virtual objects. Allowing players to play together in a real-world environment with interactive virtual objects. This paper presents a multiplayer game called SpinTop AR which can be played at any scale. All players will be able to select any character and battle together from any part of the globe. In this paper, we will show the overview of SpinTop AR, its functionalities, and design the technology used behind it. All the functionalities, designs and the technologies used in developing SpinTop AR will be explained in detail.

Keywords—multiplayer, augmented reality, synchronous

I. INTRODUCTION

Augmented Reality (AR) is a technology that evolved from Virtual Reality. It uses real-world perception and information computed by the system to create augmented scenarios. AR games allow players to interact with virtually digitized objects which are placed in the real environment.

Smartphone platforms such as Android, iOS, provide high computing and sensors to provide AR tech to a wide variety of games such as *Ingress*[11], *Kingfall*[12], *Pokémon Go* [13], *Run an Empire*[14] etc. are the most popular AR games currently available on the market. However, these games do not provide an actual AR multiplayer experience. There are other multiplayer games like *RealTag*[15] that provide an interface for multiplayer but do not fulfill an actual multiplayer experience.

As AR technology is gradually increasing year by year, game engines such as Unity3D[7] are making their own Augmented Reality API called ARFoundation[8], which completely revolutionizes AR tech by providing the combination of ARCore[10] and ARKit, *SpinTopAR* uses this technology along with Photon[9], a cloud host server, to create a functional multiplayer game.

II. RELATED WORK

In 2020 Ngoc Nguyen worked on a Multiplayer AR game using AR Foundation [1]. Unfortunately, these two expectations were not accomplished. First is the multiplayer mode, it requires more experience and time for server and cloud programming. Multiplayers in AR games and ones in normal mobile games are unlike to some extent. Second is the virtual object in the game did not blend ideally into the real world due to the shadow, lighting, and collision configurations. Furthermore, challenges occurred in the development process. The author has to buy a new phone for testing because not all Android phones are ARCore supported. Also, the testing phase is a demanding task since all the tools for AR development are still in preview and not mature enough.

Yuzhou Liu, Nikita Smirnov, and Cristina Olaverri-Monreal present a method for implementing mixed reality applications for Robot Operating System [2]. The work they presented describes a method relying on mixed reality to be applied in the testing of delivery robots' behavior and interaction in a realistic simulation framework. It showed how robots can follow each other even in MR. But the technology used was in the form of marked and coded paths that the user has entered. This removes the possibility of spatial mapping dynamically to improve the universality of MR applications.

Poonpong Boonbrahm, Charlee Kaewrat, and Salin Boonbrahm worked on generating a stable large 3D model for remote design collaboration using multiple markers were developed [3]. Users from different locations can work on the same virtual model. The platform for the mobile application was also developed. The system was implemented on the 4G mobile network with the Photon Unity Networking framework to transfer the 3D model and display it to each other. However, the concept of using multiple marker-based was initiated instead of the popular ARKit and ARCore marker-less platform. This makes it not so easily accessible to the wider audience and can only be used by those who have the markers.

Sung Lae Kim, Hae Jung Suk, Jeong Hwa Kang, Jun Mo Jung worked on Using Unity 3D to Facilitate Mobile Augmented Reality Game Development [4] by creating a game called Calory Battle AR using Unity and Vuforia, which helped to tackle the issue of obesity on a worldwide scale. It consisted of geolocation virtual bombs over the city in Korea and the player had to go to the location and try to defuse the bomb before it exploded. It explored the concept of AR exergame and also faced challenges such as GPS, collision detection between multiple AR objects, and flexibility in terms of game content management.

Xinqi Liu, Young-Ho Sohn, Dong-Won Park worked on Application Development with Augmented Reality Technique using Unity 3D and Vuforia [5] by creating a game called AR Tower Defense using Unity3D as a game engine a Vuforia as a package for AR. It emphasizes the Unity 3D technology and Qualcomm QCAR development tool. The Vuforia engine can detect the track and can set animation, play video and interact with virtual and reality via virtual button mode. When the camera lens position varies from the former one, the position and angle between the camera and the real scene also transform accordingly.

Ida Bagus Kerthyayana Manuaba worked on a Mobile-based Augmented Reality Application Prototype for Remote Collaboration Scenario Using ARCore Cloud Anchor [6] which is an application prototype for a simple remote collaboration scenario. It explores the concept of cloud anchor from the ARCore library, which allows the system to be used by multi-users. The test was on the influence of light conditions in generating dots for plane detection. Based on the performance test result, the prototype could share the video streaming and generate a virtual object overlaying on the screen according to the position input from the touchscreen.

III. CREATION OF SPINTOP AR

A. Design of Game

There are two types of strategies the player can select through the PlayerSelection menu: attack and defend modes. If the player chooses an attack-type Spinner then `spinSpeed = 3600`; and for defending type `spinSpeed = 4400`; the `spinSpeed` also behaves as the health mechanism of the Spinners.

When the spinner collides with each other damage to the Spinner will depend upon the speed of the spinner movement and the type of spinner which has been used. The more the velocity of the Attack Spinner the more damage can be done but if it takes to damage the more health decreases along with it. Defending Spinner will take less damage and thus time is taken to defeat but will take time to do damage to the opponent.

There will be three ways in which the player can play together with one being Attack/Defend, Attack/Attack, Defend/Defend. Depending on what the player chooses, there will be different ways for combat and output gained from it.

B. Technical Overview

SpinTopAR was developed in Unity3D using ARFoundation and Google ARCore. The multiplayer aspect will work using the Photon API network. The players will log in using `PhotonNetwork.LocalPlayer.NickName()`; [9] and room creation using `PhotonNetwork.JoinOrCreateRoom()`; [9] we were able to create a stable environment for our players to sync together into one room.

Each room is divided into 2 players and there are around 1000 rooms which is the limit for the Photon Public Cloud API. This is necessary since the gameplay will only start when two players are in the same room using `OnCollisionEnter()`; [9] For AR we use a Placement and Detection script used in `UnityEngine.XR.ARFoundation()`; [10] and raycasting using static `List<ARRaycastHit> raycastHit = new List<ARRaycastHit>()`; [10]. For keeping the rays coming from the center of the device used for keeping the object spawning for the center using `Ray ray = arCamera.ScreenPointToRay(centerOfScreen)`; [10] this will help for proper detection of the plane as well as placing. The basic UI/UX design while creating the game was done by Canvas which is provided by Unity3D itself which helps to create buttons, text and image placeholders for the game. The button clicks and selections of Spinner comes under the UI/UX of the game and was done by scripting the lobby manager which uses `UnityEngine.SceneManagement`; [7] for changing the scenes from one to another.

C. Challenges

The main challenges faced while developing SpinTop AR were:

a) *Lag*: This is a delay by the server and the action performed by the player as no one player has the same network or speed and lag cannot be zero but can be minimized. To combat this issue in AR, the use of `OnPhotonSerializeView(PhotonStream stream, PhotonMessageInfo info)`, and `lag = Mathf.Abs((float)(PhotonNetwork.Time - info.SentServerTime))`; [9]. This is used to stream gameplay in real time where, the data is sent in real time and plays it back to the other player like a video format to combat lag from each user.

b) *Spawning of Spinners*: As the BeyStadium is placed it can be of different sizes and positions as each of these values are unique to each other. To combat the issue in Unity, add an Empty GameObject to the gameplay scene and then use

```
int randomSpawnPoint = Random.Range(0,
spawnPositions.Length - 1); and
Vector3 instantiatePosition =
spawnPositions[randomSpawnPoint]. position; [7]
```

This will help to generate a random spawn of spinners and according to the size of the BeyStadium scale will trick the GameObject to move along with the scale.

D. Game Generation

1. In Fig 1 when the game starts it shows to enter the name. When entering the name, it saves the information onto the Photon server to be displayed for the character.

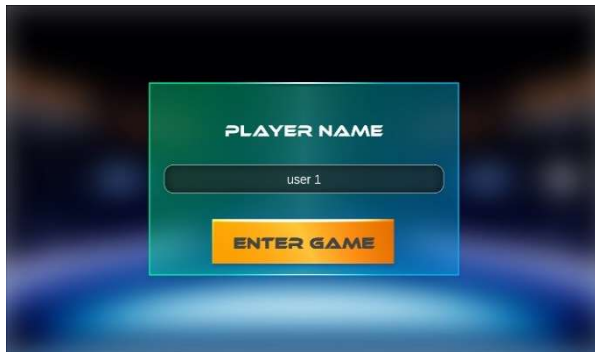


Fig. 1. Entering the Player Name

2. After the player enters their name (Fig 2.) the main lobby screen appears for “Quick Match”.



Fig. 2. Lobby Screen for SpinTop AR

3. After clicking the “Quick Match” button (Fig 3.) The Player Selection menu appears, where the player can choose between four different spinners, two for “Attack” type and two for “Defend” type.



Fig. 3. Player Selection Menu for Attack or Defend

4. After the selection of the spinners, the player can “Re-Select” the spinner again or continue for “Battle”. (Fig. 4).



Fig. 4. Re-Selection for Spinner or Battle

5. For first time uses (Fig. 5) It will ask for permission for the Camera. Click Allow to access the camera so that ARCore can start.

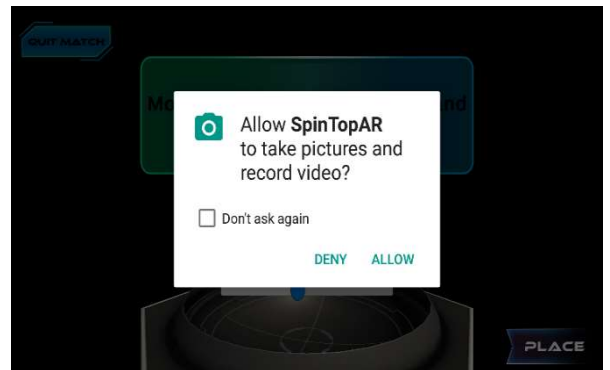


Fig. 5. Permission for Camera

6. The BeyStadium will appear on the screen (Fig 6) for placement. Here, ARCore will scan the area for plane detection to help place the BeyStadium. The slider will help to scale the BeyStadium big or small according to the player's requirements.

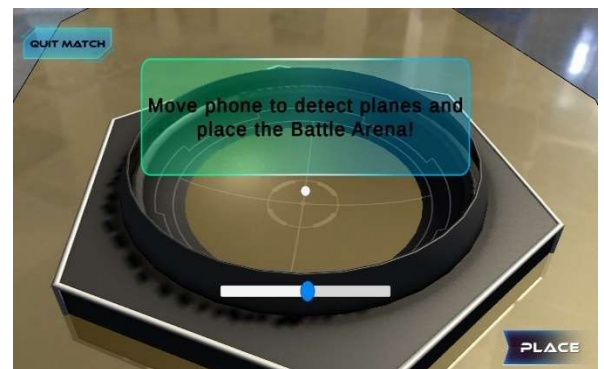


Fig. 6. Placement of BeyStadium

- After placement of the BeyStadium, the player can now “Adjust” the BeyStadium or “Search for Games” (Fig 7).



Fig. 7. Adjust or Search for Games

- Photon will create a random room for the player to join until some other player joins in as well. (Fig 8).

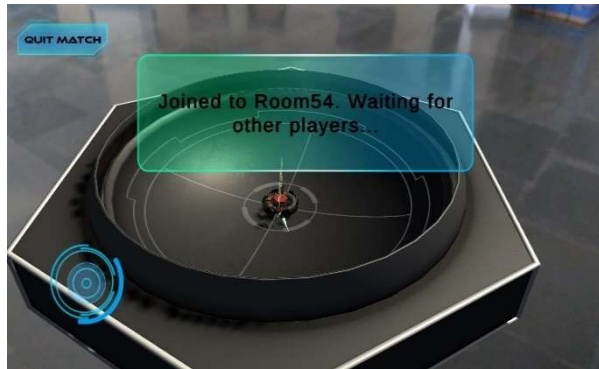


Fig. 8. Room Creation

- When some other user joins the same room, the battle starts (Fig 9) and the winner is declared when one player is defeated. Once the player is defeated or wins a respawn element comes in for 8 seconds, and the spinners will respawn back with full health and the battle starts again (Fig 10).



Fig. 9. Battle Start



Fig. 10. Loose and Respawn

- This will continue till one of the players uses the “Quit Match” button and the player will go back to the main lobby of the game (Fig. 11).



Fig. 11. Quit to Main Menu.

IV. BLOCK DIGRAM

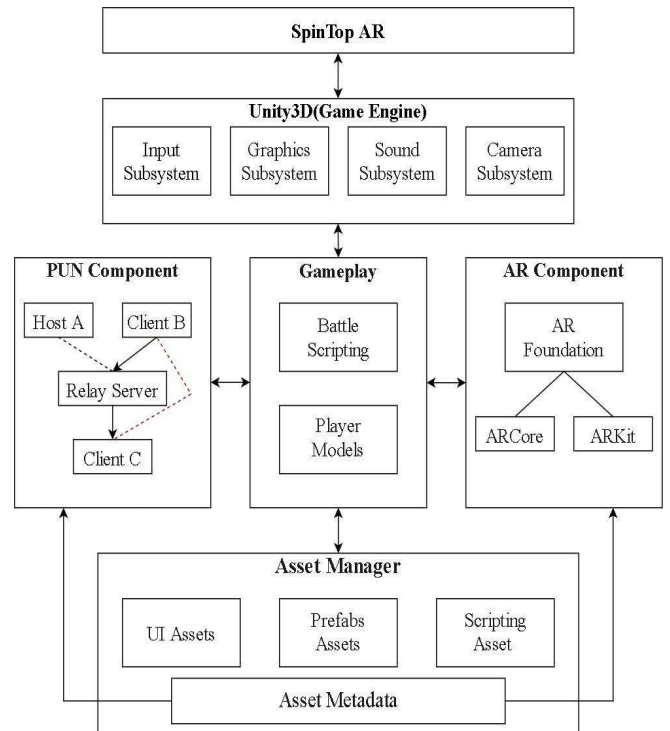


Fig. 12. Block Diagram for SpinTop AR

The proposed system SpinTop AR (Fig.12), the game is developed with Unity 3D Game Engine that consists of four subsystems are:

1. Input Subsystem, when players Player1 and Player2 enter into the game and their inputs are accepted with this
2. Graphics subsystem, which consists of some of the graphical content which is desirable by the players
3. Sound subsystem, used when players attack each other as well as create a background sound during the game
4. Camera Subsystem is the main element for designing a game as it consists of UI/UX and the main gameplay.

These subsystems in Unity Engine will be used to create Multiplayer AR Game. All of the subsystems will be constituent in the Gameplay element, which consists of Battle Scripts as well as Player Models and these two will help to create the actual gameplay during battle. As the Gameplay component does not work alone and takes the help of Photon PUN and AR Component respectfully. All of these three components will help in creating SpinTop AR.

This data is all good as UI, Prefabs, and Scripts will all be saved into one whole component called Asset Metadata. Metadata generated will help PUN and ARCore make decisions and help to create a seamless game.

V. FUTURE WORK

We have tested SpinTop AR and were able to successfully recreate a multiplayer AR game. The overall feedback from the game was positive, and we have also identified some additional ways to improve the gameplay experience.

First, as SpinTop AR is a multiplayer game, it can always be updated as technology improves. The current version of the game is just a basic multiplayer game in AR. Lighting plays an important role in AR as the camera in our phones does not capture light in a non-bright environment. So, the use of an AR/Non-AR feature can be used like in Pokémon Go. We hope to add such a feature in the future version of SpinTop AR.

Secondly, the need for variety is required as the current version only provides a basic Win/Lose scenario. The addition of other elements like a health system for regeneration of health as well as, special attacks for speed, stability and movement, more variety in BeyStadium like an Ice Stadium, Grass or Hard/Rock Stadium will allow for multitude level of difficulty along with it.

VI. CONCLUSION

This paper focuses on the Unity3D technology used for AR as well as ARFoundation package made by Unity, which ARCore and ARKit as a base to develop AR games for both Android and iOS. Photon Unity Networking (PUN) is a cloud-based server for Unity to create multiplayer games. Using this technology, SpinTop AR was created to simulate how the use of AR and multiplayer can be used. As Unity3D was used as a game engine it provided with scripting, UI/UX design framework, sounds, particle effects and animations.

Furthermore, the use of ARFoundation helped to create AR for Android for real-time synchronization satisfies the users in the real world to feel the virtual space. Unfortunately, were not able to develop the same for iOS because of lack of resources. In the process of developing SpinTop AR, we analyzed the challenges and solved those issues. These experiences can be beneficial for AR game developers who can seek this development process while creating AR content visualization and interaction.

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