Implementing games to study the impact of Virtual Reality

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1 INTRODUCTION

This report provides a comprehensive analysis of an ongoing research project that aims to investigate the effects of Virtual Reality (VR) technology on users, specifically focusing on the memory people have when using VR or the reality. VR technology has the remarkable ability to immerse users in simulated environments, offering them a sense of presence and interaction with a digitally created world. This technology continues to gain popularity across various industries and it is crucial to understand and evaluate its potential side effects on users' well-being, cognitive processes, and psychological experiences, as well as the impact it has on people's consciousness. Thus, understanding how this technology influences memory is the key aspect of this project.

2 RESEARCH GOALS

The project focuses on exploring the impact of VR on users, with a particular emphasis on presence and embodiment.

2.1 Presence

Presence refers to the subjective feeling of "being there" in the virtual environment, where users perceive the simulated world as real and experience a sense of immersion and engagement.

2.2 Embodiment

Embodiment refers to the extent to which users feel a sense of ownership and agency over their virtual avatar or representation, influencing their perception of self-identity and the integration of the virtual and physical body.

The final goal of this research study is to examine the differences in memory between VR and real experiences. To accomplish this, participants will be asked to engage in three VR games implemented using the Oculus device. In particular, these games are based on real sports, such as tennis and golf, or a simple logic game like trash bin. Subsequently, they will also play the same three games in the physical reality. After a week from the experiment, participants will be interviewed and asked specific questions to explore their memory of the experiences and to determine whether they recall the virtual and real experiences as separate entities or if there is a blending between them.

Under the supervision of Elise Bonnail, PhD student at Télécom Paris, those involved in this project will actively contribute to the execution of this research study. The project will entail setting up the experimental environment, recruiting participants, conducting the VR and reality sessions, and collecting data. A crucial role will be played in analyzing the gathered data to draw meaningful conclusions regarding the differences in memory recall between VR and reality. Participating in this project provides students a valuable opportunity to gain practical research experience and contribute to the understanding of how VR impacts memory processes. The findings from this study will contribute to the existing body of knowledge and inform the development of guidelines and best practices for the use of VR technology in various contexts. Ultimately, this research aims to enhance our understanding of memory and its relationship with immersive virtual experiences, providing insights into the potential benefits and challenges of VR applications in memory-related domains. To assess the potential side effects of VR, a rigorous methodology involving the design, implementation, and execution of studies is necessary.

In this phase of the research development we aimed to develop the three games (tennis, golf and a thrash bin game) in a single immersive ambient, where the player can interact freely with the object.

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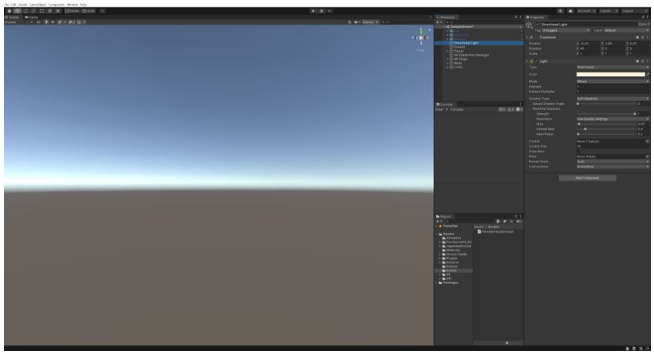

Fig. 1. Unity 3D: A high-level game design software

3 TECHNICAL DETAILS

3.1 Get familiar with Unity and Oculus Quest

Unity 3D was the primary development environment utilized for this project. Unity 3D is a powerful and widely-used game development engine that provides a comprehensive set of tools and features for creating interactive experiences, including virtual reality applications. To familiarize ourselves with Unity 3D and its functionalities, we followed tutorials to grasp the basics of animation and learn how to write scripts, even if they were relatively simple. This allowed us to gain a solid foundation in utilizing Unity 3D for game development.

During the learning process, we focused on understanding and utilizing the principal components offered by Unity 3D. These components include the Scene Editor, which allows for the creation and arrangement of game objects within a virtual environment, and the Asset Store, where we accessed a vast library of pre-made assets and resources to enhance our game development process. Additionally, we learned how to work with scripts, which are essential for implementing interactive behaviors and functionality within our VR games. By dedicating time to learning Unity 3D and its various components, we acquired the necessary skills to design and develop the VR games for our research project. After familiarizing ourselves with Unity 3D and its fundamental components, we proceeded to adapt the VR games to incorporate various interaction methods using the Oculus platform. One notable example of such adaptation was implementing the ability for players to manipulate the game environment using hand controllers. In particular, we developed a feature that allowed players to grasp the game field with their virtual hands, using the hand controllers provided by the Oculus system. By physically grabbing and holding the virtual game field, participants could manipulate its position and rotation, consequently affecting the movement of the ball within the game. This interactive mechanism enhanced the sense of immersion and embodiment, as players could physically engage with the virtual environment to control the gameplay. By incorporating these interactive elements into the VR games, we aimed to explore the impact of physical interaction and embodiment on the overall user experience. This allowed us to investigate how different modes of interaction within the virtual environment influenced the participants' sense of presence, providing valuable insights into the potential benefits and challenges of such interaction methods in VR applications.

Unity also prodives scripting support, where we the game design can apply custom interactions through a script in C#. In our application we first familiarized ourselves with the scripting API with a simple roll-a-ball game and further we made codes to limit where objects can be in our game scene and add vibration to objects' collision to make it more realistic.

3.2 Game conceptualization and constraints

Afterwards, we began creating the three games that would be used in the experiment. However, we had specific constraints and requirements for these games:

1. Game Realism and Feasibility: The implemented games needed to closely resemble real-world games that could be played in a physical room. This ensured that the participants' experiences in the virtual environment mirrored what they would encounter in reality.

2. Simplified Environment: The room where the game takes place was designed to be simple and devoid of excessive objects. This helped minimize distractions and allowed participants to focus on the gameplay itself.

3. Realism in Sensation and Physics: While the objects and the environment didn't necessarily have to be photorealistic, it was important to create an immersive experience with believable physics and interactions. The aim was to provide participants with a sense of realism and coherence in the virtual environment.

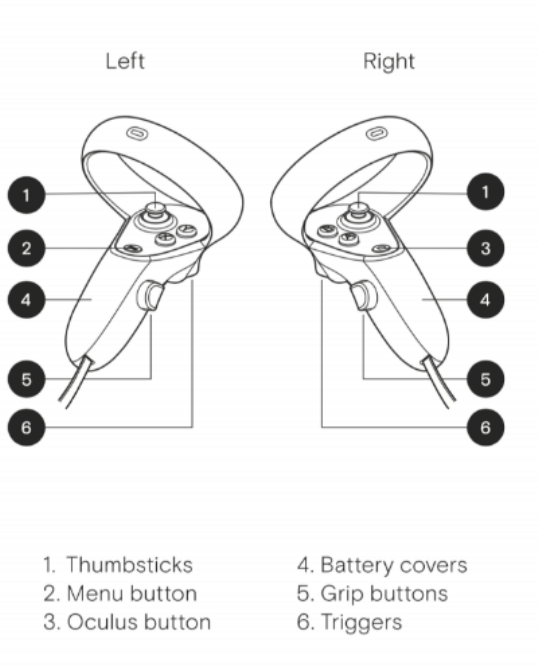

Fig. 2. VR Hand Controllers with button indicators

4. Simplicity of Gameplay: The games were designed to be straightforward and easy to understand, as participants would need to repeat the tasks multiple times during the experiment. Complex mechanics or convoluted rules were avoided to ensure that participants could quickly grasp and engage with the gameplay.

5. Time Efficiency: Considering the repeated nature of the tasks, it was essential to keep the gameplay short and concise. Participants would be playing for approximately an hour in total, so the games were designed to be engaging but not physically demanding.

6. Hand Controller Interaction: The games were designed to utilize the grip and trigger buttons on the hand controllers 5, as these buttons closely resembled the hand movements involved in grasping objects. For example, to hold a racket or a golf club in the game, participants would use these buttons to simulate the action of gripping with their hands.

By adhering to these constraints, we aimed to create a set of games that would provide a controlled and consistent experience for the participants, enabling us to effectively study the effects of VR on presence, enjoyment, and memory recall.

4 IMPLEMENTATIONS

In the process of developing the games, we encountered several challenges that required problem-solving and innovative approaches. Some of these challenges included:

1. Oculus Connectivity Issues: One significant hurdle we faced was the difficulty in establishing a stable connection between the Oculus devices and our personal computers. Each team member encountered different problems, which hindered the development process. As a result, we decided to utilize the necessary tools and

equipment available in the lab, where we could overcome the connectivity issues and continue our work seamlessly.

2. Understanding Collider Interactions: Working with colliders proved to be a complex task. Colliders define the boundaries and interactions between objects in the virtual environment. It was essential to have a deep understanding of collider properties, such as shape, size, and physics materials, to ensure accurate and realistic interactions between game objects. Managing colliders required careful consideration of collision layers, triggers, and rigidbody settings to achieve the desired behavior. Each game required specific interaction mechanics. For example, in the tennis game, we needed to implement grabbing motions with the racket and vibration when the ball hits the racket (similar for golf), while for the trash bin game, we had to enable the player to pick up and throw the ball accurately. Implementing these diverse interaction types required careful scripting and integration of the Oculus input system to ensure smooth and intuitive gameplay.

3. Managing Box Colliders: In the trash bin game, we faced the challenge of creating an appropriate collider for the bin. Initially, we used a single box collider for the entire bin, but this caused the ball to bounce off instead of entering the bin. To resolve this, we created four separate box colliders for each side of the bin, ensuring that the ball could enter smoothly without bouncing back. Furthermore, to address the issue of the trash bin potentially falling over when players swung the golf club or racket near it, we implemented a fix to stabilize the bin. Actually, in the virtual environment, every object had the same weight, which made it unrealistic for the bin to topple over due to these movements. Also for the tennis racket and the golf stick we had to handle the box colliders.

4. Precise Grip Handling: One challenge we encountered was ensuring precise grip handling with the hand controllers. Automatically grabbing objects sometimes resulted in grabbing the racket not by its handle or the golf club by its tip instead of the intended grip position. To overcome this issue, we had to separate the box colliders for different parts of the objects, allowing for more accurate grabbing and interaction with the virtual items.

By addressing these challenges and finding effective solutions, we were able to overcome technical hurdles and create games that met the specified requirements. The process not only enhanced our problem-solving skills but also deepened our understanding of the complexities involved in developing interactive VR experiences.

Afterwards, we implemented invisible walls to prevent users from accidentally going beyond the designated play area to reach the ball. We created a double-wall system, consisting of a visible virtual wall (which corresponds to the wall in reality) and an invisible wall. The invisible wall was positioned slightly before the virtual wall, allowing the ball to bounce off and preventing the user from physically crossing the boundary and hitting the real wall. This implementation ensured that users could play the games without the risk of unintended collisions or movements outside of the desired gameplay area, providing a safe and immersive experience.

boundaryControl.cs

Assets > Scripts > boundaryControl.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class boundaryControl : MonoBehaviour
{
    public float xRange;
    public float zRange;
    public float xRangeN;
    public float zRangeN;

    // Start is called before the first frame update
    void Start()
    {

    }

    // Update is called once per frame
    void Update()
    {
        if (transform.position.x > xRange) {
            transform.position = new Vector3(xRange, transform.position.y, transform.position.z);
        }
        else if (transform.position.x < -xRangeN) {
            transform.position = new Vector3(-xRangeN, transform.position.y, transform.position.z);
        }
        else if (transform.position.z > zRange) {
            transform.position = new Vector3(transform.position.x, transform.position.y, zRange);
        }
        else if (transform.position.z < -zRangeN) {
            transform.position = new Vector3(transform.position.x, transform.position.y, -zRangeN);
        }
    }
}
```

Fig. 3. One of the codded C# scripts - Create boundaries for balls

5 NEXT STEPS

The next phase of the project involves performing the initial calibration of the Oculus headset and the virtual environment. This calibration is crucial to ensure that the virtual experience aligns accurately with the physical surroundings, enhancing the realism and immersion of the VR gameplay. To achieve the calibration, we would utilize the positional tracking capabilities of the handcontrollers. By moving the handcontrollers around the table we can determine their positions relative to the virtual environment. This information allows us to align all the virtual objects in the scene with their corresponding positions in the real world and to align the walls in order to replicate the dimension of the real room. The advantage of using the hand controller localization method is its simplicity and efficiency. The relative position of the virtual objects is already modeled by the supervisor to match the real-world scene. By aligning the parent object that encompasses all the objects, we ensure their synchronized movement. This approach requires a minimum of two points, making it a practical solution for calibration. It is important to note that the calibration process needs to be performed each time the application is launched to maintain the accurate alignment between the virtual and physical environments. The subsequent phases of the project involve setting up the experimental environment, recruiting participants, collecting data, and analyzing the results. These tasks are crucial for the successful execution of the research study. The setup of the experimental environment entails configuring the necessary equipment, including the Oculus devices and VR setups, to ensure optimal functionality. Recruiting participants who are willing to participate in the study will be a significant part of the project. During the execution of the study, it is important to guide participants through the VR experience, ensuring their understanding of the tasks and procedures involved. Data collection will involve recording participants' responses, behaviors, and performance metrics throughout the session. The collected data will then be analyzed using appropriate statistical methods and techniques to uncover patterns, trends, and insights. This analysis will provide

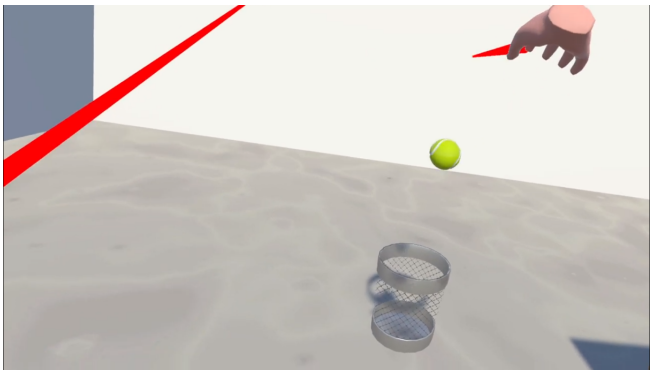

Fig. 5. Thrash bin game screenshot

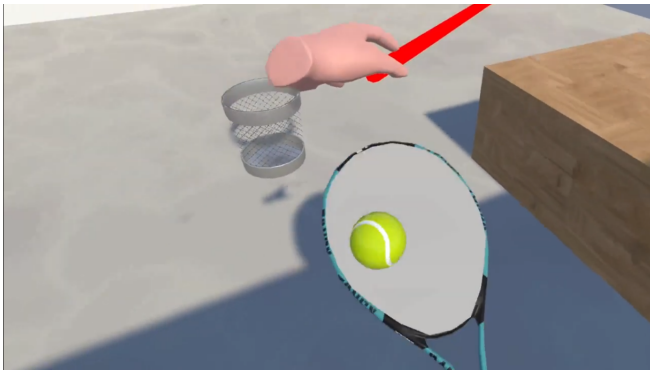

Fig. 4. Tennis game screenshot

a deeper understanding of the effects of VR on users' memory and recall, as well as their integration of virtual and real experiences. These subsequent phases of the project are essential for achieving the research objectives and advancing our understanding of the impact of VR on memory and recall.

6 CONCLUSION

Throughout this project, we familiarized ourselves with Unity 3D and the Oculus Quest platform, which allowed us to develop the VR games. We utilized various components of Unity 3D, such as the Scene Editor and Asset Store, to create interactive experiences with believable physics and interactions. By incorporating hand controller interactions, such as gripping motions using the Oculus hand controllers, we aimed to enhance the sense of immersion and embodiment within the virtual environment. We also learned some concepts of C# programming.

Finally, we arrived at an immersive VR scene with the proposed three simple games. We implemented walls to limit the space where the ball used in the games may go. Also we implemented different vibration to the golf fairways and the tennis racket.

In order to successfully reach the conclusion of this project, it is imperative implement the calibration by using of the handcontrollers', setting up the experimental environment, recruiting participants, collecting data, and analyzing the results.

In conclusion, although we are still in the early stages of this project, it has already provided us with valuable insights into the systematic and rigorous nature of research. We have begun to develop a comprehensive understanding of the systematic processes that underpin the conceptualization and execution of a research project. We are cultivating essential skills, expanding our knowledge base, and developing a critical and analytical mindset. We are progressively recognizing the significance of employing sound research practices. This includes analyse the work done after each step to identify potential gaps and errors (in this case lack of realism for istance) and correct them.

This initial phase serves as a solid foundation for the progress we will make in the project's subsequent stages, guiding us towards achieving meaningful outcomes.