Simulating Location-Based Experiences in VR

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ABSTRACT

This research is a collaboration with Aardman Animations, a world-renowned animation studio to innovate their linear storytelling into a real-time, interactive and spatially immersive experience. We developed a room-scale VR experience to simulate the installation in order to visualise the projection distortion under different conditions. A study was then conducted using our simulation to investigate the effect of distortion of the projections on the experience of immersion and how three factors effected the distortion. This paper explains the preliminary results and the process.

Index Terms: Applied computing [Media Arts]: ;— [Human-centered computing]: Virtual reality—; Computing Methodologies [Virtual Reality]: —

1 INTRODUCTION

Virtual Reality is used across many industries to simulate real-world design propositions in order to explore the implications of different designs such as manufacturing, engineering, and architecture [1]. Taking advantage of the benefits of VR to create full-scale simulations quickly, with less expense, which can be changed and easily adapted. These environments can be used as a testing ground for design choices to avoid costly mistakes and improve the design processes. [4].

The immersive storytelling industry is growing fast, with many storytellers and narrative companies such as Disney adapting well known stories and characters into immersive experiences [7]. These are often location-based experiences that audiences can attend with family and friends. The location-based entertainment industry is predicted to reach 21.42 billion dollars by 2028 [10]. They can provide a place for people to foster positive social interactions with family and friends [2]. However, new installations are often very expensive to build, utilising state-of-the-art technologies. Using new immersive installation setups can mean there is a lack of clear design methods and practices to follow [6]. Virtual Reality can provide a transformative design tool to test and iterate on designs. In this paper we explore a case study of using VR to simulate large scale immersive installations to investigate the effect of distortion on immersion and how different setups can alter this experience.

2 BACKGROUND

This project is a collaboration with Aardman Animation a world-leading animation studio, with characters such as Shaun the Sheep, and Wallace and Gromit. The aim was to innovate Aardman's stop-motion linear storytelling into digital, real-time, interactive, and spatially immersive experiences. The process was to be grounded in research: creative, methodological and technical. The other goal of the project was to design the experience for Chinese audience working with Shanghai Theatre Academy. As part of the research project, an installation was designed.

2.1 Interactive Location Based Experiences in Animation

Many world-famous animation studios are opting to bring their well loved characters to immersive location-based experiences. This enables a different kind of engagement with the characters and brings life back into old stories. These experiences can also benefit individuals and communities increasing social interaction [2]. A study of theme parks in China also showed that audiences responded well to known stories with surprising elements [3].

"World of Friendship" is Disney's new immersive experience coming to London, Paris, and Berlin this year 2023 [7]. Through the cherished friendships of their well know characters such as Lilo and Stitch, audiences explore their own friendships. The installation uses Snapchat's AR technology, audiences use their own phones to make the story come to life. Disney increased its quarterly revenue in 2022 by 4.3 billion dollars, and the CEO attributed much of this profit to the immersive experiences they had launched [9].

The Gruffalo franchise has also opened up an immersive experience in 2022 [8]. Using a mixture of real-life animals, animatronics and film clips audiences are encouraged to be more involved in conservation. Using this new storytelling medium the brand is looking to make changes in the audiences lives in how they engage with conservation.

These experiences all give new exciting ways to interact with animated characters. However, for our project audiences could not download appplications to their phone to interact, software like Snapchat are blocked in China and it would cause development issues between UK and China. We also wanted to utilise the cinematic knowledge that Aardman has in the design of the project. The experience although premiering in China was also planned to tour other venues after, meaning large animatronics would be difficult to tour.

2.2 The Research Project

The brief was also to develop an immersive and interactive design concept that could be experienced as a group without the need to put on headsets, body suits, or any external tech. The interactions would be in real world space where the audience could interact with the characters and each other in a shared space, proven to be a preferred method of interaction [2]. The design was a 15 x 15m square space with projections on the four walls and the floor Fig. 1. Within the space different sensors would enable interaction through movement, sound, and tracked props. The audience would enter the space and a narrative would play on the screen which could be interacted with. This proposition combines the cinematic medium in which Aardman is extremely experienced in with the innovation of immersive technology and interactive storytelling.

The problem of distortion was identified as a design challenge. The projections would be playing synchronous content on all five screens with characters and action moving across screens. This would produce distortion where the walls and floor met. We wanted to understand how much this distortion would affect immersion and what methods could be used to lessen the effect of the distortion. Before the full design of the space and animations were developed

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Figure 1: An image showing the immersive experience design

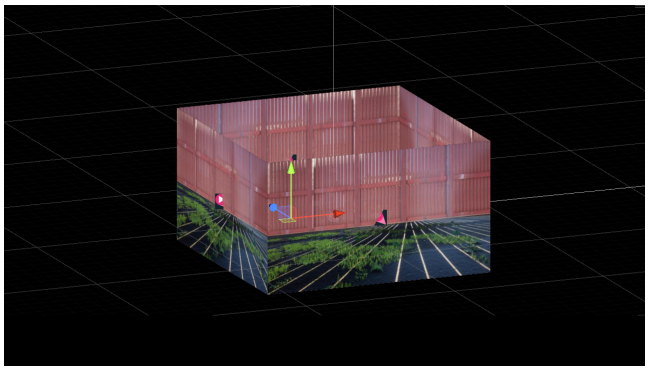

Figure 2: An image showing Project A Unity Scene

this key design issue needed to be explored. Whilst there are many immersive experiences that use projections and screens, there were none to our knowledge that had documented this particular problem.

We created a virtual environment in Unity to simulate a short scene from the storyboard. We chose a scene that involved movement of the audience through the virtual environment as this would be an example of the most extreme case of distortion. The scene starts in a barn with a platform in the middle, the audience are encouraged to stand together on the platform, this causes the platform to descend to the bottom of the barn. As it reaches the floor the barn collapses around revealing a countryside environment.

3 Experiment Design

3.1 VR Experience Set Up

Two VR projects were developed in Unity 3D for the Vive Pro 2. This setup was chosen as it enabled the highest quality of video to be used for the projection videos as Vive Pro 2 offered the highest resolution at the time of making the experiment. Project A was the simulation of the installation space with projection screens and project B the 3d models and animations were recorded to play on the projection screens. Project AFig. 2 was set up with five planes, four to simulate the walls of the installation and one on the ground for the floor projection. The planes were scaled to create a 15m x 15m box, matching the proposed installation space. Each wall could play videos synchronously. We used the AV pro Unity plugin to play the videos to ensure they would be synchronous. Project B had a 3d model of a barn with a platform in the middle. The scene was set up to play an animation of the platform descending. There were 5 cameras in the center of the barn to record the projection for each plane in the barn simulation. The videos were recorded matching the resolution of the headset to reduce aliasing which was 4896 x 2448.

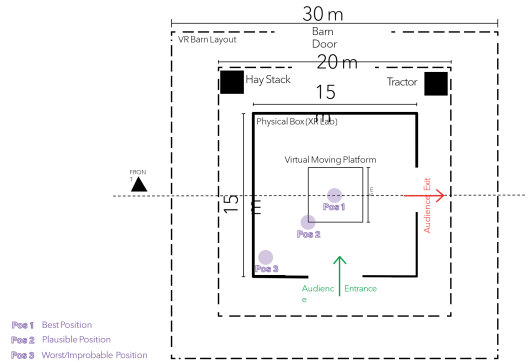

Figure 3: A image showing the floor plan of the immersive experience.

3.2 Scenario Design

The experiment Fig. 3 was designed to test three factors on how they influenced the effect of distortion on immersion. The first factor was the position in the barn: P1 at the center of the platform, P2 at the corner of the virtual platform, and P3 at the back corner of the installation space. The next factor was barn size, we tested three sizes: 30 x 30 (large) two times the size of the installation walls, 20 x 20m (medium), and 15 x 15 (small) matching the size of the installation. The third factor was whether objects were present inside the barn, between the edges of the barn and the platform, testing the effect with objects placed in the corners of the barn walls and without any objects. Each condition would feature a different combination of these three factors creating 18 scenarios. In each condition, the participant started facing the same direction, looking towards the barn door. At the end of each condition participants were asked "On a scale of 1 to 10 how much did distortion affect your experience of immersion". 1 meaning that distortion did not affect the experience at all and 10 meaning the distortion ruined the experience of immersion. Before the experiment started the participants were given the definition of what distortion meant in this context. That we were concerned with the effect of the visual distortion that stopped the images from fully aligning where the video images met. This was contrasted with the distortion experienced when the headset was not properly fitted on the head.

4 Participants and Procedure

A total of 12 participants attended our preliminary study. They were all students from Goldsmiths University. Participants were briefed on what would happen in the first 18 scenarios and told the question they would be asked. They were explained what was meant by distortion and given the chance to ask questions to develop an understanding of the context. The first 21 scenarios were played in a randomized order with the question asked between each experiment. We recorded the participant's head movement data throughout each scenario to track where they moved. We also recorded the projection screen on which the headset gaze was oriented towards, and the exact hit position of the gaze.

5 Preliminary Results

Statistical analysis has started on the results of the first 18 scenarios. We conducted a Three-way Repeated Measure ANOVA with the three factors being Position (P1:middle, P2: platform edge, P3: room edge), Barn size (S1: 30×30; S2 20×20; S3: 15×15), and Object (O1: with objects; O2: without Objects). The only statistically significant result was Position ($F(2,22) = 5.51, p = .011, \eta^2 = 0.334$). Position was expected to be a significant factor in the effect of distortion, however, how this was reflected in the results was unexpected. In the condition with no objects, in barn size

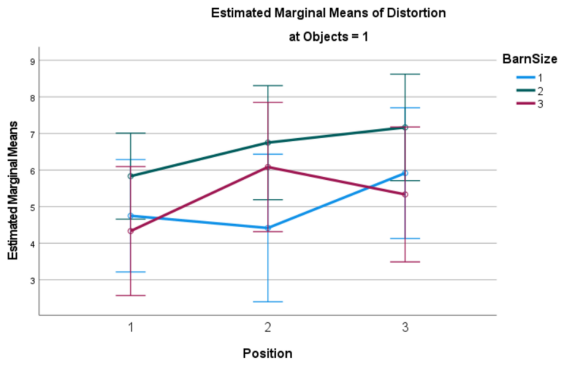

Figure 4: Estimated Marginal Means of Distortion with no objects

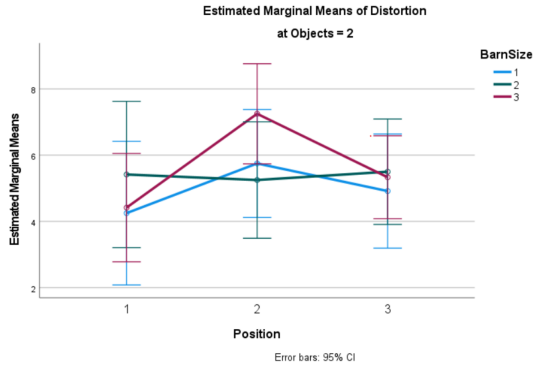

Figure 5: Estimated Marginal Means of Distortion with objects.

2 (medium) the results are to be expected with position 1 (center) resulting in the least distortion effect with distortion increasing as you move away from the center see Fig. 4. In barn size 3 (small) position 2 (corner of the platform) has slightly less distortion effect than position 1 with position 3 (installation back corner) with the biggest distortion effect. Conversely, barn size 1 (large) position 2 has the biggest distortion effect, followed by 3 and 1 being the least. In the condition with objects, the results are quite different Fig. 5. In barn size 2 there is very little difference between the three means with all three positions causing a similar distortion effect. In barn size 1 (large) and 3 (small) there is a similar trend in position 1 the least distortion effect is experienced and the largest effect is experienced in position 2. In barn size 3 (small) the difference between 1, 3 and 2 is quite large with a significant spike in the graph. These are very interesting results and more analysis of the data will be done to further explore the data. Further work will be done to interrogate the data more to better understand the results. Before making design decisions the tests will also be done with our partner Shanghai Theatre Academy to increase the participant group size and to reach the intended audience.

6 Limitations

This study had potential limitations. The experiment taking place in VR meant that the comfort and experience level with VR may have affected the results. Anecdotally the researchers felt those with more experience in VR experienced less distortion effect. This could be because those with less experience were disoriented by using the VR headset which they were not used to. In future studies, we will ask participants about their experience level with VR and only select participants that use VR regularly i.e. more than once a month. There were also factors that would not be the same in the designed experience. For example, there was no storyline or character relationship development. Furthermore, the experiment was done alone in the VR environment. These two factors would most likely increase the experience of immersion through engagement. (cite?) In the next study we will keep this the same as it offers the worst possible scenario. The final limitation we will discuss is the locomotion around the space. As we did not have a 15x15m space for the experiments the users were not able to walk around the full space as they would do during the installation. This would affect the experience of distortion as the distortion changes as you move around the space. In the next study, Shanghai Theatre Academy have a space this large so we will endeavor to make walking around the space possible.

7 Conclusion and Future Work

We created a VR experience to simulate a large-scale projection-based installation in VR. We found that VR was a useful tool in creating a model of an installation where design choices could be played out. We investigated how it could be used to measure how much distortion affected the experience of immersion and which design scenarios affected the intensity of this effect. We found that position was the only significant factor in the effect of distortion on immersion, however, this did not play out in the expected way across the different factors. More analysis of the data is needed to explore exactly how these factors interacted with each other. This is very significant in how the experience will be designed as development continues. Future work will be done expanding the participant size and carrying out tests with our partners in China. We have also been working with machine learning and body-tracking to design movement interaction for large-scale group interactions. Utilising the high rendering capabilities of Unreal we will use machine learning tool InteractML [5] to design the interaction. We have been using the Zed 2i AI camera which has a wide angle lens suitable for large areas, multiple person body-tracking and object detection for use with props.

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