Virtual Reality Game Implementation and Narrative Research

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Abstract: The virtual reality (VR) roller coaster is a popular research project since VR equipment has gradually improved. Researchers have used the VR roller coaster to test various physical reactions of users. Narrative has always been an essential element for games. In this project, the author combined narrative and VR roller coaster, using the Unity engine to develop a VR roller coaster game, and developed narrative elements and game tasks in the roller coaster scene. The purpose of the project is to explore the impact of narrative on the VR roller coaster presence. And the results of game evaluation can further provide some suggestions on VR game development and evaluation for future research. Controlled experiment method has been adopted in the experiment. Three main roller coaster scenes have been built in the game, and participants were asked to play roller coaster scene experiments step by step. In this experiment, due to COVID-19, only three participants joined the game experiment. The dissertation uses the Presence Questionnaire (PQ), Game Experience Questionnaire (GEQ) and semi-structured interview methods to analyze the experimental results. Finally, it is concluded that narrative elements can improve the presence of VR roller coaster games. More narrative elements such as interactive objects and game events in the game are important to increase the immersion of the game. This dissertation puts forward several methods where narrative virtual reality games can be improved, and through the results of participants' experimental evaluations, it provides some useful suggestions for future VR scene developers or game developers.

1. Introduction

Since Edward Link designed a simulator for training pilots in 1929, (Edwin Albert Link - A Chronological Biography)it was the first time that humans had made a sound-shaped and dynamic simulation. For the first time, this simulation content contained the preliminary ideas of virtual reality (VR). In 1984, Jaron Lanier of VPL first proposed the concept of "virtual reality". (Virtual reality: Meet founding father Jaron Lanier, 2013) In the early 21st century and even in the 1990s, many movies about virtual reality technology were born, which attracted many people's yearning for future technology. However, the reality is cruel. Although virtual reality technology has attracted many technical researchers, there are always problems difficult to break through so far. Many relevant practitioners have begun to look for other technological breakthrough, such as artificial intelligence (AI) and machine learning. Eventually, hard work pays off, virtual reality technology has made initial progress. From the birth of advanced virtual reality headsets in recent years (HTC Vive, Oculus Rift S, Valve Index), we can experience many high-quality VR movies and games. And until 2020, the appearance of an iconic virtual reality game (Half Life: Alyx) has made many computer industry practitioners look forward to and enthusiastic about VR technology again. Although the technology is still in the exploratory stage, it has gradually achieved some preliminary achievements.

2. Related Work

In 2019, there was a study on the effect of VR roller coasters on the tourism industry. (Wei, Zhang, & Qi, 2019) They wanted to know how VR roller coasters can help theme park visitors to enhance the user experience. They analyzed data in the past 12 months and found that users' sense of presence was predominantly driven by their feeling of control, followed by participation, effectiveness, curiosity, vividness, temporal association, and enjoyment provided by VR system.

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Their research focused more on the study of user experience in the tourism industry rather than the study of VR itself. But their conclusions also further verified both functional and experiential characteristics of VR applications influence theme park visitors' sense of presence. For current VR technology, the freshness of the user experience is a very important factor. Repeated exposure to VR technology will make the user gradually lose his freshness and weaken his experience of virtual technology slightly.

Another study on the VR roller coaster also focused on the construction of user experience. (Burt & Louw, 2019)They presented a model, Burt's VR Entertainment Primer, which identified critical categories and supplemental elements to consider in order to develop a successful VR enhanced roller coaster experience overlay. Among these studies on user experience, there were also some studies on the emotional impact and physiological adaptation (sickness) of people. A related study used VR roller coaster to test motion sickness. Besides, the researcher also used neural network and objective measurement to judge the severity of symptoms. (Islam, et al., 2020) Other researchers used novel spatial filtering approaches to predict self-reported emotional arousal from the electroencephalogram (EEG) signal of 38 participants who experienced immersive VR roller coaster ride.

3. Methodology

3.1 Game Development

Stage 1: Find and collect Art Resources
Stage 2: Design and create basic environment scenarios
Stage 3: Build and debug a roller coaster
Stage 4: Add narrative flow and UI
Stage 5: Modify and complete the whole game

3.2 Evaluation Steps

There are four scenes in the game, except for one starting menu scene, the other three are narrative roller coaster scenes. Participants would be asked to experience three scenes one by one in the starting scene in order. The reason why they should be executed in order is because the elements in each scene are different, and whether this evaluation can be carried out successfully is to test the three scenes step by step in order. The specific contents of the three scenarios are as follows:

Game Scene 1: A roller coaster in a blank white scene

Game Scene 2: A roller coaster in an island during the day (the roller coaster is as same as the game scene 1's)

Game Scene 3: A roller coaster in a cyberpunk city at night with narrative flow

Considering that the VR roller coaster itself will make participants feel uncomfortable, the participants can choose to pause the game in the middle of test. But the order of testing should still start from game scene 1 to game scene 3.

3.3 Gather User Data

Due to equipment and environmental constraints (COVID-19), the number of people participated in the game evaluation was 3. Although there were not many people through the game evaluation, multiple forms will be used to collect user data in order to get accurate results, including questionnaire surveys and interviews. In this chapter, the author will explain the specific methods used to collect data and describe how to improve them based on this experiment.

3.3.1 Pre-Game Questionnaire

This questionnaire will be provided before players experience the VR roller coaster game. It tells players some basic information about the game: the evaluation of the game has been divided into three steps.

3.3.2 Presence Questionnaire (Pq)

PQ was proposed by Witmer and singer in 1992 and they verified the validity of this questionnaire in 1998. (Witmer & Singer, 1998) Nowadays, virtual reality can make people completely wrapped by virtual environment, and Presence Questionnaire can be used to investigate the presence of the subject. Using this questionnaire in this VR roller coaster study can ensure the correctness and reliability of the results.

3.3.3 Game Experience Questionnaire (Geq)

Game Experience Questionnaire consists of three parts: Core Module, Social Presence Module and Post-Game Module. (Poels, de Kort, & IJsselsteijn, 2007) Since the game in this project is more about experience rather than play, only the Core module was added to my Post-Game Questionnaire. The purpose is to explore participants' Competence, Sensory & Imaginative Immersion, Flow, Tension, Challenge, Negative Affect and Positive Affect.

3.3.4 Interview Questions

Since the main purpose of this dissertation is to investigate how narrative affects the liveness of the game, the author directly asks the participants about the narrative. This interview used semi-structured interview method in order to allow participants to talk about their own experience as much as possible. Main interview questions are the following:

Q1. Do you feel unwell when playing the virtual reality game? If yes, what factors make you that?

Q2. What are the good/bad game elements you feel in the game experience?

Q3. Is the experience different after adding some sceneries to the roller coaster?

Q4. Do you think the existence of the story make the game more attractive to you? Can you explain why?

Q5. Do you have any suggestions to improve the VR roller coaster game?

3.4 Analyze Data

Among these methods of collecting data, Post-Game Questionnaire uses quantitative methods. The collected data will be sorted into tables and displayed in the final evaluation chapter, used as the most important basis for analysis. Presence Questionnaire (PQ) has been divided into four parts: Involvement, Sensory fidelity, Adaptation/Immersion and Interface quality. Since each score varies from 1 to 7, the author can add all the scores for each part to get the average.

The assessment of GEQ is different. According to the standard in the figure below, the average of the seven sets of data can be calculated. The closer the average is to 0, the lower the score is, and the closer to 4, the higher the score.

Competence: Items 2, 10, 15, 17, and 21.

Sensory and Imaginative Immersion: Items 3, 12, 18, 19, 27, and 30.

Flow: Items 5, 13, 25, 28, and 31.

Tension/Annoyance: Items 22, 24, and 29.

Challenge: Items 11, 23, 26, 32, and 33.

Negative affect: Items 7, 8, 9, and 16.

Positive affect: Items 1, 4, 6, 14, and 20.

Fig.1 The Connection between Geq Data and Items

Since the number of participants is small and so do the total amount of data, if calculate the correlation of the data, it will not get significant results. The data of each participant will be analyzed separately. Pre-Game Questionnaire and Interview Questions are using qualitative methods. The text content obtained by qualitative research will be collated by the author and used as auxiliary data to compare with the data obtained by quantitative research. And then compare or combine those data to find if new research results can be obtained.

4. Design and Implementation

4.1 Main Tools

4.1.1 Unity Game Engine

Unity is an operating platform for real-time creation of 3D interactive content. This includes many functions such as game development, art, and architecture. At the same time, the platforms it supports include mobile phones, game host, PCs (Personal Computers) and even virtual reality devices. In this project, the author used Unity Version 2019.3.8f1 to build the virtual reality game.

4.1.2 Oculus Quest

Oculus Quest is an all-in-one gaming virtual reality headset made by Oculus Company, which can be run without connecting to PC using link cable. However, in pursuit of better game running speed, the author used Oculus Link Headset Cable to connect to the computer in this project. Besides, after that, all VR operation are configured with Oculus Touch Controller as a model. The specific configuration and operation will be described in detail later.

4.2 Game Scene Design

The game has three roller coaster scenes, in addition to a start menu scene. Due to the comparative experiment, the three roller coasters will contain different elements.

4.2.1 Game Scene 1 – Baseline Roller Coaster

The first roller coaster was designed as the most common roller coaster. It has no other functions except the experience function as a roller coaster. The first roller coaster will be used as the blank control group for the second roller coaster, so no textures or models other than the roller coaster were added to it.

4.2.2 Game Scene 2 – Island Roller Coaster

The model of the second roller coaster is exactly the same as the first roller coaster. But their difference is that the second roller coaster has a narrative scene, instead of a blank roller coaster. The most important thing that distinguishes the game from reality is that the game can display endless imagination. Hence, I designed the roller coaster on an island, and it would travel through the three different planes of sea, land and air. Compared with the first roller coaster, the second roller coaster gives it a theme: the island. Although this theme does not contain any story content, it will allow players to experience different feelings of the same roller coaster in different environments.

4.2.3 Game Scene 3 – Cyberpunk Roller Coaster

The model of the third roller coaster is completely different from the first two roller coasters. I built this roller coaster according to the structure of the city. The background is set in a future city.

This city is no longer inhabited due to the war many years ago, and only robots remain in this city. The third scene will provide a complete story line and contains a task flow. In addition, the roller coaster itself will be different from the roller coaster in reality. Because it is a VR experience, it is planned to make the roller coaster look more sci-fi. The third roller coaster includes both the theme and a complete story flow, making the player feel that the roller coaster is no longer just an abrupt experience, but an immersive one.

4.2.4 Game Start Scene

Because it is a VR game, the starting scene of the game should be set in a room with science fiction. Players can enter the other three roller coaster scenes from the start scene, and can also exit the game from the start scene. Although it is only a scene transition function, it is necessary to make the interaction reasonable and applicable.

4.3 Optimization

Due to the large number of models and game objects in the game scenes, they caused some reductions in the game frame rate and loss of performance. In order to allow the game to have a better running speed and reduce the loss of equipment, the author made the following optimizations during the development process.

4.3.1 Reduce Unnecessary Game Objects

In the second roller coaster scene, without affecting the roller coaster experience, the range of the sea level and the maximum distance visible to the scenery on the island was reduced.

In the third roller coaster scene, the author deleted some urban objects that were not visible when the roller coaster was running. And reduced some lighting rendering and particle special effects (Fog Effect), but retained the most important lighting effects.

4.3.2 Lod Technology

LOD is short for Levels of Detail, which means multiple levels of detail. LOD technology refers to determining the resource allocation of object rendering according to the position and importance of the node of the object model in the display environment, reducing the number of faces and details of non-important objects, so as to obtain efficient rendering operations. Briefly, when the camera distance is very close to a GameObject, the object will looks finer, and when it is far away, the object will looks blurry. By adjusting the percentage of the LOD Group of the game object to control the distance between the object's fineness and the camera. Usually, because the experience in the game is on a roller coaster, it is usually very fast to move away from some game objects. It is difficult for the naked eye to distinguish the fineness of the objects, so the fineness adjustment will be lower.

4.3.3 Occlusion Culling

The occlusion culling function can disable the rendering of a game object when it is occluded by other objects so that the current camera cannot see it. The process of this function will use a virtual camera to build a hierarchical view of potentially visible objects and apply it to the entire scene. When the game is running, each camera uses these data to determine visible and invisible objects. This ensures that only the objects seen by the camera are rendered, reduces the number of draw calls, and improves game performance. However, due to hardware performance issues, a large number of occlusion culling methods cannot be used in the third roller coaster scene.

5. Evaluation

5.1 Participants

Since the virtual reality equipment and appropriate computer hardware are required to evaluation, meanwhile, due to the COVID-19 in 2020, only three people were able to participate in the test. They are all students under the age of 25. In this experiment, only information such as gender and age are involved, other personal information will not be leaked out. The three participants in this project are experiments conducted in the same place at different times. For the convenience of the following description, I will refer to these three persons as A, B, and C.

5.2 Results

According to three different experiments, three different sets of data were collected. For the convenience of the observation, the author sorted data in tables.

Presence Questionnaire Results Table (Table 1) (the table shows the average score of each data type, and the number is rounded to two decimal places. Rate from 1 to 7)

PQ Data	A	B	C	Total Average
Involvement	4.83	4.67	4.67	4.72
Sensory Fidelity	5.83	5.50	5.50	5.61
Adaption/Immersion	5.75	5.25	5.13	5.38
Interface Quality	4.67	4.00	3.33	4.00

Table 1 Pq Results

Game Experience Questionnaire Results Table (Table 2) (the table shows the average score of each data type, and the number is rounded to two decimal places. Rate from 0 to 4)

GEQ Data	A	B	C	Total Average
Competence	3.00	2.60	2.40	2.67
Sensory & Imaginative Immersion	2.67	3.17	2.33	2.72
Flow	2.40	2.60	2.20	2.40
Tension/Annoyance	0.00	0.00	0.33	0.11
Challenge	0.60	0.80	0.60	0.67
Negative affect	1.50 1.00	1.50	1.33	
Positive affect	2.80	3.00	2.80	2.87

Table 2 Geq Results

5.3 Analysis

The analysis includes three parts. The first is quantitative analysis. Quantitative analysis usually only analyzes the data, so as to analyze the corresponding conclusions based on the results of the data. The second is qualitative analysis. In this experiment, both interview and Pre-Game Questionnaire can be included in qualitative data. Because the number of participants is three, it is difficult to find the correlation between the data from the results of Presence Questionnaire and Game Experience Questionnaire. Hence, this dissertation will focus more on the analysis of qualitative data. In the design process of the interview question, the question was deliberately associated with the results of PQ and GEQ, so both will be analyzed together. In addition, the author himself will evaluate the game experience as a participant from the perspective of a developer.

5.3.1 Quantitative Analysis

In this experiment, quantitative contains two sets of data, one is derived from the average calculated by Presence Questionnaire Items, and the other is the average calculated by Game Experience Questionnaire Items.

The PQ data is scored from 1 to 7. The closer the data is to 7, the greater the presence degree of this data, and the more immersive the virtual reality game. 4 is compared as the overall base value.

From the table above, the overall average value of Involvement in PQ is 4.72, which means that in this evaluation, participants generally believe that the game has a certain sense of presence. Similarly, in Sensory Fidelity, the overall average reached 5.61. It shows that participants think Sensory Fidelity has more sense of presence than Involvement. So does Adaption/Immersion. While for Interface Quality, the total average is 4, which means it stays at a average value.

The GEQ data is scored from 0 to 4. The closer the data is to 4, the stronger the corresponding feature will be. If the data is closer to 0, it can be considered that the corresponding feature is weaker. 2 is a critical value representing an ordinary level, which can be compared to prove whether the data is positive or negative.

From the table above, the total value of Competence is 2.67 which is greater than 2, proving that most players still think they have enough ability to be competent in this game. However, the game itself does not have any difficulty, so this value is actually lower than the author's expectation. Because the process and tasks of this game are too simple, the game experience is reduced. Compared to Competence, Sensory & Imaginative Immersion has an expected rating score. The advantages of the game are reflected in Item 12 and Item 18 (GEQ). In the evaluation of the three participants, the game has a good graphic display and a good game imagination. Next, Flow represents the immersion of the game: whether the player forgets the real world while playing the game, according to the overall average of 2.40, we can see that the degree of this item is only better than normal. Results of items that evaluate Flow has been maintained at a stable normal level, nothing particularly noteworthy.

5.3.2 Qualitative Analysis

(1)According to the Pre-Game Questionnaire, A is young man who often plays games, but he had never experienced VR games or movies before. In the interview, he verbally described that he would feel uncomfortable in the game. The problem is not due to the dizziness of the VR equipment, but caused by the virtual reality game. In the third game scene, the game is dizzy due to the decrease of the game frame rate. At the same time, a believe shows that the better part of the game is that the game scene is realistic, which will be more immersive for VR players. However, the reduction in the frame rate of the game greatly reduces the gaming experience of the third scene.

(2)Compared with A, B was more willing to feel the narrative elements in the game. She felt that the narrative elements in the game could attract her to continue playing. But because the storyline process is too short, she thought that some newspapers and magazines that record the game world information could be added to provide players with exploration, so that players can explore and understand the world more deeply. Regarding the impact of the game experience, she felt that people who use VR for the first time may not know how the game is operated. This game needs better guidance for novices.

(3)According to her description, she believes that narrative events are indeed a good idea in the game. But game tasks can also be displayed more straightforwardly. About the game, she proposed some ideas for adding other theme park facilities in the game.

6. Conclusion

In this experiment, the VR roller coaster has a good presence because of narrative elements. But if a game lacks the core gameplay, then the game will not have a good presence. Narrative is more of an element that can enhance the user experience, but it is not a necessary element for a game. This VR narrative research has ended here. But it may be just a trivial discovery for future virtual reality research. The game development experience is the most precious award for the author. This dissertation shares some solutions and suggestions that can solve some VR development problems based on the experience of game development and game evaluation, hoping to better help the developers of related projects in the future.

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