Abstract

This bachelor thesis aims at improving the user experience and gameplay of FPS game in the field of scenery design. FPS game is currently an increasingly modern video game which is appealing to a large number of players. An elaborate scenery design can attract fresh users in an early phase and provide them with comfortable and satisfying in-game performance. Firstly, an analysis including a questionnaire is implemented to have a research on the current situation of different FPS games. After finding the possible factors, then, stages that simulates the players' in-game conditions are created by Unity3D to search for the key elements that affect the gameplay and user experience. Furthermore, a detailed and comprehensive discussion is conducted. Finally, a conclusion will be made. Some future works and limitation will be discussed to make the bachelor thesis more objective and extensible.

Table of contents

1 Introduction

The FPS (First-person shooters) game has become a sort of extremely popular game in the current game market. From the first FPS game Doom (Bethesda, 2019), released in 1993, to the most recent FPS game named PUBG (PUBG Cooperation, 2019) and Fortnite (Epic Games, 2019), the in-game design and game models have been added and improved a lot by the game developers. The first impression that an FPS game gives to the players is basically the scenery design, which has a dominant factor for players judging whether to continue playing this game or not. In the last 30 years, there is a big progress in this aspect due to the development of computer technology and people's thinking innovation.

First impressions are strongest. It is the visual that get the players interested in the games in the first place (Addo, 2017). The user experience will largely be affected by the scenery design at an early stage compared with others such as game mode, cheating rate, money charging that might be experienced after the whole game routine. Apparently, many existing game developers are still making effort to improve their, for example, stage background and model details to provide the players with a more comfortable and understandable gaming condition. The producer's investment on this part is absolutely critical and sensible, or they may lose a large number of players at the beginning phase.

1.1 Motivation

Since the scenery design has played such an important role, it deserves to do a research on it to improve the gameplay and user experience. As a matter of fact, there are still many scenery design problems in the current games, although these games might have been sold for millions of dollars. Absorb the essence and discard the dross. The elaborate and satisfied scenery design will definitely attract a multitude of fresh players when the game published, so that the profit and fame will be guaranteed.

1.2 Goal

The goal of this bachelor thesis is to, first, find the specific factors in scenery design that have impacts on the user experience and, second, improve the user experience according to the factors found above.

1.3 Method

In this bachelor thesis, it will be examined how to improve the gameplay and user experience of FPS games in the field of scenery design.

Firstly, an analysis of already existing FPS games and their scenery design will be accomplished. Information about how users react to certain sceneries will be collected. Two specific FPS games as representatives for this genre will be chosen and deeper research on them will be taken. Corresponding feedback from the first examination will be taken into account. Abstracting the key points and a detailed explanation of them will be given.

Then, a specific prototype model will be created by Unity3D to simulate the stage that the players possibly meet. It is the most effective way to test and research the problems. Many elements can be changed in this model and the feedback from testers will be recorded, presented and analyzed. The method "control variable" will be implemented.

Finally, a discussion will be made comprehensively and a full conclusion will be summarized.

2 Related Background

2.1 FPS Game

FPS games, which has a full name of First Person Shooter, is a type of shooting game. The player has the view of the character's eyes in the game, usually equipped with a gun or other weapons, and shoot the enemies or the opponent. It is a game with the 3D environment, so these games tend to be somewhat more realistic than 2D shooter games, and have more accurate representations of gravity, lightning, sound, and collisions. (Rollings & Adams, 2006) The combination of a keyboard and mouse are always used to control the characters on a personal computer.

With the development of society, to meet the needs from a variety type of players, game developers have broadened the traditional FPS games by adding new elements such as puzzle (McNeilley, 2007), role acting, Battle Royale. Therefore, the FPS game is currently a very extensive concept.

Speaking generally, the FPS game can be categorized into two types. PvE and PvP. It is a macro game classification suitable for all the video games at present.

2.1.1 PvE

PvE (Player VS Environment) is a term used in video games. A PvE game is a game type that players fight computer-controlled enemies. (Bartle, 2003) Usually, this mode can be played alone or with other online players and AI companions. With a first-person view, players can shoot the monsters and collect specific materials to accomplish the missions. Players usually pay the scenery design and story line close attentions.

Figure 2.1.1: Screenshot of Borderlands 2. A classic PvE game published in
September 2012 by 2K Games. (Amini, T, 2019)

2.1.2 PvP

PvP (Player VS Player) is a game type that players conflict with two or more live
participants. (Bartle, 2003) For an FPS game, it usually contains competitiveness and
requires an intense reaction from the players. Many world-famous gaming clubs
cultivate the professional players from an early age for this type of game to win the
international tournament and prize. A PvP game always emphasizes fairness and
equity. Hardcore and teamwork are its main elements.

Figure 2.1.2: Screenshot of CSGO, Map: Inferno. A PVP game published in 2012 by Valve and Hidden Path Entertainment. (Steam, 2019)

2.1.3 Battle Royale Game

Battle Royale game is a newly generated type of FPS game. To speak strictly, it belongs to PvE. However, a Battle Royale game combines survival, exploration, and scavenging elements in a survival game with last-man-standing gameplay. (Wikipedia, 2019) The players start with no equipment and should search the weapons and items in the maps. Their mission is to kill every opponent to win the game.

The Battle Royale game emerged firstly in Minecraft (Mojang, 2019) with a prior name "hunger game". Later, DAYZ (Steam, 2019), a mod of ARMA 2, and H1ZI (Daybreak Game Company, 2019) acted as transitional parts. Some modern games like PlayerUnknown's Battlegrounds, Apex Legends (Electronic Arts Inc, 2019) symbolize the maturity of Battle Royale game at present.

2.2 Color Psychology

Color psychology is a study of human behavior in terms of different colors. (Ferreira, 2018) Each color will provide the player with a different feeling, and then, the player will have different reactions. It is a commonly used subject that implemented in marketing theory, pharmacy, brand design, etc.

People from different cultures will give the same color diverse meanings. For example, in China, people regard red as pleasure and ceremony, but in some western countries, they think the red represents financial deficit and risks. This is an example in common knowledge to demonstrate the importance of color in multiple areas.

To have a better understanding of color psychology, we should begin with the elements of color.

2.2.1 Elements of Color

The following three terms can describe elements of color. Hue, Value, Chroma. (Itten, 1970)

Hue is one of the main properties of color. It is commonly acknowledged by people to describe a color. Under the light with different wavelength, eyes can perceive different hues, which are very apparent characteristics of colors.

Value, also known as "lightness", is a representation of variation in the perception of a color or color space's brightness. People usually express them as brighter or darker. (Nippon Denshoku Industries Co ., LTD, n.d.)

Chroma, which has another name "saturation", describes the color by its strength and brilliance. It refers to the intensity of color in an image. The chroma can be calculated by the number of grey elements in a specific color. When the saturation is zero, you will see a totally grey picture.
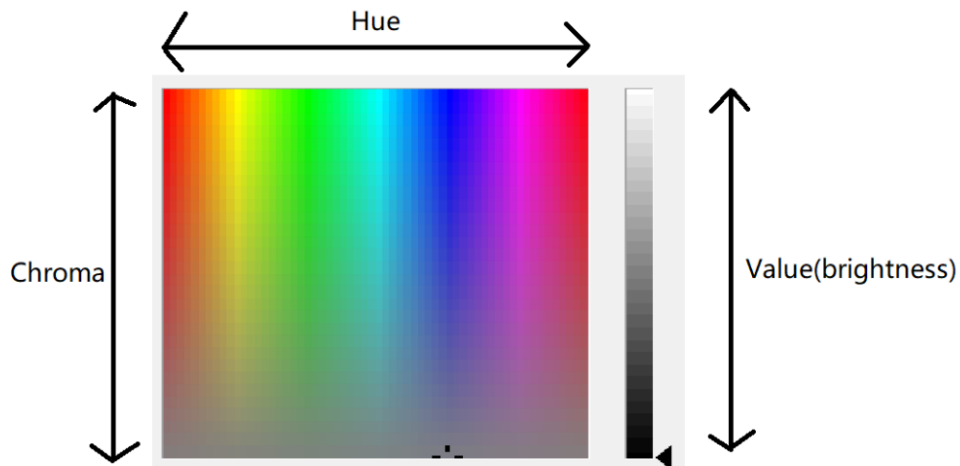
Figure: shows the relationship between these three elements in a single graph.

2.2.2 RGB Color Model

RGB color model is an additive color model that red, green and blue lights are added together in various ratios to produce a broad array of colors. (Hirsch, 2004) This model is broadly used in displaying images and videos in the field of computers and mobile phones. However, different devices will analyze and show the RGB values in various results due to the difference in manufacturers and dye elements.

2.2.3 Human Reaction to Colors

About 62-90 percent of the assessment is based on colors alone. (Singh, 2006) Besides in marketing, advertisement design and other areas, colors also play an important role in game design. Game designers tend to make the best user experience at the in-game playing. To satisfy most of the players, the scenery design should be accommodated to most of the peoples' intuitive reactions. For example, the whole background should be in a comfortable color tone. An interactive object or a specific

NPC (Non-Player Character) model in a game should be clearly identified and recognized. In this part, the importance of colors will arise.

There are so many factors contributing to the reaction of human eyes in terms of different colors. However, people may response entirely differently despite facing the same image. For example, the differentiation of screens, the people status, mood, clock time of day, age, gender. Therefore, in experiments, these minor but potential factors should be taken into consideration and avoided. Consequently, the results can be objective and reasonable.

2.2.4 Textures on Objects

Textures are images that added on the surfaces of objects. Sometimes, they are multiple colors and stripes that mixed together to cover the ground or walls. Textures are used everywhere in the game including models and backgrounds. They are used to make the game colorful and interesting instead of blank and boring. (Geig, 2013) It is hard to describe the feature of textures by a single color. People roughly describe them with hue or materials that they are made of.

2.3 Game Engine

2.3.1 Introduction

A game engine lays the ready-made framework for game developers to create and build video games. (Unity Technologies, 2019) With game engines, people can create numerous gaming applications. Reusing the engines and codes is effective and money-saving for companies. (Interesting Engineering, 2016) Most game engines comprise rendering engine, physics engine, sound, memory management, and others. Each game engine has its own features and will finally produce games with their unique characteristic.

2.3.2 Effect on Scenery Design

It is the rendering engine that decides the style of scenery and character model. A rendering machine is a software component that takes marked up content and formatting information and displays the formatted content on the screen. (Chokshi, 2015) Apparently, each game engine has its own design style in the graphic. Even some engines regard their graphic design as merit and finally become a selling point. In game forums, there are many players that are attracted by one specific graphic design and insist on playing the game that only made by this kind of game engine. Here are some popular game engines that have made so many successful games.

Unreal Engine 4 (Epic Games, 2019)

CryEngine (Crytek GmbH, 2019)

Frostbite Engine (Electronic Arts, 2017)

Unity (Unity Technologies, 2019)

Unreal Engine 4:

Unreal Engine 4 was published in 2012 by Epic Games. In the beginning, Unreal is designed for developing FPS games. The formal versions are UE3 which was published in 2006, UE2 and UE1. In the field of graphics design, Unreal has an extremely deluxe rendering system. This engine contains many advanced technologies. For examples, Lightning Path, Lit Translucency, Sub-Surface Shading, GPU particles. (Epic Games, 2019) All these elements contribute to the success of the Unreal engine. It has gained a number of zealous players and developers.

Unity3D:

Unity is a cross-platform real-time engine developed by Unity Technologies. This engine can develop both 2D games and 3D games. Within 3D developing, about the scenery design part, it contains bump mapping, reflection mapping, screen space

ambient occlusion. Because of its ease of use and cross-platform, Unity has gained a number of developers currently.

In this bachelor thesis, Unity3D will be mainly used to simulate the stages and do the user-experience test.

2.4 C#

C# is a multi-paradigm programming language with features like strong typing, imperative, object-oriented. (C# Language Specification, 2006) It is a commonly used scripting language in Unity3D. With C#, developers can tell the game objects how to behave and interact with each other. (Unity Technologies) One can get the C# tutorial either from Microsoft. Net or Unity3D tutorial. C# is originally created to substitute java. The most recent version is C# 7.3.

In this bachelor thesis, the scripts of all the software are written in C#.

2.5 ISO9241

ISO9241 is an international standard decided by International Organizational for Standardization. This standard is originally designed for office work. From 2006, the standards were retitled to the more generic Ergonomics of Human System Interaction. (In Wikipedia, 2019)

Among all the standards series, ISO9241-110 gives a general principle to design software. Here are the seven points.

- suitability for the task,
- suitability for learning,
- suitability for individualization,
- conformity with user expectations,
- self-descriptiveness,

- controllability, and

- error tolerance.

When talking about game design, it is user-centered. User-centered design is specified in EN ISO 9241-210 --- Human Centered Design Processes for Interactive Systems(ISO 9241-210 2010). (Bernhaupt, 2010) Game design is too general, including many aspects. Here, we only focus on the scenery design, which can also take these points as a reference.

3 Approach

The main research consists of six procedures.

Game collection

Game analysis

Possible factors

Game stage design

Testing

Result and analysis

3.1 Game Collection

In this phase, games in the current market will be collected according to the requirement.

3.1.1 Market Situation

There are currently thousands of FPS games in the market. Each of them has its own features and characteristics. Here, we tend to choose those game made by bigger companies or have remarkable achievement in the game field. These games are commonly accepted by most players. They also can clearly reveal the current situation of FPS games. This bachelor thesis chooses the FPS games within two methods. Official website analysis and Questionnaire. The passage below shows the details

Official website analysis:

Firstly, we make research on the website. The reason is that it can provide some reference for the following Questionnaire part. Here are some ranks and recommendations from various websites.

Table 3.1.1.1: The Most Popular Shooter Video Games Right Now (06/05/2019)

1	Tom Clancy's Rainbow Six Siege
2	Counter-Strike: Global Offensive
3	Apex Legends
4	Overwatch
5	Battlefield 1
6	Call of Duty: Black Ops ||||
7	Titanfall
8	PlayerUnknown's Battlegrounds
9	GTA 5
10	DOOM

Source: https://www.ranker.com/list/most-popular-shooter-video-games-today/ranker-games

Table 3.1.1.2: Best FPS Games to Play in 2019-Top 15 Modern Shooters
(06/05/2019)

1	Tom Clancy's Rainbow Six Siege
2	Dying Light
3	Apex Legends
4	Counter-Strike: Global Offensive
5	Overwatch

6	Paladins
7	Borderlands
8	Tom Clancy's The Division 2
9	FarCry 5
10	Team Fortress 2

Source: https://www.progamerreview.com/best-modern-fps-games/

Table 3.1.1.3: The Most Watched Games on Twitch, May 2019

1	Fortnite
2	Grand Theft Auto V
3	Overwatch
4	Counter-Strike: Global Offensive
5	PlayerUnknown's Battlegrounds
6	Apex Legends
7	Call of Duty: Black Ops ||||
8	Tom Clancy's Rainbow Six Siege

Source: https://www.twitchmetrics.net/games/viewership

Figure: 3.1.1: Steam and Game Status:

Source: https://store.steampowered.com/stats/ (Available in 07/05/2019 GMT+8 0:06)

Besides the screenshot and charts above, other rank lists are also referred. Of all the statistics, to make a comprehensive summary, these games can represent the current situation of FPS games market and will be taken into further research as candidates. (in alphabet order)

Apex Legends

Battlefield 1

Call of Duty: Black Ops ||||

Counter-Strike: Global Offensive

Fortnite

Overwatch

PlayerUnknown's Battlegrounds

Tom Clancy's Rainbow Six Siege

*If you want to realize each game in detail, links of official websites are available in References.

3.1.2 Questionnaire

This questionnaire aims to collect the ideas from those regular game players and their personal views on specific games. Since different people play a variety of games, the questionnaire will only give them possible game selections obtained from the results above.

The target testers are people who have played FPS games before and have a basic knowledge of FPS games. The questionnaire is divided into two parts. First, testers should choose the FPS games that they have played. Unique and possible questions have been prepared for each individual game. The testers will only answer questions related to the games that they have chosen. I also consult possible ideas from the testers to get a more subjective result. Second, some other general questions will be asked in order to collect their macro views to the scenery design of FPS games.

The main body of the questionnaire has been added in Appendix A.

The Chinese version is available in https://www.wjx.cn/jq/39035155.aspx

3.1.3 General Analysis and Result

This is the general result of the questionnaire.

Number of available testers: 38

Male/female ratio: 28/10

What's your frequency to play FPS games?		
	Number	**Ratio**

Every day, more than 1 hour	24	63.16%
Every day, less than 1 hour	7	18.42%
Every two or three days, 1-2hours	0	0%
Not too many times	7	18.42%

Table 3.1.3.1

Choose your most played FPS games		
Game	Number	Ratio
Tom Clancy's Rainbow Six Siege	11	28.95%
Counter-Strike: Global Offensive	16	42.11%
Overwatch	13	34.21%
Battlefield 1	4	10.53%
Apex Legends	7	18.42%
PlayerUnknown's Battlegrounds	8	21.05%
Fortnite	2	5.26%
Call of Duty: Black Ops ‖‖	5	13.16%

Table 3.1.3.2

As the previous game list shows, we can divide these games into two main types. One is two-teams FPS fighting game, one is Battle Royale. Among them, Tom Clancy's Rainbow Six Siege, Counter-Strike: Global Offensive, Overwatch, Battlefield 1 are two-teams FPS fighting games. PlayerUnknown's Battlegrounds, Apex Legends, and Fortnite are Battle Royale games. Apparently, these two types of games have become increasingly popular and have occupied most of the current game market. Making deep research and improvement on these two types of game are practical and functional for the development of FPS games.

(*Call of Duty: Black Ops ||||. Due to its high price and prohibition in some specific areas around the world, I have not tried it before and fail to make unique questions for it.)

3.2 Game Analysis

3.2.1 Two-teams FPS Fighting Games

Firstly, we come to analyze the two-teams FPS fighting games.

A general score to the graphic and scenery design of game	
Game	**Average score**
Tom Clancy's Rainbow Six Siege	4.36
Counter-Strike: Global Offensive	3.63
Overwatch	4.23
Battlefield 1	4.5 (few examples)

Table 3.2.1: Result of the question "A general score to the graphic and scenery design of game" in two-teams FPS fighting games

Tom Clancy's Rainbow Six Siege and Overwatch have higher scores in graphic and scenery design than Counter-Strike: Global Offensive (CSGO). For these three games, in the question "In the game, have you ever died because the model colors of enemies are not bright enough?" has been asked respectively. In Tom Clancy's Rainbow Six Siege and Counter-Strike: Global Offensive, 81.82% and 87.5% agree with this point. However, for Overwatch, only 30.77% agree with this point. According to the game condition, the main difference is that in both Tom Clancy's Rainbow Six Siege and Counter-Strike: Global Offensive, the body figures are real and slightly dark. In Overwatch, since the characters models and backgrounds are animated, the colors are brighter and red outlines have been added to increase the recognition degrees.

Furthermore, in the question "In the game, have you ever suffered visual fatigue when having stared at one specific dark or bright place for too long?", 72.73% agree with this statement. In the free-suggestion part, some testers argued that although the stage is real and elaborate, some parts of the map are extremely dark. This problem can interrupt the in-game performance of players. No wonder it results in negative feedback. Apparently, the background color of a map also needs to improve.

Tom Clancy's Rainbow Six Siege and Counter-Strike: Global Offensive tend to become hardcore FPS games. In the question "Do you think it is necessary to make a hardcore FPS game very real? Or you can accept some aid from graphics design?", 50% agree and 50% accept the aid. The concept "hardcore" is probably still vague or obscure in some people's mind. It can be shown that it is still a controversial question that the players need the graphics aid or not.

3.2.2 Battle Royale Games

Next, we come to analyze the Battle Royale games

A general score to the graphic and scenery design of the game

Game	Average score
Apex Legends	3.57
PlayerUnknown's Battlegrounds	3.25
Fortnite	(few examples)

Table 3.2.2: Result of the question "A general score to the graphic and scenery design of games" in Battle Royale games

In general, Apex Legends has a higher score in graphic and scenery design than PUBG (PlayerUnknown's Battleground). Apex Legends, in compared with PUBG, was published later on February 4, 2019. It should have better graphics and a more exquisite scenery design. Since the central playing method is not changed, the analysis becomes more straightforward. Besides killing the enemies, which is similar to classic two-teams FPS fighting games, the player will also face the questions of picking items on the ground to arm themselves. In the question "In the game, have you ever missed some items on the ground because the color or texture of items are so similar to the floor's?", a 50-50 result is showed in both two games, which means some people still feel annoyed and dissatisfied in this situation.

The biggest difference in PUBG and Apex Legends is that the items in Apex Legends have white outlines in contrary to those in PUBG. Please take a look at the following questionnaire results.

In your perspective, in the game, do the white outlines around the items provide you with recognition helps? (Apex Legends)	
Yes	100%
No	0%

In your perspective, is it possible to increase the recognition rate of cars and items if the game designers add colored outlines around these objects? (PUBG)	
Yes	87.15%
No	12.5%

In the game, have you ever failed to differentiate the real cars and the fake car pictures in the map? (PUBG)	
Yes	62.5%
No	37.5%

In your perspective, what do think of the final game performance if we add both the figures of enemies and mates with colored outlines? (PUBG)	
Positive	12.5%
No influence	12.5%
Negative	75%

The result shows that people find it difficult to distinguish the items and weapons on the ground with natural objects. The colors and brightness again play an essential role here. What's more, people find it reasonable to add outlines around the items and cars in PUBG to increase the recognition rate. However, few people agree to add outlines around the **enemies' figures**. Probably, they think it will make the game too easy or unreal.

Some testers also claim that the scenery is sometimes slightly dark. The graphics seem not too comfortable. This is the same problem that happened in the former analysis.

3.3 Possible Factors

As a result, both two-teams FPS fighting games and Battle Royale games need to make an improvement.

3.3.1 Factors in Two-teams Fighting Games

This is a common situation that may occur in every two teams FPS games.

Figure 3.3.1: Player should carefully watch two sides, even more.

The screenshot is from CSGO, which is a popular FPS fighting game. The enemies will appear from both two sides, but the player can only watch single side and stay alert on the other side. In this situation, **model color and background color, light condition, and visible model size** should be taken into consideration. Other elements

such as gender, personal mood, should be kept steady and equal, which means "control variable" will be implemented here.

3.3.2 Factors in Battle Royale Games

This is a common situation that may occur in a Battle Royale game

Figure 3.3.2: Items in some dark areas and corners are almost invisible

The screenshot is from PUBG. When the players land on the ground, they should search the items and weapons to arm themselves. Players may rush into the house or search outside. A clear appearance of items is critical and necessary for all the players. **Outlines** might be a good solution which is available in Apex Legends. Despite the elimination of outlines in other Battle Royale games, **colors, textures and light condition** are still worth researching.

3.4 Game Stage Design

3.4.1 Unity3D Information

Unity3D is a game engine suitable for developing small PC games and mobile phone games. It can fulfill the basic needs of stage simulation and game test. Apart from other big game engines, its low cost and ease of use are quite suitable for this game test. The texture and color of GameObject can be easily adjusted.

Unity3D provides many preset standard asset packages that all the developers can use. For example, the character of FirstPersonController, the example texture of walls, items are all utilized within this bachelor thesis. These materials are

The Unity IDE for this bachelor thesis is Personal version which is free for the small project, downloaded in https://store.unity.com/

The Standard Assets utilized in this bachelor thesis can be downloaded in https://assetstore.unity.com/packages/essentials/asset-packs/standard-assets-32351

Assets from the Asset Store can be accessed and used in this bachelor thesis. See more details in https://unity3d.com/legal/as_terms

The scripting language used in the following two situations is C#. The function is to control the trigger event and scene switching.

3.4.2 CSGO Situation

To build up the CSGO situation, we need a similar first-person view to simulate the player status at that moment. Just like the pictures showed above, two walls are put along two sides to limit the player's horizon. Opposite the player, there is a big wall that regarded as the background. Also, the light condition can be changed in this map.

When the game starts, the player is supposed to stare at the red point in the middle. After random seconds, one object will appear either from the left side or the right

side. Then, the player should press the "Space" key as quickly as possible to make the immediate reaction. After that, it jumps to a new scene and the reaction time will be shown at the top left corner of the screen. The tester can press the "Play again" button to restart the game.

In order to eliminate the uncertainty of mouse control and aim skill, we utilize the simple "Space" key as the trigger to make the reaction, which increases the stability and authenticity. Multiple colors, background texture, and light condition will be implemented into this situation to get a more detailed conclusion.
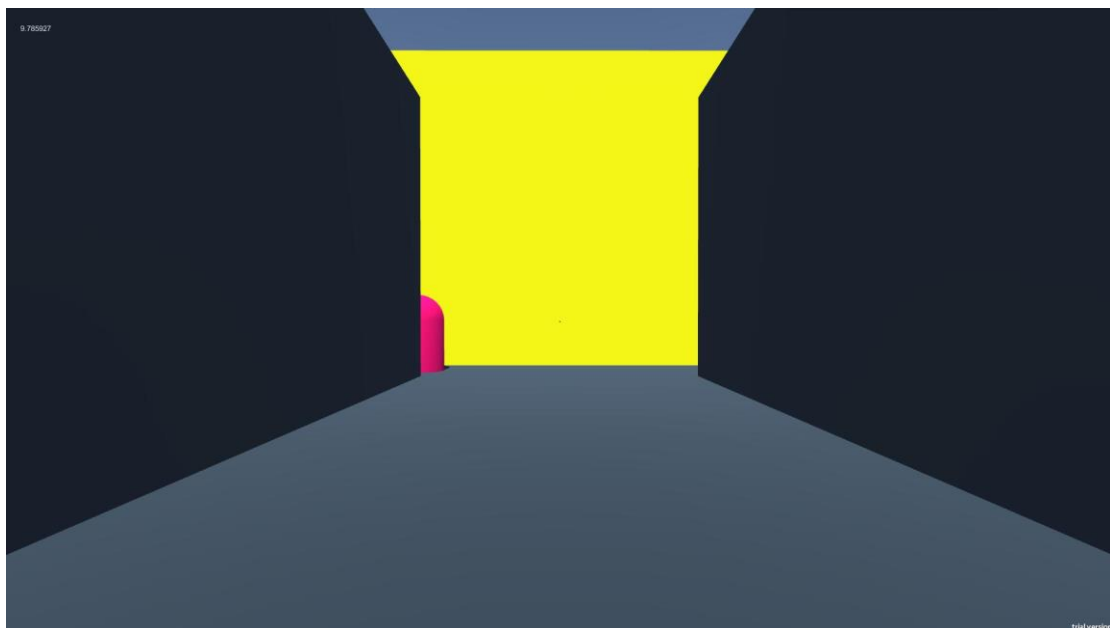

Figure 3.4.2.1: Screenshot of the demo for CSGO Situation

At the configuration part, we choose the Screen: 1920*1080, not windowed and Graphics quality: ultra. This is to provide the testers with a real in-game environment prevent the game from becoming stuck.
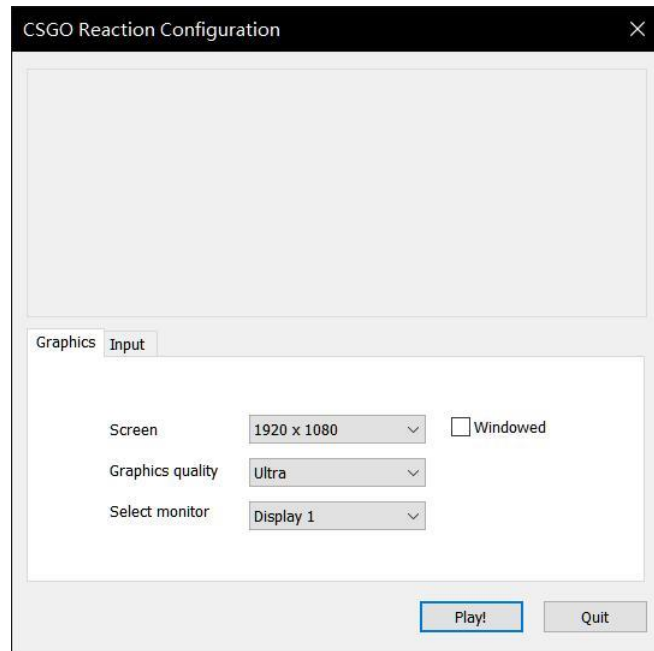
Figure 3.4.2.1: Screenshot of Configuration

The first scene is the Start scene. It contains some basic instructions to remind the testers not to forget the routine.

Figure 3.4.2.3: Screenshot of the first scene

By changing the elements listed above, multiple components in the Inspector are manipulated.

Light is set as directional light, white (RGB: 255, 255, 255). Transform.Rotation is responsible for the light condition part. After adjusting the y-axis and z-axis, we change the light condition by changing the x-axis. The final effect shows that the most apparent change of light occurs between 0' to -10', which is an ideal testing interval.

Left wall and right wall are both set to be black. Materials can be added both at the front walls and figures. All the example Materials are from Standard Assets. The Material in the Emission version is self-made.

To eliminate the psychological factors, the figures will suddenly appear from 5 positions on the ground randomly. The tester finds it difficult to keep alert simultaneously at five points so that gazing at the midpoint is the best choice.

After pressing the "Space" key, the scene changes, and the reaction time will be shown. The tester can press "Play again" to restart the game.
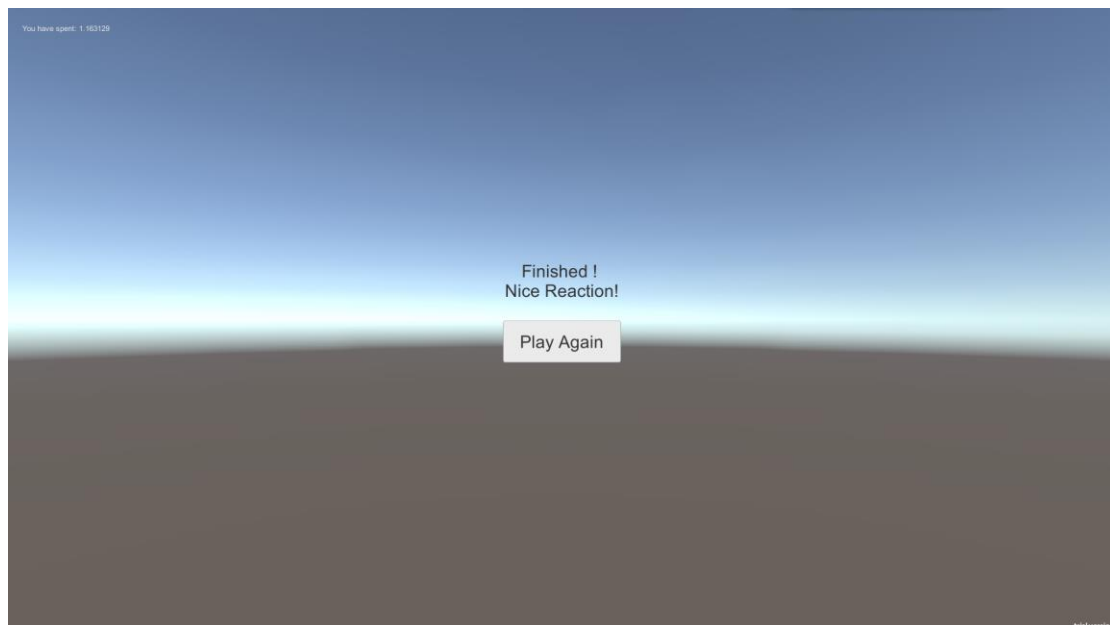

Figure 3.4.2.4: Screenshot of the Finished scene, reaction time is showed

3.4.3 PUBG Situation

To simulate the PUBG situation, we need a square plane and put several colored items on the ground. The first person view is also needed and it can move in this plane freely. A quad is placed around this plane to limit the range that the tester can reach. A light source is put above this map to simulate the light in the game.

There are ten items in this stage. The tester's mission is to collect these items as quickly as possible. When the tester press start button, he can move the character and start running. If the character moves closer to an item in a small range, this item will disappear automatically, which means the tester has succeeded to collect this item. After collecting the last items, the whole game is over and time is showed at the top left corner. The tester can press the "Play Again" button to restart the game. Multiple colors, textures, and light conditions will be implemented to get a more definite conclusion.
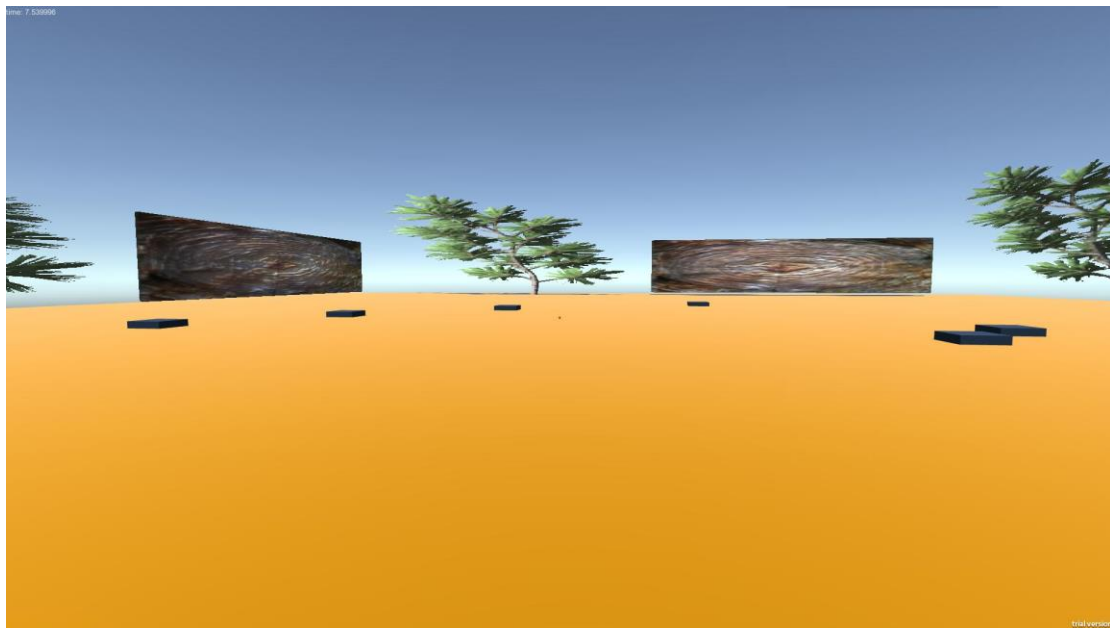

Figure 3.4.3: Screenshot of the demo for PUBG Situation

About the configuration, we also choose the Screen: 1920*1080, not windowed and Graphics quality: ultra.

The first scene is a Start scene. It contains some basic instructions to remind the testers not to forget the routine.

Light condition settings are the same as that in CSGO Situation part. The quad walls are added with tree and wooden materials to basically simulate the real stage. In some basic versions, we use the earth yellow, which is RGB (#e1a95f). In other versions, both the ground and items become textured.

Totally ten items in this map are suitable for the size of this stage and also for the whole test to save time. Each item is added with script. When the tester gets closer, it disappears automatically. After collecting the last items, it jumps to a new scene that shows the total time that the tester has used. Tester presses "Play Again" to restart the game.

Due to a variety of item types, I do not take the size of items into consideration.

3.5 Testing

3.5.1 General Testing Information

Tester number: 3

Tester genders: 2 males, 1 female

Tester ages: 21-22

Tester conditions: played FPS games before, familiar with the basic operation of keyboard and mouse.

Other details: testers with nearsightedness are allowed to wear glasses

Testing environment: normal room light, normal sitting posture, about 65cm from screen

Testing time: Evening between 19:00 – 21:00 (regular gaming time)

Testing device: HP OMEN2 i7-6700 GTX965

Keyboard info: Razer BlackWidow X

Mouse info: Razer RZ01-0213

Screen info: BOE0679, 15.3 inches, 16:9, 1920 *1080, 60FPS

3.5.2 Test in CSGO Condition

Each Tester is required to play five times in every game level. After each play, the final time will be recorded in a time list respectively. Furthermore, their direct feedback and in-game performance will also be recorded as critical reference information.

Before the exact test starts, the tester should play a demo to get familiar with the basic rule of this game. The demo is a very classic version with clear scenery design and simple graphics. After that, an inquiry is made to check whether they have realized the whole game routine. Finally, the test begins.

There are several levels on this game. At first, I have created 13 different levels to get rather fare results on each element that has effects on user experience and gameplay. During the testing phases, I may delete some useless versions and add new elements according to the feedback of testers.

The test results will be shown in the analysis part.

3.5.3 Test in PUBG Condition

The whole procedure resembles that in CSGO Condition. Except there are 12 different levels. The result will also be showed in the following analysis part.

3.6 Result and Analysis

3.6.1 Result in CSGO situation

After the elimination and adjustment of the variable versions, we finally make 13 available versions that suitable for this CSGO Situation. The results are shown above with each version's attribute.

Light angle: the light angle in the Unity3D, which represents the direction of the light above. The lower, the darker.

Wall texture/colored: material that added on the front wall. Some are simple colors; some are fully textured.

Figure texture/color: material that added on the figure. Some are simple colors; some are fully textured.

Average time of use: average reaction time for all the testers in this situation

Deviation: variance that includes all the data in this situation

Details: words that describe the testers' behaviors and feelings

*A and B means **different textures**, A and a means **similar texture**,

MF: the body moves forward

VF: intensive visual fatigue

D: disabled to react

1. Normal

2. Moving forward

3. Visual fatigue

4. Disabled

/	Light Angle	Wall Texture/Color	Figure Texture/Color	Figure size (comparative)	Average Time of Use (s)	Average Deviation	Details
0	90'	yellow	pink	normal	0.42396	0.00874	1
1	90'	yellow	pink	smaller	0.5003	0.44242	1
2	-5'	yellow	pink	normal	0.4514	0.01536	2
3	90'	A	B	normal	0.46056	0.015035	1
4	-5'	A	B	normal	0.45228	0.005846	2
5	-9'	A	B	normal	0.6627	0.037063	2, 3
6	90'	A	a	normal	0.45774	0.010842	1
7	-9'	A	a	normal	0.59456	0.040853	2, 3, 4
8	-9'	A	a	smaller	2.01814	2.000537	2, 3, 4
9	-9'	A	Emission	normal	0.40212	0.013367	3

10	90'	Yellow (single particle)	pink	normal	0.49014	0.0057	Watch particle
11	90'	Yellow (multiple particle)	pink	normal	0.48664	0.008883	Watch particle
12	rotate	yellow	pink	normal	0.56496	0.005206	uncomfortable

Table 3.6.1: Result of CSGO Situation

The table above clearly shows the result of each of the possible factors.

In some basic versions (0,1,2), the texture and color of items and walls are simply colored. Yellow and pink have a great contrast, which is suitable for tasks. No matter the size becomes smaller, or the environment becomes darker, the reaction time is almost equal. This means the player can distinguish well if the texture is simple and clear.

In versions 3,4,5, the textures between walls and figures are largely different. The result shows that, with enough light condition, players can still distinguish and react well. However, with a slightly darker environment, the players will intuitively put eyes closer to the screen to make the reaction, even though they have been told to keep normal postures to do the test. Furthermore, when the environment gets extremely dark, which is possible in some small stages in fighting FPS games, the testers have strong visual fatigue in keeping alarmed. They may blink and sometimes miss the critical opportunities to catch the figure. 0.03706, the deviation in version 5, fully demonstrates this point, which is higher than those in previous versions.
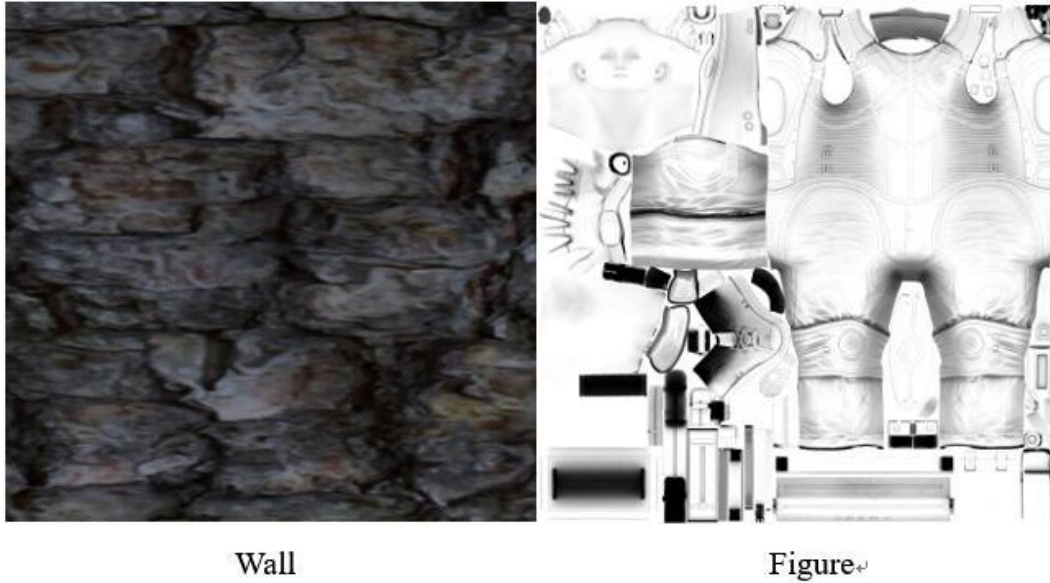
Wall   Figure

Figure 3.6.1.1: Texture comparison of wall and figure

In versions 6,7,8, the textures are nearly the same both in figures and walls. This may happen accidentally in some situations, not regularly. The result shows that if it in a bright environment, the reaction times are in ordinary. However, in the extremely dark stage, the testers sometimes become disabled to accomplish the mission. No wonder the visual fatigue occurs. The deviation raises up to 2.000, which means the testers may totally not be aware of the figure.

In version 9, an "Emission" material is put on the figure. This means there is a high-light hint that independent of the environment light. The testers still show visual fatigue because of the dark environment (-9' light), but their instant reaction times keep a high standard. It demonstrates that a graphical hint or bright outline is beneficial to the in-game performance of the player.

Figure 3.6.1.2: visible shiny figures in the darkness

In versions 10 and 11, we add small and big particle systems in the environment. This provides a distraction to the testers. The result shows that the reaction time is apparently longer than that in version 1, which is without distraction. The testers tend to unconsciously watch the small points floating in the sky. Deviation also becomes slightly bigger in stage with multiple particle systems.
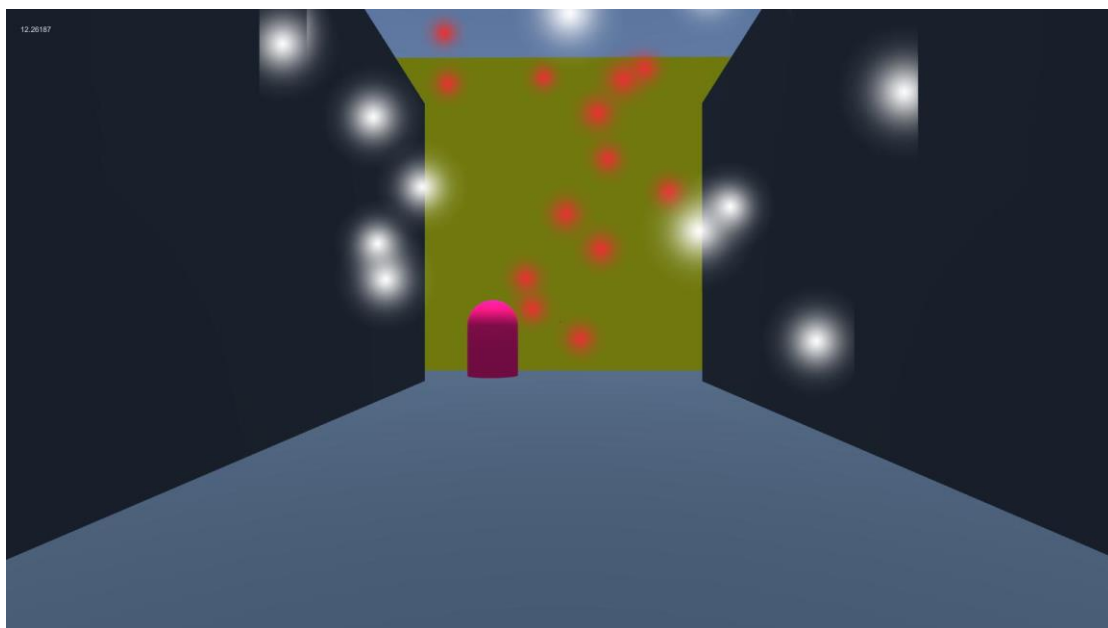

Figure 3.6.1.3: Screenshot of particle environment, causing a sudden interaction

In version 12, we rotate the light source and create the flicker effect. This condition simulates the situation which a beam emanates through a rotating fan. Most of the testers feel shocked and uncomfortable. They are largely affected and have a bad performance—0.56496s.

3.6.2 Result in PUBG situation

After the elimination and adjustment of the variable versions, we finally make ten available versions that suitable for this PUBG Situation. The results are showed above with each version's attribute.

Light angle: the light angle in the Unity3D, which represents the x-axis of the directional light.

60': normal light, 0': slightly dark, -10': dark, -12': extremely dark -15': totally dark

Ground texture/colored: material that added on the ground. Some are simple colors; some are fully textured.

Items texture/color: material that added on the items. Some are simple colors; some are fully textured.

Average time: average time that all the testers have used in this situation.

Deviation: variance that includes all the data in this situation.

Details: words that describe the testers' behaviors and feelings

*A and B means **different textures**, A and a means **similar texture**,

1. Normal

2. Looking back

3. Moving forward

4. Visual fatigue

5. Disabled

| /	Light angle	Ground texture/color	Items texture/color	Average time (s)	Deviation	Details
0	60'	Earth yellow	black	13.486	3.74843	1
1	0'	Earth yellow	black	12.964	2.66853	3
2	60'	A	black	13.508	3.70957	1
3	-10'	A	black	13.164	2.44003	2, 3
4	-15'	A	black	22.402	10.36902	2, 3, 4, 5
5	60'	A	B	13.698	8.70077	1
6	-10'	A	B	13.612	5.96817	2, 3, 4
7	-13'	A	B	14.818	7.12237	2, 3, 4
8	60;	A	a	20.324	53.10703	2, 3, 4
9	0'	A	a	20.738	11.06077	2, 3, 4, 5
10	-10'	A	Emission	11.738	1.03842	1
11	Light Rotation	A	B	12.318	1.62782	4

Table 3.6.2: Result of PUBG Situation

The table above clearly shows the result of each of the possible factors.

In version 0 and 1, both the grounds and the items are simply and clearly colored. The time of use is not largely affected in this situation. Only in the dark situation, the testers move forward and look closer to the screen. In a short time, this causes

nothing. But for a longer time, the tester may feel uncomfortable and it is harmful to their eyes.

In version 2, 3, 4, the ground is textured. It is white-black mixed and presents a complex texture. If the light is 60', which means plenty, the tester is well-performed. However, if it gets darker, the tester tends to look back from time to time. This means testers are not sure whether they have collected every item behind and need frequent checks. This will sometimes cause extra time. If the light goes to -15', the testers are usually disabled to finish the mission. They may jump higher to find the final items, causing too much time. The deviation amount justifies this statement.

In version 5, 6, 7, we add textures on items, that are apparently different from the ground. In general, although the average times are no big difference, the deviation increases a lot, which means the tester may feel confused to find the final item. The last item may coincidentally camouflage in the ground and let the tester take much time to find it. The result shows that from a favorable light condition (60') to a bad light condition (-5'), the performance becomes increasingly worse. With both textured, the light condition makes an extremely big effect on the in-game performance.
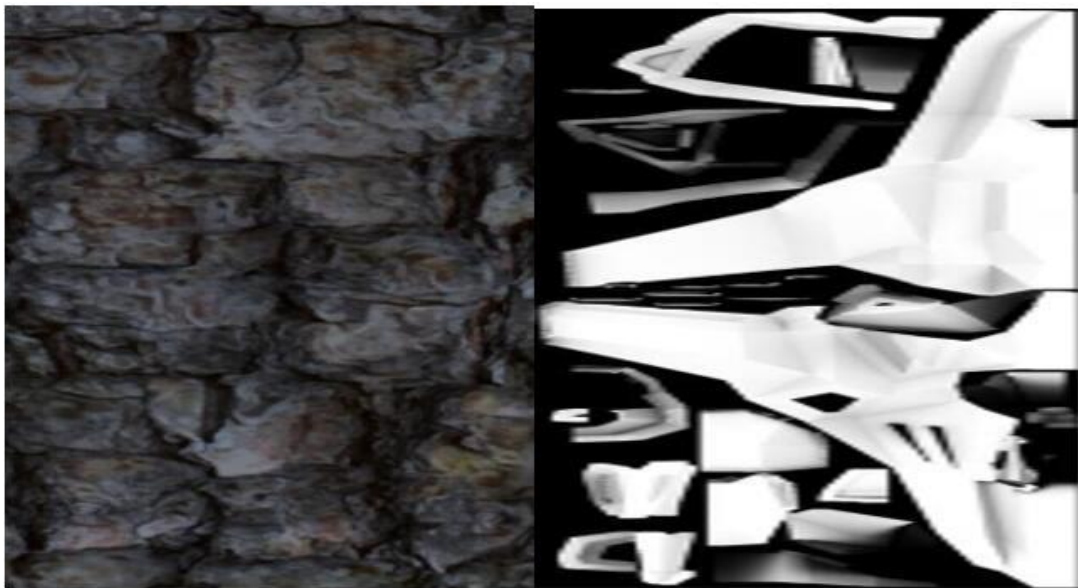
Wall   Item

Figure 3.6.2.1: Texture comparison of wall and item

In version 8, 9, both ground and items are nearly the same textured. This may happen accidentally in some bad design or in seldom situations. For example, finding a brick in the wooden ground or picking a stone in marble ground. Even the normal light, the performance is badly affected. In 0' light, which is slightly dark, the tester even cannot finish the mission. The misuse of similar texture will cause big problems both to games and users. Developers should be careful with it.

In version 10, a self-emissive material is added on each item. In the -10' light condition, they are clearly highlighted. No wonder the tester performed well, even slightly better than it in version 1.
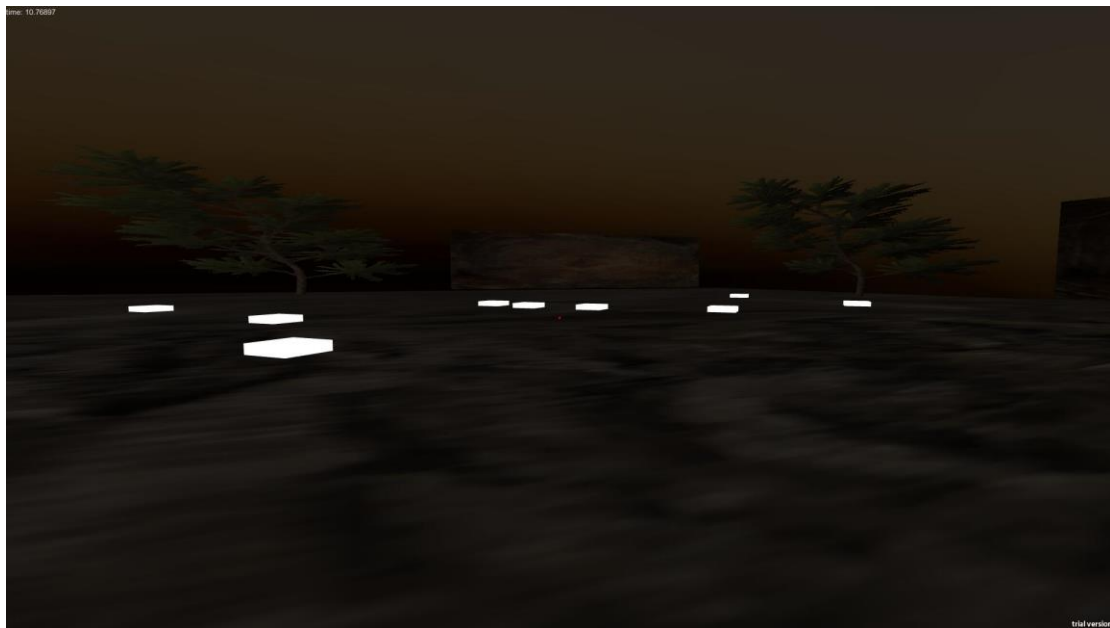

Figure 3.6.2.2: Shiny items in the darkness, extremely conspicuous

In version 11, we make a light rotation. Items and grounds are real-time rendered. The frequent change of light condition causes uncomfortable feedback from testers. Even though the time of use is not largely affected, people complain about this design too much. This may happen in some houses with broken ceilings, or a beam pass a

rotating fan. The shadows and beams are frequently changed and presented in the screen, causing a dazzling effect.
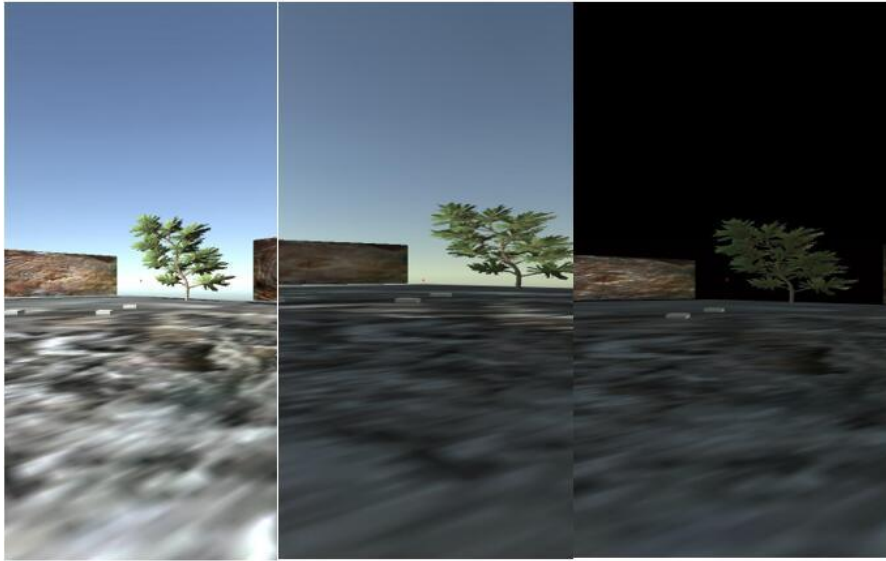

Figure 3.6.2.3: Comparison of the different light condition in the stage

4 Comprehensive Discussion

When talking about the scenery design of a game, points in ISO 9241 should always be in our minds. After the whole research, we have found there are so many elements in scenery design that can affect the in-game performance and user experience. It is not a single factor that can make a significant effect. Many factors combined together decide whether the scenery design of a game is optimal or dissatisfactory.

In the question "What is the impression in your mind about the graphics and background design?", over 70% choose "extremely important" and "comparatively important". In the question "Would you like to buy a game because of its elaborate and comfortable graphic design?", over 75% choose "absolutely" and "sometimes". This represents that most of the people care about the graphic design and even buy one game according to this point. In the question "In the game, how much degree will your in-game performance be affected by the graphics and scenery design?", nearly 70% choose "seriously" and "largely".

Deborah Todd (2007) suggests that you have to have killer graphics in making a great game. This also proves that a better scenery design will definitely help players reach high gaming level.

In the current game evolution, many FPS game companies try to make the game more real and immersive. This is a decent idea, but we should still focus on the exact user experience. After all, a game is played by humans. In some circumstances, a totally authentic stage will make the players feel annoyed and generate negative moods.

In two-teams fighting FPS game, walls and enemy figures are always textured. At this moment, the light condition gives a big contribution. A rather bright environment can undoubtedly make the graphic more obvious and clearer, which gives positive feedback.

We should also pay attention to the texture and color itself. First of all, obvious design mistakes should not appear. Furthermore, although the stage design has been perfectly made at first, some extra elements may also cause a troublesome situation. For example, the black blood sprayed on the wall may indirectly cause a dark background. This also become worse in the situation on the right of the photo. Light and shadows are needed, but the controlling of them are much more necessary. Many tests should be conducted before the game publishes.

Figure 4.1: Players tend to overlook the figures in dark places, the drops of blood on the wall make the situation worse

In a game with both competitiveness and environmental-authenticity, these elements need more sophisticated control. For other games with an anime graphic like overwatch, besides some useful graphic aids, we should also control the graphics effects. As can be shown, too many useless effects will give a big distraction to the players. A slight distraction may, unfortunately, result in unnecessary failure.

Figure 4.2: A red outline is added to help players distinguish the enemies in colorful game environments. This is a kind of graphic aid, making enemies more visible. Also an excellent example of a colorful stage without unnecessary effects

In a Battle Royale game, which is a modern game type, many more elements should be taken into consideration. Besides the possible elements and situations mentioned in the CSGO situation, the large number of items on the ground are a totally new concept. The clear appearance of items is top priority because no players want to have troubles picking items in a quite nervous and exciting game condition.

Generally, light condition is always a main factor here. With a brighter environment, the player can distinguish the items better and intuitively run to pick it up. Since items and grounds are always textured, it is essential not to build extremely dark stages. The results can demonstrate that testers performed so terrible in dark situation, even sometimes disabled.

Textures and colors are also important, even much more important than light condition. If two textures look similar, as the research result shows, people find it difficult to accomplish the tasks, even in a well-lit environment. For example, the color of guns or grenade is always wooden brown or metal black, which are in black and brown styles. Try to make the ground color in tint or just another color style.

Choosing two textures with big contrast is preferred here. Figure 4.3 gives a wrong example.

Figure 4.3: In this dark place, there is a grenade here.

Other designing mistakes are also expected to be eliminated. Frequent change of light and shadow are probably acceptable in a small range but should not be implemented in some cases within a whole screen, which is a serious burden for players.

The self-emissive items have a high recognition ratio. Therefore, it shows a positive result. This effect can be added if possible, but it is not an obligatory option. It is another kind of graphic aid, but rather acceptable in Battle Royale games. Most of the game has added outline effects or self-emissive effects to attract attentions from players, but whether it is clear enough is still a problem. These kinds of aids are supposed to conform the customs of players and game routine. Situations in Figure 4.4 is not a good example, which is not "suitability for the task".

For those games which do not need graphic aids, this is not a compulsory option. Just keep your style.
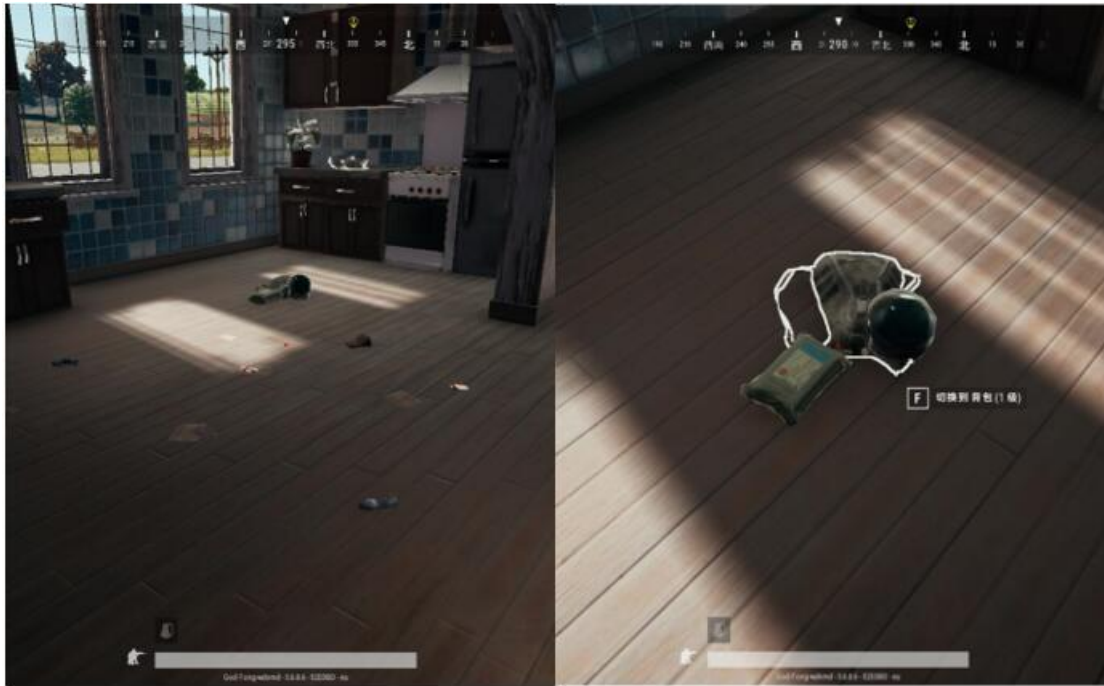
Figure 4.4: The outline does not appear until you walk closer, which is actually not so

useful in searching items

Figure 4.5: Clear notification effect even with a short distance from the items (left:

Apex Legends, right: Fortnite)

The design of items in the Battle Royale game is also suitable in some PvE situations. There are always several interactive items (weapons or scenario objects) or NPCs (Non-Player-Character). Players will enjoy the game fluently and have great fun. Everyone in the game will feel annoyed if he or she does not know what and how to do.

5 Conclusion and Future works

5.1 Conclusion

In this bachelor thesis, general research and a conclusion have been made about the topic: how to improve the gameplay and user experience of FPS games in the field of scenery design. It is not a single factor that makes it a good design, but it might be a single factor that makes it an undesirable design. For all these factors, light condition, texture, and color play rather critical roles. The light condition should become comparatively brighter to make the environment clearer. Textures and colors should be designed to have a moderate brightness and conspicuous contrasts between each other. If light condition, textures, and colors are all in a bad degree, the scenery design will no wonder become unacceptable and unsatisfied. Together with other factors like the outline and special effect are also significant, which act as an auxiliary option according to the original design pattern of specific game. Graphic aids in Battle Royale games are recommended, but it is an alternative in two-teams fighting games. In case of using them, the details and effects should be carefully controlled. Otherwise, they may cause a negative result. This research can be implemented in a variety of game types, which has a high value in the scenery part of game design.

There are still some limitations in this bachelor thesis. In the questionnaire part, only games that in the most front of the game list are considered and researched. Games in the behind of the list are not analyzed. Also, some complex effects or functions in other engines are not implemented. There are probably some other potential factors that are not realized from the research. This bachelor thesis is a basic guideline for the current game developers, helping them notice these critical factors and design more remarkable FPS games.

5.2 Future works

Since one bachelor thesis cannot cover every possible aspects, closer and more detailed research is needed. With the development of FPS games and technology, new game types, new game engines will gradually evolve and emerge in the future. Afterwards, new scenery design problems may appear inevitably. Future research should therefore concentrate on the investigation of new games and new elements that probably have impacts on the scenery design.

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Appendix A

Questionnaire:

In the following content, it will be the main body of questionnaire.

1. What's your gender?

A. Male   B. Female

2. Have you ever played FPS games?

A Yes   B. No

3. What's your frequency to play FPS games?

A. Every day, more than 1 hour   B. Every day, less than 1 hour

C. Every two or three days, 1-2hours   D. Not too many times

4. Generally, what's your main device to play FPS games?

A. Laptop   B. Monitor   C. TV Screen   D. others

5. Have you ever played the following FPS games? Choose 1-4 games that you most usually play?

A. Tom Clancy's Rainbow Six Siege

B. Counter-Strike: Global Offensive

C. Overwatch

D. Battlefield 1

E. Apex Legends

F. PlayerUnknown's Battlegrounds

G. Fortnite

H. Call of Duty: Black Ops |||

I. Other FPS games

The following are questions about **Tom Clancy's Rainbow Six Siege**

Please give a general score to the graphic and scenery design of Tom Clancy's Rainbow Six Siege(1 is the lowest, 5 is the highest)

A. 1   B. 2   C. 3   D. 4   E. 5

In the game, have you ever died because the model colors of enemies are not bright enough ?

A. Yes   B. No

In the game, have your eyes ever felt uncomfortable because of the frequent change of background ray?

A. Yes   B. No

In the game, have you ever suffered visual fatigue when having stared at one specific dark or bright place for too long?

A. Yes   B. No

In the game, have you ever suffered strong eyes stimulation because of the intensive flashbang effects?

A. Yes   B. No

In general, what's your graphics quality when playing Tom Clancy's Rainbow Six Siege?

A. High   B. Medium   C. Low   D. Very low

In field of graphics and scenery design, what's the advantages and drawbacks of Tom Clancy's Rainbow Six Siege?

The following are questions about **Counter-Strike: Global Offensive**

Please give a general score to the graphic and scenery design of Counter-Strike: Global Offensive (1 is the lowest, 5 is the highest)

A. 1   B. 2   C. 3   D. 4   E. 5

In the game, have you ever suffered strong eyes stimulation because of the flashbang effects?

A. Yes   B. No

In the game, have your ever died because the model colors of enemies are not bright enough and cause a mishoot?

A. Yes   B. No

In the game, have your ever felt dazzled for the frequent change of scenery colors?

A. Yes   B. No

In general, what's your graphics quality when playing Counter-Strike: Global Offensive?

A. High   B. Medium   C. Low   D. Very low

In field of graphics and scenery design, what's the advantages and drawbacks of Counter-Strike: Global Offensive?

The following are questions about **Overwatch**

Please give a general score to the graphic and scenery design of Overwatch(1 is the lowest, 5 is the highest)

B. 1   B. 2   C. 3   D. 4   E. 5

In the game, have your ever felt dazzled for the frequent change of scenery colors?

A. Yes   B. No

In the game, have your ever died because the model colors of enemies are not bright enough and cause a mishoot?

A. Yes   B. No

In the game, are the red outlines around the enemies' figures provide you with recognition helps ?

A. Yes   B. No

In general, what's your graphics quality when playing Overwatch?

A. High   B. Medium   C. Low   D. Very low

In field of graphics and scenery design, what's the advantages and drawbacks of Overwatch?

The following are questions about **Battlefield 1**

Please give a general score to the graphic and scenery design of Battlefield 1(1 is the lowest, 5 is the highest)

A. 1   B. 2   C. 3   D. 4   E. 5

In the game, have you ever become nervous when you are searching enemies and are facing enormous and thick smoke effects?

A. Yes   B. No

In the game, have you ever feel repressed because of the authenticity of background colors and in-game effects?

A. Yes   B. No

In general, what's your graphics quality when playing Battlefield 1?

B. High   B. Medium   C. Low   D. Very low

In field of graphics and scenery design, what's the advantages and drawbacks of Battlefield 1?

The following are questions about **Apex Legends**

Please give a general score to the graphic and scenery design of Apex Legends (1 is the lowest, 5 is the highest)

A. 1   B. 2   C. 3   D. 4   E. 5

In the game, have you ever missed some items on the ground because the color or texture of items are so similar to the floor's?

A. Yes   B. No

In your perspective, in the game, do the white outlines around the items provide you with recognition helps?

A. Yes   B. No

In the game, have you ever dazzled or have recognition mistakes when a extremely bright ray appears suddenly?

A. Yes   B. No

Do you think the graphic of Apex Legends keeps vague even though with a high resolution option?

A. Yes   B. No

In general, what's your graphics quality when playing Apex Legends?

C. High   B. Medium   C. Low   D. Very low

In field of graphics and scenery design, what's the advantages and drawbacks of Apex Legends?

<u>The following are questions about **PlayerUnknown's Battlegrounds**</u>

Please give a general score to the graphic and scenery design of PlayerUnknown's Battlegrounds (1 is the lowest, 5 is the highest)

A. 1   B.   2   C.   3   D.   4   E.   5

When you first meet this game, do you have the following experience. The items on the ground look so similar that you have trouble recognize them, even miss them.

A. Yes   B. No

In the game, have you ever failed to differentiate the real cars and the fake car pictures in the map?

A. Yes   B. No

In your perspective, is it possible to increase the recognition rate of cars and items if the game designers add colored outlines around the these objects?

A. Yes   B. No

In your perspective, what do think of the final game performance if we add both the figures of enemies and mates with colored outlines?

A. Positive   B. No influence   C. Negative

In field of graphics and scenery design, what's the advantages and drawbacks of PlayerUnknown's Battlegrounds?

The following are questions about **Fortnite**

Please give a general score to the graphic and scenery design of Fortnite (1 is the lowest, 5 is the highest)

A. 1   B. 2   C. 3   D. 4   E. 5

In the game, have your ever felt dazzled for the frequent change of scenery colors?

B. Yes   B. No

In the game, do you think the items on the ground have enough recognition degrees? Or need to improve it?

A. Yes   B. Need to improve

In field of graphics and scenery design, what's the advantages and drawbacks of Fortnite?

Other questions about your mind in graphic design.

What is the impression in your mind about the graphics and background design?

A. Extremely important

B. Comparatively important

C. Important

D. Not so important

E. No attention

Would you like to buy a game because of its elaborate and comfortable graphic design?

A. Absolutely

B. Sometimes

C. No

In the game, how much degree will your in-game performance be affected by the graphics and scenery design?

A. Seriously

B. Largely

C. Normally

D. A little bit

E. No effect

Do you think it is necessary to make a hardcore FPS games very real? Or you can accept some aid from graphics design?

A. To be real

B. Accept aid from graphic design

Appendix B

Resource of codes and testing data

Two games with their different versions and testing data are available in GitHub: https://github.com/Rickylht/Bachelor-Thesis