

Game Design Based on High-Definition Render Pipeline in Unity

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Abstract. In the last few years, more and more people want to get involved in game production and with the development of Unity, the render result in games are becoming more and more realistic. High-Definition Render Pipeline is the best render pipeline in Unity for present, but High-Definition Render Pipeline is not easy for beginners. Therefore, this paper will go through the game design process of an environmental protection game to provide a simple workflow based on High-Definition Render Pipeline for readers. In this project, Blender was used for most of modeling work, Marvelous Designer for the fabric modeling, Substance 3D Painter for textures making. Finally, the researcher's friend participated in a test of this game, although the testers say that this game could rise their awareness of environmental protection, but this game use a lot of resources from CPU and GPU due to the large number of models and the lack of optimization algorithms created.

Keywords: Unity, game design, video game.

1. Introduction

In recent years, the game industry has been development rapidly, and more and more people want to enter the game industry and be able to participate in the game production. Unity is a powerful game engine, which can provide a complete set of game development solutions, and can be used to create different forms of games such as 3D game, 2D game and VR game. What's more, Unity can be used to developed for multiple platforms including PC, cell phones and so on. Unity's High-Definition Render Pipeline allow Unity to produce games with a more realistic performance and stronger graphical expression, meeting the advanced needs of game makers and game developers.

Therefore, game production is not a simple matter. First of all, there are a lot of 3D software to choose to make models for game, and each software has its own specialty, and not all of them are perfectly adapted to High-Definition Render Pipeline, so in order to improve work efficiency and make the game have the best performance, game developers should choose the most suitable software in different steps. Secondly, High-Definition Render Pipeline is more complex than other Render Pipelines, it can lead to a different workflow for game developers than a normal rendering pipeline.

In this article, we will present some scenes in the game made by this project, sort out the process of making this game, open up the game making process from Blender to Unity, and present the exposure settings of HDRP rendering pipeline in this project.

2. Game Design

2.1. Background Story

Nowadays, environmental pollution is becoming more and more serious and the necessary of environmental protection is gradually increasing [1]. Therefore, there is a opinion that according to the theory of evolution put forward by Darwin, human beings are the winner of the struggle for survival among other creatures of nature, and naturally have the right to subjugate other animals [2]. Also, human beings can be separated from nature by the use of human technology and science. However, environmental problems in now days shows that current state of technology of human beings cannot complete separate human beings from nature just like the theory suggest. The theme of this game is to express that human technology should help natural animals and plants to have a better habitat, rather than separate from nature.

The game takes place after the extinction of the human being, and the protagonist escapes from the extinction by trapping into a cannibalistic flower. In the game, the protagonist will gradually explore the world, use her intelligence to help animals live better, and gradually discover the history during she was unconscious.

2.2. Scene

This game has 4 main scenes. The first is the whale fall scene Fig.1. The main game objects in this scene are whale carcasses and jellyfishes. In this game due to the pollution of the ocean, jellyfishes come to the ground to survive. In this scene the jellyfishes are eating the body of the whale. In order to add some mystery to this scene, there is a particle system in this scene. This scene is mainly used to show that in this world, because of the pollution of sea water, creatures in sea have to change their living place, so as to remind people to protect the environment (Fig.2 and Fig.3).



Figure 1. Wheal Fall Scene (Picture credit: Original)

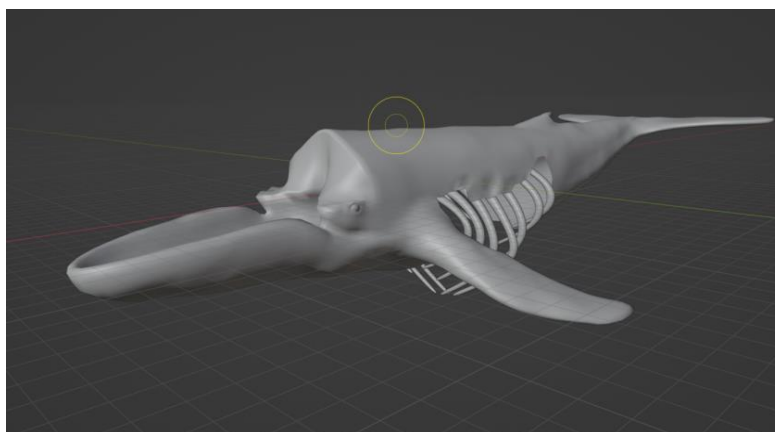


Figure 2. Whale Carcass Model (Picture credit: Original)

Next is the abandoned factory scene Fig.4. In the game this is a seawater purification plant where a war for resources broke out, and because the waste discharged from the factory has caused huge damage to the surrounding environment, there is no creatures around the factory and the color of the soil is different from other place. In the game, the player will learn about the damage that factory waste may cause to the environment, and learn that due to the shortage of resources caused by environmental pollution, a war will break out in the end, so as to warn the player to protect the environment.

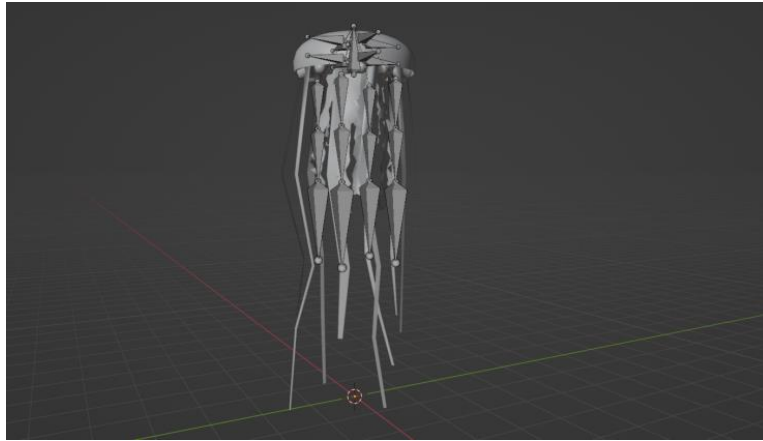


Figure 3. Jellyfish Model (Picture credit: Original)



Figure 4. Abandoned Factory Scene (Picture credit: Original)

Then there is an ancient ruins scene Fig.5. The ruins are mainly built mainly with stone and therefore can be preserved for a long time Fig.6. In the story, the protagonist learns a lot about human's technology, which she uses to help the animals. There are also a lot of turtles in this scene Fig.7. In the game, also due to the water pollution of the sea, the turtles survive in a lake on land and hatch their eggs on the shore of the lake.



Figure 5. Ancient Ruins Scene (Picture credit: Original)

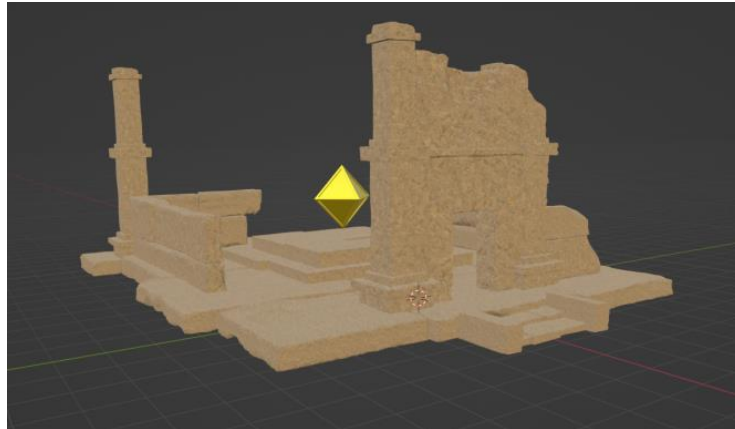


Figure 6. Ancient Ruins Model (Picture credit: Original)

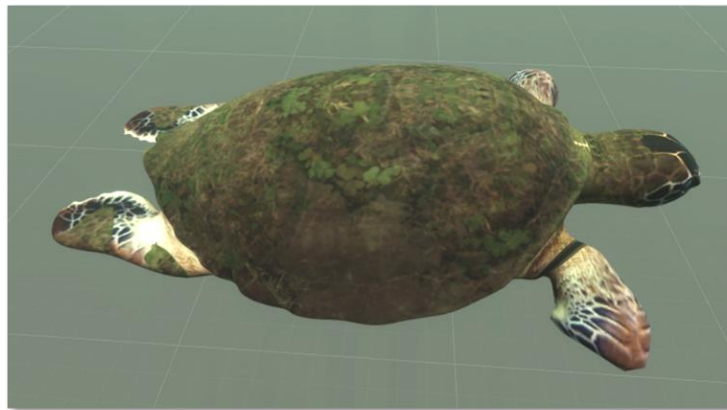


Figure 7. Sea Turtle Design (Picture credit: Original)

And finally, is the satellite wreckage scene. This satellite has record all of humanity's history and technology in its server. At the end of the story the satellite will crash on earth due to the lack of power. The protagonist learns about the history of mankind through this satellite. At the end of the game, the computer camera of the player's computer will be used, allowing the player's face appear in the game's footage and triggering the player's thoughts (Fig.8 and Fig.9).



Figure 8. Satellite Wreckage Scene (Picture credit: Original)

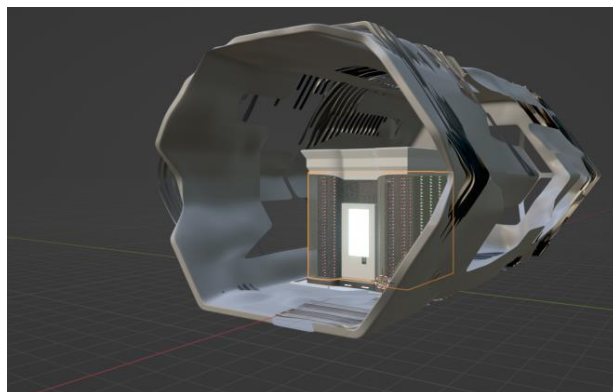


Figure 9. Satellite Wreckage Model (Picture credit: Original)

2.3. Character

The appearance of protagonist will change through the story Fig.10. When the protagonist first wakes up, a portion of her skin and the cannibalistic flower blend into each other, creating a half-human, half-plant state. As she helps the animals, her arms and legs gradually return to normal. At the end she changes back to human form (Fig.11). The change in the protagonist's appearance is a process that reflects the change in protagonist's self-perception. In the beginning of the game, the protagonist just weak up, she has lost all her memories, she believes that she is like other animals in this world that she is part of this environment. As she explores the world, the protagonist gradually realizes that she is a human and gradually detaches herself from this environment. The model is based on the setup image, but some changes were made to make it easier to model.

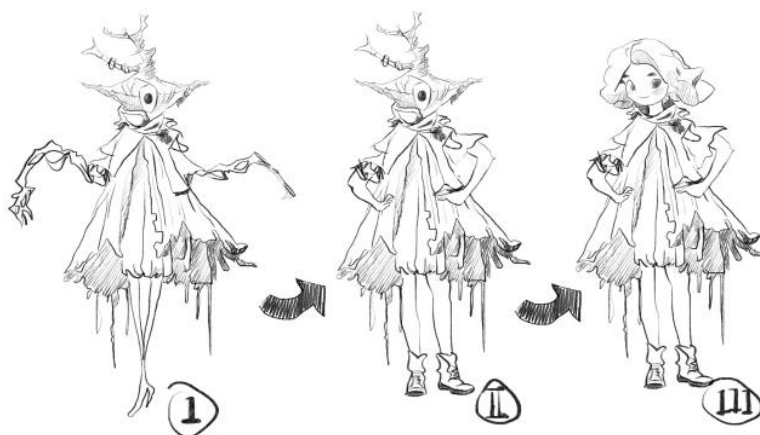


Figure 10. Character Design (Picture credit: Original)



Figure 11. Character Model (Picture credit: Original)

3. Creation Method

3.1. Workflow and Version Control Tool

The workflow of this project was referenced from the workflow of other researchers [3], the workflow of this project was to do the basic settings of the project in Unity, then edit the models that are needed for the game in other 3D software, after that import them into Unity for editing, like put models into right place and write C# scripts, and test them after that. In addition, this project use Plastic SCM as a version management tool. Compare with GitHub, Plastic SCM can not only manage version control and collaborative development in a group, but also importing Unity projects is much easier than GitHub, the user just needs to switch workspace or pull them to local file from the Plastic SCM client. As for GitHub, the user needs to replace the old project in the folder, which is relatively in convenient.

3.2. Modeling Methodology

All model is created in Blender, a powerful complete flow scheme 3D software. After a model is complete, it needs to unfold UV in Blender in order to have the correct material in Unity. Since this process does not use texture painted in Blender, smart UV project which is a powerful UV tool provide by Blender can achieve the requirement of this project in most case. It can unfold UV accurately and quickly and the layers of UV are logically.

3.3. Textures Making Methodology

As for textures, this project decided to uses Substance 3D Painter after referring to other independent game developer's process [4]. Substance 3D Painter has some advantages over Blender for creating texture. To begin with, the shader which was edited in Blender with node cannot be used in Unity directly, it needs to go through the process of texture baking., but in Blender, user should bake textures one by one, and in the process, the new texture will replace the old texture, so the operation is easy to make mistakes. On the contrary, Substance 3D Painter can bake multiple textures at the same time, and the user can export them with one step. Besides, Substance 3D Painter supports the production of textures for High-Definition Render Pipeline, users can export texture of base color, normal map and mask map, it is convenient to restore material in Unity, and it is easy to make realistic style textures in Substance 3D Painter due to it has massive realistic style textures (Fig.12). Blender does not have the corresponding support, and it is hard to make a realistic style texture in Blender. All in all, using Substance 3D Painter to make texture is simpler and more efficient. After the model is finished, export the model to FBX format, and then import it into Substance Painter, select "Unity HD Render Pipeline (Metallic Standard) (starter assets)". After doing this, the textures will be rendered in a right way in High-Definition Render Pipeline.

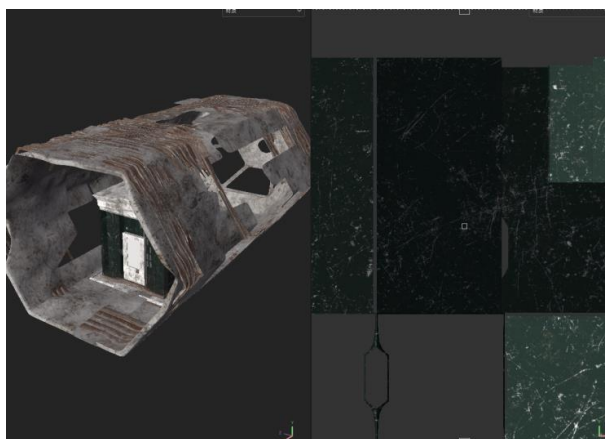


Figure 12. Textures in Substance 3D Painter (Picture credit: Original)

3.4. Animation Production

The animation of the character and animals in this project are made in Blender. For character animation, since this project do not have money to use motion capture technology and human animation is difficult to create, this project used free character animation in Unity access store. The animation of animals was made in Blender, and the bone binding are doing in Blender. After that the vertex weights affected by each bone are bound are adjusted to make the model's movement closer to reality Fig.13. It is recommended to turn on symmetry editing during weight painting process. Although the movement of animal cannot be perfectly symmetrical, but this project does not require high precision movement. If other researchers need some more detailed movements, they can use symmetry editor to determine the general shape, and then turn off the symmetry editor to adjust details.

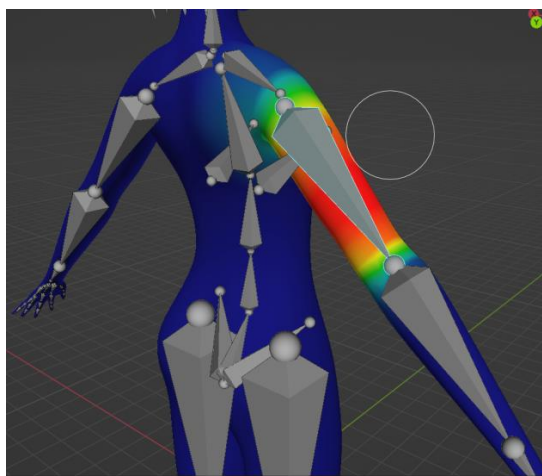


Figure 13. Weight Drawing in Blender (Picture credit: Original)

3.5. Character Clothing Production

This project used Marvelous Designer to make character's clothes Fig.14, because Marvelous Designer is more convenient to make clothes, and it has a fast and accurate fabric simulation system, which can achieve the needs of this project in an efficient way. Although it is possible to make clothes and do fabric simulation in Blender, but the modeling in Blender need to consider the layout of the wires and the fabric simulation need to play animation. In Marvelous Designer, clothes are modeled through drawing plates, and then connect each plate, this process does not need to consider the layout of the line. In comparison, it is much easier to create clothes in Marvelous Designer. When the clothes were finished in Marvelous Designer, exported them in FBX format and imported them into Blender, transferring the vertex weight of the character to the clothes, so that the clothes will have the correct animation.

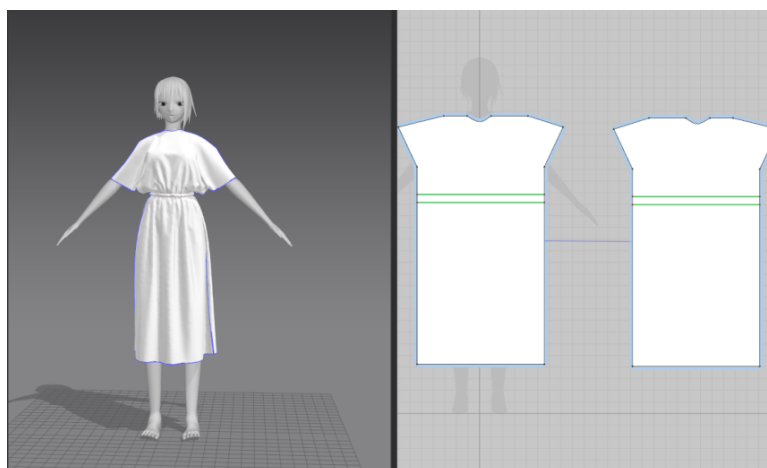


Figure 14. Clothes Model in Marvelous Designer (Picture credit: Original)

3.6. Terrain Production

The terrain in this game was created in Unity using the Terrain Sample Asset Pack package, which provide more terrain brushes, vegetation and textures. By using this package, more realistic terrain can be created. Although it is possible to use other 3D software such as Houdini or 3D Max[5], but this project due to the immaturity of the technology, the terrain is not determined at the beginning, in the later process in this project there will have possibility to modify terrain, so it is not convenient to create terrain in other 3D software, it need to modify in the software and import it in Unity again, in that case, all the things that have placed on the old terrain have to place it again. Besides, the terrain system which is provide by Unity is powerful enough for use in this project [6].

3.7. Setting in Under High Definition Render Pipeline

High-Definition Render Pipeline is a Scriptable Render Pipeline produced by Unity. It can render Lit Material and use Forward or Deferred rendering [7], which has a better render result for light and special materials like glass [8]. In order to get a better rendering result of the game, corresponding effect in the HDRP Global Settings in the Graphics of the project settings should be enabled. In this project, shadow is enabled for rendering shadows, Screen Space Ambient Occlusion is used for rendering the part of the object's surface where ambient light is obscured, and the Sky Type in Visual Environment is set to HDRI Sky, so that the sky box in the scene can use HDR textures. In addition, Motion Blur is used to create motion blur, and Water Rendering is also enabled, as it allows for quicker creation of water bodies such as oceans. In the game scene, Directional light is used to simulate sunlight, and Shadow and Volumetrics need to be enabled, the exact values are given in the image. After that, add Sky and Fog Volume to the scene and enable all the options in Fog, the values are given in the Fig.15 and Fig.16. Results are shown in Fig. 17 and Fig. 18.

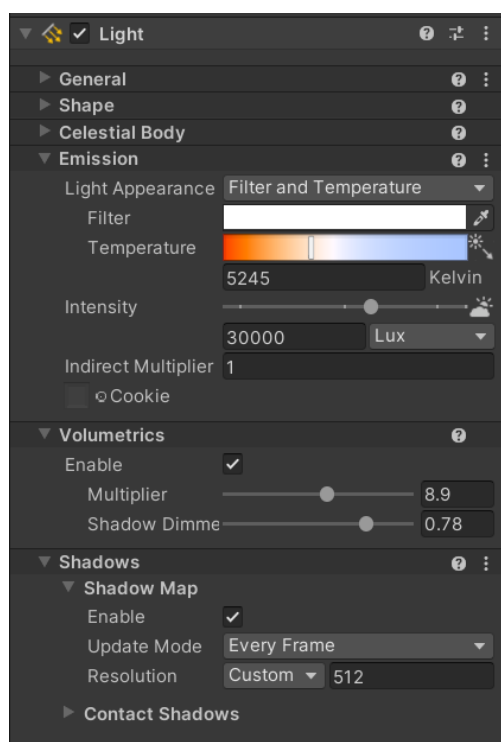


Figure 15. Setting of Directional light (Picture credit: Original)

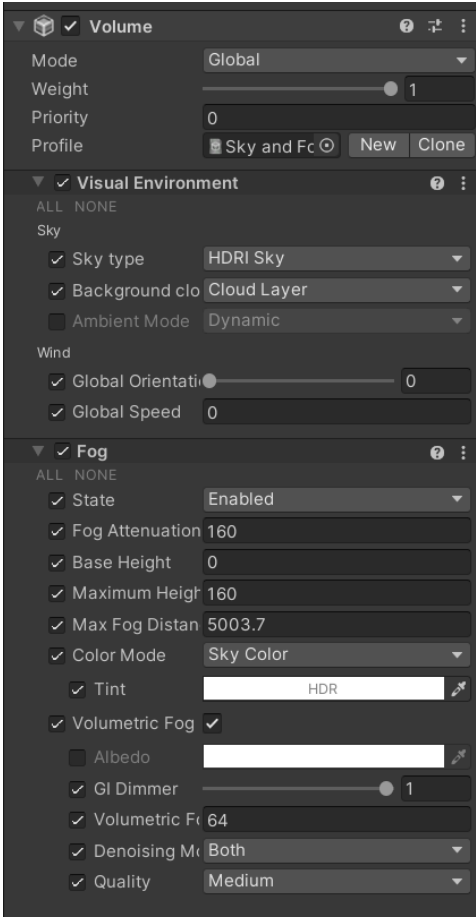


Figure 16. Setting of Sky and Fog Volume (Picture credit: Original)



Figure 17. Render Result Before Settings (Picture credit: Original)



Figure 18. Render Result After Settings (Picture credit: Original)

3.8. Character Control Method

The character control of this game is first person view control, WASD buttons control the character's forward and backward movement, and the mouse forward and backward movements controls the viewpoint's move up and down, left and right rotation. Currently there is already a very mature third person view character control template [9], this game's character animation blend tree Fig.19 and camera control is similar to third person view game. In the character direction control script, by obtaining the main camera rotation information, let the character follow the camera rotation.

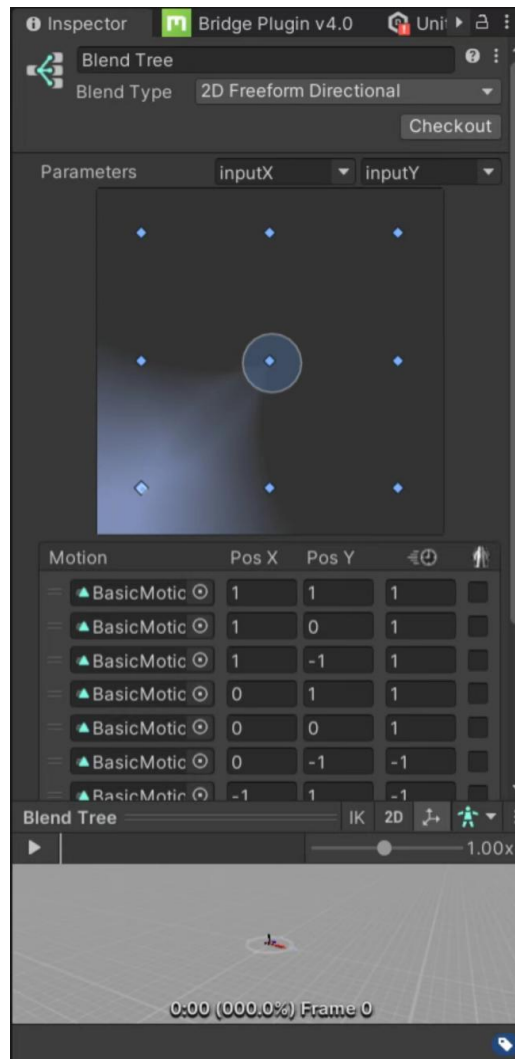


Figure 19. Blend Tree of Character Animation (Picture credit: Original)

4. Experiment & Result

Two friends of the researcher of this project were invited to play this game. For starters, they all reported that the game was very unsmooth, the reason for this will be explain later. What's more, they both found the idea of showing the player himself through the camera on the player's computer at the end of this game is a very interesting idea. As for the thematic expression of the game, one of the friends said that the design of the possible future world caused by the environmental problems now days was very interesting. Another friend said that since the story of the game happen in the future world, it is far away from the present situation because the game is about the long-term effects of environmental problems. The game will raise the player's awareness of environmental protection, but the player may not know how to act on it. This is really a lack in the expression of the theme of the game.

This project was tested by Profiler in Unity. As the charts Fig.20 show, this game requires a lot of sources from computer, with very high CPU utilization. The charts show that most of the resource is spent on rendering due to placing too many items in the game scene, which causes a lot of pressure on game's rendering.



Figure 20. Profiler In Unity (Picture credit: Original)

Referring to the test result from other researcher [10], there are several reasons for the result of the game. First of all, the models that placed in the scene are high poly model, the number of faces of some model has come to over 1,000,000 faces. So many faces will inevitably consume a lot of resources of computer, making the game run very slow. On of the reason for using high poly models is that even the tiny bumps and depressions on the surface of these models are made by sculpting, if these details are made by normal maps, low poly models will be available to presentation details, and making the game run more smoothly. Second, the models in this game use a lot of materials. In order to make objects in different places have different appearance, even same material will use two different material spheres. Besides, the game does not use an object pool, these reasons lead to a lot of pressure on the game's rendering.

5. Conclusion

This paper presents a workflow for designing an environmental protection game based on the High-Definition Render Pipeline, showcasing the use of modern tools and techniques to create engaging and meaningful game experiences. Throughout the game development process, software such as Blender, Marvelous Designer, and Substance 3D Painter were utilized for tasks like modeling and texture creation, offering readers a simple game design workflow.

Through the participation of the author's friend in testing the game, the paper also demonstrates the game's potential in raising players' awareness of environmental issues. However, it highlights issues related to performance optimization, as the game consumes significant CPU and GPU resources due to a large number of models and a lack of optimization algorithms, affecting gameplay smoothness and overall experience.

In the future, further improvements can be made to enhance this environmental protection game by optimizing algorithms and reducing resource consumption to boost game performance, allowing more players to enjoy a seamless gaming experience. Additionally, the inclusion of more interactive

elements and educational content could attract a broader player base and deepen their understanding of environmental issues. By continually refining and innovating, environmental protection games can serve as a beneficial form of entertainment while promoting environmental awareness and encouraging support for environmental conservation efforts.

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