Space Rift: An Oculus Rift Solar System Exploration Game

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ABSTRACT
Virtual reality utilizes software and computer peripherals to allow users to interact with a digitally replicated environment. In this paper, we describe *Space Rift*, a virtual reality game that utilizes the Oculus Rift The game teaches children about the solar system by allowing them to explore it in the virtual environment. *Space Rift* was tested with grade 5 students. The students described the game as enjoyable and immersive, although they experienced difficulty in understanding in-game text information.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *artificial, augmented, and virtual realities, evaluation/methodology.*

General Terms
Human Factors, Experimentation, and Documentation

Keywords
Oculus Rift, Virtual Reality, Education, Learning

1. INTRODUCTION

1.1 Virtual Reality
Virtual reality refers to a digitally-created, immersive and highly interactive world [5]. Software involved creates the virtual environment that the user then interacts with or views through specialized hardware. There are two main uses or applications of virtual reality: instruction or game play [8]. For an application to be considered virtual reality, it should make use of three-dimensional, life-sized models of objects, whether are real or fictional [5]. It should also detect user head movement and adjust the user's view accordingly [5].

1.2 Immersion and Interaction
The challenge of any virtual reality devices is create immersion with precision and calibration [5]. If we were to compare watching a cinema screen and having a head-mounted device, the latter offers greater immersion as the device blocks out the viewer's surroundings. The use of a head-mounted device diminishes the reality that surrounds a person, and replaces it with another environment.

In addition to immersion, virtual reality also provides interaction. Virtual objects within the environment react to movement dynamically, based on the user's movements or manipulations.

Latency, nausea, and refinement are problems associated with virtual reality. Establishing a virtual environment that the brain accepts as a reality is a difficult task that is concerned with the human senses. A head-mounted display projects to the eyes and ears, but does not cater to the other senses.

1.3 The Oculus Rift
One current example of virtual reality technology is the Oculus Rift, a head-mounted display. The Oculus was presented during E3 events like last June 2013, where it featured the movie *Man of Steel* [4]. E3 is a prestigious event held every year that showcases computers, video games and similar materials..

The Oculus Rift makes use of HDMI and USB ports to connect with a platform and the interfacing is simple – very similar to a projector. Launching applications built for the Rift hardly requires any setup and seamlessly launches in windowed mode. As of the last quarter of 2013, the funding for the device increased by $75 million dollars, a sign of recognition for the device and the premise it brings. [4]

Figure 1: The Oculus Rift [7]

1.4 Education Applications of Games and Virtual Reality

There are many studies that illustrate the use of games in education. Some of these theoretical conclusions state that worlds created by games and by merely playing inside these worlds already induce productive learning that is supported by cognitive sciences, albeit not all experience with these kinds of games present the theory [1].

In general, the greatest benefit in using a game for learning is interactivity [3]. This creates an experiential type of learning that allows the students to apply what they learned directly within the game context. Games also keep students interested [3]. Virtual reality-based games augment this quality further by providing a greater sense of interactivity and immersion.

As early as 1998, the educational effects of virtual reality have already been explored [6]. As mentioned above, some games provide students a chance to learn concepts by actively constructing the knowledge themselves in learning by doing situation rather than information simply presented to them. This kind of learning is called constructivist learning [6]. Virtual reality technology allows three kinds of experiences that are important for this kind of learning. The first kind of experience is the

experience in size. Virtual reality devices directly place the student in stereoscopic 3D within the environment allowing them to experience size differently than in an ordinary game [6]. This allows them to see information in their correct scaling. The second experience is transduction, which pertains to the use of interface devices to present information that are not easily perceived by the senses [6]. These include changes in the sound to indicate distance or changes in motion speed to indicate movement in different terrains [6]. The last experience is reification, is the process of representing objects or events that have no physical form into perceptible objects [6]. With these three factors in, almost every study conducted with virtual worlds have been proven to be educationally effective [6].

Hence, this project aims create a virtual reality-based learning application, *Space Rift*, to teach about the different planets within our Solar System. The effectiveness of this project will be tested to address the viability of virtual reality for the future industry in terms of education, while taking note of its hindrances.

2. GAME CONCEPT

The game is a space simulation. It is largely similar to the game *Titans of Space* developed by Drash [2]. *Titans of Space* focuses on providing its audiences with a guided virtual tour of the solar system. Since the game is a tour, users can look around each tour stop, read the information panel and proceed to the next destination when the user is ready. See figure 2.1 for a sample screen shot.

Figure 2: Titans of Space [2]

Although much of the inspiration comes from *Titans of Space*, the main difference of *Space Rift* is that the players are free to navigate around the solar system with full control rather than just be fixed with the tour stops. There are other game mechanics as well which will be explained in more detail in the next section. Similar to *Titans of Space*, planetary information is visible as the player hovers close to the body. The player will not be able to fly too much outside of the system and the planets will have external boundaries.

2.1 Objectives and Gameplay

The players start outside the solar system and the primary goal is return to Earth. The spacecraft's fuel is limited and if it runs out before reaching Earth, then the player loses the game. Energy spheres are available around the planets however; one of the challenges of the game is to figure out a path that will provide the spacecraft with enough supplies to reach Earth. The energy spheres are strategically placed to assist the player in navigating through space. Planets and their satellites have mass and colliding with them or being hit by them in their orbits will cause the spaceship to crash.

Once the player reaches Earth, the game ends. There will be no story line for this game.

2.2 Scenario and States

.Game mode:

There is only a single scenario in the game – free exploration. However, the player is limited to a time described by a bar labeled energy.

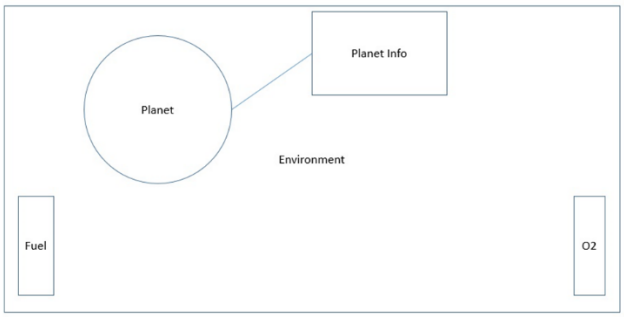

Figure 3: Prototype Sample Head-up Display (HUD)

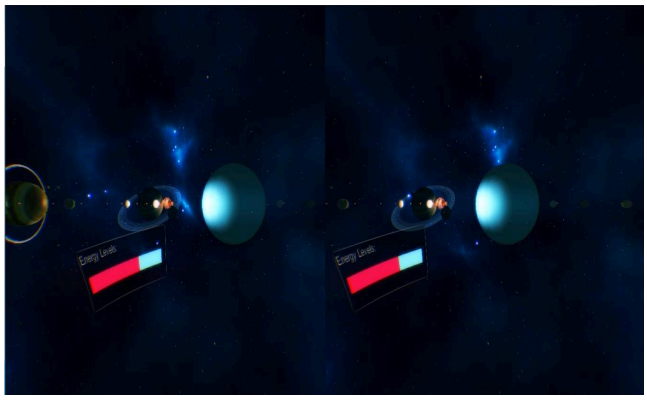

Figure 4: Implemented Head-up Display (HUD)

Figure 2.2 represents the prototype display we were working on and Figure 2.3 is the final implementation for the game. It shows the dual camera feature of virtual reality projection – each half showing a view specific to each eye. The planets and the spaceship's fuel can be seen in Figure 2.3, and the pop-up information windows can be seen in Figure 3.1.

Win Condition:

Player is presented with a victory message.

Requirements:

- The player must find the correct path with enough energy to reach Earth

Lose Condition:

When a player loses, a short message is displayed on screen before the screen returns to the main menu.

Requirements:

- When the ship's energy runs out
- Getting hit by planets and satellites

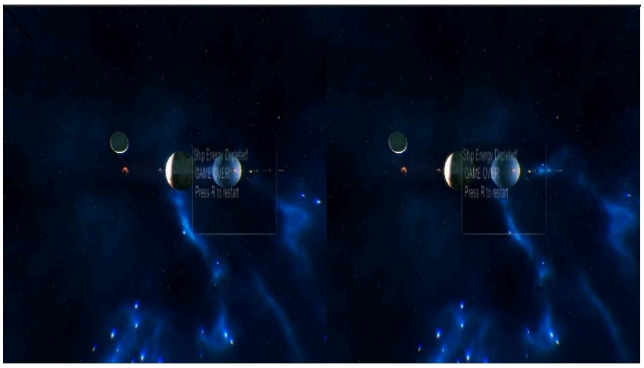

Figure 5: Game over screen

3. LOOK AND FEEL

The game utilizes a first person perspective. A full 360 degree turning point is available. Forward movement of the ship will create the possibility of turning around, similar to that of a normal vehicle. The virtual world is premade; hence all elements are essentially in view as long as the explorer corresponds to the environment. A sample screenshot with planet information display is shown in Figure 3.1.

Figure 6: Sample screenshot

Standard vehicle controls will be used to navigate the ship. WASD for basic movement and the mouse for 3D movement. However, the Oculus Rift that the game is designed for will be used to navigate 3D as well. Movement of the device that is worn by the player will contribute to the realistic feel of the game while serving as navigation at the same time. Head movement, then, will correspond with the ships nose movement.

Colliding with the energy spheres will collect them.

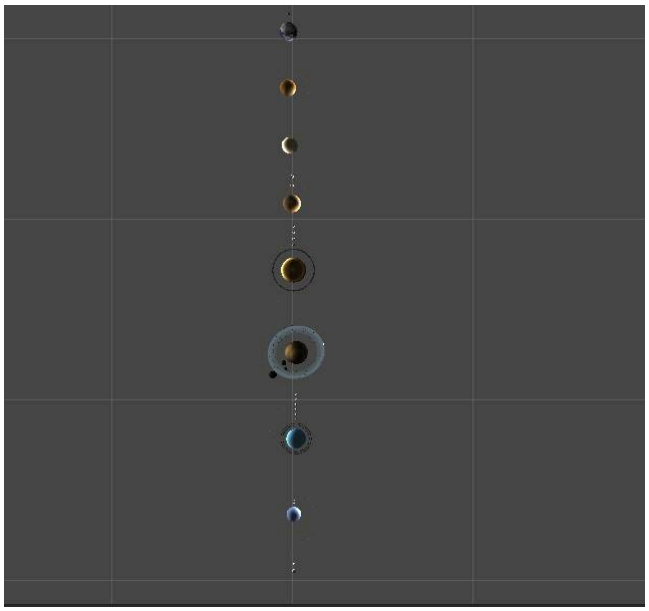

Figure 7: Overall map of planets

Figure 3.2 shows the layout of the planets that follow a straight line. The map of planets follows a linear organization with proper positioning of the planets according to the real Solar System, except for the Earth which is the established end point.

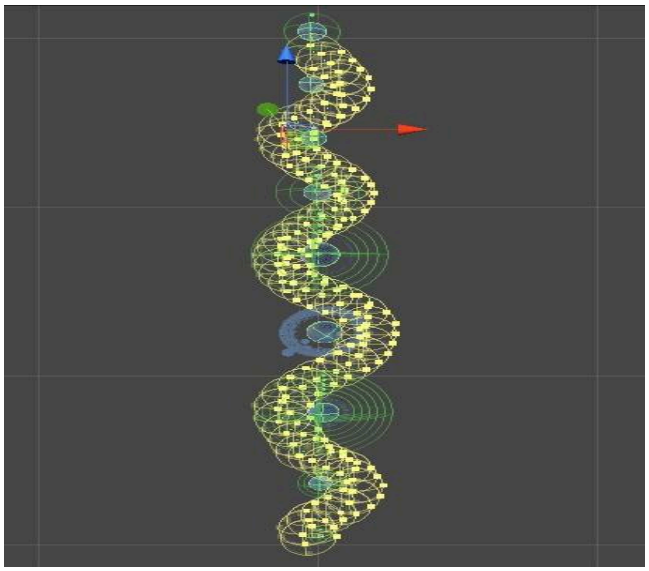

Figure 8: Energy Spheres

To maintain the sense of exploration without being dulled by the straight pattern of the planets, the energy spheres are positioned in an alternating, snake-like fashion as shown in Figure 3.3. The yellow circles represent the energy spheres' position while the blue spheres aligned in a linear manner represent the planets.

4. IMPLEMENTATION

The Oculus Rift comes with an SDK with a C++ based API in order to fully integrate the Oculus Rift with a game. However, there are also other versions of the API that can be integrated with pre-existing game engines such as Unity3D and Unreal Engine 3. Using the C++ plain API would be more flexible and robust however, due to the time constraints for this project, Unity3D will be used instead.

The advantages of using a game engine such as Unity3D is that most of the common game functions are already abstracted hence developers would just need to modify certain attributes of objects to create a desired effect as compared to creating everything from scratch.

A space exploration game was chosen in order to avoid the creation of too many complicated models.

Models were created using the free version of Google Sketchup and with textures that are freely available online. According to the Titans of Space webpage, some agencies or research centers such as NASA does offer some textures or even models.

The group integrated the game with the Razer Hydra, a gaming controller in the form of two joysticks that features motion detection. This led to controlling the spaceship with the Hydra instead of the mouse and keyboard.

5. TESTING

As part of the development process, we have to test the educational ability of virtual reality with a young audience. Also, we would like to test the capabilities of virtual reality and its limitations.

5.1 Inclusion Criteria

- Grade school students of grade 5 or higher
- 10 – 13 years old
- Versed with computer games (esp. FPS)
- Mix of having proper vision and nearsightedness

These criteria are derived from the nature of the game to entertain its players with a.) the prospect of virtual reality and b.) the setting of outer space. We want to target a group with these characteristics partly because of the primary vision we had in mind of teaching elementary students. Grade 5 students are already assumed to have basic knowledge regarding the solar system while being able to competently play a first-player perspective game. Also, we would like to see if vision impairment can cause early dismissal of the experience.

5.2 Testing Methods

Access to Ateneo Grade School and selective choice of students are granted to guarantee the demographics.

- A maximum of 10 minutes will be allotted for each student (5 minutes for game time, 5 minutes for post interview)
- They will be instructed of basic controls (WASD, mouse, head movement)
- The specific endpoint, that is Earth, will be the target
- After debriefing about virtual reality and the game concept, testing will ensue
- Assistance will only be given if they are having problems with vision or hand positioning (observed as a common problem)
- Coaching as to where the energy spheres are at first is expected
- Special attention to information displayed about the planets will be provided throughout the game
- Observation of using the mouse and head for movement will be vital (i.e. are they using the mouse or head exclusively, or a combination of both?)

5.3 Post Game Questions

Questions will be administered verbally after the game. They will include, but not be exclusive to:

- How many satellites does planet [..] have?

*It is noted before the game through casual questions if they have knowledge regarding satellites. Also, this pressures them to look for information about satellites that are placed just below the planet label.

- Describe your overall experience with the game?
- Was it fun? Do you feel dizzy?
- Did you think the game was immersive (it took you to the virtual world quite convincingly)?
- Can you name a few trivia points the game provided? Or were you too focused with navigating?

*This is meant as a less specific question in contrast to the first. Rather than a specific point, we are looking at whether they paid attention to other details of the planet information.

- Did it help you understand outer space interaction more?
- Can you describe if virtual reality is different form a normal game?

This was structured to be more of an interview with the interviewer taking specific notes from the answers that relate to this list of questions.

5.4 Testing Results

We tested with five respondents from the Ateneo de Manila Grade School that are all grade 5 students. Their ages range from 10 – 12. 4 out of 5 play videogames frequently and had no eye problems. 1 singled out plays only when he has the chance and has nearsightedness/astigmatism. One of them has prior knowledge of the Oculus Rift but all five have an understanding of virtual reality

The experiment was conducted in a classroom. After the devices were set up, satellites of planets were explained using Earth's Moon as a general analogy. The children had a misconception about real and artificial satellites, initially.

They took turns for the device and given 2 tries per game, except for the first who was given 3 tries to compensate for being the first to try. After finishing, the student is taken outside for interviewing while the following student is administered the game due to time constraints.

5.4.1 Game Results

The students were briefed concisely of how the game works. They were not given mouse control as space was a problem, and had to rely entirely on WASD plus the Oculus for control.

- 4 out of 5 managed to finish the game (reached the endpoint of Earth), although they all required at least one try
- 4 out of 5 managed to get a good grasp of using the combination of keyboard keys and the navigation with the Oculus Rift, this was observed by how fast they managed to learn how to control the camera by not dying after the game starts or plummeting out of control
- The one who did not manage to finish the game, although played video games frequently, was the one with nearsightedness
- They finished roughly at the same timings, missing only a couple of energy spheres

5.4.2 Interview results

3 students were questioned individually. Due to time constraints, the remaining 2 were questioned at the same time.

- Only the student with nearsightedness expressed dizziness after playing the game. Also, a specific mention from him is that the game was too blurry that he did not manage to reach 3/4 of the way through the game
- 5 out of 5 rated that they enjoyed the game
- 5 out of 5 also felt that the simulation portrayed a better experience of describing outer space, especially if the room was not noisy nor hot
- Keywords that they expressed include – "crazy," "enjoyable," "amazing," and one of the students expressed that he felt "curious" afterwards
- Only 1 out of 5 successfully answered a question regarding a planet's satellites
- 0 out of 5 remembered anything regarding other trivia points
- 1 out of 5 expressed trouble with his neck when using the Oculus to navigate, the remaining 4 waved off the difficulty

Judging from the student's responses and general behavior, they have a positive reception for virtual reality. They either wanted to go first, propose trying another game, or request another go at the game. They managed the controls effectively after an initial run on the device.

The main concern, however, is the educational side of the experiment. Only one student remembered the satellites of the planet in question, even when urged to take note of the trivia. When asked of the problem, they all replied that the text was too blurry to read. They remembered details of the planets (color, rings) when asked with follow-up questions, but the texts were simply ignored because of the difficulty in perusing it. This can be because of the grainy graphics of the game alongside the minimal size of text and it's positioning to not hinder the ship's path. Also, one student said that he wanted to finish the game quickly and was worried about the fuel to actually pay attention to the text.

When asked a follow-up question, however, they would want to learn more about the planets through this game rather than a textbook, albeit exclaiming again about the difficulty in reading the text.

6 CONCLUSIONS

The purpose of this paper was to discuss the development of *Space Rift,* a virtual reality game. It served to educate the targeted users with information regarding our Solar System.

Most features of the game were successfully implemented It lacked only menu boards and possibly recording high scores measured in time of completion. As a result, the game can be played to its end by casual gamers, after familiarization with the controls. *Space Rift*'s implementation as a virtual reality-based game received positive feedback from the testing respondents and casual testers with the usual comment that we can improve on it more.

However, the game's feature of education is heavily hampered by the digitized text of the Oculus Rift when importing the game from Unity. The underutilization of planet information display proved to disjoint a main feature of the game. Although this can be solved with tweaking of the text, it will take additional refinement to design it in such a way such that it does not obscure the camera's viewpoint while remaining readable. The illegibility of the text elicited negative reactions from the testers. However, it was clear from the respondents that the game was immersive and interactive. We therefore conclude that *Space Rift* was able to convey an experience of outer space exploration to those with less knowledge about the topic.

7. ACKNOWLEDGMENTS

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