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# Designing a Virtual Reality Flight Simulator

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**Abstract:** Virtual Reality has been gaining popularity in recent years and has been applied in various fields. One of its uses is for Virtual Reality games and simulators, which targets a wider range of consumers. Flight simulator is one of the more well-known simulators on the market, which is used by both gamers and aspiring pilots. However, developing a simulator that is realistic enough to provide a life-like experience often requires space, suitable environment, and realistic controllers that are often expensive. Virtual Reality can help reduce the production cost of traditional flight simulator by replacing the function of some hardware in making a realistic simulation. In this paper, we present a VR Flight Simulator that runs on Android mobile devices with an external Bluetooth controller. We studied the degree of realism it provides and its effect on player's enjoyment. The preliminary results show that the flight simulator provide enough visual realism to make an enjoyable and immersive game experience.

**Key words:** Virtual Learning; Flight Simulator; Simulation; Virtual Reality; Visual Realism

## 1. Introduction

Virtual Reality (VR) can be described as a display and controlled technology that allows users to have an immersive experience in an artificially generated environment (Rae, 2014; Wexelblat, 2014). It has been gaining popularity in recent years because of the realistic experience it provides and its possible applications in various fields, such as rehabilitation for patients with disabilities, flight training, language education and property viewing to name a few.

One of its applications of VR is in Virtual Reality simulators, which has the potential to be a useful tool for education and training purposes (LaValle, 2017). A simulator is a software which runs on a Computer device (such as a game) or dedicated rig/device that models and realistically represents or simulates aspects of a real-life situation such as flight simulators that simulates the experience of flying an aircraft.

Virtual reality can cut down the cost of building a full-scale flight simulator for training purposes by simulating the sceneries of a flight that generates high visual fidelity, which refers to the degree of conformity to real life visual features (Robinson & Mania, 2007; McMahan, Bowman, Zielinski, & Brady, 2012). VR headsets are the kind of VR display devices that is based on the computer or mobile phone showing 3D content (Xiangyuan, 2015). It has an appearance that is quite like glasses, with lenses that converts images for both eyes with a certain offset creating an illusion of depth and realism (LaValle, 2017).

In this paper, we present a VR Flight Simulator that runs on Android mobile devices with an external Bluetooth controller. Our research question is if the proposed simulator offers enough visual realism to provide an enjoyable and immersive game experience for the players.

The rest of the paper is structured as follows. Section 2 describes the design and development of the Flight Simulator. Section 3 presents the results of a preliminary evaluation study. Section 4 concludes the paper and outlines future work.

## 2. Design and Development Process

During the process, a game engine was written to create both the game's visual and non-visual elements. The visual elements included a cockpit, sky, terrain and lighting. Some non-visual elements were collision detection and player movement. Hardware used were Android phones, Bluetooth controller and a VR Box.

### *2.1 Cockpit*

Initially, the cockpit was made from a cubemap, which is a cube textured on each side. After getting some user feedback, a highly detailed pre-made 3D plane model was introduced to the world to improve realism.

### *2.2 Sky*

To create a realistic sky, a series of photographs of a clear sky were used to texture the skybox. In game development, a skybox refers to a huge cube that is textured and moved according to player's position to give an illusion of an infinite, bigger world.

### *2.3 Terrain*

The plane in this flight simulator can usually travel very far, so we want the terrain to be present regardless of distance travelled. The approach that we took was to create terrain chunks and to divide the world into quadrants. If the player travelled to another quadrant, the terrain chunk that is far away from the player is translated to a new position. This way, there is no need to implement frustum culling – a performance optimization technique that only renders objects inside the frustum – as only the nine terrains near the player was generated at once.

### *2.4 Lighting*

We used a form of lighting called "Directional Lighting" that mimics a distant light source such as the Sun. Directional Lighting emit parallel rays of light in a single direction but from no apparent source and as such it can have an infinite distance. Because of this, the intensity of the light with Directional Lighting is always a constant luminosity and only its rotation values have an impact (the direction). This type of lighting is perfect for illuminating large areas such as open spaces or cities and as such, is the reason why we decided this to best fit our project as the user will be flying through a large open world/terrain.

### *2.5 Player Movement*

In this project, we used Vector Physics to move the player around in our three-dimensional world/space. This vector arrow serves as to show essentially instructions on how to get from Point A to Point B. Due to the limited time frame available for this research, it was decided not to factor in the physics of flight and aerodynamics into the player movement calculations.

## 3. Preliminary Evaluation

The flight simulator has two unique stages with different environments that can be selected from the menu screen. Each game stage has its own theme with a skybox and endless terrain. During gameplay, a 3D cockpit model based on a real-life plane is present to give the player the impression of being inside a cockpit. The following figures shows the simulation experience.

**Figure 1 a player interacting with our game**

**Figure 2 Day flight simulation.**

A pilot study was conducted to assess the visual fidelity of the flight simulator. We asked 12 volunteers (aged 18-29) to grade each visual component of the simulator from 0-10 and provide some feedback on how the visuals could have been improved. Table 1 shows the average score for each visual component.

| | Visual Component (%) | | | |
|---|---|---|---|---|
| | Cockpit | Sky | Lighting | Terrain |
| **Average** | **88.00** | **92.00** | **69.00** | **71.00** |

**Table 1 Participant's subjective grading for the visual components of our VR Flight Simulator**

In general, the participants felt that the simulator provides an enjoyable and immersive experience akin to a game. However, it was not realistic enough as the plane movement was not as smooth as expected due to the absence of plane flight physics, and the terrain did not have enough variation. They also felt like the day mode feels more natural than the night mode due to the lighting.

## 4. Conclusion

In this paper, we presented a VR Flight Simulator that runs on Android mobile devices with an external Bluetooth controller. We studied the degree of realism it provides and its effect on player's enjoyment. The preliminary results show that the flight simulator provide enough visual realism to make an enjoyable and immersive game experience. Going forward, we want to address the received feedback by applying physics of a plane flight into the simulator. We also want to improve the lighting of the night flight simulator to make it feel more natural.

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