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Virtual Reality Flight Simulator

Kelvin Valentino, Kevin Christian, and Endra Joelianto, *Member, IEEE*

***Abstract*— Flight simulators are currently used to train prospective pilots who will fly aircrafts. However, the flight simulator usually need more space, more budgets, and another things so that the simulator can be operated as similar as possible to a real aircraft. Responding to the challenges that faced today and going into the era of portable that permeated whenever and wherever, in this paper, it is developed a virtual reality flight simulator. The virtual reality flight simulator is intended to act as the conventional flight simulator that simulates the environment of real flight. In addition, it can be used anywhere and anytime. The paper presents virtual reality, flight simulator, and programming process of virtual reality flight simulator. Flight simulator using virtual reality is able to provide strong sensations like being in a plane cockpit.**

***Index Terms*— flight simulator, aircraft model, virtual reality, mobile learning**

I. INTRODUCTION

THIS day, simulators are widely used in a variety of things in human life, especially in areas that require special skills which can only be obtained through practices or hours of flying time. The use of simulators is a very effective method of learning to know the functions and workings of a tool or a unit, especially for novice. By using the simulator, the learner will be able to use the tools or the original unit much better than before. In field of aviation, especially in pilot training, a pilot needs to carefully know the right procedures to operate an aircraft, the uses of each panel or tools. The advantage of using a simulator compared to actual flight is the flight simulator gives a better safety, in which in the simulator, pilots can even try many scenarios of unusual or even life-threatening events, and in some cases an event which required a specific flight condition that rarely happens, can be simulate so pilot will have a better knowledge when taking a real flight so the pilot has better approaches and do the best procedure that can be used in these circumstances [1]. If the simulator is effective, then an hour of training in a simulator could replace an hour, or even several hours training in an aircraft. A flight simulator should be made as closely as possible to the real situation they would have when riding a plane. Even a flight simulator can be used too for research and simulation for new model of an aircraft. Another advantage is unpolluted environment, where in one flight, the burning of kerosene will be reduced so that the air is not polluted. And a simulator will give financial benefit which cost is much lower that an actual flight [2].

Along with the development of technologies, where all devices (gadgets) can be taken anywhere and at any time, it will be more convenient if a simulator is able to be used portable. This could be used from young children to adults, even for pilots. Where flight simulator is commonly used, even become a part of curricula, in flight school [3]. All in all, the cost of building a full-scale flight simulator facility is so much higher than building it in a virtual reality device. The presence of virtual reality features into this world of technology makes the future of the simulator could develop to this stage. Virtual reality world is still developing and it starts bustling used by many people. However, to enter into the world of the simulator, at the moment there are not many people wearing it and still not developed much. Therefore, in this paper, it is attempted to take this momentum by designing a flight simulator in virtual reality technologies.

A. Flight Simulator

A flight simulator is a device that recreates an aircraft and its environment or any events where it flies. It is a world where someone who wants to become a pilot, or someone who just wants to learn how to drive a plane, or just to play without having to use the original plane. In this case, the flight simulator is very important for the learning of prospective pilots or airline pilots. To support this pilot prospective study, the flight simulator should be made as closely as possible to the real situation they would have when riding a plane. In this manner, this device needs to include equations of how an aircraft is flying, how flight controls react when it is triggered, effects of other aircraft systems, and reaction of aircraft to external factors such as damping, gravity, air density, turbulence, etc.

In a flight simulator, it is presented some of the best models that each plane has its own character and its specifications. Generally, if a prospective new pilot learns to ride a plane, then the plane chosen is usually the best Cessna 182 because the plane is the most frequently used by someone who first

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learned and also has a relatively affordable price for most laymen that laypeople also sometimes have the aircraft. Some other models are often used in the world of flight simulator is the Air Force, Army, and Navy. A military air force would often practice for driving a fighter by first using a flight simulator beforehand so it can be more proficient and is used in an exercise using an actual plane. Even this has become a regulation, such as in Federal Aviation Administration, for pilot to adapt in flight [4]. simulator.

B. Virtual Reality

Virtual reality (VR) is a new technology that is being developed, which included softwares that give illustrations and also sound similar as possible as if it was in the world given. The virtual reality gives priority to the visual perception of each user, so as to create strong imagination of moving pictures and sound presented by the software. Or you can just say it like a window or a gate to look into a new world, a virtual world. Virtual reality is used by using a special tool fastened to the head, and then we watch a show that is presented inside a special device. Such tools are usually have specially adapted screen field of vision with our eyes so we can see it clearly. In this virtual reality, a person is able to look around in the virtual world, can also interact with the surrounding, supported the use of headphones create an atmosphere like being entered into the virtual world. The support is obtained due to sensors that are needed in the world of virtual reality like a gyroscope sensor, proximity, and also an accelerometer, so the ability to interact with the virtual world could be more exciting again.

The VR technology has leaded to many research and development, such on education: as to assist teachers in teaching students about optical waves [5][6], to teach in medical class that provides great advantage for medical interns to enter medical field [7], to teach anatomy for students so they can be familiar with it, which saves a great expense in experimental materials [8], to teach more effectively about sign language because the students are in 3D domain [9], to educate and training to hydrogen fuel station staff by constructing various scenarios that could happen on 3D VR platform so the staff could understand better the standard of handling process and troubleshooting in an accident [10]. It has also been used in learning vehicle simulation platform, which used to developed driver skills for security verification test platforms [10][11][12][13].

C. Unity

Unity is a software to create a game that will be distributed to the public. Unity has also been widely used by developers to create games based on Android, Windows, Apple, etc. Unity can be used by anyone for a variety of purposes, ranging from personal purposes, learning purposes, until the purposes in commercial terms. This software is very supportive of making games in three dimensions so that the game is made more real taste. And for realistic purpose, Unity has physics element such as center of gravity in object. Unity also supports the creation of a virtual reality game so that the game becomes more real and more real as well as what to expect in a virtual reality. Inside the unity, there is a programming language used, namely C#. The language is familiar to someone already knows the programming language C or C ++ programming languages.

II. STAGES OF PREPARATION

In the development of virtual reality flight simulator, we set up the hardware and software consisting of

- Samsung Galaxy S7
  a. Android Marshmallow v6.0.1
  b. Chipset Exynos 8890 Octacore (4x2.3 GHz Mongoose & 4x1.6 GHz Cortex-A53)
  c. 4GB RAM
  d. 32 Internal Memory
  e. Virtual reality support

Fig 1. Samsung Galaxy S7

- Samsung Galaxy Gear VR

Fig 2. Samsung Galaxy Gear VR

- Gamepad

Fig 3. Gamepad

- Laptop with specifications:
  a. Processor intel i3
  b. Ram 4GB
  c. Hard disk 500GB

- Software Unity Personal Edition

In this case, the ability of the software on the laptop is still very limited in comparison with the developers who have already made and also developed their game or simulator.

III. Stage of Construction

First, for the software, it requires us to have Unity program. Unity Personal Edition is sufficient to make a prototype of this virtual reality flight simulator. And then we need some specific assets files that will be used in the construction of this virtual reality flight simulator. For example of this assets files is a 3D models of an aircraft, codes, objects, and many else.

The process of making this flight simulator has two parallel steps. The first step is making the flight model, such as 3D aircraft model and the environment. In this software, we create a simple landscape with a single road, trees, valleys and hills for the flight test. For the 3D model, Unity has a basic model of Cessna aircraft to be used.

After building the flight environment, we develop scripts for the input controller of the 3D model aircraft. For this controller, we use one-handed gamepad which have two index buttons and a control stick. The upper button functioned as reset button and the lower button functioned as throttle. The control stick functioned to control the movement direction of the aircraft. Also can be controlled by moving of our head. If our head looks to the right, our plane will turn right too and if our head looks to the left, our plane will turn left too.

The movement of the 3D model aircraft needs to be as actual as it can. We need to implement the equations of motions of the Cessna 182. First, we compute the aerodynamic coefficients of the aircraft, such as the angle of attack and sideslip. Then, with the result of computation of aerodynamic coefficients, we compute aerodynamic forces and moments. These forces and moments are combined with the computation from moments and forces generated from engine to compute the body frame of linear and angular accelerations. These accelerations are integrated to form the body frame linear velocities and the body frame rates. The steps to prepare the script shown in following diagram (Fig 4).

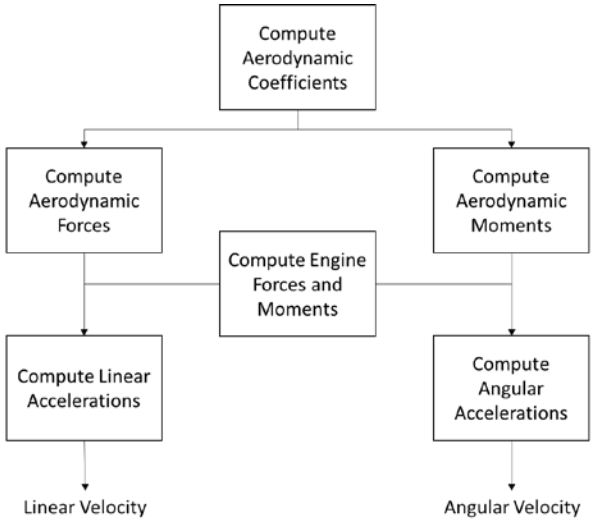

Fig 4. Workflow of computing equation of motions

After the process of building a terrain and movement, the next is rendering the game. The rendering process of the simulator takes a long time, it takes until 25 hours to complete rendering the simulator. This rendering time is depending to compatibility of computer that is used and how large space the flight model used. After rendering, it will form of an *.apk* file which is the base application of the Android. After that, the *apk* file is ready to be installed in the intended gadget and ready to be used to play as the flight simulator. Overall, the stages of construction are shown in Fig 5 that describes the work flow of making the virtual reality flight simulator.

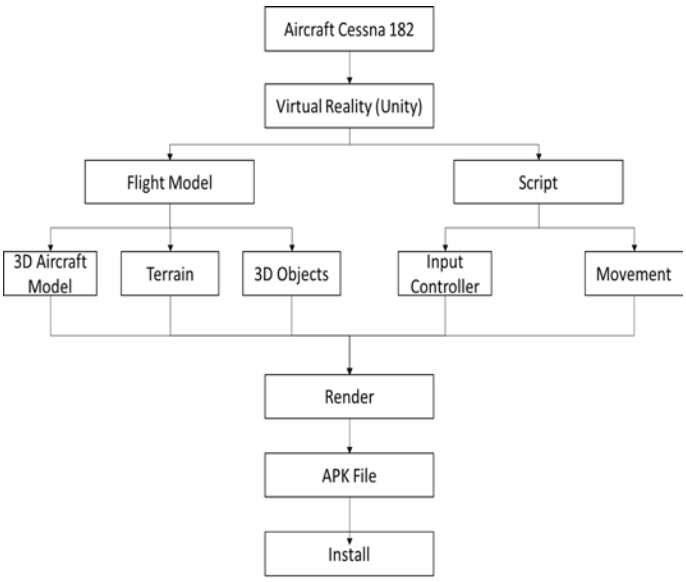

Fig 5. Workflow of the construction

IV. Results

Fig. 6 shows how the process to play the virtual reality flight simulator. The results of the game are a plane that can go and it will fly. The plane is also controlled using a gamepad that has been programmed**.** The results for the flight simulator are shown in the following figures. The flight simulator was

simulated in a computer, because in the gadget, the screenshot cannot be taken. However, the simulation is similar to the gadget. The results of game are given in Fig. 8, Fig. 9, Fig. 10, Fig. 11. In Fig. 8, the airplane is in stand by position and ready to take off. In Fig. 9, the airplane is taking off and flying to another place until in Fig. 10, the airplane flies into outer border of terrain. In Fig. 11, the airplane tries to fly to another terrain. This flight simulator in virtual reality can make a sensation during take-off and landing, because of the difference in the current conditions on the runway and while on the sky. The performances of the development process of the virtual reality flight simulator is summarized in Table 1.

TABLE I
PERFORMANCE OF VIRTUAL REALITY FLIGHT SIMULATOR GAME

Rendering	25 hours
Duration of Simulation	4 hours
Frame per Seconds	75 frame per seconds

Fig 6. Architecture of Virtual Reality Flight Simulator

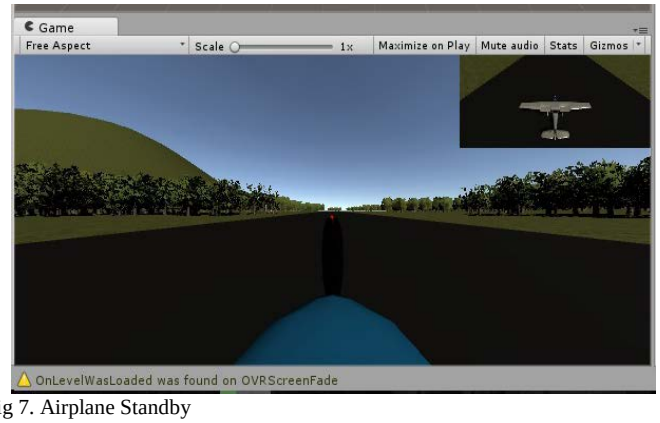

Fig 7. Airplane Standby

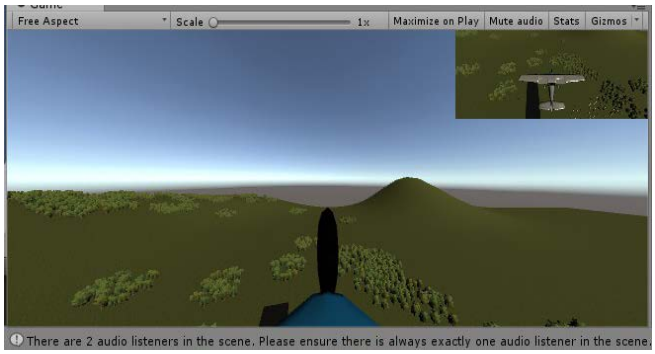

Fig 8. Airplane Taking Off Process

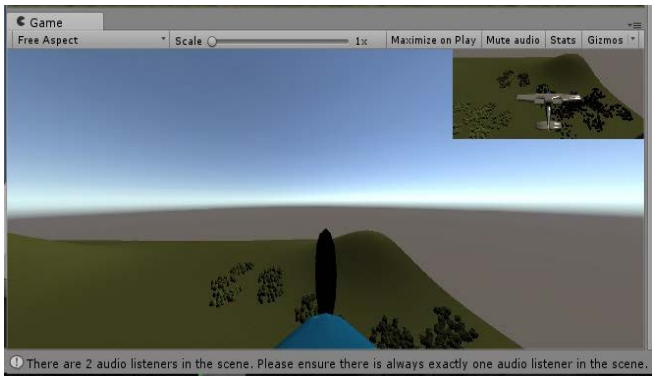

Fig 9. Airplane Fly to Outer Border of Terrain

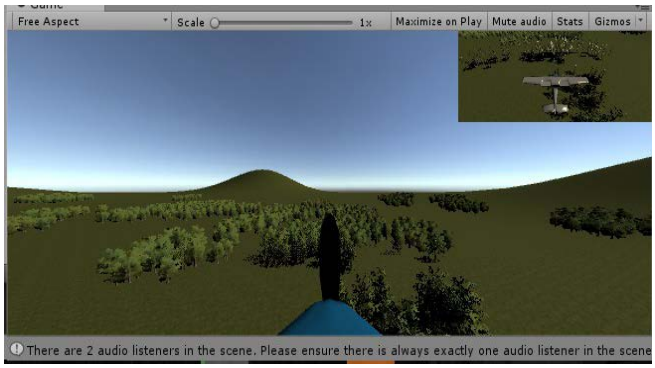

Fig 10. Airplane Flying to Another Terrain

V. CONCLUSION

In this paper, a virtual reality flight simulator was developed successfully to simulate the flying of the airplane with a simple flight dynamics, limited terrain and objects. It gives great perspective of flying in mid-air. The virtual reality flight simulator was not a complete and powerful flight simulators as the actual airplane flight dynamics were not incorporated into the developed program. In other words, virtual reality flight simulator which is a new technology for virtual environments allows one to interact with the environment generated by the computer. The weakness in this virtual reality flight simulator is different gestures used for a normal flight (joystick, pedal, button, etc), it still needs a better facility for having an experience that are closed to the real experience. So it should be a semi-portable devices to ensure a better experience. For the next stage, the complex flight dynamics of the airplane are

going to be included with better terrains and more realistic plane object.

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