Pakistan Journal of Engineering and Technology, PakJET
Multidisciplinary & Peer Reviewed
Volume: 4, Number: 2, Pages: 131- 138, Year: 2021

An Android Based Flight Simulator using VR Technology

Muhammad Tahir[1], Rabia Noor Enam[2], Syed Muhammad Nabeel Mustafa[3], Rehan Qureshi[4]

[1,4]Software Engineering Department, Sir Syed University of Engineering & Technology, Karachi, Pakistan
[2]Computer Engineering Department, Sir Syed University of Engineering & Technology, Karachi, Pakistan
[3]Computer Science and Information Technology Department, NED University of Engineering and Technology, Karachi, Pakistan
Corresponding author: Muhammad Tahir (e-mail: tahirfattani@gmail.com).

Abstract- **For training young pilots. Flight simulators enhance the safety measures, as the risk factor of severe injuries is eliminated since the training is now synthetic. However, flight simulators also require large space, large budget and does have many high-end requirements, which are to be met to make the simulator respond and perform identical to that of a real aircraft. Flight simulators do have their hardware constraints and because of these limitations, the simulators are not of generic nature that supports different sort of aircraft. In this paper, the simulator environment is deployed in virtual reality to simulate similar controls on a stereoscopic environment. Deployment of the simulator is such, that experience of flying an aircraft from the cockpit will give a sensational view to the user. Virtual reality is used for learning purpose, as a normal person can experience what it will be like, to fly an aircraft**

Index Terms-- **Aircraft training, Flight simulator, Virtual reality, 3D application**

I. INTRODUCTION

For the last 40 years or so, technology has completely revolutionized the training of young and inexperienced pilots. Flight simulators are used for ages for training purposes, as well as for the simulation in the development of aircraft as well. These simulators evolved with time as the technology advances, their results become more accurate and performance becomes efficient to that of a real situation. However, despite so many functionalities and characteristics, these simulators have their drawbacks such as high costs and space dependencies. The hardware that is required to build these simulators is very expensive and big, eventually resulting in heavy costs and requiring a large space to function. The immersion of Virtual Technology evolves flight simulators by replacing the costly hardware and using virtual environments to depict the same functionalities. But these simulators lack efficiency, functionalities, and response time as contrary to large simulators, but cost and space requirement decreases greatly.

Flight simulators are commonly used for a variety of purposes that includes, development of an aircraft, training of young pilots, investigation of a catastrophic event, etc.… Before these simulators, young pilots had to use real aircraft for training, which increases the chances of severe injuries or in some cases costs life. Aircraft simulators played a pivot role in grooming young trainee pilots who will fly aircraft. These simulators were designed to train a pilot more effectively, allowing a young trainee to learn about all the controls and functions that would be required for a safe flight, it also aids in creating an emergency within the simulator to train a pilot to deal with such hazards. However, these simulators are built on large scales and mostly could support a single type of aircraft.

Virtual Reality or augmented reality is the product of technology that could be used in different perspectives like entertainment. In the virtual environment, the deployment illustrates such real-world experience, as if it is there. This technology is now gaining popularity because of its diverse nature, as it could support entertaining needs, but more importantly, it could be used in a learning perspective. Virtual reality functionality has also become a standard part of commercial flight simulator software like Laminar Research's X-Plane and Lockheed Martin's Prepar3-D [1]. Usually, the user is provided with a series of images that are deployed in a virtual world, allowing a user to interact with it. This idea is now being used to develop many applications that allow a person to experience such sensations as flying an aircraft.

A. PROBLEM STATEMENT

In this paper, we introduce a model, which includes a realistic learning environment of how to fly an aircraft, the controlling mechanism are deployed with much more accuracy. The virtual environment will be a learning experience for normal people to learn and understand the controls of an aircraft, as well as respond to different controls of aircraft. The controlling mechanism will be motion-less. This will be a low-cost simulator, contrary to those high-end simulators, which does not give liberty to different environments. The research aims to introduce a less costly, yet effective virtual application that will summarize the importance of the learning factor of this technology, rather than only using it for entertainment purposes.

The contributions of the research are detailed below:

- Provides realistic environment so that the learner can get hands-on
- The virtual environment will help learners in better understanding
- A low-cost simulator gives easy access to the learners.

II. LITERATURE REVIEW

The response virtual reality has generated among different communities and organizations is huge. The development of this technology could be beneficial for many reasons, but could also be a hazard for society. There might be a possibility of it being used for wasteful purposes, indulging people in only entertainment. Maintaining its positive learning perspective is our responsibility [2].

The simulators are not identical to that of a real aircraft, which hinders the handling qualities of a real aircraft. The deployment is not on a level where flight behavior towards the pilot is presented realistically, not making it easier for the pilot to understand the functions and controls correctly, which eventually leads to an error. Illustration techniques are not as real as they should be [3].

It is also observed that those trainers that were trained with fixed-based high-cost simulators that allow motion movement as well have a great understanding of landing an aircraft. Those trained in motion-less low-scale simulators also showed great signs of learning and understanding, except their response time was a bit slow. This also showed the significance of altitude and height parameters in-air flight training [4].

Having too many options in your application or adding many irrelevant features will eventually result in the slowdown of the system. The latency is also dependent on the quality of hardware used, the requirements are met and the designed model is not flooded with extra options, the application will run smoothly [5].

A young trainee should get his hands on a simulator rather than on a real aircraft directly. Simulator experience would be fruitful for adjusting in a real aircraft [6].

Since virtual reality is a new technology, a lot of development is being done to make it more accurate. However, the deployed simulators are not very powerful or identical to real aircraft. Its experience gives a great understanding of what it is like to take off or land a plane, the development should be near to real if not real [7].

Virtual buttons are used to interact with the virtual environment of the simulator rather than a physical mock-up. This showed no signs of any less responsive rate [8].

The virtual simulator proves to be a great step in decreasing anxiety and improving comprehension. The goal is to achieve a better working simulator that gives a thrilling and refreshing air, allowing experiencing a great flight [9].

According to research, it is observed that Virtual Reality technology is for gaming purposes, as usually, gamers have access to high-end systems that are compatible with Virtual Reality environments, the requirements of the graphics. The virtual reality genre also attracts nongamers, but usually, they don't have the supporting hardware to experience the environment [10].

There are still many constraints relating to Virtual Reality technology, as the inexpensive and easily available products are not built on a scale that could be used as a general application. Cost is reduced but at the expense of quality. Similarly, we found many drawbacks in already developed systems for fear of flying as they don't expose the user in the real situation. Protocols and standards are such that it is hardly possible to develop a system that would be very efficient as well as cost a significantly low amount of money [11].

Undergraduate students obtaining a Restricted Airline Transport License were given specific hours of flight training in a virtual reality flight simulator in this study. The students were instructed to conduct training flights using the PilotEdge software, which provides a high-fidelity simulation of interaction with ATC staff within the National Airspace Systems [12].

In research, it is observed that the response rate of users present in a real environment is more than those in a virtual non-immersive environment. Usually, the design and implementation of the environment lack the realism factor, making it uncomfortable for the users. The rate of presence is not very efficient for those in a virtual environment as contrary to those, which are physically present in an actual environment of that illustration [13].

The immersive VR technology could be the modern style of learning, as it enhances the ability of users to experience and learn about things that are not physically present. But the learning perspective is very limited in contrary to the entertainment industry, as industries are usually targeting gaming audiences. VR can revolutionize learning methods by making unreachable environments available [14].

Flying Phobia is common among people, and it is considered a mental disorder. It is needed to be cured via many therapies and exposures to different sessions. It includes everything related to a normal flight from getting on to the plane, taking off of the plane till the landing. All these situations are illustrated in a Virtual Environment to create a similar situation and make the affected people learn and experience more about it [15].

To train the aviation personals, a VR-based simulator is introduced which, lets the aviation officers learn and practice in the simulated environment [16].

In [17], authors present a fully immersive merged reality flight simulation system that bridges the gap between virtual flight training and real-world flight. Pilots gain more realistic flight training and feel more comfortable and confident during their first flight with the proposed technology technology.

[18] outlines a study that looked into how better learning diagnostics could improve training efficacy. In a virtual reality flight simulator, authors investigate how different types of knowledge assessment are related to different categories of task knowledge and task performance. The findings show that individuals who had better training comprehension on conceptual (and to a lesser extent, declarative) information, as judged by diagnostic test questions, also had better knowledge transfer in the VR flight simulator.

Idea is to reduce the cost of simulators by introducing the concept of virtual reality. The intent is to develop a system that illustrates the sound experience of flying an aircraft to normal people. It has been the goal to illustrate a realistic environment in a virtual reality-based simulator, covering the main aspects and functions of a safe air flight. Working is continuously being done to promote a low-cost system that covers all major functions of that fixed space holding simulator that have high hardware constraints and still cost a great amount of budget. The motive was to promote awareness about an air flight firsthand experience.

A. STATISTICS OF SIMILAR VR SIMULATOR APPLICATIONS

TABLE I: Statistics of Similar Applications

S No.	NAME	RAM	FPS	CPU	PLATFORM
1	VR Flight FS	172 MB	31 FPS	7%	ANDROID
2	VR Airplane FS (2016)	240 MB	57 FPS	11%	ANDROID
3	VR Airplane F-Simulation (2018)	230 MB	32 FPS	9%	ANDROID

Table I represents the data values or log values of similar VR simulator applications that are already developed. The logs include RAM usage, CPU Usage, and evaluate performance based on FPS. These applications are of a similar genre; hence the comparison is possible.

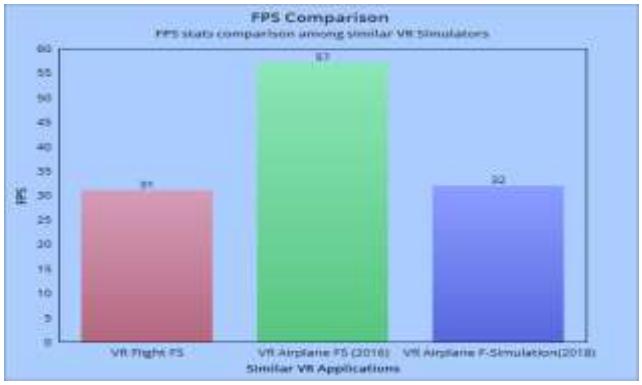

FIGURE 1: FPS comparison between similar VR Apps

In Fig. 1, a graph represents the comparison between different applications based on frame rate per second. This is an ideal way of examining and comparing VR gaming applications

B. VR FLIGHT STATISTICS

According to the log of VR Flight Simulator, the performance is not good as well as the control because you have to move your head to control the controls of the plane which is not comfortable for the user or pilot and causes an effect of neck pain and as well as eyesight problem due to movement of the head. No hardware like (controller) is connected with mobile to control the plane in this VR Flight Simulator [19].

These are the statistics of VR FLIGHT which is also an Android Virtual Reality Application that demonstrates the air flight

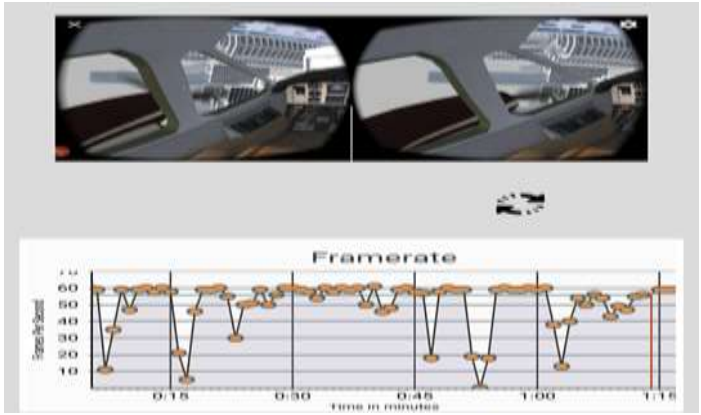

FIGURE 2: Frame per Rate of VR Flight

Figure 2 showed the fps calculators of VR Flight application. Since the fps isn't maintained at a good level, thus the game will lag at points where the details are not easily handled by phone, giving a negative user experience.

TABLE II: Test Results

Application	Test Duration	Resource Usage			Performance
		CPU	RAM	GPU	
VR Flight FS	3 Minutes	7%	172 MB	N/A	N/A

As the logs are shown in Tab.II, the testing was performed to analyze the application. VR Flight while in execution uses 7% CPU and around 175MB of ram, which is not a very high-end requirement, since the application isn't designed with deep detailing. Handling of the application will be normal on an average android phone. GPU and performance as fps couldn't be measured because of the amount of variation in fps that occurs while the application is running.

III. VR AIRPLANE FLIGHT STIMULATOR

According to the log of this VR application the overall specs of this is just fine not so good and you can control the movement only with the movement of your phone no controller can control the movement of plane and it has the worst FPS which lags a lot and the overall performance is just fine [20]. The fps level is

maintained, but the detailing and modeling must not be good enough as the fps remains around 30 as shown in Fig. 3.

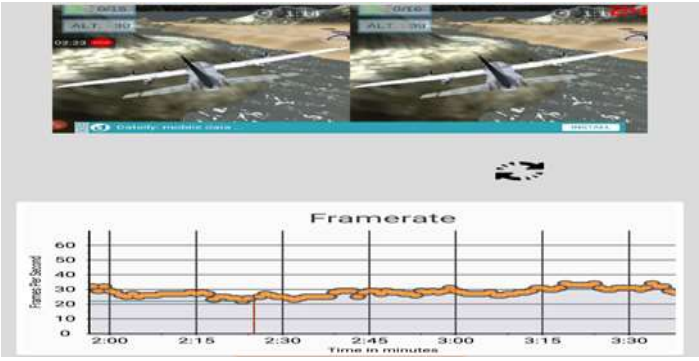

FIGURE 3: FPS Level

TABLE III: Logs of the Application

Application	Test Duration	Resource Usage			Performance
		CPU	RAM	GPU	
VR Airplane Simulator 2018	3 Minutes	9%	230 MB	91%	32 FPS

Table III shows the logs of this application, it depicts the CPU usage is maintained within minimum range, i.e., 9% and ram usage is calculated around 230 MB. The GPU usage is very high, since the application isn't giving performance according to the resources it is consuming. As the table shows, the fps is maintained but at a low level which shows that the modeling and detailing is performed on a low level.

IV. METHODOLGY

The concept of Virtual Reality is combined with creativity in order to create a learning environment that would be beneficial to the user. Rather than making negative use of technology, it is deployed in order to enlighten people. It is very important that such technologies be implemented for the betterment of humans rather than, for any other catastrophe **[**3**].** The main emphasis was to promote the virtual environment in such a creative way that it will prove to be an element of educating others [13]. Many simulators have been built, but they lack realistic representation of things that are required in training. They are more of gaming genre applications, rather than focusing more on improving the standard of training, on the other hand reducing the cost as much as possible [12]. The major problem faced, while training on such simulators, the behavior of flight does not reflect reality, and controls are not defined according to what a pilot will experience in a real flight. It is very important to deploy the system on such level, that it should be as close to real air flight experience, as one could get.

This will be an android based flight simulator, which will not require expensive hardware that are must have in order to have virtual experience through computer systems. Hence, non-computer gamers can also enjoy the flight simulation through their android phones [10]**.** The system will depict somewhat of a real flying experience, so those having flying phobia could train themselves better [14]. There will be height and altitude adjustments, which pilot will have to make according to the given situation, and airports with advanced lightings will be deployed in virtual environment, in such a way that interaction between the environment and the user will be maximum, as we do not see such options in motion less cues [4] It will be a motion less experience that is less physical, where the cues are controlled via a joy pad rather than expensive gadgets. The speed and height parameters will be briefly defined, giving a real flying experience. The system in future could be enhanced to reach the accuracy, that of a motion cue simulator, because such environment will be built and the risk factors are given in Tab. IV.

TABLE IV: Risk Factors to be Counted during development

Category	Risk
Development Risk	Ability to develop according to user's need
Cyber Sickness Risk	When exposure to the virtual environment causes symptoms that similar to motion sickness symptoms.
Data Security Risk	Payment & personal information submitted to technology could be accessed by hacker.
Production Desogn and Integration Risk	Insufficient resources , rigidity, reliability, occurrence of malfunctioning
User Risk	User not comfortable with product during the operation
Technology Risk	Battery consumption, mobile heating

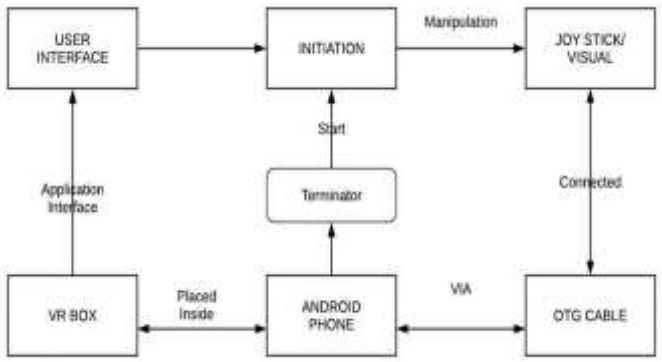

FIGURE 4: System Block Diagram

Figure 5 demonstrates how all the modules of the system including user and environment will interact with one another in a nutshell. Just after execution the user will experience the virtual environment where the input will be given through control medium and the system will respond in that virtual world. The controls are deployed in order to make user interact with the

environment and getting the output of his actions that he entered using the default control system. All these modules that conclude of Interaction between user and system are designed in accordance to their communication with other modules.

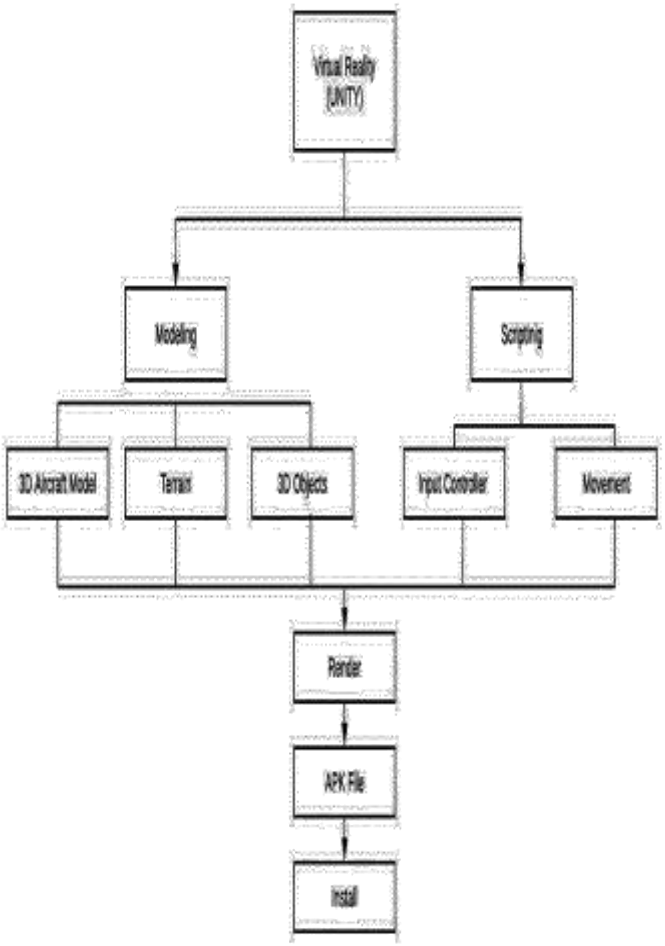

FIGURE 5: Procedural Flow of the application

Figure 5, is the demonstration of procedural structures and activities that will flow with accordance to the situation, the series of procedures followed and what activity covered first. The virtual world consists of two packages, its designed environment and its deployed controls. The environment will consist of accurate deployment of 3D Aircraft Model; terrain will serve as the platform of the environment containing different objects of the environment. The scripting procedure concludes of how the movement and environment will interact with the user, keeping a track of realism factor. After finalizing the series, the rendering of the whole thing will merge things down to a real-world application and reducing its size significantly, allowing it to be functioning on devices easily. The whole process will finish with converting and merging all these rendered files into a single .apk file that would be installed on the device.

Table V, comprises of the details about the software and hardware components that were utilized in the development of this application.

TABLE V: Hardware and Software components used for development

Component/Software	Version/Memory
Operating System	Microsoft Windows 10 Professional
Processor	Intel Core i5
Ram Memory	4GB minimum
Technology	Unity Engine (Any Edition)
SDK	Mono Developer
Scripting Language	C#
3D Modeling Software	Blender/3DS MAX

The Recommended specifications of phone to run the High Sky VR application smoothly are as following;
The Software requirements of the application are Android Version 5.0 or above, along with drivers for the respective joy pad the user will play.
The Hardware recommended to run the application smoothly consist of,

- Processor Chipset Snapdragon 820 or above, with minimum Ram Memory required is 2GB.
- Application will require 1 GB space on your phone.
- A VR Box in order to use the application is required. A headphone will be used for audio purpose.

V. RESULTS

The statistics of High Sky VR that includes complete tracking of Fps, Ram and CPU Usage are given in Tab. VI.

TABLE VI: Statistics of High Sky VR

S. No.	Environment	Batches	RAM	AVG. FPS	Platform
1	User Interface	280	68 MB	49 FPS	Android
2	Desert	195	210 MB	45 FPS	Android
3	Sea	400	30-70 MB	34.5 FPS	Android

A. USER INTERFACE STATISTICS

User interface is the landing page or the main menu of the application, where user will be landed after the execution of application. In order to check the quality and stability of the environment, we performed testing for FPS, RAM and CPU. All the parameters are given in Tab. VII.

TABLE VIII: Log Results of User Interface Testing

Environment	Testing			Resource Usage			FPS	Average FPS
	List of Tests	Duration	Avg. Duration	CPU (%)	RAM (MB)	GPU		
User Interface	Test 1	3 Min	3 Min	6	95	N/A	50	49 FPS
	Test 2	3 Min		4	74	N/A	49	
	Test 3	3 Min		5	91	N/A	49	
	Test 4	3 Min		5	96	N/A	50	
	Test 5	3 Min		7	158	N/A	46	
	Test 6	3 Min		6	161	N/A	49	
	Test 7	3 Min		4	80	N/A	50	
	Test 8	3 Min		6	111	N/A	50	
	Test 9	3 Min		6	103	N/A	50	
	Test 10	3 Min		6	79	N/A	49	

As shown in Tab. VIII, we performed 10 tests on User Interface to get the best average results. All the tests were conducted for 3 minutes in order to check their resources consumption and analyze the output in fps. The reason for testing this environment for 3 minutes, which is just a menu of the app, is to check the stability of the application and nothing more.

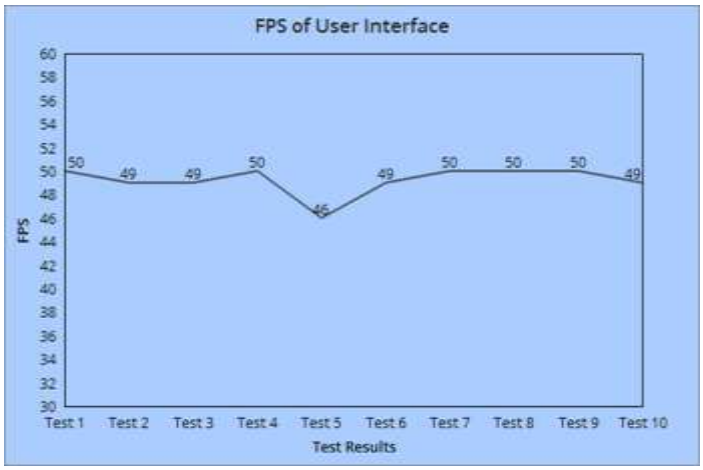

FIGURE 6: Graph showing FPS for all 10 tests on User Interface Environment

Table VIII depicts stability in all the aspects the test was conducted. CPU consumption remains very low which allows the phone to keep most of its resources free for other applications. RAM varies according to the usage and the consumption is low for it too. FPS is maintained for all the tests, which is a positive result for the application. In Fig. 6, the graph represents the values of FPS during ten tests that were conducted in order to evaluate the results in term of fps. Over the course of all the ten tests, the results were positive as the graph didn't show any steep deviation, maintaining consistency. This result shows that game play will be smooth without any lags, the consumption of resources of CPU & RAM are also under control.

B. SEA ENVIRONMENT

Sea Environment is one of the environments designed for the game. It has the greatest number of batches because of high detailing of the environment. In order to check the stability of this environment even after such high-quality graphics, the results are given in Tab. XI:

TABLE XI: Log Results of Sea Environment Testing

Environment	Testing			Resource Usage			FPS	Average FPS
	List of Tests	Duration	Avg. Duration	CPU (%)	RAM (MB)	GPU		
Sea Environment	Test 1	3 Min	3 Min	6	95	N/A	45	45 FPS
	Test 2	3 Min		6	74	N/A	46	
	Test 3	3 Min		6	74	N/A	46	
	Test 4	3 Min		5	70	N/A	46	
	Test 5	3 Min		7	103	N/A	44	
	Test 6	3 Min		8	68	N/A	45	
	Test 7	3 Min		5	71	N/A	45	
	Test 8	3 Min		6	83	N/A	42	
	Test 9	3 Min		9	111	N/A	46	
	Test 10	3 Min		7	76	N/A	45	

Just according to previous testing, we performed 5 tests for 3 minutes respectively, to check this environment as well. Table XI represents, all three tests showed almost identical results, confronting the stability of this environment as well. The FPS remained stable despite of greater number of batches. The 46 average fps shows that the environment will be a lag free and smooth experience to the user.

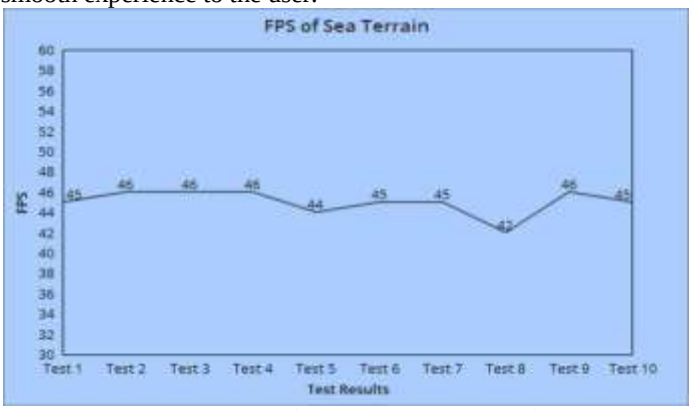

FIGURE 7: Graph showing FPS for all 10 tests on User Interface Environment

Figure 7 is representing the frame rate per second counts of Sea Terrain. The graph depicts consistency over the course of 10 different tests, as the fps of doesn't deviate much from the threshold point. It shows that the environment is stable for the application to perform up to the required standards. The lowest fps recorded was 42 which increase in batches during that session.

C. DESERT ENVIRONMENT

Testing was performed thrice on this environment as well to continue the format and check the quality of this environment. All ten tests were conducted for 3 minutes to completely analyze any bugs or lags in this environment. The FPS, CPU and RAM statistics of this environment are as following;

TABLE X: Log Results of Desert Environment Testing

Environment	Testing			Resource Usage			FPS	Average FPS
	List of Tests	Duration	Avg. Duration	CPU (%)	RAM (MB)	GPU		
Desert Environment	Test 1	3 Min	3 Min	6	335	N/A	34	34.5 FPS
	Test 2	3 Min		5	324	N/A	35	
	Test 3	3 Min		7	373	N/A	35	
	Test 4	3 Min		5	320	N/A	35	
	Test 5	3 Min		7	311	N/A	35	
	Test 6	3 Min		5	379	N/A	32	
	Test 7	3 Min		9	365	N/A	35	
	Test 8	3 Min		9	411	N/A	34	
	Test 9	3 Min		8	373	N/A	35	
	Test 10	3 Min		6	355	N/A	35	

Table X contains the results of all three tests performed to analyze the desert environment. The CPU resources are consumed in a very less manner just like other environments; however, RAM consumption increases because of the type of rendering system will perform in order to combine batches and shows the result. FPS is maintained without any steep deflection, which shows that the application will run successfully without any lag.

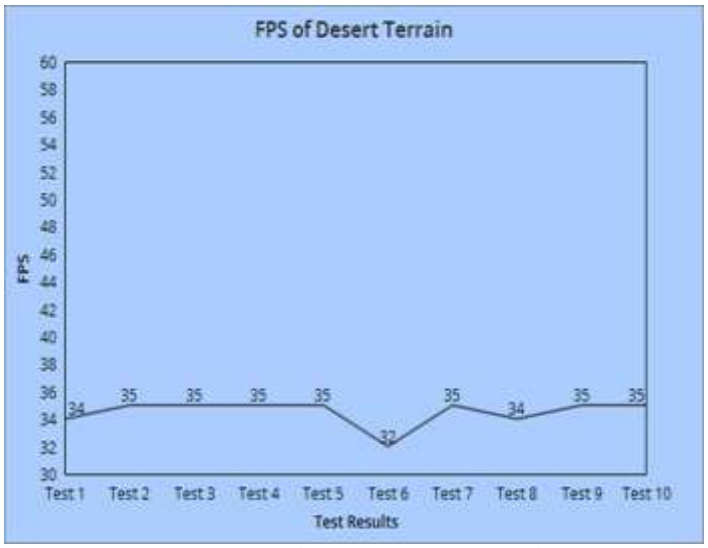

FIGURE 8: Graph showing FPS for all 10 tests on User Interface Environment

The graph in Fig. 8 depicts consistency during all the tests conducted, as the fps remains close to Average FPS calculated for the environment. Since fps remains consistent, the application will not lag during execution.

VI. CONCLUSION

In this paper, it is presented how Virtual Reality is used in the development of an effective flight simulator for demonstrating different dynamics of an air flight. The learning perspective of VR technology is promoted, giving an idea of how simulators could be revolutionized by this concept, improving the cost and space efficiency of flight simulators. Realistic cockpit view is introduced which could be a new experience for many people. We have discussed three scenarios in the research and the existing results have showed that Virtual Reality Flight Simulator (VRFS) is a better flight simulator. The experiments were conducted on user interface, desert and sea environments. We conducted 10 experiments on the selected environments. The results showed average Frames per seconds (FPS) of all the mentioned scenarios as 45, 49 and 34.5 respectively. The results have shown that our application uses 49.37% less CPU and memory than other applications, which depicts positive results of application. The findings of this research have created a difference with the previous research works. However, the intent is to promote the idea of deploying simulators using VR Technology as it could reduce the expensive hardware that is used for the development of flight simulators. If work is done on proposed idea, in future simulators will be free of their hardware constraints, which will allow many universities to set up their own simulator for undergraduate or postgraduate programs. Environment deployment should be done on standards defined by aerospace centers, as it could be the future of flight training system for young pilots. A successful program will be capable of carrying out most flight activities of young pilots with great efficiency, as well as greatly reducing the cost and injury factors that a young trainee usually has to face.

REFERENCES

[1] Wallace, Jon W., Zhengxie Hu, and Daniel A. Carroll. "Augmented Reality for Immersive and Tactile Flight Simulation." *IEEE Aerospace and Electronic Systems Magazine* vol. 35, no.12, pp. 6-14, 2020.

[2] Mazuryk, Tomasz, and Michael Gervautz. "Virtual reality-history, applications, technology and future." 1996.

[3] Perry, David Howard, L. H. Warton, and C. E. Welbourn. "A flight simulator for research into aircraft handling characteristics." 1966.

[4] Bauer, Maria C. *Evaluating the effectiveness of training system approaches for highly complex flight training*. University of Central Florida, 2005.

[5] Aslandere, Turgay, et al. "A generic virtual reality flight simulator." *Virtuelle und Erweiterte Realität, 11. Workshop der GI-Fachgruppe Tagung Band*. Shaker Verlag, 2014. http://elib.dlr.de/90891/

[6] Kljuno, Elvedin, and Robert L. Williams. "Vehicle simulation system: controls and virtual-reality-based dynamics simulation." *Journal of Intelligent and Robotic Systems* vol. 52, no.1, pp. 79-99, 2008.

[7] Valentino, Kelvin, Kevin Christian, and Endra Joelianto. "Virtual reality flight simulator." *Internetworking Indonesia Journal* vol. 9, no.1, pp. 21-25, 2017.

[8] Aslandere, Turgay, Daniel Dreyer, and Frieder Pankratz. "Virtual hand-button interaction in a generic virtual reality flight simulator." *2015 IEEE aerospace conference*. IEEE, 2015.

[9] Marquess, Matthew, et al. "A pilot study to determine if the use of a virtual reality education module reduces anxiety and increases comprehension in patients receiving radiation therapy." *Journal of Radiation Oncology* vol. 6, no.3, pp. 317-322, 2017.

[10] Thiebaut, Chase. "Effectiveness of virtual reality in gamers versus non-gamers." 2017.

[11] Riva, Giuseppe. "Virtual reality in psychotherapy." *Cyberpsychology & behavior* vol.8, no.3, pp. 220-230, 2005.

[12] Usoh, Martin, et al. "Using presence questionnaires in reality." *Presence* vol. 9, no.5, pp.497-503, 2000.

[13] Walden Ph D, Austin T., and Michael Pritchard Ph D. "Exploring VR with PilotEdge in a University Part 141 Environment." 2020.

[14] Freina, Laura, and Michela Ott. "A literature review on immersive virtual reality in education: state of the art and perspectives." *The international scientific conference elearning and software for education*. vol. 1. no. 133. 2015.

[15] Campos, Daniel, et al. "An Internet-based treatment for flying phobia (NO-FEAR Airlines): study protocol for a randomized controlled trial." *BMC psychiatry* vol.16, no.1, pp. 1-11, 2016.

[16] Bulai, Andrei, Diana Andronache, and Dorin-Mircea Popovici. "Design features of a VR software system for personnel training in aviation." *rochi-International Conference on Human-Computer Interaction*. 2020.

[17] Cardenas, Irvin Steve, et al. "Immersifly: next generation of immersive pilot training." *2017 International Conference on Computational Science and Computational Intelligence (CSCI)*. IEEE, 2017.

[18] McGowin, Gregory, et al. "Examining Enhanced Learning Diagnostics in Virtual Reality Flight Trainers." *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. vol. 64. no. 1. Sage CA: Los Angeles, CA: SAGE Publications, 2020.

[19] VR Flight Simulator [Google Play store VR Application] by http://www.beenoculus.com/.

[20] Flight Simulator 2016 [Google Play store VR Application Offered By Integer Games]