The University of the Western Cape
Department of Computer Science

An Investigation of Immersive Technologies

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Date Submitted: 19 April 2018

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Declaration

I, **Justin Erasmus**, declare that this thesis *An Investigation of Immersive Technology* is my own work, that it has not been submitted before for any degree or assessment at any other university, and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references

Signature: . . . . . Date: . . . . . .

Justin David Erasmus

Abstract

Immersive technology is a rapidly developing field and received good feedback from the world by the release of Pokemon Go. This project intends to set a foundation for the a new immersive technology course conducted at the University of the Western Cape. The desired outcome of this project is to produce substantial research about immersive technology and simultaneously implement a software system utilizing such technology. This project also defines a solution that address the problem of learning how to fly drones with a lowered risk of crashing into objects. In addition to this we will explore the option of creating an augmented reality environment for drone pilot trainees, to improve their flying skills without the risk of flying into objects in mid-air.

Key Words

UAV

FPV

Drone

Augmented Reality

Virtual Reality

Immersive Technology

Acknowledgements

I would like to express my deep gratitude to Professor Bagula and Dr. Isafiade, my research supervisors, for their patient guidance, enthusiastic encouragement and useful critiques of this research work. I would also like to thank Dr. Fish, for her excellent efforts to impart good mathematical knowledge in my academic career.

I would also like to extend my thanks to the staff of the laboratory of the Computer Science department for their help in offering me the resources in running the project. I would also like to thank Accenture Education Trust for financing my academic career since 2016.

I would also like to express my gratitude towards Mr Garth Brydon for being my mentor of the technology industry and encouraging me to complete my honours degree.

Finally, I wish to thank my family and fiance for their support and encouragement throughout my study.

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Glossary

UAV: Unmanned Aerial Vehicle

FPV: First Person View

Drone: A remote controlled unmanned aircraft

Augmented Reality: A technology that places computer modelled and generated objects in the real world view of the user.

Virtual Reality:

A 3D computer generated environment that can be interacted with in a pseudo-real way.

Immersive Technology: Technology that integrates a virtual and real world giving the sense of immersion.

Chapter 1

User Requirements Document

1.1 Introduction

The following chapter will evaluate the issue of drone pilot accidents from a user point of view. We will discuss the problem, in addition to this, a proposed solution to accommodate the users need.

1.2 Users view of Problem

UAV pilots that are trained and untrained spend large sums of money on flight training, typically from accidents caused by winds and physically objects being in the way of the aerial vehicle. To eliminate one of these costly accidents and potentially lower the risk of wind accidents, the user requires a system that will create a virtual environment in order to train the pilot to fly through obstacles.

1.3 Description of the problem

UAV pilot training is typically an expensive ordeal, costing thousands of rands in order to gain training. Although, supervised training is highly effective, when accidents occur, due to poor skills or lack of supervision, repairing drones is an expensive process.

Drone repair engineers charge around R450 as an hourly rate to fix drones, this excludes extra parts, firmware upgrades and assessment fees. With these potential risks that could occur, many prospective pilots would find that practicing their flying is an expensive risk.

The primary problem in this project is the high barrier of costs that is involved in drone pilot training. One can lower the barrier by lowering the risk of expensive accidents. In turn, this will allow for more people to become UAV pilots.

1.4 Related Work

1.4.1 Augmented Reality

A paper written by Krzysztof Lis suggests that flying a drone in an augmented reality is possible by using tools such as Unreal Engine and a parrot bebop drone.

1.4.2 First Person View From Drone

Several UAV devices have built in camera's, and some drones come with a headset to allow the user to view the flight from the drones point of view as well use gesture controls (e.g. turn head) in order to move the camera. (1) (2)

1.4.3 Location Based Augmented Reality

In this paper the author describes that GPS based augmented reality is feasible but highly inaccurate. In addition to this the author suggested that using the mobile phones accelerometer, magnetometer and gps (3), one can use the pose estimation algorithm to analyse the pose of the mobile device. Having all these factors calculated one can place augmented objects almost accurately on certain gps coordinates.(4)

(5)

1.5 Proposed Solution

Using immersive technology, one can mitigate the risk of flying into objects by creating an augmented reality environment where one can place virtual objects in reals space. This will allow the pilot to use an open space to navigate around more complex obstacles. The user will be immersed in an augmented reality space viewing from the drones point of view. The solution will also provide users with telemetry data such as wind, temperature and altitude so that the pilot can adjust their vehicle to remain in the safest position.

1.6 Expectations of the software solution

The software developed should be a user friendly and graphically attractive solution in order to simulate life size objects. The solution should provide the users with different types of obstacles in order to adjust their level of skill.

1.7 Conclusion

We have thoroughly analysed the problem from the users point of view and discussed other related work to this project. We have also suggested a solution of creating a augmented reality UAV pilot training course and proceeding, we will analyse the list of requirements in order to solve the existing problem.

Chapter 2

Requirements Analysis Document

2.1 Introduction

2.1.1 Document Purpose

The purpose of this document is to collect complete, unambiguous and reliable requirements of an Immersive Technology project, at the University of the Western Cape, under the department of Computer Science. The manner in which this document will be written would notably contain technical terminology in addition to this it would be minimal and concise. The requirements of the project will be modelled using a use-case approach for the sake of standards and simplicity.

2.1.2 Intended Audience

The primary intended audience for this document would be the supervisor and project owner of this particular project. The key stakeholders such as the supervisor/project owner as well as the co-supervisor must have the ability to verify all the content of this requirements document to be of the standard of completeness, accuracy and clarity.

All academic staff including, prospective postgraduate students may find this document as a guide in order to address similar requirements. Due to the manner in which the document is written, all stakeholders should have the ability to comprehend the requirements with ease.

2.1.3 Project Background

Primary Focus:

Due to the commitment by The University of the Western Cape to invest in an immersive technology training academy, a need has arisen for a studio space and research laboratory for the creation and implementation of newly authorised projects. Immersive technology development studios provide several benefits and solutions that bring the real world into the virtual world. In addition to this, relevant solutions should reduce the cost of training, development of products and enhance research in certain fields. In order to supplement the establishment of a new field of study, a sufficient understanding of immersive technology is required. In order to achieve this, an implementation of immersive technology can assist with surfacing relevant knowledge and content. In addition to this an investigation in immersive technology is required to determine the most relevant tools for an immersive technology project.

Tools Required:

Several tools are required to achieve a working implementation of immersive technology Augmented Reality development platform such as Unity with added plugins such as Google AR Core, AR Kit, OpenCV and MapBox. An UAV (Unmanned Aerial Vehicle) to test the Augmented Reality training environment. In addition to this an immersive headset will be required in order for the pilot to see from the UAVs point of view

Desired Outcome:

The ideal outcome of this project is to produce a state-of-the-art studio that will set the foundation for immersive technology as a course. In addition to this, an implementation of a Drone Pilot Training application would be another ideal outcome. This Drone Pilot Training application uses immersive technology to bring the training environment to the drone pilots, this will be elaborated further in the document.

2.1.4 Benefits

The implementation of this project would produce the following benefits for the University of the Western Cape and the immersive technology community of South Africa as a whole:

- The University will able to provide an additional computer science course to the degree.
- Cutting edge research will be produced after completed project, which can be used as reference to future immersive technology projects.
- The University will be able to use the completed project for commercial use in order to gain a return.
- Local drone pilot may benefit from this tool provided it is used commercially
- The University would additionally be able to train prospective drone pilots using this technology.

2.1.5 Assumptions

To proceed with the systems development, it is essential to make a few assumptions about the problem scenario. Some of these assumptions are as follows:

- The drone pilots have basic knowledge about flying
- The system would be an inexpensive system
- The system would lower the risk of drone accidents.

2.2 Requirements Scope

2.2.1 In Scope

- Augmented Reality environment development
- 3D Modelling of objects
- Displaying of telemetry data
- Mapping flying route

2.2.2 Out of Scope

- Autonomous flight
- Maneuvering suggestions to avoid crashes
- RTL (Return to Launch)

2.3 Functional Requirements

2.3.1 Use Case Diagram

2.3.2 Formal Use Case Specification

Table 2.1: Select UAV

Use Case Name	Select UAV (Unmanned Aerial Vehicle)
Description	UAV/Drone pilot selects the type of UAV they are using
Goal Level	User Goal
Actor	UAV Pilot
Precondition/s	Drone details had been added to the database
Main Success Scenario	1. Drone Pilot Enters or Select UAV device used. 2. System adds vehicle to database or finds vehicle on list 3. Drone Pilot selects environment suited for UAV type 4. User completes course and exits training.
Failure Extensions	1. System malfunction 2. Virtual object interfere too much with real world 3. Application cannot connect to database.
Error Handling	Drone Pilot selects environment suited for UAV type

Table 2.2: Select Environment

Use Case Name	Select Environment
Description	UAV/Drone pilot selects the type of virtual environment they would like to train in.
Goal Level	User Goal
Actor	UAV Pilot
Precondition/s	Environment is already on the database
Main Success Scenario	1. Drone Pilot Enters or Select UAV device used. 2. User selects AR environment for training 4. User completes course and exits training.
Failure Extensions	1. System malfunction 2. Virtual object interfere too much with real world 3. Application cannot connect to database.
Error Handling	Restart Application

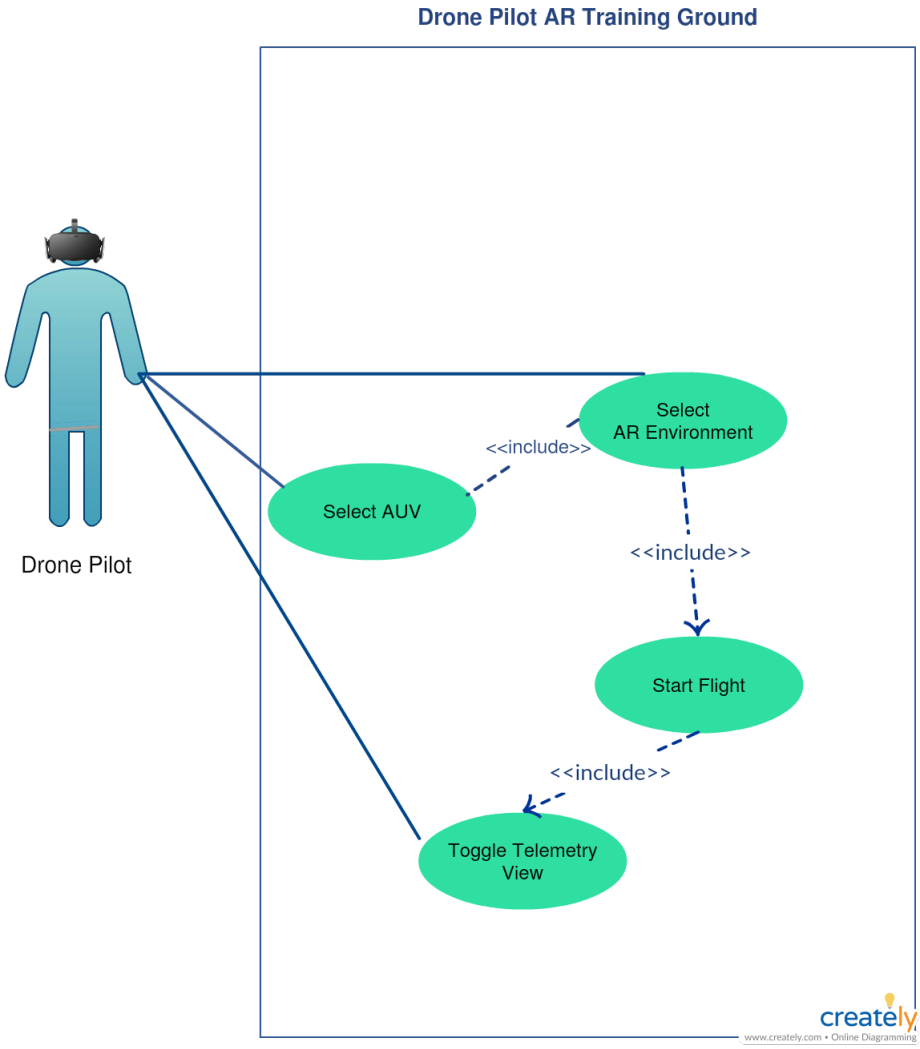

Figure 2.1: Figure 1:UAV Pilot AR training system

Table 2.3: Toggle Telemetry View

Use Case Name	Toggle Telemetry View
Description	UAV/Drone pilot can show or hide telemetry data
Goal Level	User Goal
Actor	UAV Pilot
Precondition/s	Drone has telemetry technology
Main Success Scenario	1. Drone Pilot Enters or Select UAV device used. 2. User selects AR environment for training 4. User toggles telemetry data view on and off. 4. User completes course and exits
Failure Extensions	1. System malfunction 2. Virtual object interfere too much with real world 3. Application cannot connect to database.
Error Handling	Restart Application

2.4 Non-Functional Requirements

2.4.1 Usability Requirements

Usability requirements are non-functional requirements which pertain to how a system is perceived by the users. The main rationale behind these requirements is to ensure that the system meets the users halfway in terms of ease of use. The system should put into consideration the disabled community. Whether the user is deaf or lack limbs, she/he should be catered for by the system. However, the following requirements are particular to the UAV Drone Pilots.

Accessibility

The system should be accessible to any drone pilot trainee. This mean they should be able to get access to the software from a downloadable source. In turn this would enable the trainee to access the application on demand.

Consistency

The system must be consistent in terms of its features across all its components. The screens whether showing displaying telemetry data or the augmented reality virtual objects should be simplistic and not distracting.

Customisation

The systems interface would be very standard, which implies that the user would have no need to customise the interface. However, the user will be able to able to change their virtual environment, suitable to their desire.

Feedback

The system is required to indefinitely maintain visual and audio communication with the user. It is suggested that user should be informed of all the actions taken place on the augmented reality system. This is includes feedback on telemetry data as well whether the user has been following the correct path and not intersecting with the virtual objects.

Comprehensibility

The system is required to be comprehensible. In addition to this, users should be able to comprehend the full augmented reality immersion. Since the system is a mixture of the real world and virtual world, users would be able to adapt quicker to the full immersion.

Learnability

In order to account for the learnability factor, the system would guide the user through the process of selecting the environment and other options. A user will also be able to read the virtual manual in order to understand the application. The system will not be exaggerated in terms of functions, which implies the user should be able to learn the system in a short period of time.

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