Real World Object-Capture in a Mixed-Reality Environment

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School of Computing

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Authorship Declaration

I, Beej Persson, confirm that this dissertation and the work presented in it are my own achievement.

Where I have consulted the published work of others this is always clearly attributed;

Where I have quoted from the work of others the source is always given. With the exception of such quotations this dissertation is entirely my own work;

I have acknowledged all main sources of help;

If my research follows on from previous work or is part of a larger collaborative research project I have made clear exactly what was done by others and what I have contributed myself;

I have read and understand the penalties associated with Academic Misconduct.

I also confirm that I have obtained informed consent from all people I have involved in the work in this dissertation following the School's ethical guidelines.

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Abstract

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Acknowledgements

Insert acknowledgements here

I would like to thank my widely-desired work ethic, talk-of-the-town dedication and my optimistic opinions of my abilities.

1 Introduction

1.1 Background

This project has three main background components to discuss. These are mixed reality, the Microsoft HoloLens and Vuforia.

1.1.1 Mixed Reality

1.1.1.1 Virtual Continuum

Mixed reality (MR) is a variation of virtual environments, or virtual reality. A virtual environment is one in which a user is immersed inside a synthetic environment. Whilst in this environment the user cannot see the real world around them, what they see is entirely virtual. In a mixed reality environment, however, the user is able to see aspects of both the real world and super-imposed virtual objects. MR "supplements reality, rather than completely replacing it" [1].

MR is often considered as encompassing both augmented reality (AR) and augmented virtuality (AV), both of which reside along the "virtuality continuum", a term coined by Milgram and Kishino in 1994 [2], with the real world at one end and the virtual at the other. AR refers to an otherwise real world environment in which there can be seen virtual augmentations, often viewed through a clear screen. AV, conversely, attempts to merge real world scenery or objects into an otherwise virtual world.

1.1.1.2 Applications and Devices

The nature of combining real and virtual objects can be utilised in a variety of ways and can enhance a user's ability to perform certain tasks and interact with the world. Whilst initially prevalent in the arts and entertainment industries, MR has a number of practical uses and is being taken advantage of by businesses today, particularly in the fields of military training, manufacturing and education [3, 4]. Many devices utilise these virtual environments, such as the Oculus Rift and the HTC Vive, headsets that need to be con-

nected to a computer or console, both released in 2016, but the Microsoft HoloLens is one of the few standalone devices available that offers mixed reality capabilities in a head-mounted display.

1.1.2 Microsoft HoloLens

The Microsoft HoloLens is a mixed reality holographic head-mounted display unit with an adjustable cushioned headband released in 2016 [5]. It is "the first fully untethered holographic computer running Windows 10", enabling a mixed reality experience with no wires, no external cameras and no connection to a PC required [6].

1.1.2.1 Hardware, Sensors and Features

The optics are two separate displays, which are viewed through glass lenses, on to which images are projected and layered to produced what the user can see in their space. The HoloLens' system is essentially mobile hardware featuring an Intel Cherry Trail Atom chip, housing the central processing unit and graphical processing unit, a 64GB SSD and 2GB of RAM and based on x86 architecture [7]. Additionally, however, it runs a few processors that make it unique. There is an inertial measurement unit (IMU), which includes an accelerometer, gyroscope, and magnetometer, and there is an aptly name Holographic Processing Unit (HPU), that handles where the user is looking, gesture tracking, spacial mapping and more. [6].

It has four "environment understanding cameras", two on each side, which provide the basis for tracking the user's head; a depth camera, which helps with hand tracking and performs surface reconstruction (for placing holograms on physical objects); a video camera and an ambient light sensor. These sensors work with the optics module and the IMU and is packaged for the Intel Atom chip by the HPU to produce fast response times to movement so that the user's position is updated and displayed in less than 10ms to ensure the holograms feel part of the world. The HoloLens also features four microphones for user commands, mounted stereo speakers providing spatial sound and both WiFi and bluetooth [8].

1.1.2.2 Practical Applications

As of 2018 there has only been a few practical applications of the Microsoft HoloLens and a number of them have only been proof of concepts so far. Notably there has been a number of applications developed by NASA in partnership with Microsoft. In 2015 they teamed up for the OnSight and Sidekick projects, utilising the HoloLens on the International Space Station for communication and real-time guidance with ground operators, and later again in 2017 to help find the best places on Mars to build bases [9, 10]. There are also examples of use in medicine in 2017: a team of surgeons used the HoloLens to visualise MRI and radiography information whilst operating on a patient with a malignant tumour patient [11, 12]; a ultrasound training simulation was designed to teach healthcare workers proficiency in anatomy through the use of interaction with 3D holograms of internal human structures [13, 14].

Vuforia

1.2 Aims and Objectives

Overview Of Project Content and Milestones

This is a sub sub section with a list of bullet points.

- A working X, that will be used for this investigation.
- Investigation of current tools and their potential use during an investigation of X .
- Programming of X with related frameworks Y and Z.
- That is all.

1.3 Scope and Limitations

1.4 Structure of this Dissertation

2 Methodology

And so on for each of the chapters. The template automatically starts new chapters on a new page. The associated guidelines tell you what the available styles do and also how to structure a report. There is a section break on this page that you should be careful NOT to delete otherwise the references and appendices will be numbered continuously with the rest of the document.

3 Implementation

4 Evaluation

5 Conclusion

5.1 Future Work

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Appendices

A Initial Project Overview

SOC10101 Honours Project (40 Credits)

Title of Project:
Real world object-capture in a mixed-reality environment.

Overview of Project Content and Milestones:
This project will look to evaluate the effectiveness of capturing real world objects using Vuforia on the Microsoft HoloLens. Initially, a method to capture a simple object will be developed, before attempts to capture more complex (or multiple) objects and real-time object manipulation will be implemented. The project aims to explore to what extent this can be done.
The milestones will be:

- simple object capture
- simple object manipulation
- complex object capture
- real-time object manipulation.

The Main Deliverable(s):
Object capture and manipulation software.
Dissertation.
Poster.

The Target Audience for the Deliverable(s):
Technical mixed-reality game developers looking for new game mechanics.
Enthusiasts interested in new game technologies.

The Work to be Undertaken:

Research similar attempts at mixed-reality object manipulation.
Design a method to capture a cube (or similar object) using Vuforia.
Build and apply simple shaders to the object.
Expand on above methods to capture more complex objects.
Explore and evaluate the extent to which the objects can be manipulated in real-time.
Document and report findings.

Additional Information / Knowledge Required:
Creating and managing Unity projects.
How to use Vuforia.
Improve understanding of shader usage.

Information Sources that Provide a Context for the Project:
General Development Page for the HoloLens:
`https://developer.microsoft.com/en-us/windows/mixed-reality/development`
Some related downloadable tools:
`https://developer.microsoft.com/en-us/windows/mixed-reality/install_the_tools`
Vuforia Specific:
`https://developer.microsoft.com/en-us/windows/mixed-reality/vuforia_development_overview`
`https://developer.vuforia.com`

The Importance of the Project:
Mixed-reality is an emerging games technology with great potential for immersive story-telling and innovative game design. This project looks to explore an aspect of that and if successful could be beneficial to those interested in designing such games.

The Key Challenge(s) to be Overcome:
Lack of similar projects documented.
Fairly niche/specialist/obscure software, mostly new territory.

B Report on the Interim Review Meeting

SOC10101 Honours Project (40 Credits)
Week 9 Report

Student Name: Beej Persson
Supervisor: Kevin Chalmers
Second Marker: Gregory Leplatre
Date of Meeting: 20/11/2017
Can the student provide evidence of attending supervision meetings by means of project diary sheets or other equivalent mechanism? **no***
If not, please comment on any reasons presented
No evidence provided but no indication from supervisor that there was a problem with weekly meeting attendance.

Please comment on the progress made so far

The work done focused on identifying ways of working with a Hololens, i.e., the output side of the project. This was useful, but the main challenge of the project is object recognition and augmentation, which would have been useful to deal with earlier. This would also have allowed you to engage with relevant literature on the subject.

Is the progress satisfactory? **unsure**
Can the student articulate their aims and objectives? **Partly**
If yes then please comment on them, otherwise write down your suggestions.

The overall goal (altering the appearance of real-world objects using AR) is clear. What specific alterations, to which objects and in which context remains to be determined. Familiarity with relevant literature will help you

specify your project more accurately. Many things are possible, some more complex than others. For this type of project, a good approach would be to consider what operation would have the highest visual impact while having a manageable development cost. There is definitely potential in your project.

Does the student have a plan of work? **Yes**
If yes then please comment on that plan otherwise write down your suggestions.

Unfortunately, the plan is limited to work already done.

Does the student know how they are going to evaluate their work? **partly**
If yes then please comment otherwise write down your suggestions.

The proposed approach is sensible but it is difficult to be more specific at this stage as the functionalities of the system aren't clearly defined.

Any other recommendations as to the future direction of the project

With Vuforia, you should be able to capture objects in a scene (in advance) and then track these objects. The acquisition/tracking effectiveness probably depends on the complexity of the object, which you should establish. Once you know the limits of what you will be able to track, you can focus on real-time alterations. Your incremental development approach is suitable, but it needs to be better controlled. Once you know what you are aiming to do, you can define the incremental steps that will lead you there. The core of the research in this area is about achieving realism, which involves lighting and material acquisition. Potentially impactful results can also be achieved by taking slighting different directions. Giving an object a stylised look is one of them. Anecdotally, magic tricks are high impact and can be technically cheap. A magic trick you could implement could be: give a physical object

to a user (that you will have previously scanned with Vuforia). Ask them to put it on a table (that you have also previously scanned), and make the object disappear (assuming the user is wearing a Hololens).

Signatures:	Supervisor	Kevin Chalmers
	Second Marker	Gregory Laplatre
	Student	

Please give the student a photocopy of this form immediately after the review meeting; the original should be lodged in the School Office with Leanne Clyde

C Diary Sheets (or other project management evidence)

Insert diary sheets here together with any project management plan you have

D Appendix 4 and following

insert content here and for each of the other appendices, the title may be just on a page by itself, the pages of the appendices are not numbered, unless an included document such as a user manual or design document is itself pager numbered.