User Generated Augmented Reality

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Abstract

This report details the design and development of a web-based tool that will allow users to generate their own augmented reality content, without having knowledge or experience of augmented reality.

This report shall outline the aims, objectives and expected outcomes of the project. This report shall discuss the professional and ethical issues that could arise during the project's lifetime. This report shall discuss the current tools, technologies and solutions that are available for user-generated augmented reality content. Based on this research, this report shall detail the requirements and functional behaviours of the tool. Lastly, this report has a detailed plan of the necessary stages required to complete the project.

Contents

1. Introduction

Augmented Reality (AR) is a technology medium that integrates 3D content within a user's reality, in real time [1]. Using a camera on a computer or a smart device with an AR developed experience, a user is able to interact with the experience's content by tapping and swiping the device's screen.

Due to the rise of the smartphone, AR is increasingly being introduced into everyday life. Popular examples of AR include Pokémon Go [2] (a gamified AR experience), IKEA's Place app [3] (a lifestyle AR experience), Instagram [4] and Snapchat [5] (social media inspired AR).

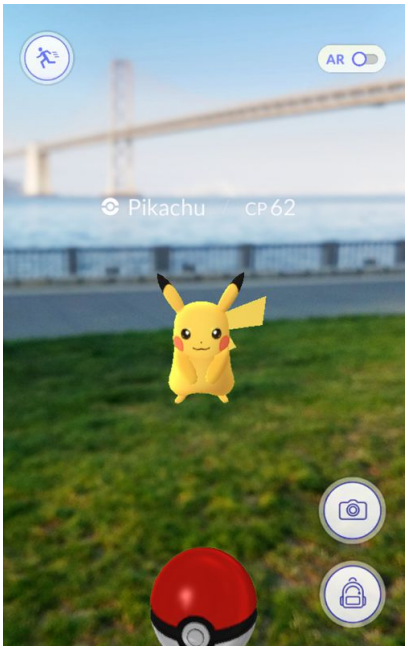

Figure 1 Pokémon Go, a gamified AR experience [2].

AR development is a specialist field, as most methods used to develop AR experiences require specialist skills and software, and the developer needs to be competent at programming.

This project and report is focused on User-Generated AR content; allowing individuals to develop their own AR experiences without having knowledge of AR. There are tools in the industry that allow users to generate AR experiences without knowledge of AR, such as BlippAR's BlippBuilder [6]. However, while they are considered to be user-generated AR, the experiences developed by these tools don't allow the user in the experience to produce their own content.

1.1. Project Description

The overall aim of this project is to allow users, who have no knowledge of AR, to be able to produce their own AR content.

This project is part of a wider project, 'Place Based Narratives' [7] run by the University of Sussex and the University of Brighton. Primarily, working with primary schools, the project is investigating how local communities can connect with their cultural environment using web-based AR; AR hosted on the internet and operated via a web browser [8].

Figure 2 Physical Models on a map, AR Models on an AR map [7]

In a series of workshops run in 2019, the project asked primary school children to produce 3D physical models of their homes. The 3D models produced a map of Brighton, according to these children. These models were digitised into a virtual map using web-based AR, which the children could experience using a web browser [7].

1.2. Project Problem Area

The problem area of the 'Place Based Narratives' project is in its current state, the tool developed in this project cannot function independent of middlemen AR developers. In order to digitise the children's content into 3D models in an AR environment, the developers had to take photos of the content, produce a texture for the 3D model using the photos, apply the texture to the 3D model, and incorporate the model in the AR environment [7]. Using the middlemen AR developers gave the children little input into the experience, reducing their interactivity and interest in the project.

Therefore, the motivation for my project is to automate the process. Automating the process would remove the need for middlemen AR developers and give control to the users, making the experience interesting and engaging.

In order to automate the process, one would need to produce a tool that does what is outlined above: take the user's content, create a texture using the content, apply the texture to a 3D model, and incorporate the 3D model in an AR environment.

1.3. Project Aims and Objectives

As previously mentioned, the overall aim of this project is to allow users, with no knowledge of AR, to be able to produce their own AR content. In order to be compatible with the 'Place Based Narratives' project, this project needs to web-based, so will have to utilise web technologies, as well as web-based AR frameworks, technologies and libraries.

1.3.1 Primary Objectives

The primary objectives of this project are:

- Create a web-based user interface using HTML, CSS and JavaScript that allows the user to use a web-based tool.

- Create a web-based tool using JavaScript that:
    - allows the user to take a photo using a smartphone camera
    - converts the photo content into a glTF texture [8]
    - applies the glTF texture to a glTF cube model [8]

- Incorporate the textured cube model into a web-based AR environment using the A-Frame framework, AR.js libraries and a ficidual marker.

- Provide some basic interactivity between the user and their cube model, e.g.: the ability to spin the model.

1.3.2 Extensions

The possible extensions of this project include:

- Provide a long-term storage solution for user-generated images

- Provide more complex interactivity between the user and the model

- Support the creation of more complex 3D models

- Constrain the types of content being used in the experience, e.g. preventing the use of offensive images

1.3.3 Expected Outcomes

The expected outcome of this project is the user should use the tool independently and be able to produce a cube in a web-based AR environment. The cube should be visible, dressed in a texture made of the user's submitted content, and the user should be able to interact with the cube.

1.4. Project Relevance

This project will require knowledge of HTML, CSS and JavaScript which I used in the first-year module: 'Introduction to Digital Media'. This project will use the concepts learned in this module, while expanding and developing my knowledge as required to complete this project. This project will also require knowledge of 3D Modelling and Rendering, which I studied during the second-year modules: '3D Modelling and Rendering' and 'Programming for 3D'. This project will use the concepts I learned during these modules. In addition, this project will require knowledge of AR, a topic I will learn during the development of this project.

2. Professional Considerations

This project will run user testing with both adults and children. Therefore, I must seriously consider the professional and ethical issues that could arise, as these issues could affect the project members and the participants.

2.1. BCS Code of Conduct

This project has been aligned with the BCS Code of Conduct, derived from the Chartered Institute for IT:

*"**1. Public Interest***
You shall:
a. have due regard for public health, privacy, security and wellbeing of others and the environment.
b. have due regard for the legitimate rights of Third Parties.*
c. conduct your professional activities without discrimination on the grounds of sex, sexual orientation, marital status, nationality, colour, race, ethnic origin, religion, age or disability, or of any other condition or requirement
d. promote equal access to the benefits of IT and seek to promote the inclusion of all sectors in society wherever opportunities arise [9]*."*

In accordance with point 1(a), the project shall have a regard for the participants involved in the project.

Before a participant participates in the user testing, the participant shall be required to sign a consent form. In the case where the participant is under 18, the parent or guardian shall be required to sign the consent form, allowing their child to participate.

Any content or data created during the project will be anonymised in order to ensure the privacy, security and wellbeing of the participants. During the rounds of testing with children, anonymisation shall be ensured by the teacher and the teaching assistant. The teacher and the teaching assistant will undergo training and check that each photo captured by the tool contains no personal data relating to the participants. At the end of the project, any content created during the project will be destroyed.

In accordance with point 1(c), the project shall not discriminate on any grounds; all children will be able to participate. During the rounds of testing with children, the children shall be supported by a teacher and teaching assistant, ensuring all of the children use the tool and produce their own AR content.

In accordance with point 1(d), the project shall promote the benefits of IT equally because the tool will be free to use. The testing will take part during school time, ruling out any discrimination based on economic background or access to technology.

*"**2. Professional Competence and Integrity***
You shall:
a. only undertake to do work or provide a service that is within your professional competence.
b. NOT claim any level of competence that you do not possess.
c. develop your professional knowledge, skills and competence on a continuing basis, maintaining awareness of technological developments, procedures, and standards that are relevant to your field.
d. ensure that you have the knowledge and understanding of Legislation and that you comply with such Legislation, in carrying out your professional responsibilities.*
e. respect and value alternative viewpoints and, seek, accept and offer honest criticisms of work.
f. avoid injuring others, their property, reputation, or employment by false or malicious or negligent action or inaction.
g. reject and will not make any offer of bribery or unethical inducement [9]*."*

In accordance with points 2(a), 2(b) and 2(c), I have discussed the project with my technical supervisor and we believe the project is within my professional competence.

In accordance with point 2(d), I shall not break any legislations during the project's lifetime.

In accordance with point 2(e), I shall regularly share the progress of the project with my technical supervisor as well as members of the wider project, 'Place Based Narratives'. Sharing the progress of the project will allow the other members to provide feedback and criticism to improve the tool.

In accordance with point 2(f), I shall ensure the project is completed with a functioning tool that meets it's aims and objectives, and can be integrated into the wider project, 'Place Based Narratives'. Not completing the tool would hinder their progress and delay their development plans and opportunities, which would be unfair.

In accordance with point 2(g), I shall not be tempted by bribery or unethical inducement nor will I encourage it.

"3. Duty to Relevant Authority
You shall:
a. carry out your professional responsibilities with due care and diligence in accordance with the Relevant Authority's requirements whilst exercising your professional judgement at all times.

b. seek to avoid any situation that may give rise to a conflict of interest between you and your Relevant Authority.

c. accept professional responsibility for your work and for the work of colleagues who are defined in a given context as working under your supervision.

*d. **NOT** disclose or authorise to be disclosed, or use for personal gain or to benefit a third party, confidential information except with the permission of your Relevant Authority, or as required by Legislation.*

*e. **NOT** misrepresent or withhold information on the performance of products, systems or services (unless lawfully bound by a duty of confidentiality not to disclose such information), or take advantage of the lack of relevant knowledge or inexperience of others* [9]*."*

The relevant authority for this project is the School of Informatics at the University of Sussex.

In accordance with point 3(a), I shall ensure that during the project's lifetime, I meet the requirements of the University. I shall do this by producing the deliverables for each of the project's deadlines.

In accordance with point 3(b), I shall avoid any conflicts of interest that may arise through the development of the project between myself and the University. I shall do this by ensuring to meet the aims and objectives of the project, as well as the requirements stated by the University.

In accordance with point 3(c), I shall accept full responsibility for the project and the project's success, since the project was selected based on my professional competence.

In accordance to point 3(d), I shall not disclose confidential information about the project by refusing to comment when asked, and not discuss confidential information outside of the project members and the project spaces. In addition, I shall not disclose confidential information discovered during the testing of the project by ensuring all content produced in the project is anonymised, maintaining the privacy and security of the participants.

In accordance to point 3(e), I shall not misrepresent or withhold information about the project by remaining honest about the progress of the project. This is to not hinder the progress of the 'Place Based Narratives' project. In addition, I shall not take advantage of any members involved in the 'Place Based Narratives' project.

*"**4. Duty to the Profession***
You shall:
a. accept your personal duty to uphold the reputation of the profession and not take any action which could bring the profession into disrepute.
b. seek to improve professional standards through participation in their development, use and enforcement.
c. uphold the reputation and good standing of BCS, the Chartered Institute for IT.
d. act with integrity and respect in your professional relationships with all members of BCS and with members of other professions with whom you work in a professional capacity. [9]*"*

In accordance with points 4(a), 4(b) and 4(c), I will undertake this project in a professional manner, ensuring the project remains in accordance with the BCS Code of Conduct.

In accordance with point 4(d), I shall treat all members of the BCS in a professional manner, ensuring integrity and respect.

2.2. Ethical Issues

Due to this project having the primary target user of children aged 9 and 10, this project will require a full ethical review because children are vulnerable individuals [10].

However, as the system is still under design, and the ethical review application requires a detailed description of the software to be tested, it is not yet appropriate to submit the ethical review application.

The user testing phase of the project involves two rounds of testing; one with adults and one with children. The round of testing with adults will be completed at the University of Sussex with members of the 'Place Based Narratives' project. The round of testing with children will be completed in participating schools and will be completed later in the project, due to the participating schools' schedules.

The user testing will take place in familiar environments to those participating, this is particularly important for the round of testing with children. In this round of testing, the testing will take place in the children's classrooms, with their regular teacher and teaching assistant leading the testing. This will ensure the participants feel comfortable taking part.

All participation will be voluntary, and participants will be told they are free to end their participation in testing at any time. Before a participant participates in the user testing, the participant shall be required to sign a consent form. In the case where the participant is under 18, the parent or guardian shall be required to sign the consent form, allowing their child to take participate. The consent form will detail the tasks and activities the participants will have to undertake, the potential risks of the testing, and the information that will be stored.

Post the project's completion, any information stored about the participants will be destroyed.

3. Requirements Analysis

3.1. Background research

3.1.1 Existing Solutions

3.1.1.1 Place Based Narratives Project

This project is part of a wider project called 'Place Based Narratives' [7]. This project works with primary school children around Brighton and is encouraging the children to explore their cultural environment using web-based AR and AR maps.

The children were asked to produce physical 3D models of their homes, which were digitised into 3D models that operate in a web-based AR environment [7]. The problem with this project is the project required middlemen AR developers to digitise the content, which made the experience less interactive and less engaging. [11]

The process of digitisation was completed offline. The developers took photos of all the models using a camera, which were turned into texture maps and applied to 3D models using 3D modelling software, Blender. The 3D models were saved in a glTF file format, which could then be used in the web-based AR experience [7].

Figure 3 Models and AR Map

The outcome of the 'Place Based Narratives Project' was an AR map of Brighton that relied on a ficidual marker. The user scans the ficidual marker to produce the whole map of AR models [7].

The most useful takeaway from studying this project is the tools used to develop the experience. The project uses HTML, CSS and JavaScript to host the experience in a web browser, and AR is incorporated into the experience using the A-Frame framework [12] and AR.js libraries [13]. Another useful takeaway from this project is the process required to digitise the physical models to 3D models in an AR environment; the process I shall automate in my project.

The main issue with this project is it isn't completely user-generated AR, because the user did not complete the whole experience themselves. Therefore, my project needs to feature automation in order to be successful.

Further issues discussed in this project, I must consider include the variety of screen sizes and how they affect the experience, the computational power of smartphone CPU and GPU units, and the lack of functionality on iOS devices [7]. In addition, results from their user testing revealed the users felt

there was a lack of instruction of how to use the tool [7]. I will take these issues into consideration when designing and developing my project.

3.1.1.2 BlippAR Augmented Reality Butterfly

BlippAR is an AR development company. One of their educational projects, the AR Butterfly [14], uses user-generated AR to create a unique experience targeted at children.

In this experience, the user is provided with a paper template of a butterfly. The template is the ficidual marker for this experience and once coloured in by the user, becomes a unique marker. The user scans the coloured marker with their smartphone camera and a butterfly appears, dressed in the user's coloured texture and is animated fluttering around in the user's reality.

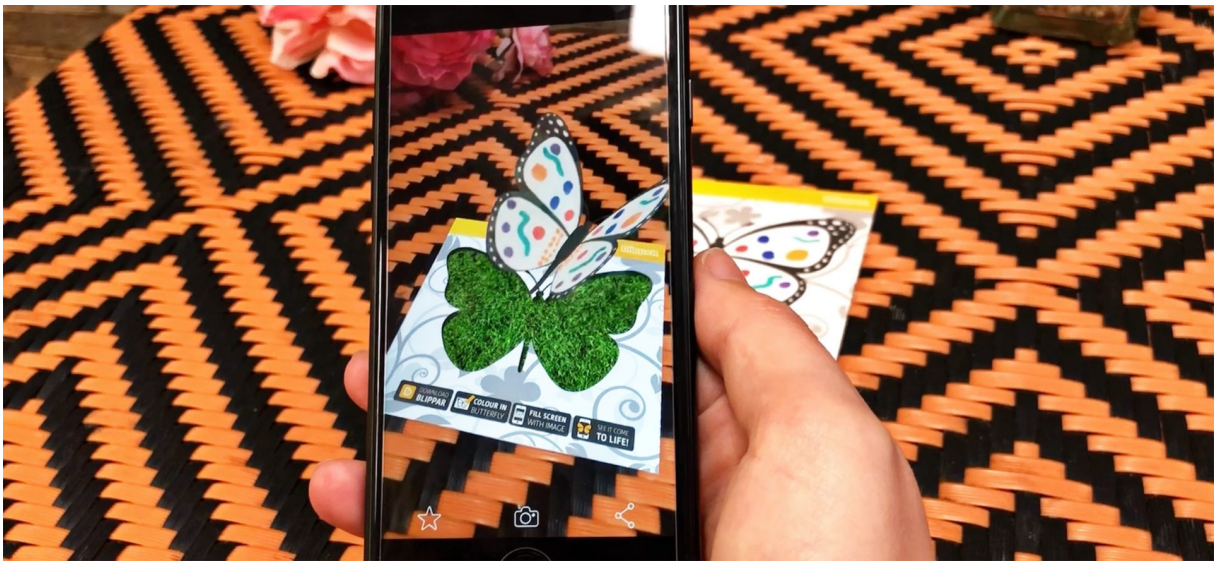

Figure 4 BlippAR Butterfly Project [14]

The experience is an example of user-generated AR because the user completes each stage of the experience independently. The user generates the content by colouring in the template, scans the marker and inspects their content.

A key takeaway from this project is the way the user generates the content because it uses a standardised approach – colouring in a template. Having a standardised approach to the content's creation is important because it makes the marker recognition easier. In my project, I am going to have to consider how I can make the content capture stage of the experience follow a standardised approach, especially as I am relying on the technical competence of the user.

The issue with studying this project is it is unclear how the experience has been developed; there is no documentation. Having this knowledge would have benefited the development stages of my tool.

Overall, this project is very relevant to my project because the experience is targeted at primary school children and shows user-generated AR is possible, using mobile devices too.

3.1.1.3 Augmented Reality Colouring Books

Similar to BlippAR's Butterfly [14], many other user-generated AR experiences also use colouring as the way the user creates their own content.

These experiences require the user to colour in the pages of the colouring book, and using a corresponding app downloaded onto the device, the user scans and initiates the AR experience. The AR experiences generated from these books are simple and display the model on the paper as if in reality, coloured in the user's coloured texture. These books have a greater number of models, since each page of the book has a different AR experience.

Figure 6 Model of a Dragon from Crayola's Colour Alive AR Colouring Book [37]

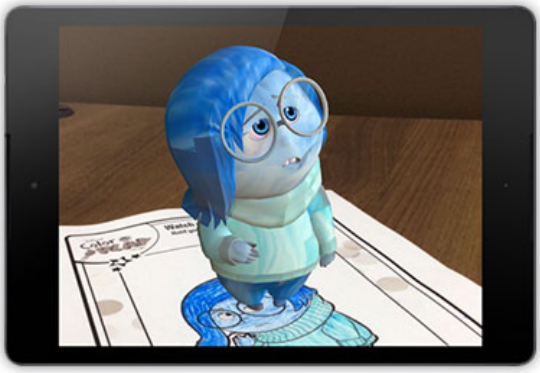

Figure 5 Model of Sadness from Disney's Colour and Play AR Colouring Book [36]

Again, these books use a standardised approach towards the content creation. Without providing a template, producing a model using children's drawings would be extremely complex and require a lot of computational power.

However, having studied the development of such a book, the challenges arise with the model's texture. The main issue with using colouring to form the texture is the colouring is 2-dimensional, whereas the AR models are 3-dimensional. The issue is the texture for the "hidden" regions cannot be generated off of the colouring, as there is no data, and have to be generated via another process [15]. In my project, I will not have to consider this issue because my project is only going to texture one face of a 3D cube.

3.1.2 Tools and Technologies

3.1.2.1 BlippAR BlippBuilder

BlippAR also provide software that allows users to generate AR content without knowledge of AR. BlippAR's BlippBuilder [6] has a drag-and-drop user interface that allows the user to design and develop their own AR experiences. In order to develop their own experiences, the user must drag and drop assets onto the ficidual marker to make 'Blipps' that are individual experiences [6]. These assets can be animated and customised to perform different actions, based on a user's interaction [16].

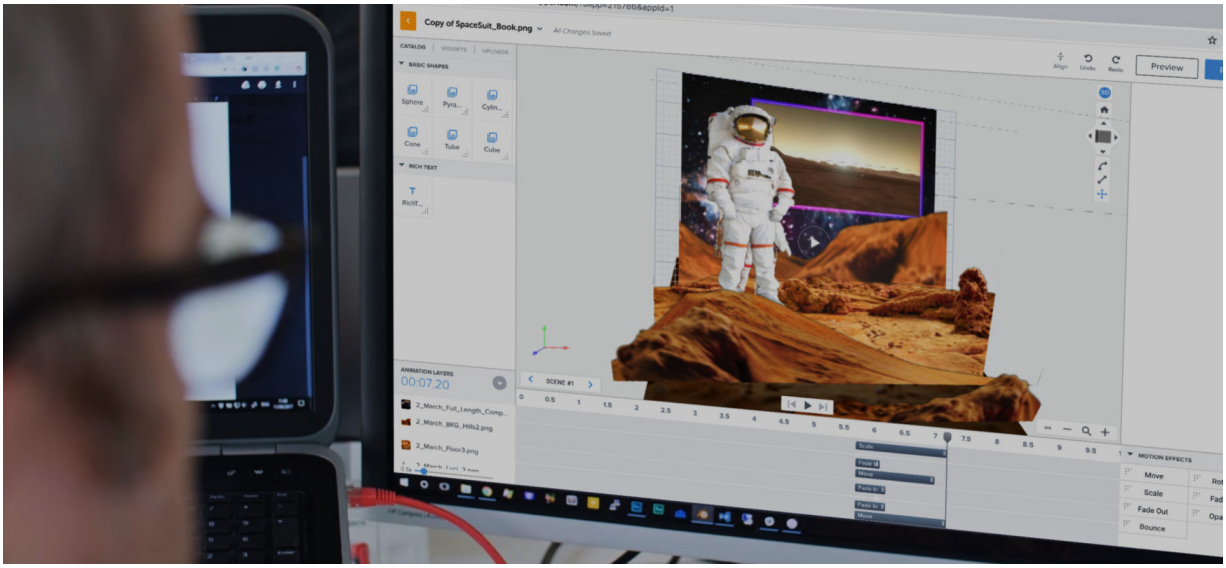

Figure 7 BlippAR's BlippBuilder

While this form of development is considered user-generated, as the content has been produced without any knowledge of AR, it doesn't allow the users using the experience to generate their own content. The experience is pre-set, and the user can only interact with the given content. Therefore, my project and experience will have to allow the user to generate their own content during the experience to meet this need.

3.1.2.2 Vuforia

Vuforia [17] is an open-source engine that supports the development of AR experiences. Integrated into software such as Unity, Vuforia has an API library that allows developers to produce their own AR experiences.

There are many issues with using Vuforia for my project. Firstly, Vuforia is a platform for users to create their own AR experiences to be deployed. This doesn't allow users using the AR experience to create their own content within the experience. In addition, despite being an open-source development platform, the developer has to pay for their experience to be deployed, which isn't ideal for my project. Finally, in order to develop using Vuforia and software such as Unity, the user has to have a competent knowledge of programming which would not be expected of a child aged 9 and 10.

3.1.2.3 Web-Based AR Frameworks and Libraries

Due to developing a web-based AR tool, I researched the different methods of incorporating AR into a web-based platform. There are a variety of frameworks and libraries available, including A-Frame [12], AR.js, 8th Wall [18] and Awe.media [19]. Even though A-Frame and AR.js are both a requirement for the wider project, 'Place Based Narratives' [7], they are still the preferred framework and library for my experience.

8th Wall [18] is a framework that uses JavaScript and WebGL to incorporate AR into web-based platforms. The downside of using 8th Wall is it requires developers to pay for its services. Being closed-source is the reason many of the frameworks weren't considered for my project. A-Frame and AR.js are superior because they are designed for web-based AR and are completely open-source.

3.1.2.4 3D Models

Due to the focus of the project being web-based, the experience is limited to the types of models that can be used. From my research and experiments, the A-Frame framework has its own models: boxes [20] and spheres [21], and while they would function for this project, they limit the project's future as they are too simple. Ideally, the future of the project should allow users to generate their own models and respective content. Therefore, glTF models have been chosen for this project, because glTF models are required for the 'Place Based Narratives' project, but also glTF models are more complex with functionality to appear more realistic [22].

3.1.2.5 Textures

The most complex part of this project is the transition from the user's generated content to a glTF model. Due to its complexity, I have yet to come up with a solution of how this will be implemented.

In order to be compatible with the glTF model, the user's content will need to be converted into a glTF texture map before it can be applied to a glTF model.

A solution I have explored, but not tested is using BlackThread.io [23], an online converter that inputs a 3D model and a texture and converts the pair into a glTF model. This solution could work, since A-Frame and BlackThread.io are both based upon three.js [24], using a GLTFExporter function [25] that delivers and loads 3D content. However, the content needs to be in the correct format to be applied to a model. From my study of the 'Place Based Narratives' project, the texture map needs to be an unwrapped cube texture with one face as the user's content [7]. Due to the experience operating online, I will need to find an online photo editor suitable for manipulating and producing this texture map.

I will be further researching this part of the project and testing possible solutions during the development process.

3.2. Requirements

During the 'Gathering Requirements' stage of my project, I met with the members of the 'Place Based Narratives' project to discuss their project and identify any requirements that arose from their user testing, that should be incorporated into my project and tool.

These included:

- The experience being free and accessible for all participants
- Having a standardised approach for capturing content with a camera
- Having a standardised approach for generating 3D models
- Allowing for repetition in the tool's functionality
- Allowing for content to be uploaded, having been captured on another device, e.g. flat-bed scanner

Having considered the aims and objectives for this project, I have compiled a list of requirements. Split into functional, non-functional and domain requirements, these make up the necessary functionalities that need to be implemented in the tool.

FUNCTIONAL REQUIREMENTS			
Statement	**Requirement**	**Input**	**Behaviour**
WEB-BASED TOOL			
Allow the user to take a photo using a smartphone camera.	**The tool shall allow the user to use a smartphone camera.**	User User's camera	The tool will open up the user's camera.
Have a standardised approach for taking photos.	**The tool should have a standardised approach for taking photos.**	User User's camera	User takes a photo.
Capture 1 image.	**The tool shall allow one image to be captured.**	User User's camera	User takes a photo.
Allow the user to upload a photo, captured on another device.	**The tool should allow the user to upload a photo, captured on another device.**	User User's content	The user's content is uploaded to the tool's file space.
The user's photo is stored.	**The tool shall store the user's photo in the file space.**	User User's photo	The user's photo is stored in the file space.
Converts the user's photo into a glTF texture map.	**The tool shall convert the user's photos into a glTF texture map.**	User User's photo	The user's photo is converted into a glTF texture map.
Have a standardised approach for converting the user's photo to a glTF texture map.	**The tool should have a standardised approach for converting the user's photo into a glTF texture map.**	User User's photo	The user's photo is converted into a glTF texture map.
Applies the glTF texture map to a 3D glTF cube.	**The tool shall apply the glTF texture map to a 3D glTF cube.**	User User's texture glTF cube	The glTF texture map is applied to a 3D glTF cube.
WEB-BASED AR ENVIRONMENT			
Content appears by scanning the ficidual marker with a smartphone camera.	**The 3D cube shall appear by scanning the ficidual marker with a smartphone camera.**	User User's camera Ficidual marker	The 3D cube appears.

Display the 3D cube in an AR environment.	**The web-based AR environment shall display the 3D cube in an AR environment.**	User User's camera	The 3D cube is visible in an AR environment.
Provide basic interactivity between the user and the 3D cube.	**The web-based AR environment shall allow the user to spin the model in the AR space.**	User	The cube will spin based on the user's interactions.

NON-FUNCTIONAL REQUIREMENTS	
Statement	**Requirement**
Accessible via a web-browser.	**The experience shall be developed using HTML, CSS and JavaScript.**
Guide the user through the experience.	**The user interface shall guide the user through the whole experience.**
Accessible to all.	**The experience shall use open-source technologies.**
Rely on a ficidual marker.	**The web-based AR environment shall use a ficidual marker.**
Compatible on mobile and desktop devices.	**The experience shall be compatible on mobile and desktop devices.**
Require low computational power.	**The tool shall require low computational power.**
Operate in real time.	**The tool shall operate in real time.**

DOMAIN REQUIREMENTS	
Statement	**Requirement**
Designed to appeal to children aged 9 and 10.	**The experience shall appeal to children aged 9 and 10.**
Easy to use.	**The experience shall be intuitive.**
Have a standardised approach.	**The experience should have a standardised approach.**
Allow for repetition.	**The experience should allow for repetition.**

Table 1 Requirements Table

4. Project Plan

The plan for the project, including its individual tasks and their respective deadlines is laid out in Table 2 below.

#	Activity	Start Date	Predecessor	Duration (In Days)				Expected End Date	Deadline
				Optimistic	Normal	Pessimistic	Expected		
1	Background Research	30/09/2019	N/A	6	8	10	8.00	09/10/2019	N/A
2	Project Proposal	10/10/2019	1	4	6	8	6.00	16/10/2019	17/10/2019
3	Requirements Gathering	21/10/2019	1	2	5	8	5.00	25/10/2019	N/A
4	The Interim Report	28/10/2019	3	5	7	10	7.16	08/11/2019	14/11/2019
5	Tool Development	11/11/19	3	20	25	30	25.00	20/12/2019	N/A
6	Ethics Application	03/12/19	3	3	5	10	5.50	08/12/2019	13/12/2019
7	User Testing 1	28/01/2020*	5,6	1			1	28/01/2020*	N/A
8	Feedback Analysis 1	29/01/2020	7	1	2	3	1.83	31/01/2020	N/A

9	Software Improvements 1	01/02/2020	8	5	10	15	10.00	10/02/2020	N/A
10	User Testing 2	11/02/2020*	6,9	1			1	11/02/2020*	N/A
11	Feedback Analysis 2	12/02/2020	10	1	2	3	1.83	14/02/2020	N/A
12	Software Improvements 2	15/02/2020	11	2	5	7	4.83	21/02/2020	N/A
13	Draft Report	17/02/2020	5,7,8,9,10,11,12	15	20	30	20.83	09/03/2020	12/03/2020
14	Poster Creation	05/03/2020	13	2	5	7	4.83	10/03/2020	12/03/2020
15	Poster Presentation	TBC	14	TBC					
16	Software Improvements 3	16/03/2020	12	5	10	15	10.00	27/03/2020	N/A
17	Final Report	15/04/2020	13	15	20	30	20.83	04/05/2020	11/05/2020

**Date dependent on participants*

Table 2 Project Plan

5. Bibliography

[1] R. T. Azuma, “A Survey of Augmented Reality,” Hughes Research Laboratories, Malibu, 1995.

[2] The Pokémon Company, “Pokémon Go,” 2019. [Online]. Available: https://www.pokemongo.com/en-gb/. [Accessed 28 October 2019].

[3] IKEA, “IKEA Mobile Apps,” 2019. [Online]. Available: https://www.ikea.com/gb/en/customer-service/mobile-apps/. [Accessed 12 November 2019].

[4] Instagram, “Instagram,” 2019. [Online]. Available: https://about.instagram.com/. [Accessed 12 November 2019].

[5] Snapchat, “Snapchat,” 2019. [Online]. Available: https://www.snapchat.com/. [Accessed 10 November 2019].

[6] BlippAR, “BlippAR BlippBuilder,” BlippAR, 2019. [Online]. Available: https://www.blippar.com/build-ar. [Accessed 21 October 2019].

[7] L. D. e. a. Karina Rodriguez Echavarria, “Augmented Reality (AR) Maps for Experiencing Creative Narratives of Cultural Heritage,” The Eurographics Association, Brighton, 2019.

[8] Khronos Group, “glTF Overview,” 2019. [Online]. Available: https://www.khronos.org/gltf/. [Accessed 1 October 2019].

[9] BCS The Chartered Institute for IT, “BCS Code of Conduct,” 5 June 2019. [Online]. Available: https://www.bcs.org/membership/become-a-member/bcs-code-of-conduct/. [Accessed 30 October 2019].

[10] School of Engeineering and Informatics, The University of Sussex, “Information for Students,” 2019. [Online]. Available: http://www.sussex.ac.uk/ei/internal/forstudents/informatics/undergraduate/finalyearprojects/informationforstudents. [Accessed 7 October 2019].

[11] A. D. Adrian Clark, “An Interactive Augmented Reality Coloring Book,” The HIT Lab NZ, University of Canterbury, Christchurch, 2012.

[12] A-Frame, “A-Frame - Introduction,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/introduction/. [Accessed 1 October 2019].

[13] J. Etienne, “AR.js - Augmented Reality for the Web,” 2019. [Online]. Available: https://jeromeetienne.github.io/AR.js/. [Accessed 1 October 2019].

[14] BlippAR, “Butterfly,” 2019. [Online]. Available: https://www.blippar.com/work/butterfly. [Accessed 21 October 2019].

[15] D. T. N. e. a. Stéphane Magnenat, “Live Texturing of Augmented Reality Characters from Colored Drawings,” *IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS,* vol. 21, no. 11, 2015.

[16] J.-P. v. Arnham, “BlippAR for Education,” 2016.

[17] Vuforia, “Vuforia Developer Portal,” 1 October 2019. [Online]. Available: https://developer.vuforia.com/. [Accessed 10 November 2019].

[18] 8th Wall Inc., “Products,” 2019. [Online]. Available: https://www.8thwall.com/products. [Accessed 3 October 2019].

[19] Awe Media, “Awe Media,” 2017. [Online]. Available: https://awe.media/. [Accessed 7 October 2019].

[20] A-Frame, “<A-Box>,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/primitives/a-box.html. [Accessed 21 October 2019].

[21] A-Frame, “<A-Sphere>,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/primitives/a-sphere.html. [Accessed 21 October 2019].

[22] A-Frame, “gltf-Model,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/components/gltf-model.html#why-use-gltf. [Accessed 21 October 2019].

[23] L. Blue, “Convert 3D Models to GLTF,” 2018. [Online]. Available: https://blackthread.io/gltf-converter/. [Accessed 10 November 2019].

[24] A-Frame, “Developing with three.js,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/introduction/developing-with-threejs.html. [Accessed 10 November 2019].

[25] three.js, “GLTFExporter,” 2019. [Online]. Available: https://threejs.org/docs/#examples/en/exporters/GLTFExporter. [Accessed 10 November 2019].

[26] J. Medley, “Welcome to the Immersive Web,” 2018. [Online]. Available: https://developers.google.com/web/updates/2018/05/welcome-to-immersive. [Accessed 1 October 2019].

[27] Georgia Tech Research Corporation, “Argon.js,” 2019. [Online]. Available: https://www.argonjs.io/. [Accessed 7 October 2019].

[28] K. Lesiński, “ImageOptim,” 2019. [Online]. Available: https://imageoptim.com/api. [Accessed 7 October 2019].

[29] P. R. e. a. Xiuquan Qiao, “A New Era for Web AR with Mobile Edge Computing,” Beijing University of Posts and Telecommunications, Beijing, 2018.

[30] P. Mendigochea, “WebAR : Creating Augmented Reality Experiences on Smart Glasses and Mobile Device Browsers,” HoloLeo Studios, Los Angeles, 2017.

[31] A. O. e. a. Ann Morrison, “Like Bees Around the Hive: A Comparative Study of a Mobile Augmented Reality Map,” Helsinki Institute for Information Technology HIIT, Boston, 2009.

[32] E. F. Alexander Ilic, “Augmented Reality and the Internet of Things,” Auto-ID Labs, Zurich, 2016.

[33] F. Leighton, “The PortARble Museum: Developing Augmented Reality For The Web Using AR.Js,” 2018. [Online]. Available: https://mw18.mwconf.org/paper/the-portarble-museum-developing-augmented-reality-for-the-web-using-ar-js/. [Accessed 1 October 2019].

[34] Warner Bros Entertainment Co., “Harry Potter: Wizards Unite,” 2019. [Online]. Available: https://www.harrypotterwizardsunite.com/. [Accessed 28 October October].

[35] I. A. C. G. e. a. Pietro Cipresso, “The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature,” *Frontiers in Psychology,* vol. 9, no. 2086, p. 2, 2018.

[36] Disney, “Disney Colour and Play Books by Bendon,” 2019. [Online]. Available: https://www.colorandplaybooks.com/. [Accessed 10 November 2019].

[37] Crayola, “Colour Alive,” 2018. [Online]. Available: http://www.crayola.co.uk/splash/product/colour-alive.aspx. [Accessed 10 October 2019].

[38] Tech Research Corporation, “Argon.js,” 2019. [Online]. Available: https://www.argonjs.io/. [Accessed 14 October 2019].

[39] Google, “Augmented Reality,” 2019. [Online]. Available: https://arvr.google.com/ar/. [Accessed 10 November 2019].

[40] LayAR, “Augmented Reality | Interactive Print,” 2019. [Online]. Available: https://www.layar.com/. [Accessed 10 November 2019].

[41] Magic Leap, “Magic Leap,” 2019. [Online]. Available: https://www.magicleap.com/. [Accessed 10 November 2019].

[42] H. K. e. a. Mark Billingshurst, “The Magic Book,” 2001.

6. Appendices

6.1. Project Proposal

Working Title:

User Generated Augmented Reality Content

Aims and Objectives

The overall aim of this project is to allow users without the knowledge of Augmented Reality (AR) to be able to produce their own basic AR content.

This project is part of a larger project, known as 'Place Based Narratives' run by the University of Sussex and the University of Brighton. The project, 'Place Based Narratives' is investigating how communities can connect with their cultural environment using web-based AR and AR Maps [7].

In its current state, the tool developed in the 'Place Based Narratives' project cannot function independent of middlemen AR developers. These AR developers take the user's content, transform it into 3D models, and incorporate these models into the AR space [7]. The motivation for this project is to introduce automation into the tool. This would remove the need of the middlemen developers, allowing the whole experience to be driven by the user.

Primary Objectives

The primary objectives of this project are:

1. Create a web-based user interface using HTML5, CSS and JavaScript that allows the user to use a web-based tool.

2. Create a web-based tool using JavaScript that:
   - allows the user to take a minimum of 4 photos using a smartphone camera
   - converts the photo content into a glTF texture
   - applies the glTF texture to a cube model

3. Incorporate the textured cube model into a web-based AR environment using the A-Frame framework, AR.js libraries and a ficidual marker.

4. Provide some basic interactivity between the user and their cube model, e.g.: the ability to spin the model.

Extensions

The extensions of this project are:

1. Provide more complex interactivity between the user and the model.
2. Support the creation of more complex 3D models.

3. Constrain the types of images being turned into 3D models, e.g. preventing the use of offensive images.

Expected Outcomes

The expected outcome of this project is the user should use the tool independently and be able to produce a cube in a web-based AR environment. The cube should be visible, dressed in a texture made of the user's submitted content, and the user should be able to interact with the cube.

Relevance

The project is relevant to my degree course because it utilises skills and knowledge I have learned from previous modules.

The project will require knowledge of HTML5, CSS and JavaScript which I used in my first-year module: 'Introduction to Digital Media'. In addition, the project will require knowledge of 3D Modelling, which I learned during my second-year modules: '3D Modelling and Rendering' and 'Programming for 3D'. Furthermore, the project will require knowledge of AR, a new topic and one I will have to learn during the development of this project.

Resources Required

Smartphone with camera functionality

Personal Weekly Timetable

The minimum number of hours I will spend on this project is 11 hours a week. The scheduling and arrangement of these hours is displayed below:

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
09:00		Visual Effects (Lab)	Computer Security (Lecture)	Computer Security (Lecture)	
10:00					
11:00	Project Time		Human Computer Interaction (Seminar)	Computer Security (Lab)	Project Time
12:00					
13:00					
14:00	Human Computer Interaction (Lecture)	Project Time	Project Time	Project Time	
15:00					
16:00					

Bibliography

[1] R. T. Azuma, “A Survey of Augmented Reality,” Hughes Research Laboratories, Malibu, 1995.

[2] The Pokémon Company, “Pokémon Go,” 2019. [Online]. Available: https://www.pokemongo.com/en-gb/. [Accessed 28 October 2019].

[3] IKEA, “IKEA Mobile Apps,” 2019. [Online]. Available: https://www.ikea.com/gb/en/customer-service/mobile-apps/. [Accessed 12 November 2019].

[4] Instagram, “Instagram,” 2019. [Online]. Available: https://about.instagram.com/. [Accessed 12 November 2019].

[5] Snapchat, “Snapchat,” 2019. [Online]. Available: https://www.snapchat.com/. [Accessed 10 November 2019].

[6] BlippAR, “BlippAR BlippBuilder,” BlippAR, 2019. [Online]. Available: https://www.blippar.com/build-ar. [Accessed 21 October 2019].

[7] L. D. e. a. Karina Rodriguez Echavarria, “Augmented Reality (AR) Maps for Experiencing Creative Narratives of Cultural Heritage,” The Eurographics Association, Brighton, 2019.

[8] Khronos Group, “glTF Overview,” 2019. [Online]. Available: https://www.khronos.org/gltf/. [Accessed 1 October 2019].

[9] BCS The Chartered Institute for IT, “BCS Code of Conduct,” 5 June 2019. [Online]. Available: https://www.bcs.org/membership/become-a-member/bcs-code-of-conduct/. [Accessed 30 October 2019].

[10] School of Engeineering and Informatics, The University of Sussex, “Information for Students,” 2019. [Online]. Available: http://www.sussex.ac.uk/ei/internal/forstudents/informatics/undergraduate/finalyearprojects/informationforstudents. [Accessed 7 October 2019].

[11] A. D. Adrian Clark, “An Interactive Augmented Reality Coloring Book,” The HIT Lab NZ, University of Canterbury, Christchurch, 2012.

[12] A-Frame, “A-Frame - Introduction,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/introduction/. [Accessed 1 October 2019].

[13] J. Etienne, “AR.js - Augmented Reality for the Web,” 2019. [Online]. Available: https://jeromeetienne.github.io/AR.js/. [Accessed 1 October 2019].

[14] BlippAR, “Butterfly,” 2019. [Online]. Available: https://www.blippar.com/work/butterfly. [Accessed 21 October 2019].

[15] D. T. N. e. a. Stéphane Magnenat, “Live Texturing of Augmented Reality Characters from Colored Drawings,” *IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS,* vol. 21, no. 11, 2015.

[16] J.-P. v. Arnham, “BlippAR for Education,” 2016.

[17] Vuforia, “Vuforia Developer Portal,” 1 October 2019. [Online]. Available: https://developer.vuforia.com/. [Accessed 10 November 2019].

[18] 8th Wall Inc., “Products,” 2019. [Online]. Available: https://www.8thwall.com/products. [Accessed 3 October 2019].

[19] Awe Media, “Awe Media,” 2017. [Online]. Available: https://awe.media/. [Accessed 7 October 2019].

[20] A-Frame, “<A-Box>,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/primitives/a-box.html. [Accessed 21 October 2019].

[21] A-Frame, “<A-Sphere>,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/primitives/a-sphere.html. [Accessed 21 October 2019].

[22] A-Frame, “gltf-Model,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/components/gltf-model.html#why-use-gltf. [Accessed 21 October 2019].

[23] L. Blue, “Convert 3D Models to GLTF,” 2018. [Online]. Available: https://blackthread.io/gltf-converter/. [Accessed 10 November 2019].

[24] A-Frame, “Developing with three.js,” 2019. [Online]. Available: https://aframe.io/docs/0.9.0/introduction/developing-with-threejs.html. [Accessed 10 November 2019].

[25] three.js, “GLTFExporter,” 2019. [Online]. Available: https://threejs.org/docs/#examples/en/exporters/GLTFExporter. [Accessed 10 November 2019].

[26] J. Medley, “Welcome to the Immersive Web,” 2018. [Online]. Available: https://developers.google.com/web/updates/2018/05/welcome-to-immersive. [Accessed 1 October 2019].

[27] Georgia Tech Research Corporation, “Argon.js,” 2019. [Online]. Available: https://www.argonjs.io/. [Accessed 7 October 2019].

[28] K. Lesiński, “ImageOptim,” 2019. [Online]. Available: https://imageoptim.com/api. [Accessed 7 October 2019].

[29] P. R. e. a. Xiuquan Qiao, “A New Era for Web AR with Mobile Edge Computing,” Beijing University of Posts and Telecommunications, Beijing, 2018.

[30] P. Mendigochea, “WebAR : Creating Augmented Reality Experiences on Smart Glasses and Mobile Device Browsers,” HoloLeo Studios, Los Angeles, 2017.

[31] A. O. e. a. Ann Morrison, “Like Bees Around the Hive: A Comparative Study of a Mobile Augmented Reality Map,” Helsinki Institute for Information Technology HIIT, Boston, 2009.

[32] E. F. Alexander Ilic, “Augmented Reality and the Internet of Things,” Auto-ID Labs, Zurich, 2016.

[33] F. Leighton, “The PortARble Museum: Developing Augmented Reality For The Web Using AR.Js,” 2018. [Online]. Available: https://mw18.mwconf.org/paper/the-portarble-museum-developing-augmented-reality-for-the-web-using-ar-js/. [Accessed 1 October 2019].

[34] Warner Bros Entertainment Co., “Harry Potter: Wizards Unite,” 2019. [Online]. Available: https://www.harrypotterwizardsunite.com/. [Accessed 28 October October].

[35] I. A. C. G. e. a. Pietro Cipresso, “The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature,” *Frontiers in Psychology,* vol. 9, no. 2086, p. 2, 2018.

[36] Disney, “Disney Colour and Play Books by Bendon,” 2019. [Online]. Available: https://www.colorandplaybooks.com/. [Accessed 10 November 2019].

[37] Crayola, “Colour Alive,” 2018. [Online]. Available: http://www.crayola.co.uk/splash/product/colour-alive.aspx. [Accessed 10 October 2019].

[38] Tech Research Corporation, “Argon.js,” 2019. [Online]. Available: https://www.argonjs.io/. [Accessed 14 October 2019].

[39] Google, “Augmented Reality,” 2019. [Online]. Available: https://arvr.google.com/ar/. [Accessed 10 November 2019].

[40] LayAR, “Augmented Reality | Interactive Print,” 2019. [Online]. Available: https://www.layar.com/. [Accessed 10 November 2019].

[41] Magic Leap, “Magic Leap,” 2019. [Online]. Available: https://www.magicleap.com/. [Accessed 10 November 2019].

[42] H. K. e. a. Mark Billingshurst, “The Magic Book,” 2001.

6.2. Project Log

04/10/2019 – Meeting with Technical Supervisor

I met with my technical supervisor to discuss the project as a whole, and what would be required. The meeting was beneficial because it allowed me to learn more about the project, but also the tools and technologies I would need to use to complete the project.

07/10/2019 – A-Frame Experiment

I created a cube and a sphere using the A-Frame framework and AR.js library. The cube was created using <a-box> [20], and the sphere was created using <a-sphere> [21], another primitive in the A-Frame framework. I played with the primitives' attributes and changed the model's colours and positions.

Figure 9 shows a cube and sphere in a web-based AR environment.

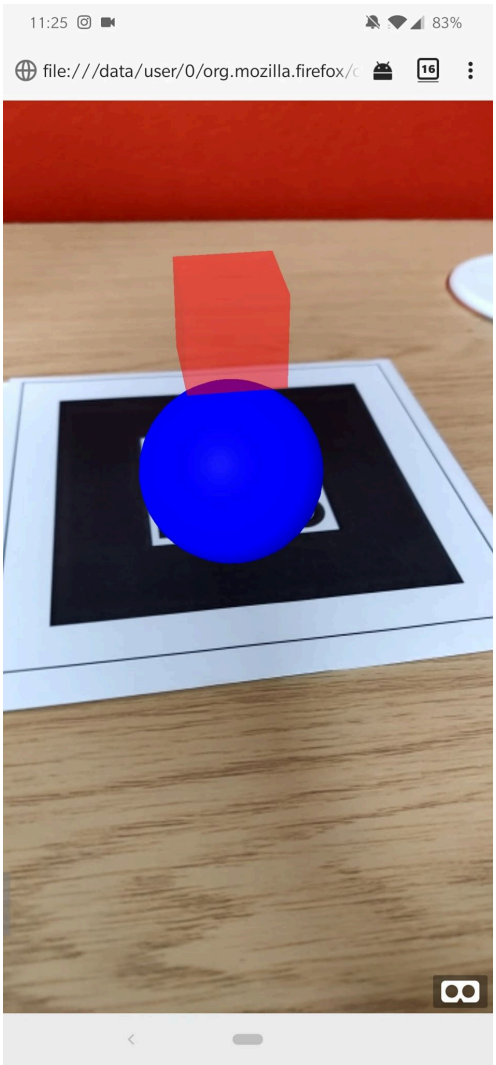

Figure 9 Sphere and Cube using A-Frame and AR.js

This experiment was beneficial because it allowed me to get to grips with using the A-Frame framework and AR.js libraries, before the development stage of my project. The next experiments I need to do are produce a glTF model in a web-based AR environment, and apply a texture to a glTF model.

14/10/2019 – BlippAR Case Study

While on my year in industry, I went to a talk by the AR developers BlippAR about their work. One of the pieces in their portfolio, the AR Butterfly [14] was similar to my project. I spent some time investigating the case study in an attempt to learn how it worked. The study was beneficial because the BlippAR AR Butterfly is similar to my project, which suggests the project is realistic and achievable.

18/10/2019 – Meeting with Technical Supervisor

I met with my technical supervisor and discussed the project proposal. I obtained clarifications for parts of the project I was unsure about, including the target user of the project; confirmed as primary school children. I discussed the timescale of the project, including the project's deadlines and deliverables. In addition, I discussed the requirements for the interim report, the next deliverable after the project proposal. Also, I brought up the BlippAR case study, and it was suggested I should experiment using BlippAR.

22/10/2019 – Meeting with Wider Project Members

I met with the members of the wider project, 'Place Based Narratives' run by the University of Sussex and the University of Brighton. During the meeting, we discussed the current project, the future of the project and where my project would fit within the wider project. The meeting was beneficial as it brought up issues such as standardisation and the need for repetition, which one had not considered before.

24/10/2019 – BlippAR Experiment

Another experiment I conducted was using BlippAR, after studying their AR Butterfly project. In this experiment, I produced a plane that sat flat against the ficidual marker. The BlippAR experiment used JavaScript and JSON.

Figure 10 shows a plane in an AR environment.

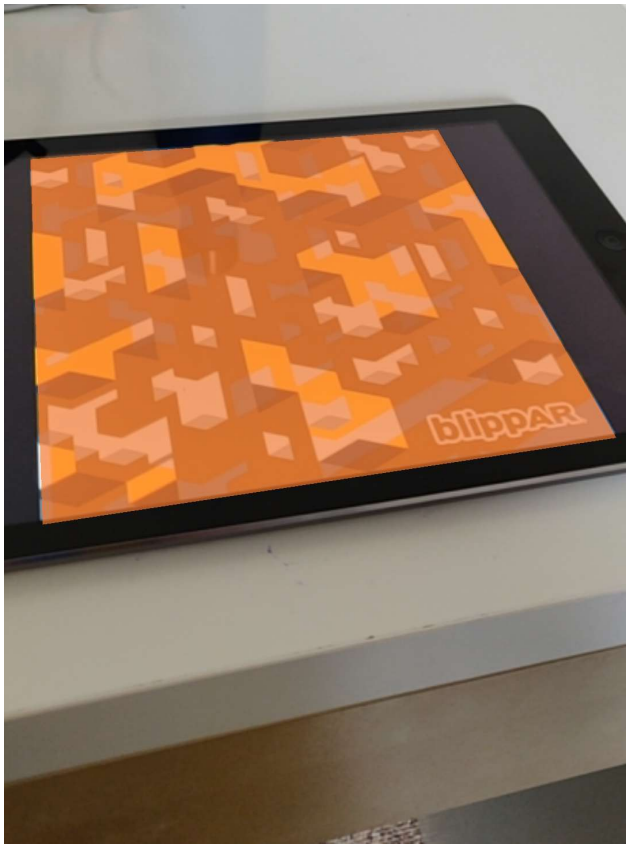

Figure 10 Plane using BlippAR

This experiment was beneficial because I was interested in how BlippAR develop their AR experiences and it was very similar to my previous experiment, only with different technologies. Furthermore, I found a lot of documentation for developing using BlippAR. I believe this documentation will be useful for the development of my project, because both systems (A-Frame + AR.js and BlippAR) use JavaScript.

05/11/2019 – Meeting with Technical Supervisor

I met with my technical supervisor to discuss the progress of my interim report and to get some further clarifications on the project.

6.3. Ethical compliance form

Ethical Compliance Form for UG and PGT Projects*

School of Engineering and Informatics

University of Sussex

This form should be used in conjunction with the document entitled "Research Ethics Guidance for UG and PGT Projects".

Prior to conducting your project, you and your supervisor will have discussed the ethical implications of your research. If it was determined that your proposed project would comply with **all** of the points in this form, then both you and your supervisor should complete and sign the form on page 3, and submit the signed copy with your final project report/dissertation.

If this is not the case, you should refer back to the "Research Ethics Guidance for UG and PGT Projects" document for further guidance.

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1. Participants were not exposed to any risks greater than those encountered in their normal working life.

   Investigators have a responsibility to protect participants from physical, mental and emotional harm during the investigation. The risk of harm must be no greater than in ordinary life. Areas of potential risk that require ethical approval include, but are not limited to, investigations that require participant mobility (e.g. walking, running, use of public transport), unusual or repetitive activity or movement, physical hazards or discomfort, emotional distress, use of sensory deprivation (e.g. ear plugs or blindfolds), sensitive topics (e.g. sexual activity, drug use, political behaviour, ethnicity) or those which might induce discomfort, stress or anxiety (e.g. violent video games), bright or flashing lights, loud or disorienting noises, smell, taste, vibration, or force feedback.

2. The study materials were paper-based, or comprised software running on standard hardware.

   Participants should not be exposed to any risks associated with the use of non-standard equipment: anything other than pen-and-paper, standard PCs, mobile phones, and tablet computers is considered non-standard.

3. All participants explicitly stated that they agreed to take part, and that their data could be used in the project.

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*This checklist was originally developed by Professor Steven Brewster at the University of Glasgow, and modified by Dr Judith Good for use at the University of Sussex with his permission.

Participants cannot take part in the study without their knowledge or consent (i.e. no covert observation). Covert observation, deception or withholding information are deemed to be high risk and require ethical approval through the relevant C-REC.

If the results of the evaluation are likely to be used beyond the term of the project (for example, the software is to be deployed, the data is to be published or there are future secondary uses of the data), then it will be necessary to obtain signed consent from each participant. Otherwise, verbal consent is sufficient, and should be explicitly requested in the introductory script (see Appendix 1).

4. No incentives were offered to the participants.
   The payment of participants must not be used to induce them to risk harm beyond that which they risk without payment in their normal lifestyle. People volunteering to participate in research may be compensated financially e.g. for reasonable travel expenses. Payments made to individuals must not be so large as to induce individuals to risk harm beyond that which they would usually undertake.

5. No information about the evaluation or materials was intentionally withheld from the participants.
   Withholding information from participants or misleading them is unacceptable without justifiable reasons for doing so. Any projects requiring deception (for example, only telling participants of the true purpose of the study afterwards so as not to influence their behaviour) are deemed high risk and require approval from the relevant C-REC.

6. No participant was under the age of 18.
   Any studies involving children or young people are deemed to be high risk and require ethical approval through the relevant C-REC.

7. No participant had a disability or impairment that may have limited their understanding or communication or capacity to consent.
   Projects involving participants with disabilities are deemed to be high risk and require ethical approval from the relevant C-REC.

8. Neither I nor my supervisor are in a position of authority or influence over any of the participants.
   A position of authority or influence over any participant must not be allowed to pressurise participants to take part in, or remain in, any study.

9. All participants were informed that they could withdraw at any time.
   All participants have the right to withdraw at any time during the investigation. They should be told this in the introductory script (see Appendix 1).

10. All participants have been informed of my contact details, and the contact details of my supervisor.

    All participants must be able to contact the investigator and/or the supervisor after the investigation. They should be given contact details for both student and supervisor as part of the debriefing.

11. The evaluation was described in detail with all of the participants at the beginning of the session, and participants were fully debriefed at the end of the session. All participants were given the opportunity to ask questions at both the beginning and end of the session.

    Participants must be provided with sufficient information prior to starting the session, and in the debriefing, to enable them to understand the nature of the investigation.

12. All the data collected from the participants is stored securely, and in an anonymous form.

    All participant data (hard-copy and soft-copy) should be stored securely (i.e. locked filing cabinets for hard copy, password protected computer for electronic data), and in an anonymised form.

Project title: User-Generated Augmented Reality

Student's Name:

Student's Registration Number:

Student's Signature:

Date: 14/11/2019

Supervisor's Name:

Supervisor's Signature: _____

Date: _____