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WATERFORD INSTITUTE OF TECHNOLOGY

S.A.R.I.
SPATIAL AUGMENTED REALITY INVESTIGATION

Entertainment Systems | Sarah Loh – 20046704

DECLARATION OF AUTHENTICITY

Unless stated otherwise, the work represented by this report is my own. I have not submitted the work represented in this report in any other course of study leading to an academic award.

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ABSTRACT

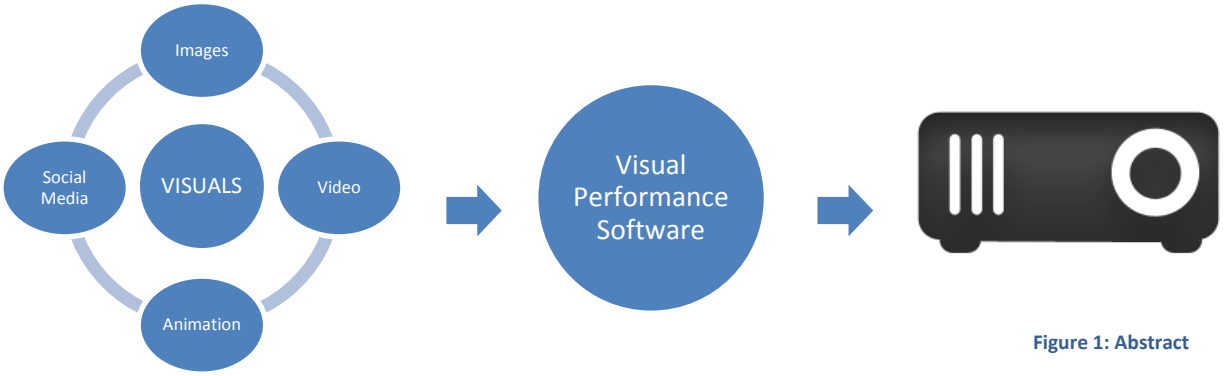


Figure 1: Abstract

Spatial augmented reality, also known as projection mapping, is a technology whereby video projectors overlay video and image content onto physical objects. This project is an investigation into projection mapping, exploring all aspects of the technology. Topics under examination include the differences between internal and external projection, how the size and type of the object or surface affects the projected media and the hardware and software required for various scenarios. The project investigates and details projection parameters such as size, distance, lumens and power. The project also investigates content creation tools, graphical programming environments and visual performance software. We use these tools to process social media feeds and to create reactive and generative visuals.

"Generative art is a term given to work which stems from concentrating on the processes involved in producing an artwork, usually (although not strictly) automated by the use of a machine or computer, or by using mathematic or pragmatic instructions to define the rules by which such artworks are executed", (Ward, 2005).

Jeya's (2009) examples of generative art (Figure 2) were created using Flash/ActionScript.

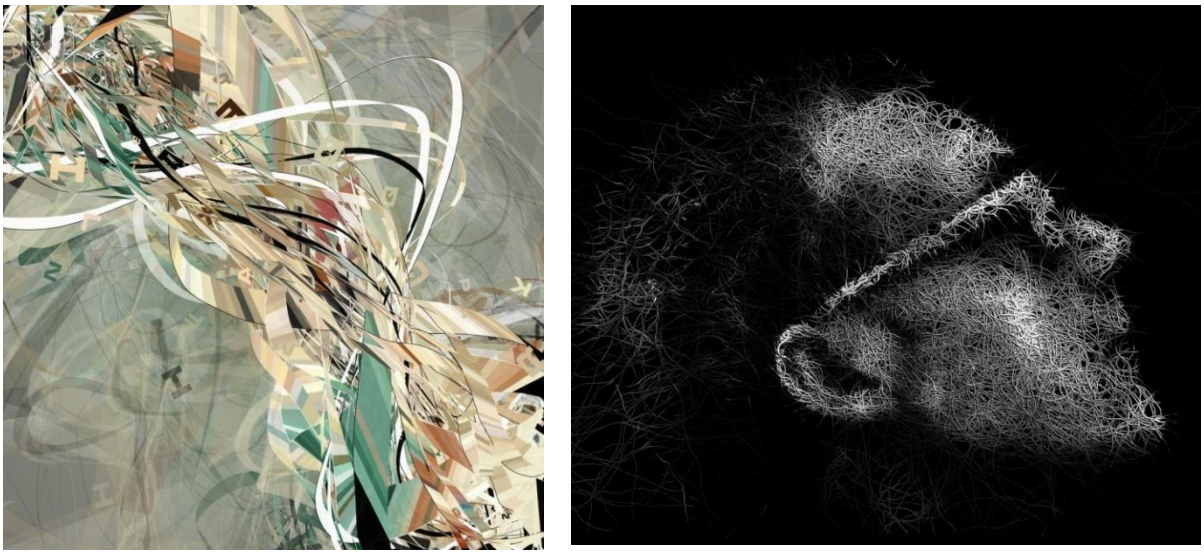


Figure 2: Generative Art

The project looks at the methods and tools for creating generative art, in particular the area of creative coding. **Creating Coding for Live Visuals** (2013) describes creative coding as involving "the creation of high-tech interactive digital artworks by using open-source as well as affordable commercial tools and hardware that was not available before. The creative coding philosophy is also about how to make programming and computer technology more accessible to artists and designers, thus allowing them to create artworks and design prototypes faster, cheaper and with less effort than before". Products of creative coding include art installations, interactive video and large-scale public projections. It translates the world of computers and code to everyday experience and has an active community of people who write libraries, create tutorials and teach with it (Kirn, 2013).

GOALS

This project analyses the requirements and variables associated with projection mapping technology. The major goals are outlined below:

1. To build an internal projection mapping system onto objects and surfaces of different materials.
2. Utilise social media feeds in a 3D projection mapping performance.
3. Create/program a reactive visualizer to utilise social networks, feeds and audience participation through mobile devices.
4. Experiment with using creative coding to generate live visuals.
5. Build an internal projection mapping installation demonstrating goals 1-4.
6. Create an instruction manual and video for projection mapping.

FEASABILITY STUDY

The basic feasibility of this project is determined by whether or not I can project media onto a surface. This has been achieved (internal) and I can therefore state that it is feasible. Further study can be done on the feasibility of external projection mapping.

"The main technical issue with successful outdoor projection is the brightness and contrast of projection needed to overcome ambient light", (Head, 2012).

Before the problem of ambient light, there is the issue of obtaining the correct hardware for external projection. In his report on the issues associated with outdoor architectural projections carried out at the Illuminate Bath 2012 festival, Head (2012) also offers information on projector types and costs. For external projection the main types of projector used are LCD (Liquid Crystal Display*)* and DLP (Digital Light Processing). They range from 15,000 lumens to 33,000 lumens and cost between £1,000 and £7,000 a week to rent. For financial reasons it is not possible to hire the necessary projector for outdoor use and so it can be said that external projector is not feasible for this project.

RISK ANALYSIS

REQIREMENTS RISK

An elementary requirements risk was getting a projector. I have obtained the use of a projector for the duration of the project. With regards to software, there are many open source tools which intend to experiment with and there are commercial tools which have a free version for non-commercial use. Some software tools are platform specific. I have a Sony Vaio laptop running Windows 7 and an iMac running Mac OS X 10.8. In a performance situation a laptop is preferable over a desktop machine for portability reasons. If the software required for a demonstration is Mac specific, I would need access to a suitable laptop running the desired software. In order to maximise the time to work on the project, a space/room is required so that the equipment can be set up and remain in place. A digital camera is required to capture the projections in progress and to make the tutorial video. I have a suitable camera with an 8GB memory card.

SKILLS RISK

PROGRAMMING

Programming skills are required to use the social media APIs. I have sufficient programming skills to implement the APIs and have experience using the Facebook developer's API and authentication system. Scripting languages such as JavaScript and ActionScript are used in some of the graphic programming environments. Others use programming languages C++ and Java. I have experience using all of the above languages with the exception of C++.

GRAPHIC

The creation of graphic/image content requires knowledge of both the software to produce it and the formats to export to. Applications such as Photoshop and Flash Professional are quite complex and take time to become comfortable with. There are tutorial videos and user manuals available for most applications which will provide any help needed.

VIDEO

Video recording and editing skills are necessary for the visual documentation of work completed and also for the tutorial video. I have completed several tutorials using iMovie to edit material and create a video. In addition, I will be completing a module on photography in semester 2 which will provide me with better knowledge of lighting, composition and camera operation.

CREATIVE

This is very much a creative project with an emphasis on generating visual content and interactive media. Creation and editing skills with graphics and video are required to produce quality material.

WRITING

Writing and composition skills are required to create the instruction manual on projection mapping. I have experience writing reports and research documents from the internship I completed last year in TSSG (Telecommunications Software and Systems Group).

TECHNOLOGICAL RISK

Some of the experiments planned have an element of technological risk in that I do not know if some of the surfaces are suitable for projection. It is, however, the purpose of the experiments to find out what works, what doesn't work and to discover new methods of projection. Projection mapping is a relatively new technology and part of this project is to see how it is achieved.

TOOLS

The tools outlined here are software applications, libraries, programming languages and programming environments that are used to create media content, map it onto objects and surfaces, and 'perform' it. Performing the media content means to add effects to it in real-time and to manipulate its behavior, often with the use of a controller sending MIDI or OSC messages. Musical Instrument Digital Interface (MIDI) is a protocol developed in the 1980's which allows communication between electronic instruments and digital musical tools. Open Sound Control (OSC) is a protocol for communication among computers and multimedia devices.

PROJECTION MAPPING TOOLS

These software applications and libraries are used to define how the media content is displayed on the physical object or surface. They usually use a combination include a masking feature to ensure only the desired areas are projected onto.

MADMAPPER

MadMapper (MadMapper, 2013) is a tool for video-mapping projections and LED mapping. It requires an Intel Mac running at least OS X 10.6. It has a free demo version with the save option disabled. MadMapper uses Syphon (Syphon, 2013) which allows the sharing of video content between applications. Syphon is an open source Mac OS X technology for sharing video and image frames in real-time.

VPT

Video Projection Tool (VPT, 2013) is a free projection mapping software for mapping real-time media. It runs on Mac OS X and Windows.

TOUCHDESIGNER

TouchDesigner (TouchDesigner, 2013) is a visual development platform for interactive multimedia projects that supports projection mapping. It requires Windows 7 or 8 and offers a free non-commercial version.

GRANDVJ XT

GrandVJ XT (arkaos, 2013) is an extended version of GrandVJ adding the Video Mapper feature for projection mapping. GrandVJ is an application for mixing real-time video. It requires Windows (XP, Vista, 7, 8) or Mac OS X 10.6 (and up) and offer a free demo version with saving disabled.

LPMT

Little Projection Mapping Tool (LPMT, 2011) is a simple free tool for projection mapping. It uses adjustable quads to map onto objects and allows complex setups to be saved. It is based on OpenFrameworks (OpenFrameworks, 2013), a C++ library for creative coding. LPMT was developed on a Linux environment and although written to be cross-platform, it is not widely-tested on Windows or Mac OS X yet.

SURFACEMAPPER

SurfaceMapper (Ixagon, 2012) is a library for the Processing (Processing, 2013) programming environment for projecting textures onto multiple surfaces. It is tested on Mac OS X and Windows with Processing v1.5.

DYNAMAPPER

DynaMapper (Reo-Tek, 2013) is an interactive projection mapping app for the iPad. It requires an iPad 2 or newer using iOS 4.2 (or higher).

VISUALIST PROGRAMMING ENVIRONMENTS

These graphical programming environments allow the user to program images, animations, video and interactions. They provide a language for prototyping and development of digital art installations.

PROCESSING

Processing (Processing, 2013) is a programming language and development environment for creative coding. It was developed in the MIT Media Lab (MIT, 2013).

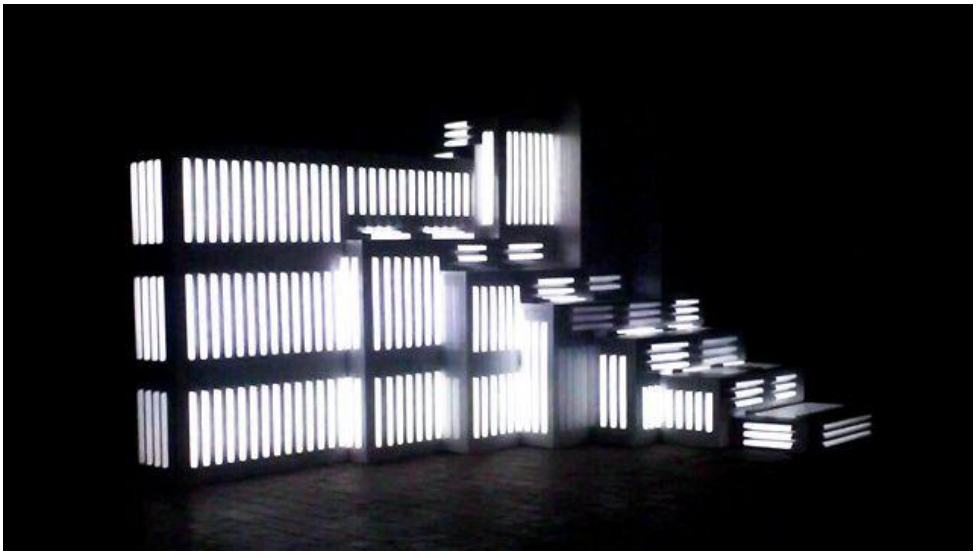
VVVV

vvvv (vvvv, 2012) is a graphical programming environment with projection mapping capabilities. It is a multi-purpose toolkit for real-time video synthesis. It is free for non-commercial use.

VISUAL CONTENT CREATION TOOLS

Visual content in this instance refers to the images and videos used for projection. In projection mapping, existing content can be mapped onto an object, or specific content can be created to fit the desired object. An example of this can be seen in the installation below. Both Processing and vvvv can be included in this section as they are used for creating generative art.

Figure 3: Projection Mapping Installation



PHOTOSHOP

Photoshop (Adobe, 2014) is digital imaging software used by photographers, video professionals and designers. Photoshop CC requires at least Windows 7 and Mac OS X 10.7.

AFTER EFFECTS

After Effects is “the industry-leading animation and creative compositing software used by a wide variety of motion graphics and visual effects artists”, (Adobe, After Effects, 2014). After Effects CC requires at least Windows 7 and Mac OS X 10.7.

FLASH PROFESSIONAL

Flash Professional is “the industry-leading authoring environment for creating and delivering immersive experiences, games, and interactive content”, (Adobe, Flash Professional, 2014). It uses the ActionScript (ActionScript, 2013) programming language. Flash Professional CC requires at least Windows 7 and Mac OS X 10.7.

METHODOLOGY

While the primary focus of this project is not on software development, I researched several software development methodologies to determine a project management lifecycle that would suit my needs. In the end, I came up with a hybrid process combining elements from the Prototype methodology and the Agile methodology.

Following the Prototype model (Figure 4), the project will begin with the design and construction of a prototype. This will demonstrate 3D projection mapping onto a simple object using basic graphics/video. The plan for the end of the project is to have explored all aspects of projection mapping. This will be achieved through compiling and carrying out a series of experiments and revisions to the original prototype. In keeping with the Agile model (Figure 5), each experiment and/or revision will make up an iteration. Instead of a finished product at the end of each iteration, I will have an altered version of the original prototype.

I chose the Agile methodology because it accommodates for change by allowing decisions to be made during the course of the project. As there is an emphasis on practical work in this project, the Prototype methodology gave me a starting point to work from.

Figure 4: Prototype model

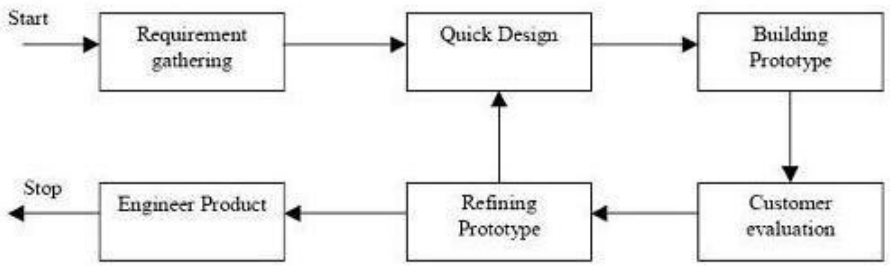
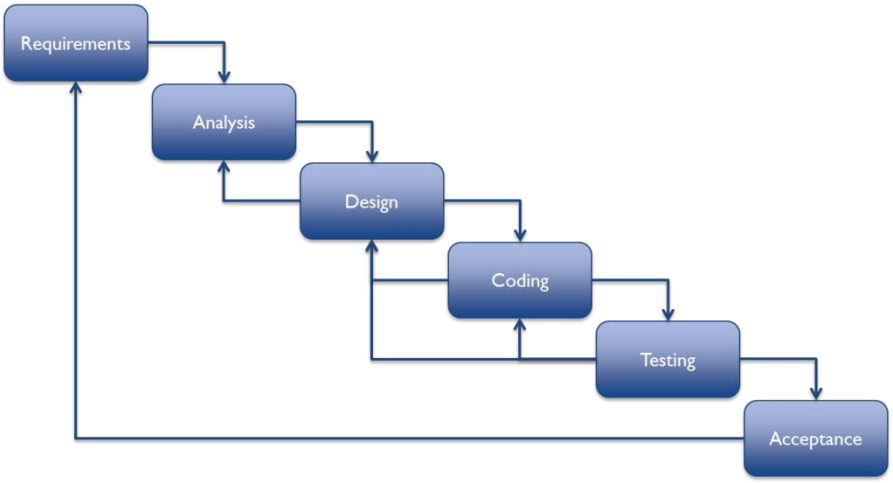


Figure 5: Agile model



PROTOTYPE

The prototype has been created to illustrate a basic example of projection mapping. A cardboard box was painted white and used as the object to map onto. Keeping in mind that the prototype is the basis for future iterations, I decided to use my laptop and not the iMac for portability. After researching the different tools available, I opted to use LPMT. First, I installed Ubuntu 12.04 LTS 64-bit alongside Windows 7 on the laptop. As LPMT is based on OpenFrameworks, I downloaded it from GitHub (https://github.com/openframeworks/openFrameworks), installed the dependencies and compiled it. I then downloaded LPMT from http://hv-a.com/lpmt/?page_id=63, placed it in the apps directory inside the OpenFrameworks installation and ran it.

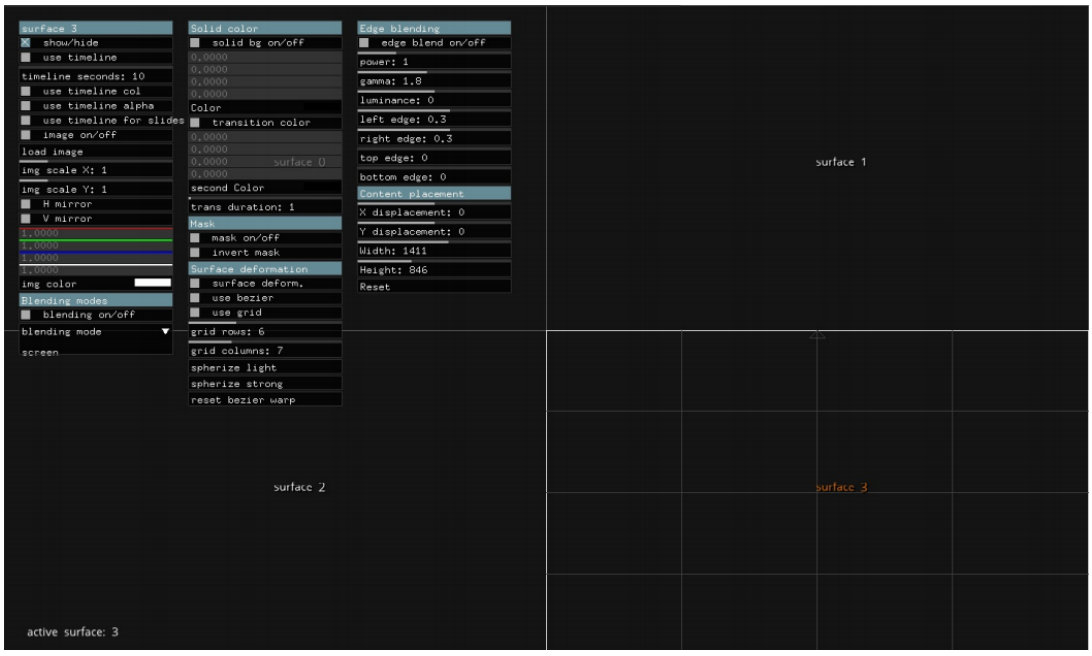


Figure 6: LPMT opening screen

I used the tool to map onto two sides of the box and used a separate video as the source for each side. A video of the running prototype is available on my YouTube channel at http://www.youtube.com/watch?v=PGv6Y6Gh27Q.

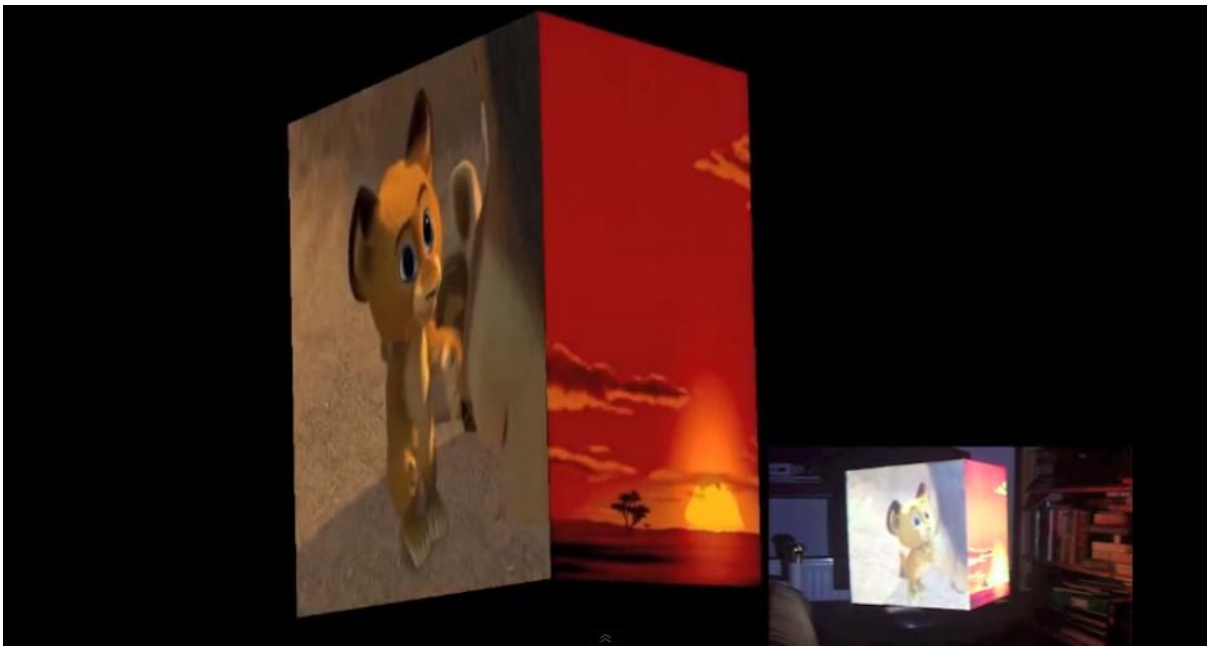


Figure 7: Prototype

ITERATIONS MAP

The Iterations Map is a plan for the work needed to realize the goals above. An iteration lasts for two weeks. It begins with creating an outline. The outline will detail the subject matter, the software/hardware needed and the steps to be taken to carry it out. At the end of the iteration, a report will be written detailing any problems encountered and a video will be made. The video will show the outlined tasks in progress and provide visual evidence of the work completed.

ITERATION 1 – SURFACES

Iteration 1 addresses the first goal identified – 'To build an internal projection mapping system onto objects and surfaces of different materials'. The materials I hope to project onto in this iteration are water, glass and air using a fog machine.

ITERATION 2 – TWITTER

Iteration 2 addresses third goal identified – 'Create/program a reactive visualizer to utilise social networks, feeds and audience participation through mobile devices'. This involves creating a Twitter application on https://dev.twitter.com/ to obtain authentication for use with the Twitter API. The API will be used to access live text from trending topics such as

'#SARI' and obtain profile pictures. The media gathered will be used as the input to a software visualizer. The output of the visualizer will then be projected onto an object.

ITERATION 3 – CREATIVE CODING

Iteration 3 addresses the fourth goal identified – 'Experiment with using creative coding to generate live visuals'. Processing, vvvv and Flash are applications used for producing generative art in creative coding. This iteration will look at each application and determine the most suitable one for use later on in the project.

ITERATION 4 – INSTALLATION 1

Iteration 4 addresses the fifth goal identified – 'Build an internal projection mapping installation demonstrating goals 1-4'. The installation is an important part of the project as it will be used as part of the final demonstration at the end of the semester. For this reason, the creation of the installation is spread over two separate iterations, namely iteration 4 and iteration 5. This iteration will cover the design and construction of the objects. Objects and surfaces of different materials will be incorporated and the social media visualizer from iteration 2 will be added.

ITERATION 5 – INSTALLATION 2

Iteration 5 deals with the creation of reactive and generative visuals to complement the objects and surfaces that make up the installation. Motion detection will be used for audience interaction. This follows on from the work on creative coding completed in iteration 3.

ITERATION 6 – MANUAL

Iteration 6 addresses the sixth goal identified – 'Create an instruction manual and video for projection mapping'. This manual will be created for use in the Live Performance Technology module on the BSc in Entertainment Systems course.

AUDIENCE DEFINITION

The primary audience for this project is the visualist community (VJ). The project is also of interest to educators with regards to the projection mapping manual.

SCENARIOS

These scenarios or user stories detail the characters' experience of the system. There are two characters in these stories. **John** is the projection designer. **Anna** is an observer/ audience member. **Mick** is the social media aggregator.

John arrives at the venue and gets access to the space. He gets his equipment out of the van: laptop, projector, extension leads, cables/connectors and object. He finds a source of power and sets up his equipment. This involves connecting the laptop to the projector, opening the software and ensuring the projector is angled correctly onto the cube object.

Anna tweets including #SARI. Mick the social media aggregator sees Anna's tweet in his feed reader and selects the tweet to be passed on for graphical treatment and incorporation into the projection mapping installation. John receives Anna's twitter profile image and projects it onto the top of the cube object. The text for her tweet scrolls across and around two sides of the cube.

SCHEDULE

Figure 8: Schedule

Week Start	Outline	Mon	Tue	Wed	Thu	Fri	
13/01	1	**Outline**					Iteration 1
20/01	2				**Report**	**Video**	
27/01	3	**Outline**					Iteration 2
03/02	4	Poster due			**Report**	**Video**	
10/02	5	**Outline**					Iteration 3
17/02	Study						
24/02	6				**Report**	**Video**	Iteration 3
03/03	7	**Outline**					Iteration 4
10/03	8	Poster Day	Poster Day	Poster Day	**Report**	**Video**	
17/03	9	**Outline**					Iteration 5
24/03	10				**Report**	**Video**	
31/03	11	**Outline**					Iteration 6
07/04	12				**Report**	**Video**	
14/04	Easter			Final Report	Final Report	Final Report	
21/04	Easter						
28/04	Study						
05/05	Exam						
12/05	Exam					Final Report	
19/05	Demos				Student Fair		

NAMING STRUCTURE

PROJECT FILES

<studentNo>_<StudentName>_<module>_<filename>

e.g. 20046704_SarahLoh_P1_report1, 20046704_SarahLoh_P1_abstract, etc.

ITERATION FILES

<studentNo>_<StudentName>_<module>_<interationNo>_<filename>

1. 20046704_SarahLoh_P1_iter1_outline
2. 20046704_SarahLoh_P1_iter1_report
3. 20046704_SarahLoh_P1_iter1_video

GLOSSARY

External projection: Projecting media onto a surface out-of-doors.

Internal projection: Projecting media onto a surface inside with little or no sunlight.

Iteration: A single revolution of the project lifecycle. Each iteration has a design document at the beginning and a product at the end.

Mapping tool: A software application for mapping media onto an object.

Media: Video, images, text, and camera feeds for projection.

Object: A 3D item such as a box. An object is a type of surface.

Product: The resulting video and report at the end of each iteration.

Surface: The substance or material that media is projected onto.

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