Department of Computing
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# Augmented Reality Navigation System for Commercial Spaces

Proposal

by

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## Abstract

Frustration and confusion are common emotions that are apparent at large shopping centres. After analysing recent studies, it is evident that shopping centres have a huge role to play in the overall retail experience. In order to provide greater value to both consumers and retailers, retail settings are being challenged to become smarter. One approach that is becoming increasingly recognised is mobile augmented reality apps. Many consumers have difficulties in locating the store which satisfies their needs. In this research, we endeavour to outline the market requirement of developing an application that allows for smart retail and describing how additional value is created to customers as well as benefiting retailers. It is proposed that the application will implement a 3D model of various shopping centres, featuring navigation functionality to assist users in finding their desired store.

## Word Count

xyz

computed by `TeXcount`

## Supervisor

Dr. Basil Elmasri

# Contents

# List of Figures

# Nomenclature

| | |
|---|---|
| AR | Augmented Reality |
| GDPR | General Data Protection Regulation 2016/679 |
| GPS | Global Positioning System |
| IDE | Integrated Development Environment |
| IP | Intellectual Property |
| MVC | Model-View Controller |
| SDK | Software Development Kit |
| UI | User Interface |
| UML | Unified Modeling Language |
| UX | User Experience |
| VR | Virtual Reality |

# Chapter 1

# Concept Introduction & User Needs

The main concept for this project revolves around the use of augmented reality (AR) navigation on smartphones. AR is the superimposing of a computer-generated image onto a user's view of the real world [1]. This technology first came about in the 1960s [2] but has recently gained wide-spread consumer attention after the use of it on Snapchat filters [3], and the 2016 game *Pokémon Go* for example. There have been many times where people get lost in unfamiliar spaces such as a museum, immersed by the culture around them, and their sense of direction. This project aims to tackle this issue by allowing users to restore their orientation by having an AR platform to route users to their destination. The platform will use the device's camera to work out its surrounding, and will produce a highlighted line on the screen to their destination in real time.

This concept has various applications to other similar scenarios such as finding products in a supermarket, or books in a library. Further, the concept could also use machine learning in identifying user's traits in places visited in a museum in order to give personalised recommendations at other similar exhibitions.

# Chapter 2

# Stakeholder Requirements

After consultation with the main stakeholders (museum visitors and staff), and potential users of the proposed application, a better understanding was available, concerning the need shown in the market regarding museums. Out of the 21 responses received, 15 potential users admitted to visiting museums at least once a month; showing some level of frequency in their visits, and that something can be offered to this group of people.

Since the concept principally considers the use of navigation in museums, when users were asked, "do you find yourself using the maps in the museum more than once?"- 100% of visitors agreed that they referred to the maps around the museum multiple times, and some respondents over 10 times. However, these maps are not free; in most museums, including the Natural History Museum, and Science Museum in London, charge a fee of £1.

18 of the respondents agreed they preferred using their phone to navigate rather than the paper maps. Outlining a clear need for an accessible tool other than the maps around the museum.

Based on the stakeholder research, the project requirements are,

- Navigate the user to a museum through the use of AR.
- Display navigational routes in real time.
- Calculate the shortest route to the user specified location.
- Work transferrably in other museums/commercial spaces.
- Contain accessibility features such as inverted colours.

Another key stakeholder are museum staff as they are instrumental to any on-the-ground navigational assistance. Furthermore, the application should endeavour to make it easier for museum staff to assist visitors.

The stakeholder requirements of museum staff are,

- Exhibit an effective and easy-to-use design.

- Be economic and effective in its use of data, as most data would be sourced from the museum Wi-Fi.
- Written content and other media to be controlled by the museum.

During the field research, museum-floor staff and receptionists were consulted. The staff approached all received navigational inquiries, either from themselves or visitors. Although positive responses were received several concerns were cited,

- Battery performance
- Data usage
- Ease of use

# Chapter 3

# Prior Knowledge

## 3.1 Current Solutions & Competitors

The market of indoor museum navigation has become more competitive in recent years with solutions being submitted due to a growth in indoor navigational research. Most solutions on the market cater well for a basic navigation of large public spaces, but fails to display an even proportion of navigational and interactive content with well-presented data.

Since most museums use portable audio guides, user experiences can be vastly improved by mobile devices. Currently only a few solutions can be found; the Orpheo group [4] provide a unique app for each place; their solution is somewhat cumbersome to regular museumgoers who wish to have a hassle-free setup. As the aim is to appeal to museums, having an application whereby the user can walk into a museum or exhibition, and be greeted with relevant information is vital in comparison [5].

If museums wanted a solution for navigation, due to the low number of museum-specific competitors, would choose to use a standard indoor mapping software [6]. However, while there are many options out there from Google and Mapspeople [7] who try to provide this, they lack exigencies that are imperative for museums like heavily integrated AR, intelligent tour guiding from your location, and virtual reality to take a scene from the museum, for instance, and place the user to the artefact's original time and place.

From a technological point of view, an apparent problem in the solutions that museums implement today, would be their paper maps not processing real-time locations. AR allows for real-time data processing, picking up the user's current location, and displaying the best route for the user to take through their device's camera. One huge benefit of implementing AR is the unique approach to today's navigation solutions, whilst also allowing for user's to create their own content enabling more opportunities to interact with the application.

# Chapter 4

# Design

## 4.1 Importance of Design

Having a design process allows for greater efficiency, and transparency when coming to design the application. It overcomes the risk of referring back to the drawing board during implementation, setting in stone the main features, and functionality of the application.

## 4.2 Unified Modeling Language

Effective design strategies were carried out through the implementation of the UML.

The implementation of the use case diagram outlines different scenarios in which users would function the application. (Figure A.1). UML was implemented to further support, and refine the designing phase of the software development through an activity diagram. (Figure A.2).

The use case diagram represents the functional behaviour of the system in terms of the goals (as defined in the stakeholder requirements) that can be fulfilled by the system. The activity diagram was designed to model the work flow of the system; this was essential as these diagrams are easily comprehensible for both analysts, and stakeholders. By producing these models, there is a clear understanding of what the application does, and enables the visualisation of the application for the future.

## 4.3 Service Model

The following cases are born out of one important principle, convenience. The **lost** use case comes from the user that could be lost for whatever reason. The service provided would be the quickest, and most convenient solution to finding their destination whether that be the exit or a particular exhibition. The **exploration** case, would be more convenient with the museum, and all its exhibitions will be at the user's fingertips (instead of existing museum navigation options like paper maps).

## Model around two cases

Both cases have a linear-stream of logic:

1. User enters within the radius of an environment (museum) modelled by the service.
2. User's location is picked up once they give use permission to.
3. User selects their destination.
4. That location is then taken, and passed through an algorithm calculating the quickest route between the user's real-time location, and their destination.
5. User is displayed the route, and directed towards their destination via their camera.
6. User is given curated suggestions on possible places they can go.

# Chapter 5

# Prototyping

## 5.1 Augmented Reality Libraries

In order to identify libraries that are good for implementing AR on mobile devices, prototyping was divided into three platforms to explore them, building test applications to discover how they assist with implementation.

### Vulforia (Unity/Android)

Unity is a cross-platform game engine, used to test a simple AR camera prototype where the device's camera hovers an image, and displaying information about that image on the device (Figure B.1). The application was built using Vuforia, an SDK that enables recognition, and tracking of image targets. This library can be used for the exploration case in the use case model. Although, there is a lack of tools for locating user current location compared to Android.

### ARKit (iOS)

A similar prototype to Unity (Figure B.2) was built on Apple's ARKit using Swift [8], which was easy to learn. It was intuitive to implement AR features as there was detailed documentation but logging GPS data was harder compared to Android.

### ARCore (Android)

ARCore was used to create a simple 3D model showing on a mobile device when its camera targeted flat surface (Figure B.3). Compared to iOS, it is easier to log GPS location (Figure B.4), although connecting the user interface to the scripts was more challenging.

## 5.2 User Interface/User Experience Designs

The project lends substantial importance to its user interface and experience. As it will be used from a wide range of technical ability, the aim will be to make the app as simple as possible without having an impinging effect on any major service the end product will feature. This prerequisite was clearly outlined in the surveying of museum guests and staff alike. The first mission was to determine what interfaces, and experiences currently exists within the museum sector. Many museums employed simple interfaces but due to their mass-manufacturing, their design felt unoptimized, with simple barebones media not beyond text and images. Furthermore, this design would fail to deliver anything more complex than texts and images.

The approach to the UX/UI prototyping was to create different interface mockups and exhibit them alongside existing solutions. Three team members independently drew up potential interfaces (Figure B.10 B.11 B.12). These candidates were then put to stakeholders, and all the positive attributes were combined into one (Figure B.13).

# Chapter 6

# Functional Specification

The main functional elements of the concept are:

### Route Calculations

1. Receiving the **current coordinates** of the user, and the coordinates of the destination will be needed to create the starting and end points for calculating the route. The current location will come from sensors on the user's device, and the destination location will be queried against a mapping system.

2. The platform can **calculate the quickest route between two points** specified by the user. Data from the above, and the museum model will be required for this calculation.

### Superimposition

3. A **3D line will be superimposed** that navigates the user to their destination. Sensor data from the user's device along with the user's relative position in the model will be required to show the line. Access to the user's camera is essential in this element.

### Suggestions/Reviewal

4. When the user arrives at their destination, the **system will give recommendations** based on their current route, allowing them to rate their journey.

5. The **user's camera can recognise artwork/objects**, displaying further information about the piece. A storage area of current pieces in the museum will exist so that the camera can query the information.

# Chapter 7

# Technical Architecture

## 7.1 Means of Software Development

### SDKs

Google's **ARCore** kit gives the ability to apply the AR to the application without having to spend time pre-defining AR methods. It has distinct advantages over Apple's ARKit as ARCore can detect horizontal surfaces that is similar to motion tracking, and can accurately anchor virtual objects. [9]

### Platform & Languages

The app will be developed on Android since ARCore only it. Java is imperative to the project since android development is only possible in this language.

### IDE

Android Studio will be utilised because it involves a number of relevant exclusive packages. Other IDEs, requires them to be pre-defined, and therefore takes out valuable time from application development.

### Architectural Pattern

The application fits under the MVC (Figure B.16) pattern perfectly be it that the following are true.

- Model: Data provided by the user (e.g. geolocational data)
- View: Front-end interface (e.g. 3D line to location)
- Controller: Algorithms between the model & view (e.g. route calculation)

The pattern's simplicity makes the most sensible one we can use.

## 7.2 Satisfying User-Related Questions From the User Stories

### Questions

1. How will the navigation system get me from point A to point B? (Figure A.3)

   In order for users to get from one point to another, the quickest route will be calculated.
   Route Calculations:

   - Algorithms to request, and process GPS signal.
   - Algorithms to calculation quickest route when user enter their destination.
   - Once calculated, show the result for user to start their journey.

2. How easy will it be to grasp the app?

   The layout would be simple and the basic map/guidance will work straightforwardly. Once the route has been calculated, a 3D line will be superimposed on the users screen.

3. Can the app be used without Internet?

   No, otherwise the app would not have access to the user's real time location, and would take up too much storage space on the user's device otherwise.

# Chapter 8

# System Requirements Specification

# Chapter 9

# Ethical Audit

AR is currently not heavily regulated in the UK owing to the emergence of this new technology. It should be noted that AR will involve collecting extensive amounts of data per user such as names and emails, but also real time location, and interactions with other users. Within the scope of this project, we will not be working with minors and vulnerable adults. Since the concept of the project relies on the user's camera, accelerometer, and GPS on the user's device, ensuring this data cannot be obtained unlawfully, fitting the scope of the Data Protection Act (1998), and GDPR is of most importance.[10]

Based on large VR companies such as Oculus, these obligations are addressed by the form of a privacy policy, to detail how data is collected, used and if it is shared with third parties. It is critical these regulatory issues are addressed before the completion of the product and not after.

Another regulatory standard is the IP of the software. The source code that serves as the underlying foundation of the platform will be be original and qualify for copyright protection. Since computer software is usually excluded from patentability in the UK, any ideas that uses AR producing a technical effect, and its associated hardware can be protected by patents. Based on our competitors, it is important that we do not infringe on their patents owned by third parties.

Equally, if the concept makes new technical developments in the AR field, there should be consideration whether it would be eligible for patent protection. The project could take on a machine learning viewpoint by recognising artworks captured on the user's camera. This could cause an infringement claim since AR could be replicating, replacing trademark or copyright works, or distorting the artwork.

# Chapter 10

# Evaluation Plan

# Chapter 11

# Project Management

In order to manage the development process, the agile methodology using the scrum framework will be employed. In the scrum team, the project supervisor will serve as product owner, acting as the primary liaison for the project, and ensuring the key stakeholders' vision are at the forefront of decisions made by the team.

The project manager will serve as scrum master, coordinating the scrum team, and managing scrum processes such as sprint planning, execution, and review. They will lead daily stand-up meetings, and decision-making processes so that any impediments that affect the team are removed efficiently. The scrum team, and the scrum master are responsible for all actions in the sprints; prioritising items in the backlog (Figure B.15) for sprint planning [11].

A Gantt chart will be used to visually represent sprints and progress made. Trello will host the scrum board to track sprints, and other deadlines such as module milestones. Any specific development issues will be tracked on Gitlab so that they can be easily attributed to the affected code. For each repository commit that happens, a code review will take place by other team members before integration. This is to ensure there is a high level of consistency, maintainability, and secure code across the implementation and testing of the project.

# Chapter 12

# Conclusion

# Appendix A

# Systems Requirements Specification

## A.1 Purpose

The main goal of this concept is to provide an exciting, and enjoyable experience for museum-goers through the use of AR. It includes users being lost, or searching for a specific location within the museum. The target audience is aware of this concept during the field research, it was discovered that the concept would make life easier for users and the museums since it would allow easy access to the information based on exhibitions.

## A.2 Scope

This project will include creating an AR application for people to get an enjoyable journey in the museum. The project will be completed by 29 April 2019. The AR application will include simple navigation system to direct various part of the museum. Getting information on the user screen using the user's camera, and explore various museum using the app.

## A.3 System Overview

The application will perform all the basic tasks to help users with their journey in the museum. Such as navigating from point A to B, getting the user back on track in case they are lost, allowing the user to view information based on camera recognition of an exhibit.

## A.4 References

## A.5 Definitions

## A.6 Use Cases

The use cases have been defined as follows:

1. Use Case Model
2. Activity Model
3. User & Acceptance Stories
   (a) In Exhibit going from A to B
   (b) Getting information from an exhibition
   (c) Exploring the museum
   (d) User get lost in the museum

### A.6.1 Use Case Model

Two scenarios have been taken into account, where the user gets lost in the museum, and the user wants to explore the museum. When a user is lost, they need to enter their destination where the app will calculate their current location, and find the quickest route from the user's current position. The user follows that navigation until they arrive at their destination. For the exploration, the app will show the details where user know what they going to see in the museum.

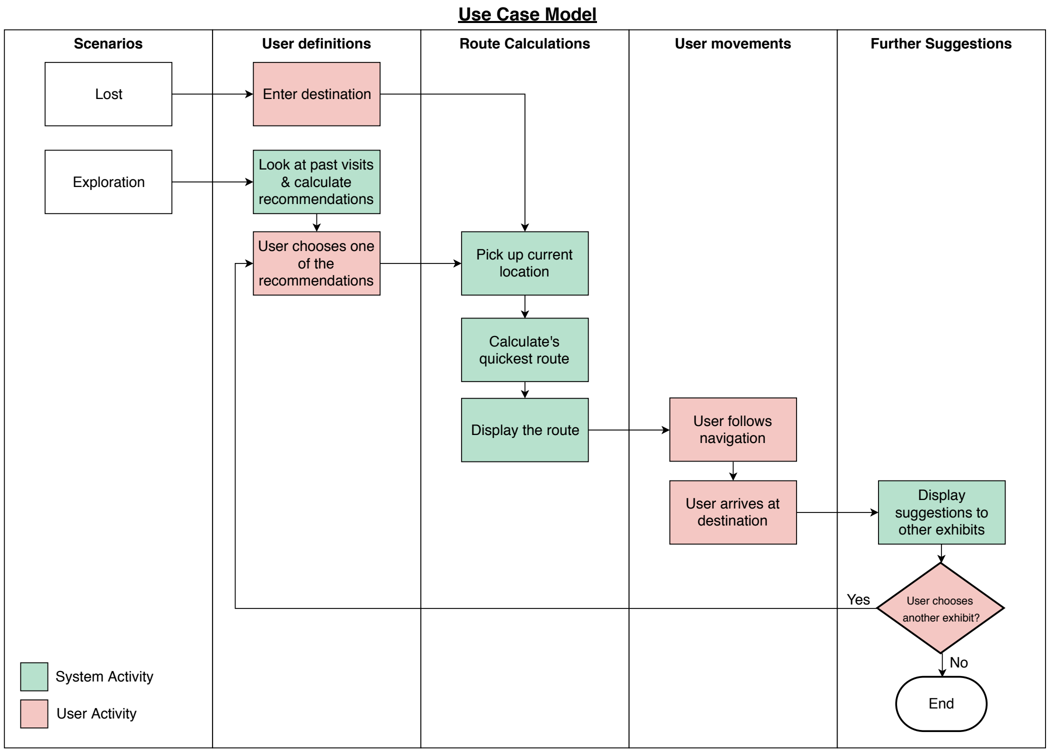



Figure A.1: Use Case Diagram

### A.6.2 Activity Model

This is based on the back-end of the application for example when the user searches about the museum, this history saved in the server where if the user wants to go to the same place then they can use our function called past visit.

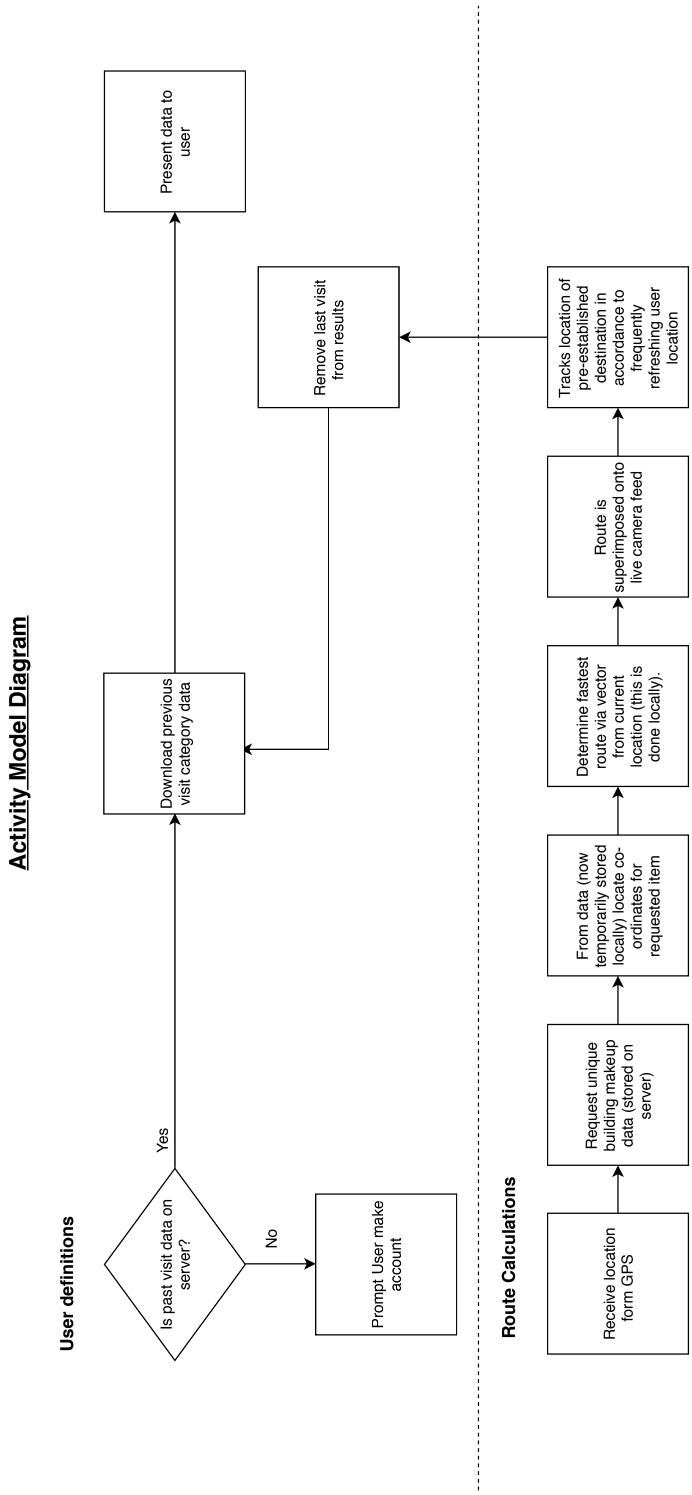



Figure A.2: Activity Model Diagram

### A.6.3 User & Acceptance Stories

This will describe what will be achieved once the application is ready to be used by the user. A diagram has been created based on different scenarios where it can be found if the application has achieved the user needs.

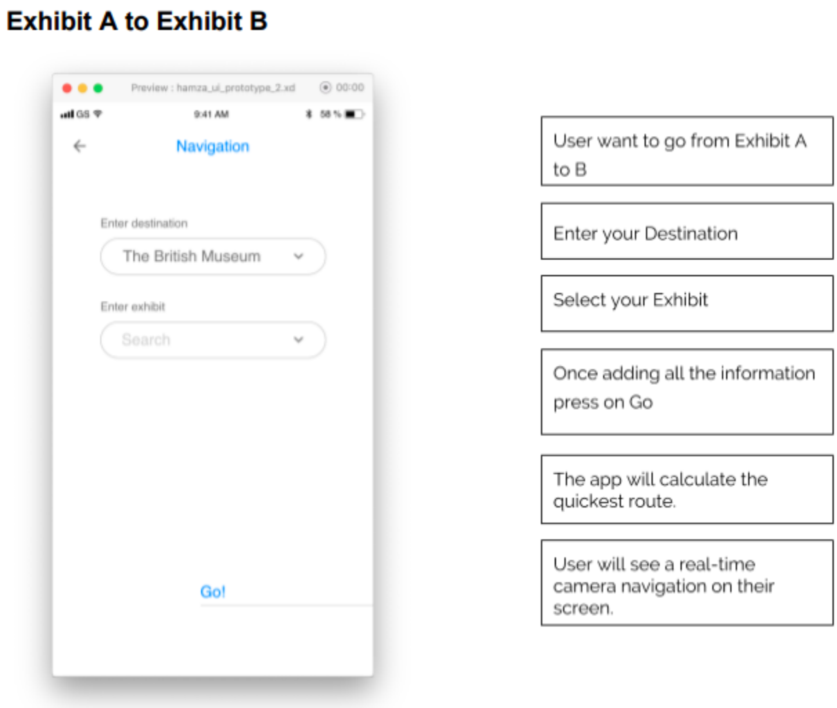



Figure A.3: Going from point A to point B

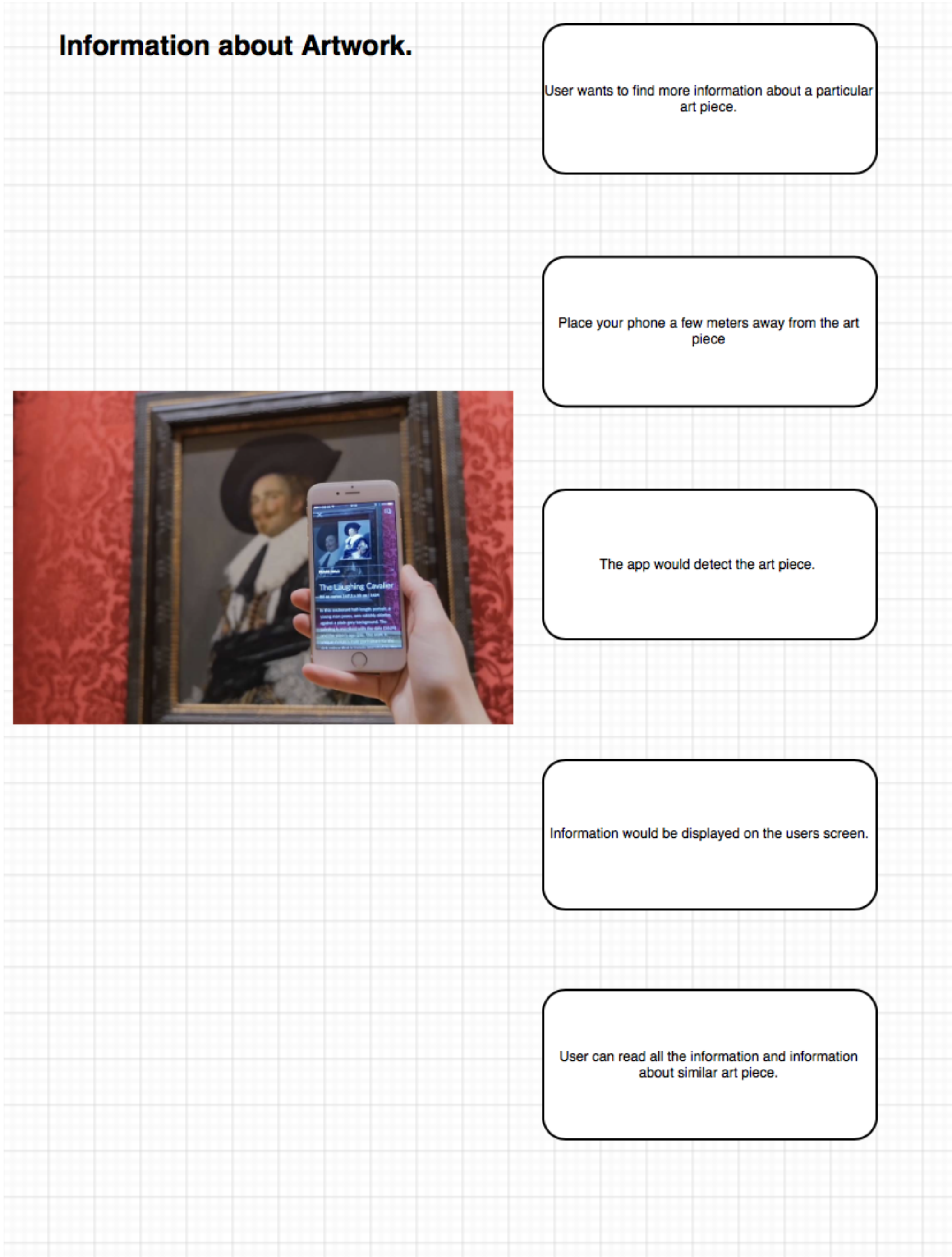



Figure A.4: Getting information from exhibition

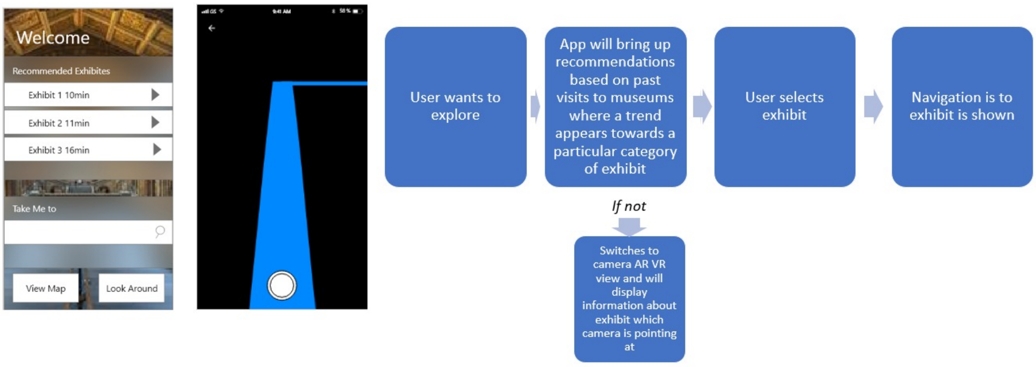



Figure A.5: Exploring the museum

## A.7 Functional requirements

- Needs to be able to navigate the user to an exhibit through the use of AR.
- The app should be able to display navigational routes in real time.
- It should be able to calculate the quickest route to a destination.

## A.8 Non-functional requirements

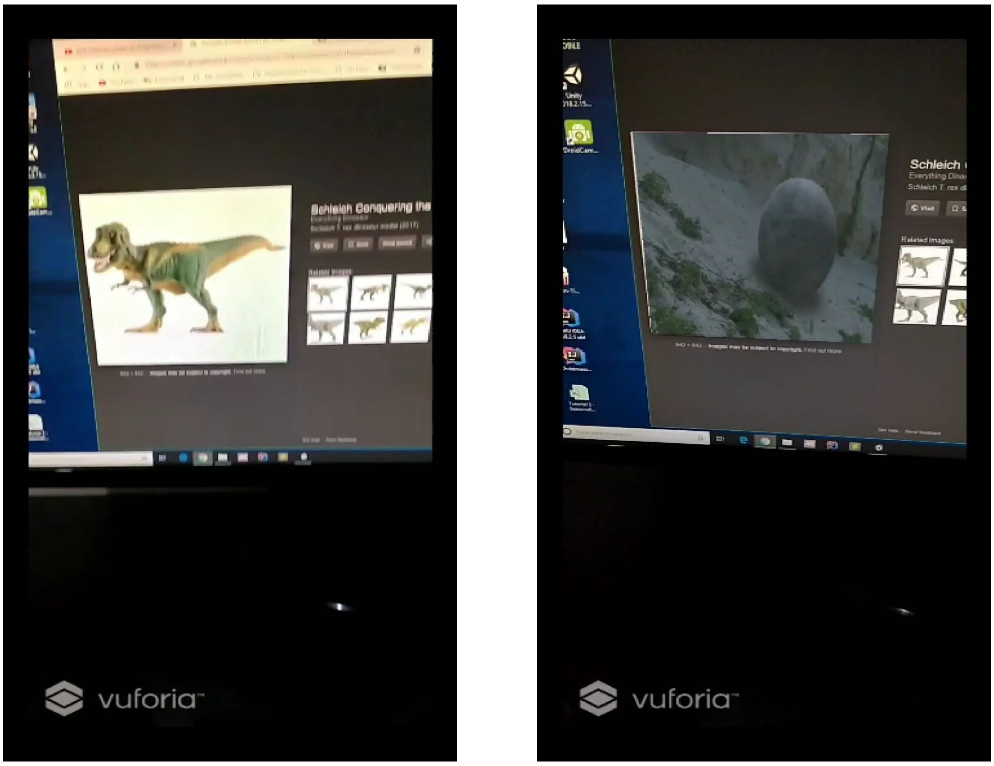
# Appendix B

# Figures

## B.1 Prototyping

### B.1.1 AR Prototypes

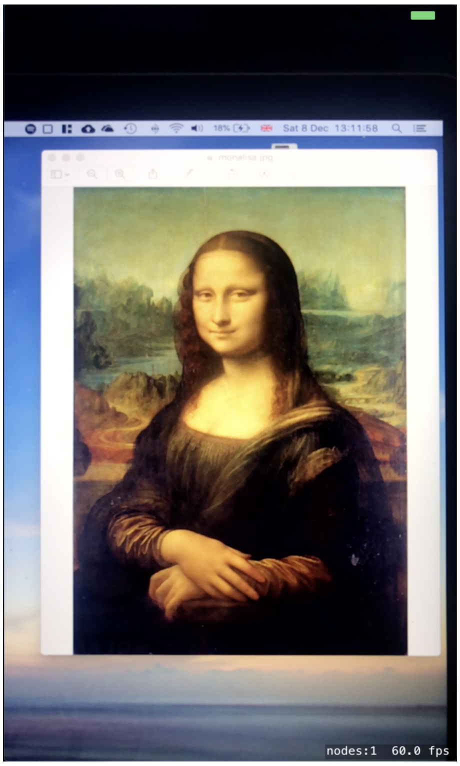
#### Vulforia



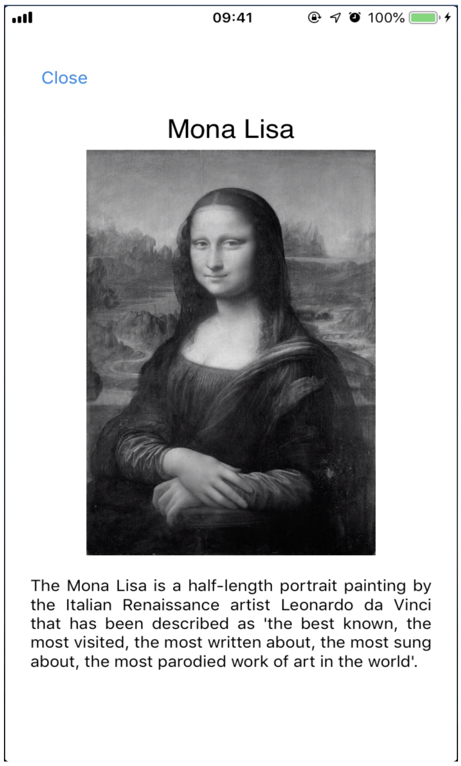

(a) Camera over image (b) Video superimposed on top of image

Figure B.1: Vulforia prototyping on Android device

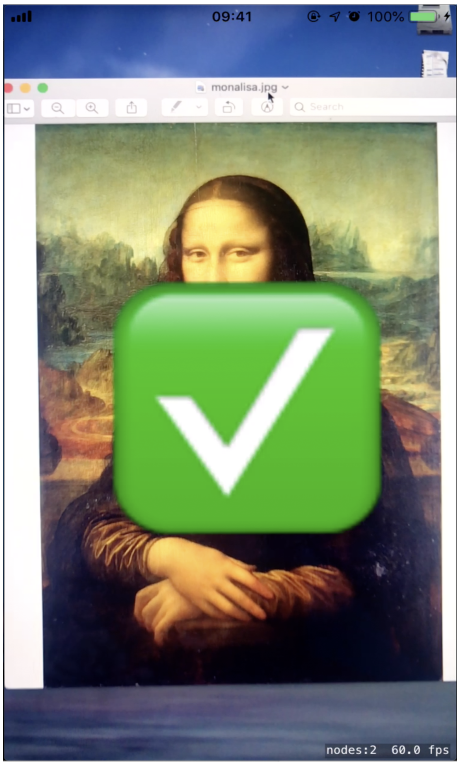
## ARKit




(a) Camera over image



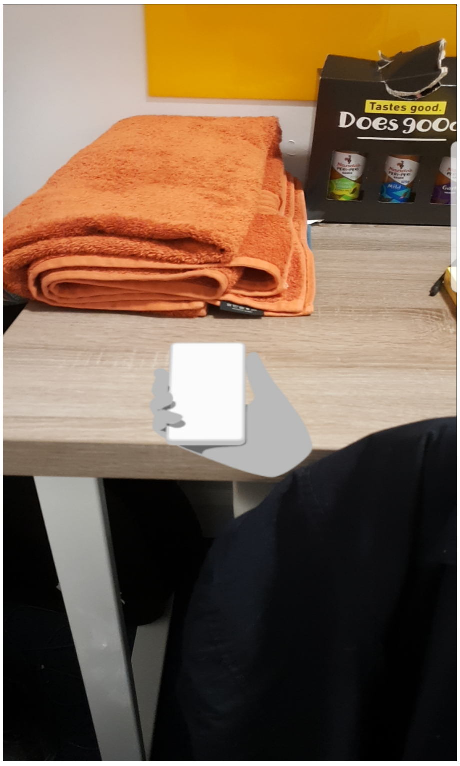

(b) Image recognised and displaying information



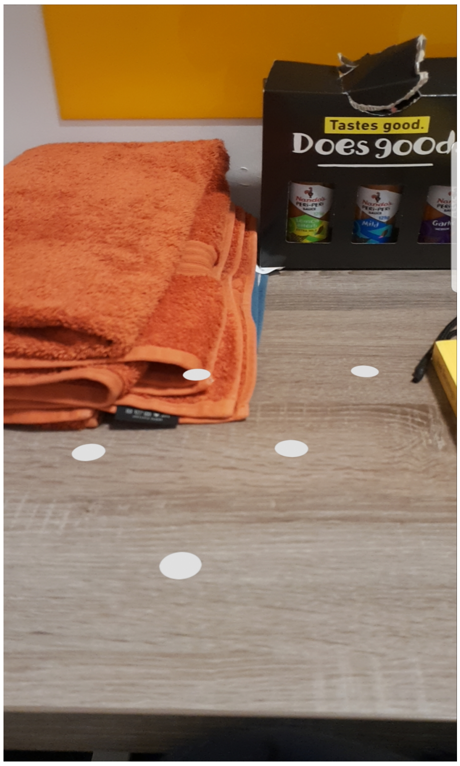

(c) Image scanned before; showing the green tick

Figure B.2: ARKit prototyping on iOS device

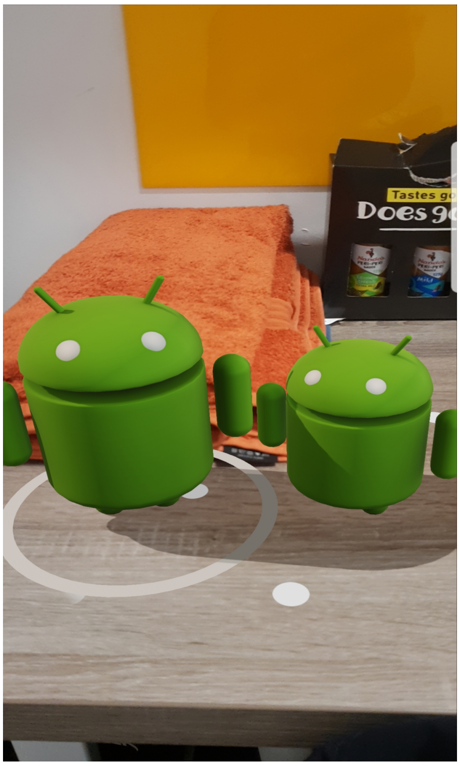
## ARCore




(a) Initial view




(b) Detection of surface



(c) Objects superimposed on surface

Figure B.3: ARCore prototyping on Android device

## Android Sensors Logging

File - unknown

```
 1 12-09 21:27:37.766 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Longitude: -0.233472 Latitude :
   51.5864779
 2 12-09 21:27:37.896 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Accelerometer: X: 0.15203181 Y
   :-0.006584055 Z: 10.422559
 3 12-09 21:27:37.896 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Gyroscope: X: 0.0077231675 Y:-0
   .013848438 Z: -0.0018642128
 4 12-09 21:27:38.016 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Accelerometer: X: 0.16579847 Y
   :-0.021547815 Z: 10.41777
 5 12-09 21:27:38.016 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Magnetometer: X: -32.58 Y:22.68
    Z: -7.38
 6 12-09 21:27:38.016 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Gyroscope: X: 0.005060006 Y:-0.
   010652645 Z: -0.0018642128
 7 12-09 21:27:38.196 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Accelerometer: X: 0.1400608 Y:-
   0.01616086 Z: 10.435128
 8 12-09 21:27:38.196 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Magnetometer: X: -29.1 Y:20.88
   Z: -9.78
 9 12-09 21:27:38.196 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Gyroscope: X: 0.005060006 Y:-0.
   010120012 Z: -0.002396845
10 12-09 21:27:38.376 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Accelerometer: X: 0.15861586 Y
   :-0.004189853 Z: 10.428544
11 12-09 21:27:38.376 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Magnetometer: X: -25.62 Y:19.02
    Z: -12.24
12 12-09 21:27:38.376 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Gyroscope: X: 0.0061252704 Y:-0
   .00958738 Z: -0.0029294773
13 12-09 21:27:38.556 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Accelerometer: X: 0.14425065 Y
   :-0.029927522 Z: 10.4644575
14 12-09 21:27:38.556 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Magnetometer: X: -22.14 Y:17.22
    Z: -14.7
15 12-09 21:27:38.556 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Gyroscope: X: 0.004261058 Y:-0.
   010918961 Z: -0.0026631611
16 12-09 21:27:38.736 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Accelerometer: X: 0.142455 Y:-0
   .019752163 Z: 10.431537
17 12-09 21:27:38.746 22767-22767/sp14.androidsensors I/
   MyActivity: Sensors & GPS - Magnetometer: X: -18.66 Y:15.42
```

Page 1 of 24

Figure B.4: GPS, accelerometer, magnometer, and gyroscope sensor data from an Android device over 1 second period

### B.1.2 UI/UX Prototypes

#### Storyboard

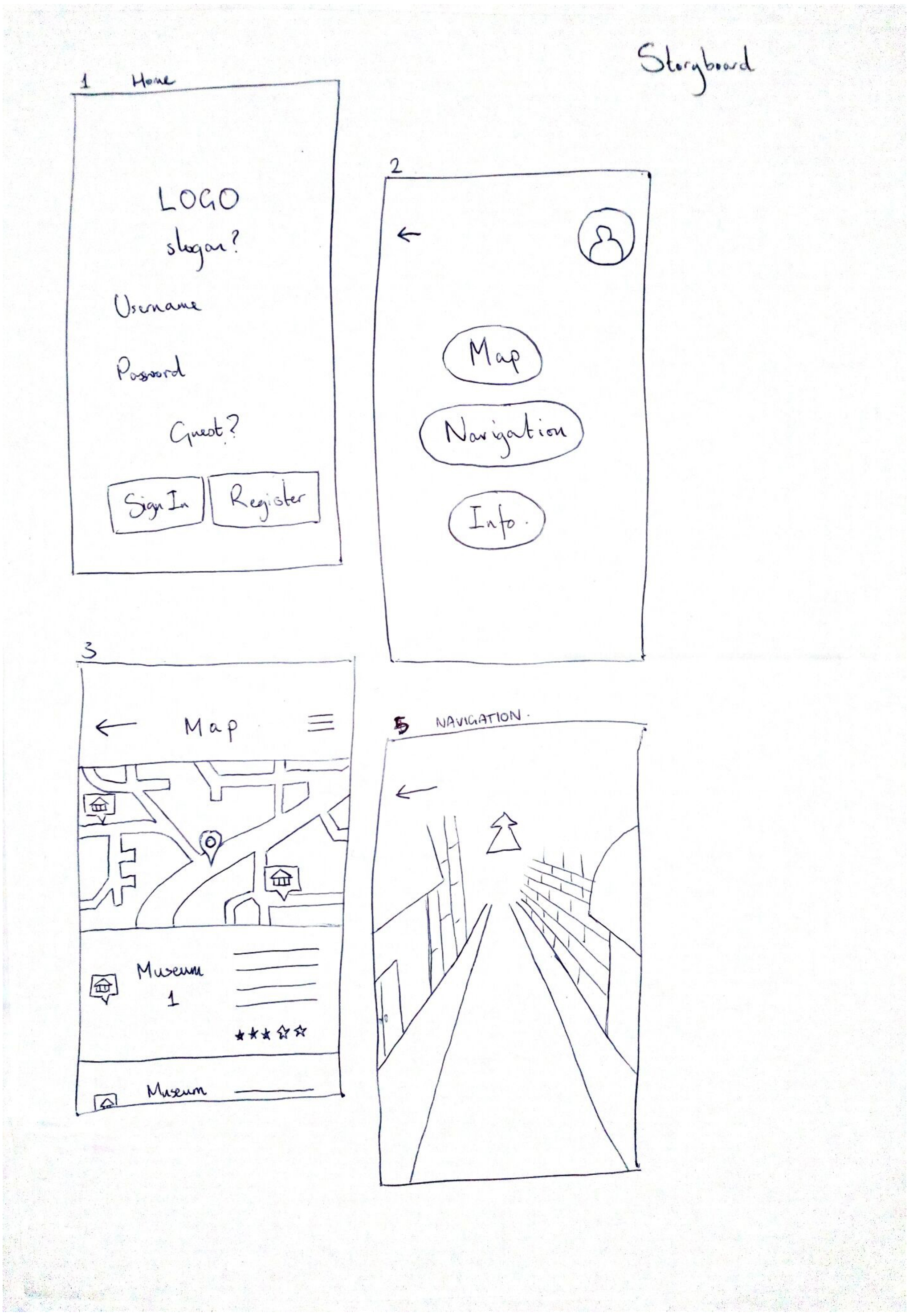



Figure B.5: Storyboard UI Drawings Page 1

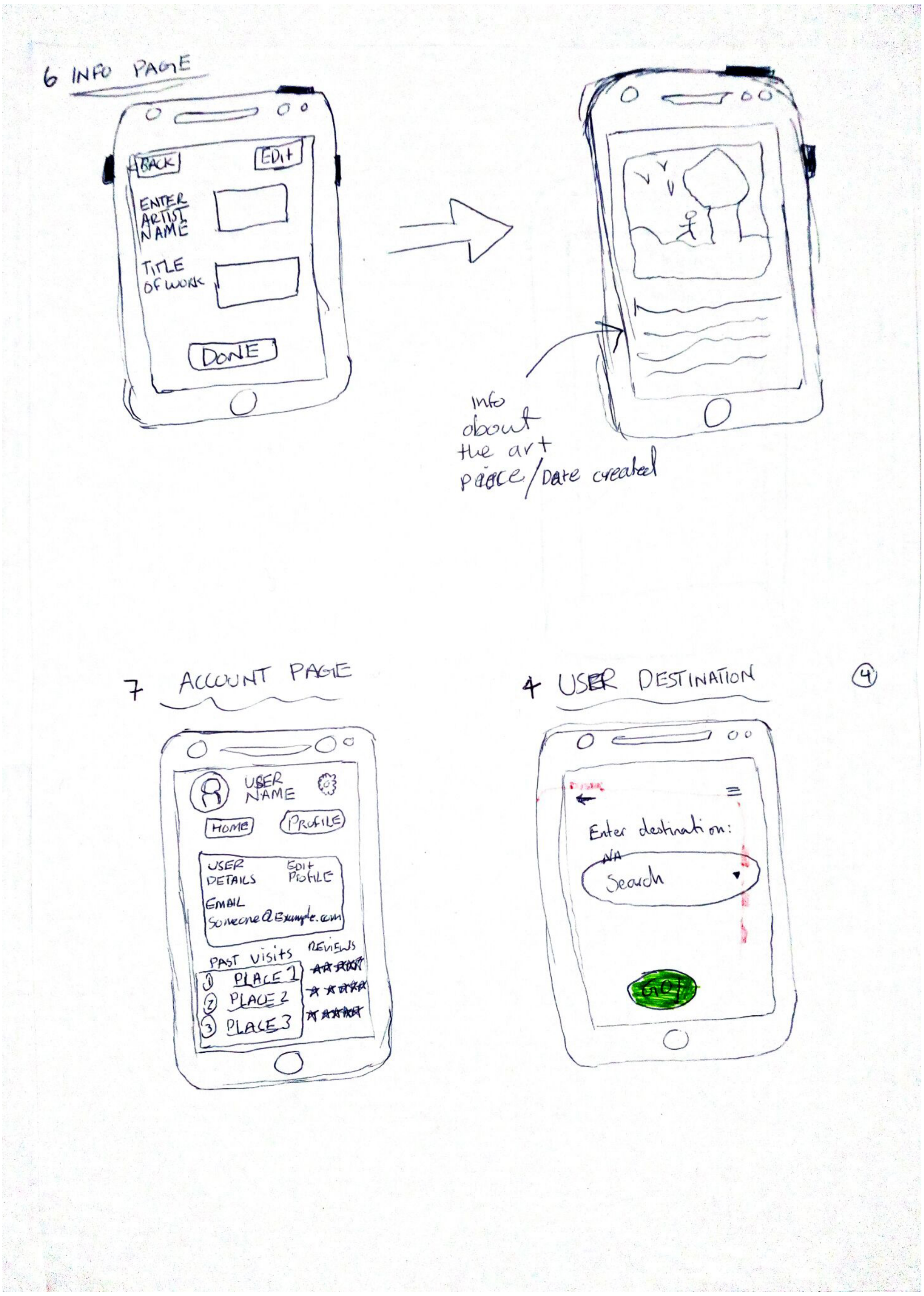



Figure B.6: Storyboard UI Drawings Page 1

1 HOME PAGE

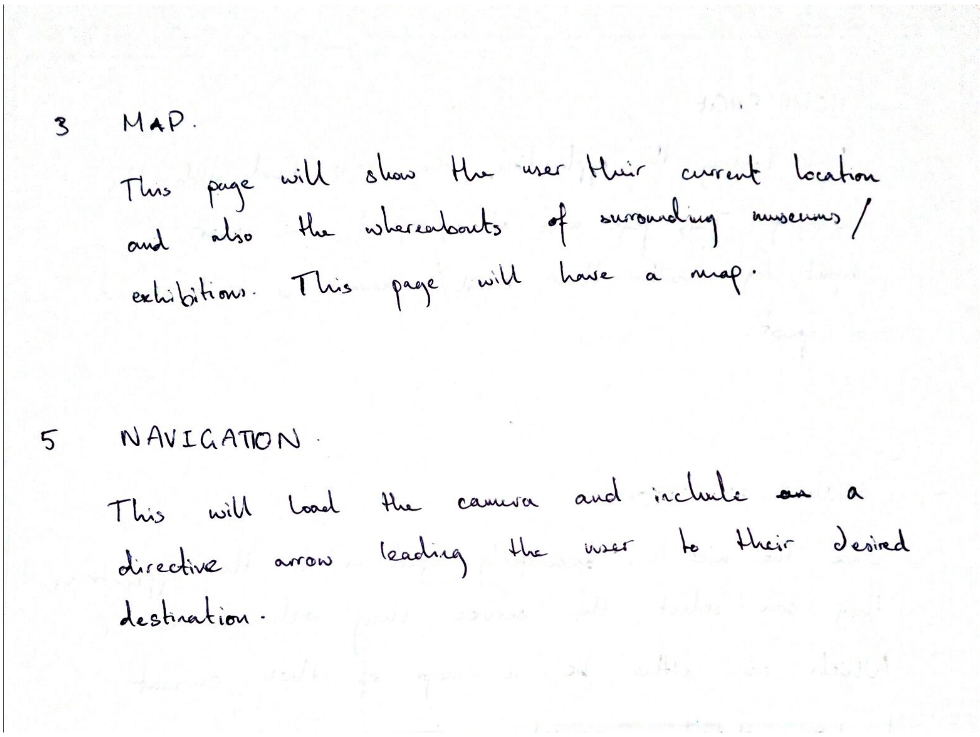
Upon loading the application, the user is faced with the homepage. This page will allow / request the user to input / login with their email / username or continue as a guest.

2 SERVICE SELECTION.

Once the user has successfully signed in to the application, they can select the service they wish to utilise. Which can either be a map of their current location detailing nearest museums / exhibitions, the navigation feature* which navigates the user to their desired destination (a museum or exhibition) and finally an "info" page which the user can find out further information about a specific exhibit.

* The navigation will take the user to the "user destination" page (4).

Figure B.7: Storyboard UI Descriptions Page 1



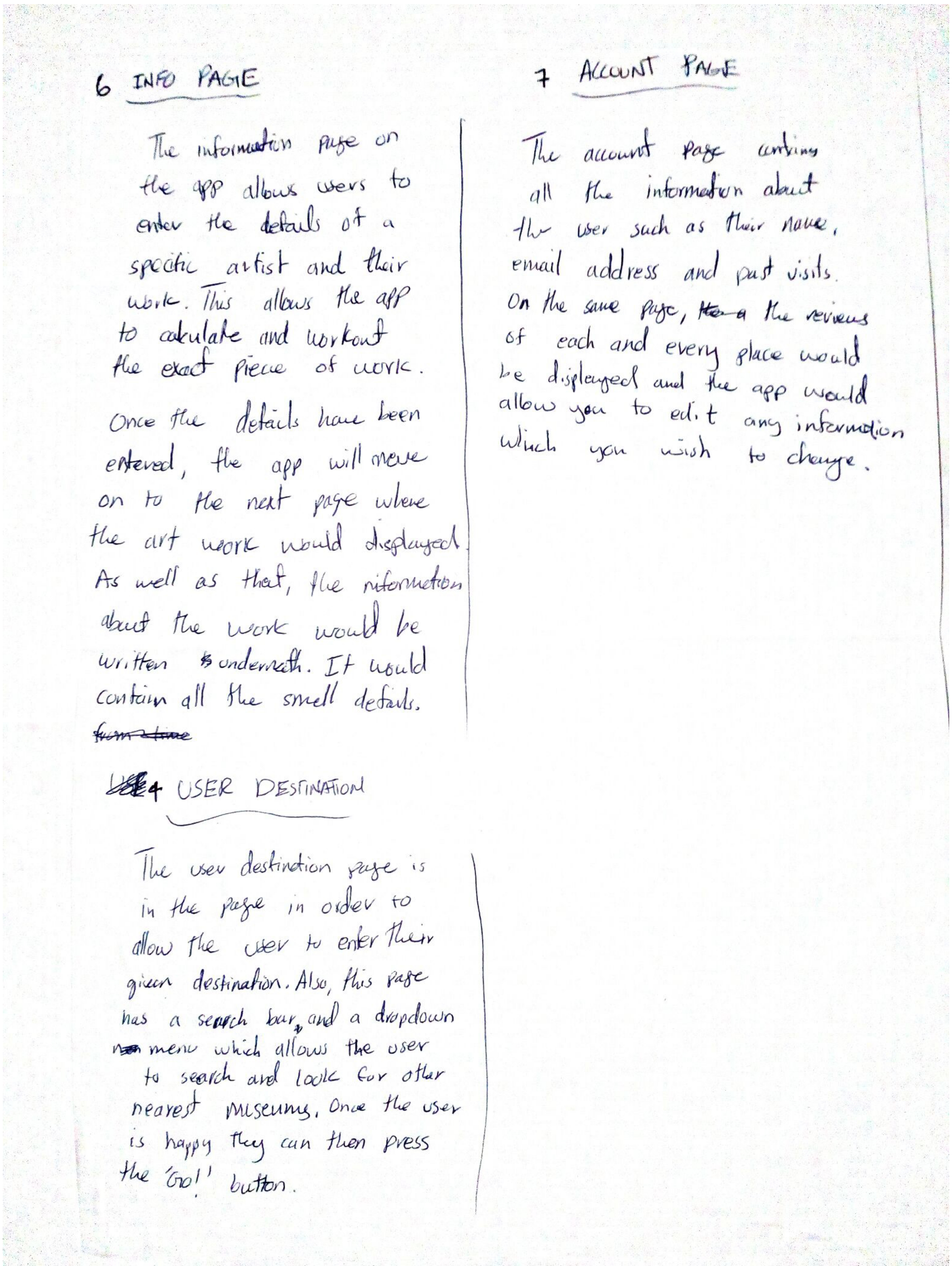
3 MAP.

This page will show the user their current location and also the whereabouts of surrounding museums/ exhibitions. This page will have a map.

5 NAVIGATION.

This will load the camera and include ~~an~~ a directive arrow leading the user to their desired destination.

Figure B.8: Storyboard UI Descriptions Page 2



6 INFO PAGE

The information page on the app allows users to enter the details of a specific artist and their work. This allows the app to calculate and workout the exact piece of work.

Once the details have been entered, the app will move on to the next page where the art work would displayed. As well as that, the information about the work would be written underneath. It would contain all the small details. ~~from time~~

4 USER DESTINATION

The user destination page is in the page in order to allow the user to enter their given destination. Also, this page has a search bar, and a dropdown menu which allows the user to search and look for other nearest museums. Once the user is happy they can then press the 'Go!' button.

7 ACCOUNT PAGE

The account page contains all the information about the user such as their name, email address and past visits. On the same page, the reviews of each and every place would be displayed and the app would allow you to edit any information which you wish to change.

Figure B.9: Storyboard UI Descriptions Page 3

## Prototype 1

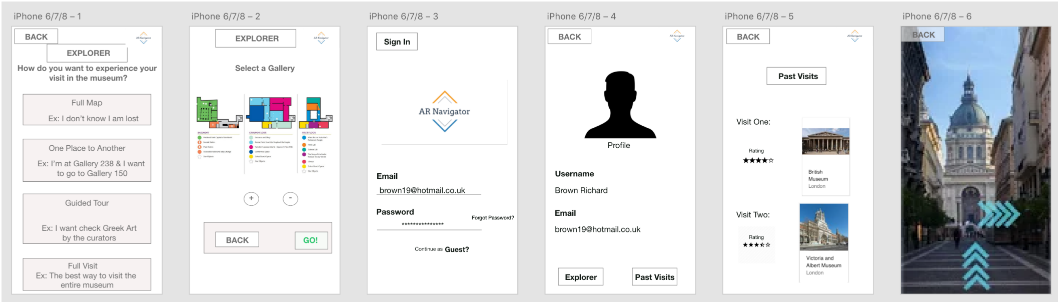



Figure B.10: Overview of UI Prototype 1

## Prototype 2

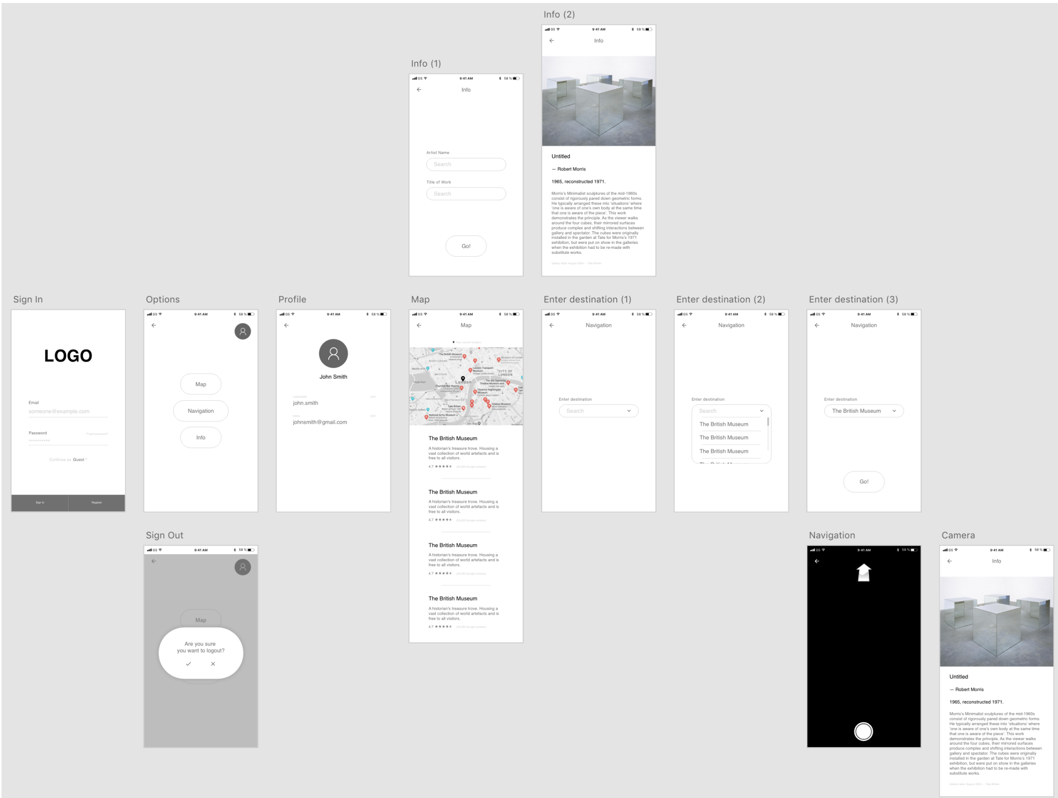



Figure B.11: Overview of UI Prototype 2

## Prototype 3

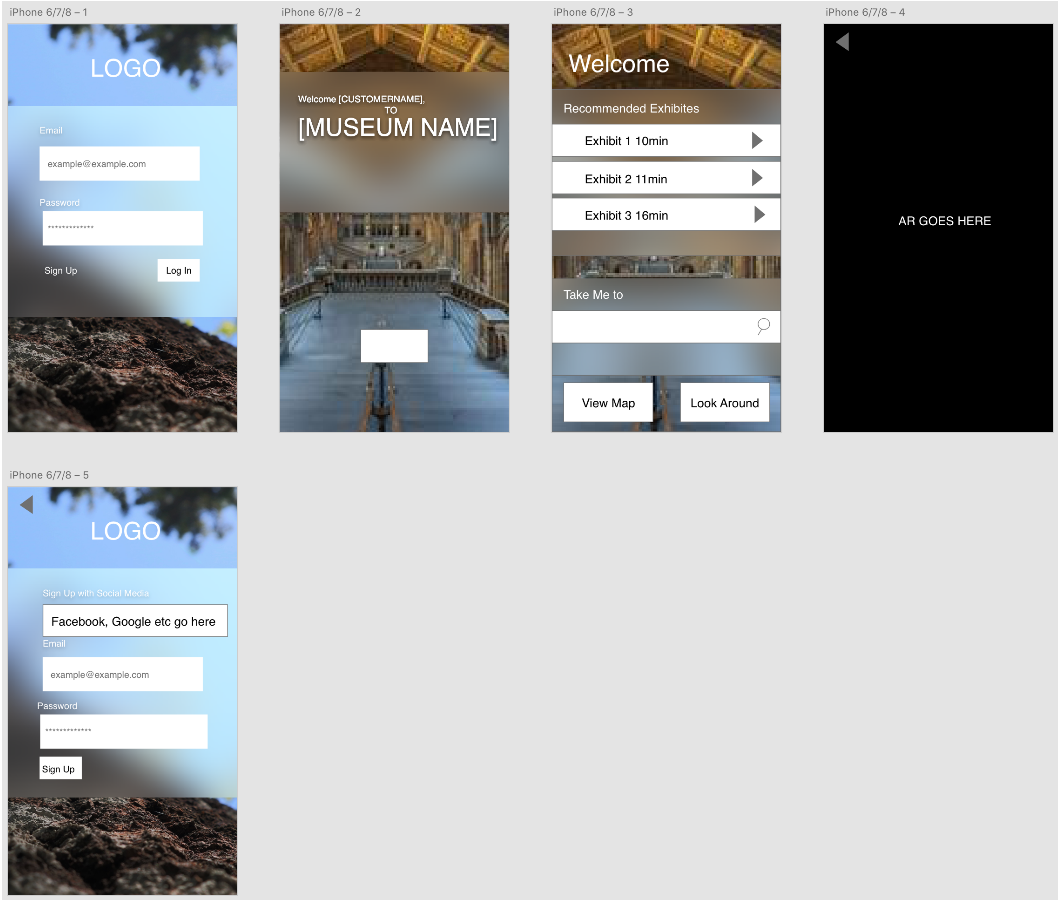



Figure B.12: Overview of UI Prototype 3

**Prototype Reviews**

**Prototype 1**
This prototype again is very plain but this is made to look it as it looks more professional and although the prototype has a lot of buttons, this greatly considers the end user and what things we would want to do on the application making the potential of it greater. The search function and the map feature makes it a lot more personal to the user with potential options that they may select. Overall, because it considers the user more, this type of format at least should be used in the final version. One suggestion would be to maybe include colour as well as improve the logo because it is not very clear what the application is from looking at this, so have a logo to reflect this. The separate page for the use of AR is very good but one concern is how the the app will detect will where the user is or whether they can use the AR feature anywhere even without visiting the museum.

**Prototype 2**
The prototype at first glance looks very plain and with not much information or scope for the user to explore the app and seems very limited. One of the key things which could improve the app is simply to add colour to make it more appealing and engaging to users. Also, it is not very clear what the application is used for and how it can improve the existing method of visiting a museum - which I now know what the app's purpose is - where a visitor can just have a guided tour from an expert or even an auditory tour. Certain features of the prototype were good such as the search feature and the clarity making the app user-friendly. As well as this, the fact that the app shows the closest museum to the input given is very helpful, showing the rating given by visitors making easier to choose which museum to visit. The fact that it also has logout confirmation page and a page showing the users account where they can add favourite museums and add ratings and reviews gives other users better choice where they can make a more informed decision.

**Prototype 3**
The prototype is quite plain at first glance although the use of colour through the background is good. It is more appealing and engaging. However, use of the application seems very basic and limited with little function. The prototype consists mainly of buttons and doesn't allow much user input, that being said, the search function is a good addition. Overall, this prototype is very limited and use of the prototype 2 should be used over this one.

## Final Prototype

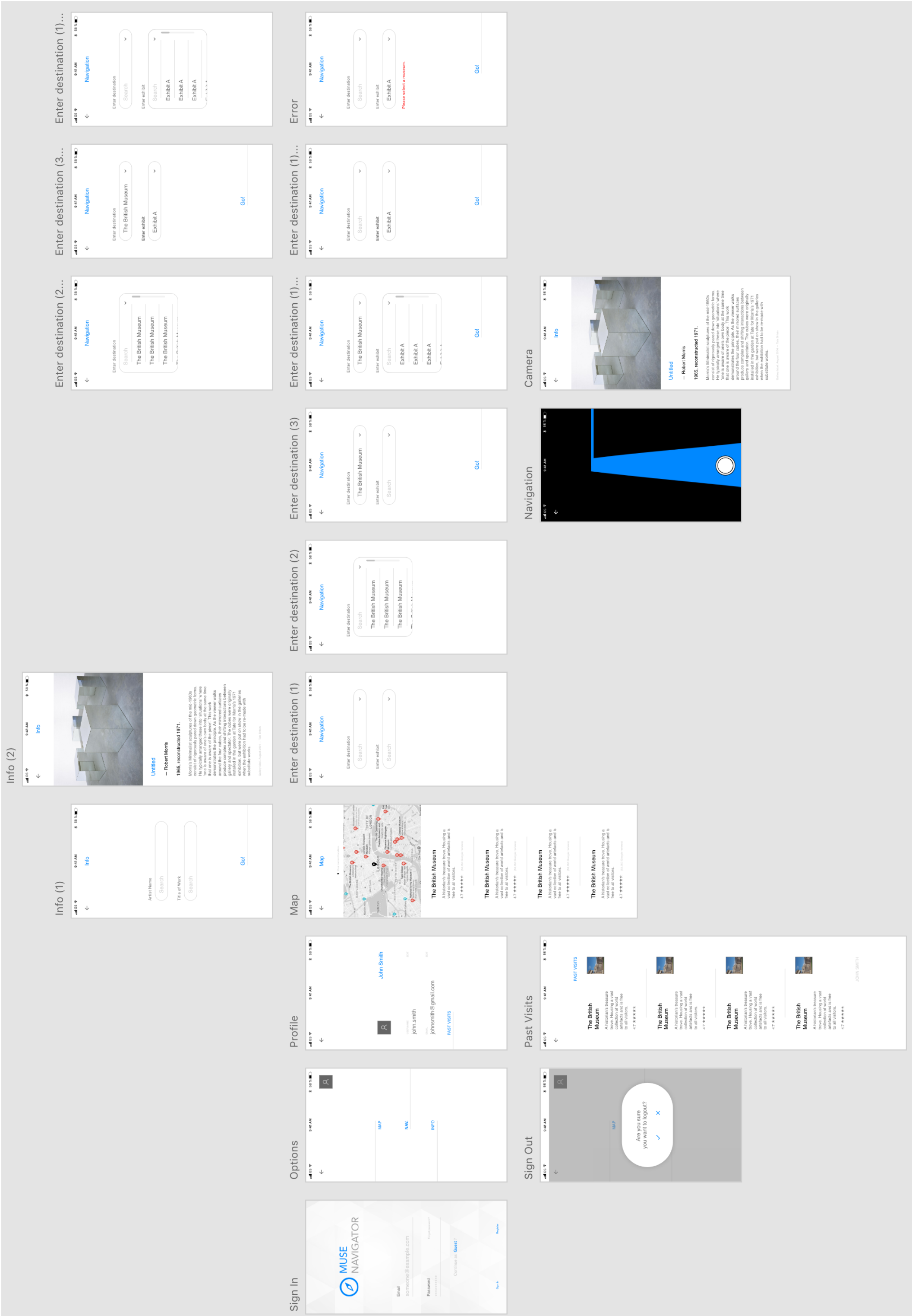
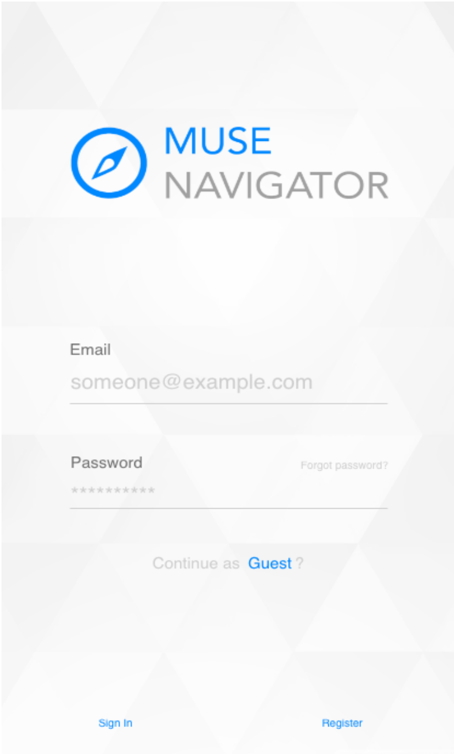
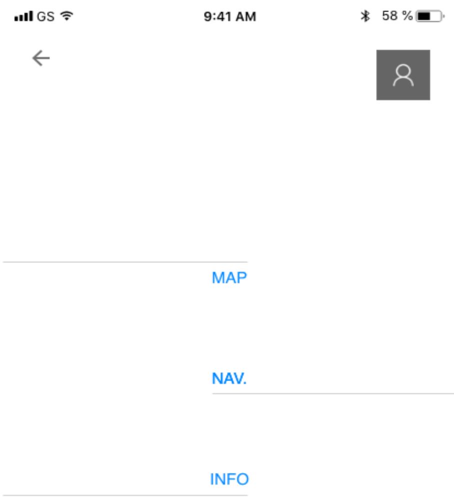


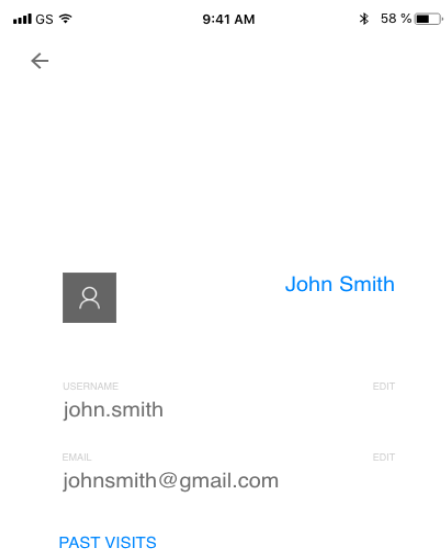

Figure B.13: Overview of final UI prototype



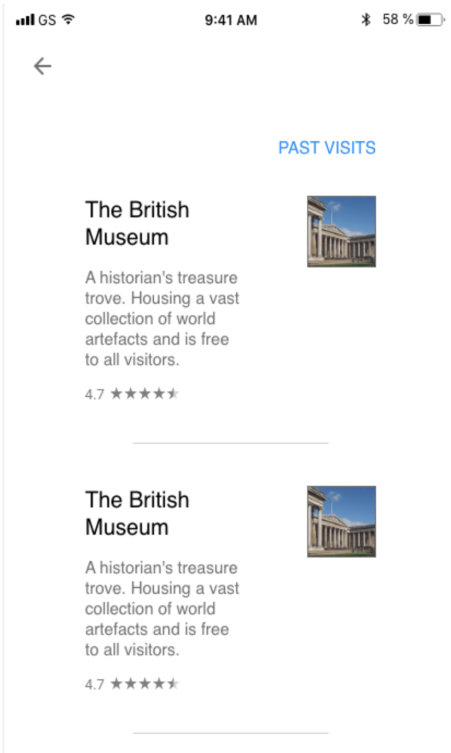

(a) Sign in




(b) Options

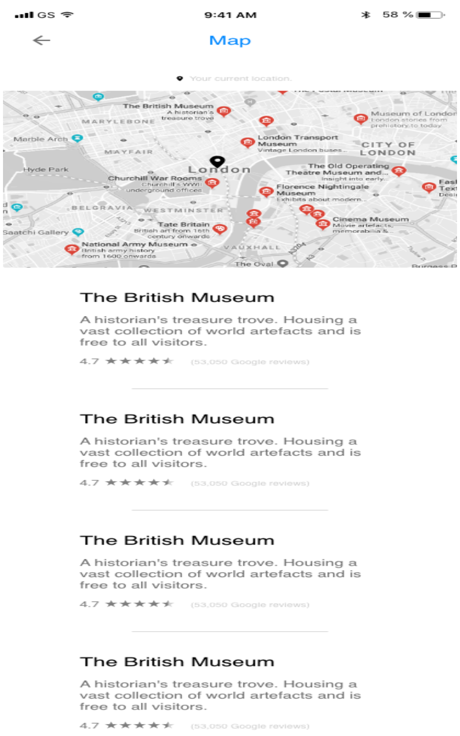



(c) Profile

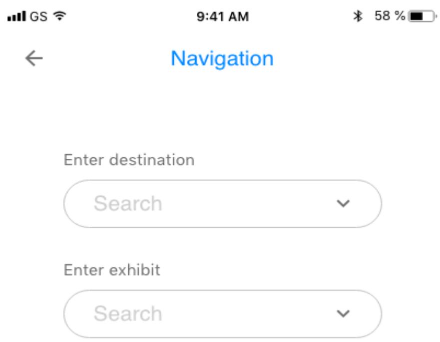



(d) Past visits

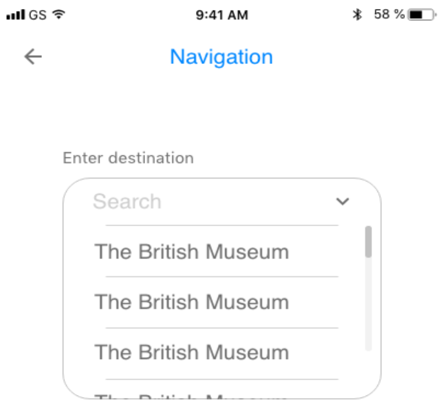
Figure B.14: Final UI Designs of App



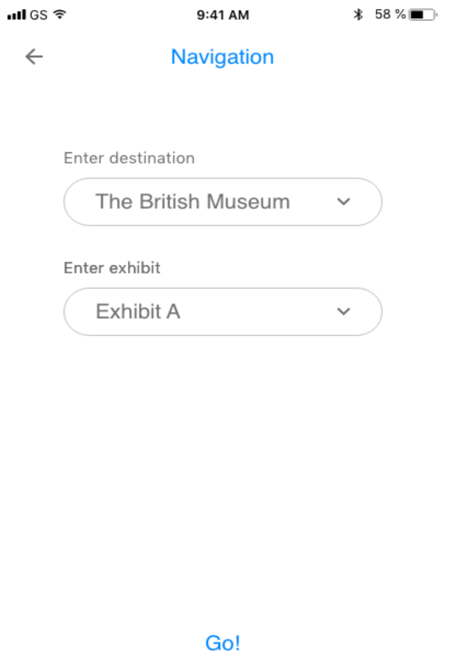

(e) Map of museums



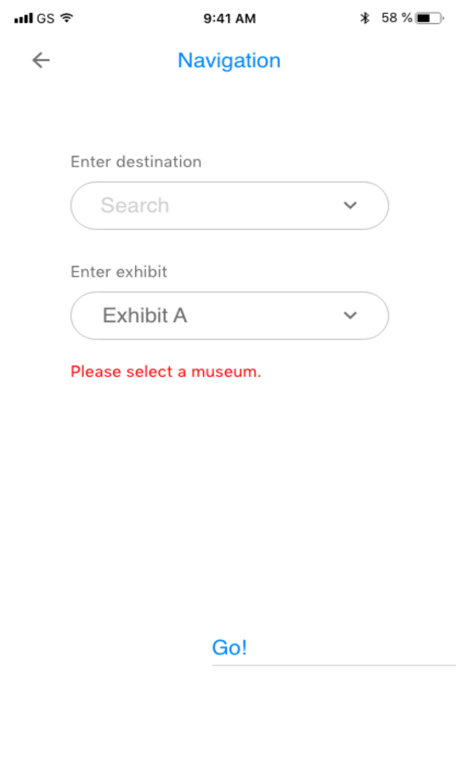

(f) Destination



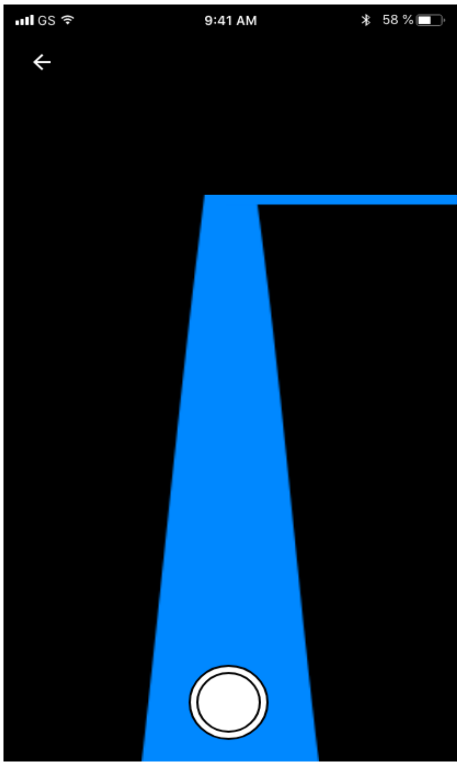

(g) Destination Dropdown



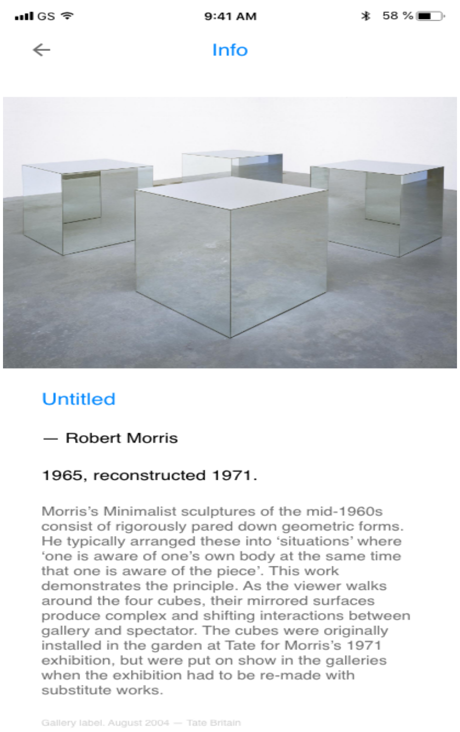

(h) Filled



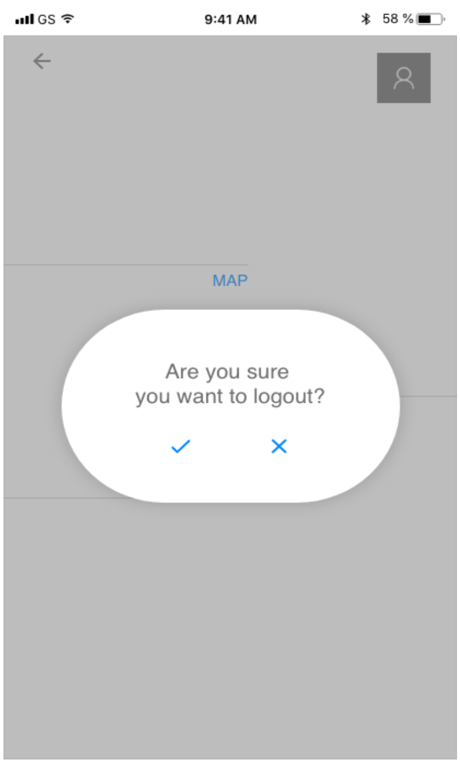

(i) Error message




(j) AR Navigation




(k) Artwork description




(l) Sign out

## B.2 Technical Architecture

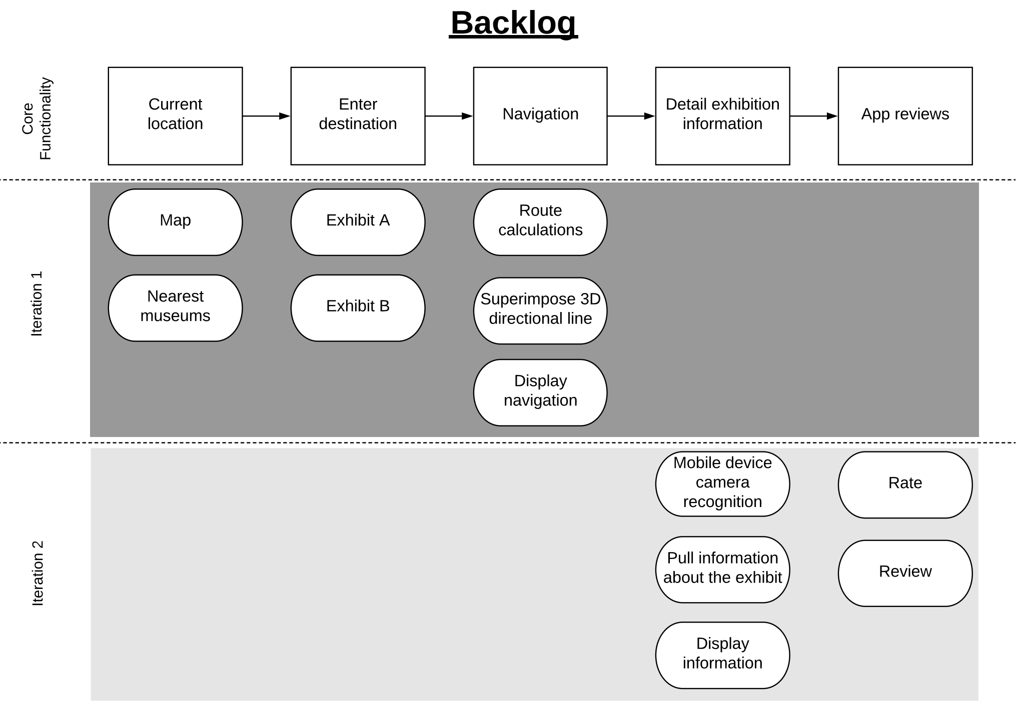



Figure B.15: Backlog Diagram

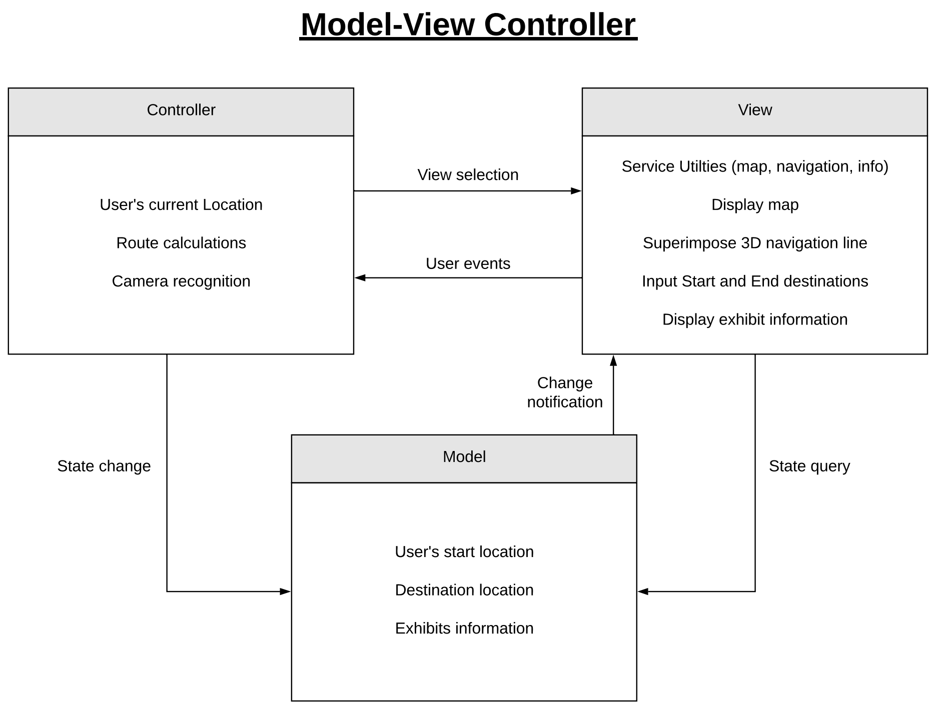



Figure B.16: Model-View Controller Diagram

# Appendix C

# Meeting Minutes

## Structure

Academic weeks are indicated in brackets.

All weekly meetings are structured as:

- Monday (in person) - Lab sprint planning
- Thursday (virtual) - Team sprint review
- Friday (in person) - Project supervisor meeting

## Week 1 (1)

### Thursday 4 October 2018

- Meeting all team members
- Discussing potential concepts

## Week 2 (2)

### Monday 8 October 2018

- Reviewing potential concepts discussed
- Considering stakeholders

### Thursday 11 October 2018

- Reviewing project concept

### Friday 12 October 2018

- Submission of project tracking form
- Meeting project supervisor
- Submission of project concept

## Week 3 (3)

### Monday 15 October 2018

- Updating project tracking form
- Tweaking project concept to be museum focused
- Creating scrum board to track tasks
- Allocating market research
- Creating stakeholder requirements activities
- Allocating questionnaire

### Thursday 18 October 2018

- Updating project tracking form
- Reviewing market research
- Reviewing questionnaire

### Friday 19 October 2018

- Submission of project tracking form
- Submission of market research
- Submission of questionnaire
- Further research on different stakeholders of different demographics suggested by project supervisor

## Week 4 (4)

### Monday 22 October 2018

- Building use sequence model
- Allocating activity model
- Allocating service model

### Thursday 25 October 2018

- Updating project tracking form
- Reviewing use sequence model
- Reviewing activity model
- Reviewing service model

### Friday 26 October 2018

- Submission of project tracking form
- Submission of all models
- Updating supervisor on team collaboration

## Week 5 (5)

### Monday 29 October 2018

- Creating open questions
- Allocating storyboard
- Creating outline for proposal
- Creating Gantt chart
- Allocating UI/UX prototyping
- Allocating AR libraries investigation

### Thursday 1 November 2018

- Reviewing storyboard
- Reviewing project tracking form

### Friday 2 November 2018

- Showed our storyboard
- Submission of project tracking form
- Updating supervisor on storyboards and current prototyping
- Collate all half term work in one document and send to supervisor

# Week 7 (Reading week)

## Thursday 8 November 2018

- Gathering raw stakeholder research information
- Analysis and review on raw stakeholder research
- Updating project tracking form

# Week 7 (6)

## Monday 12 November 2018

- Reviewing Gantt chart
- Reviewing open questions
- Reviewing stakeholder research
- Creating plans for stakeholders using prototypes
- Peer-reviewing of UI/UX prototypes

## Thursday 15 November 2018

- Updating project tracking form
- Review of the peer-reviews
- Start with UI/UX prototypes
- Research on Android/iOS platforms

## Friday 16 November 2018

- Submission of project tracking form
- Demonstrating individual UI/UX prototypes to supervisor
- Demonstrating each AR library research to supervisor

# Week 8 (7)

## Monday 19 November 2018

- Reviewing Gantt chart
- Reviewing research on Android/iOS platform
- Building final UI/UX prototypes

### Thursday 22 November 2018

- Updating project tracking form
- Review final android prototype
- Review final UX/UI prototype

### Friday 23 November 2018

- Submission of project tracking form
- Presentation on everything completed so far to project supervisor
- Submission of all prototypes

## Week 9 (8)

### Monday 26 November 2018

- Reviewing Gantt chart
- Allocating backlog
- Allocating open questions
- Allocating MVC
- Reviewing functional specification chapter

### Thursday 29 November 2018

- Updating project tracking form
- Reviewing backlog
- Reviewing open questions so far
- Reviewing design chapter

### Friday 30 November 2018

- Submission of project tracking form
- Presentation of open questions
- Presentation of backlog
- Spoken about fuse comapany
- Progress of framework of technical architecture
- Finish user stories by next week
- Finish off technical architecture (milestone) by next week

# Week 10 (9)

## Monday 3 December 2018

- Reviewing Gantt chart
- Reviewing backlog, open questions, and MVC
- Reallocating chapters 5, 6, 7, 8 of proposal due to change in guidelines
- Reallocating user stories
- Preparation for concept presentation

## Thursday 6 December 2018

- Updating project tracking form
- Reviewing written chapters of proposal
- Reviewing user stories
- Reviewing all technical architecture work

## Friday 7 December 2018

- Submission of project tracking form
- Submission of technical architecture work
- Explanation about open questions, backlog, MPV and user stories
- One-to-one discussion for how things are going within the group
- Discussion about 5 minutes presentation which going to take place on Monday next week

# Week 11 (10)

## Monday 10 December 2018

- Reviewing Gantt chart

## Wednesday 12 December 2018

- Proof reading all chapters
- Writing abstract and conclusion of proposal
- Completion of meeting minutes
- Submission of proposal

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