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.

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Nomenclature

AR	Augmented Reality
GDPR	General Data Protection Regulation
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

The main stakeholders are museum visitors and staff. After consulting with them, and potential users of the proposed application, we were able to gain a better understanding of what the apparent need was in the relative market regarding museums. Out of the 21 responses received, 15 potential users admitted to visiting museums at least once a month. This shows some level of frequency in their visits, and that there is something that can be offered to this group of people.

Since our 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?"- a very reassuring 100% of visitors had agreed that they did in fact refer to the maps around the museum more than once, some respondents going on to say that they referred to it over 10 times. However, these maps are not free; in most museums, including the Natural History Museum and the Science Museum in London, require a fee of £1.

18 of the respondents had agreed they would much rather prefer using their phone to navigate rather than the paper maps. This shows that there is an evident need for an accessible tool other than the maps around the museum in order to assist visitors' navigation around the museum.

Based on the stakeholder research, the project requirements are,

- navigate the user to a museum through the use of augmented reality
- to 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 magnified text and inverted colours for example

One key stakeholder whom would be affected are the museum staff as they would be instrumental to any on-the-ground assistance and would be the first point of contact for assistance in navigation. Furthermore, the platform should endeavour to make the jobs undertaken by museum staff with relation to the parameters of platform easier.

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 the app would download would be sourced from in-museum Wi-Fi.
- Written content and other media to be within control of the museum.

During our field research we spoke to museum-floor staff and receptionists. Most importantly, all staff members whom we spoke to had received a navigational inquiry, either from themselves or members of public. All staff responded positively to the use of a phone but cited concerns about efficiency of the concept with specific references to battery performance and data usage. One major concern highlighted by every member of museum staff was ease of use, and therefore, we suggested to supply a solution to this by designing a simple and efficient graphical user interface. Another potential factor that became apparent upon speaking to staff was the fetching of information and data - aiming to minimalise the use of data where necessary.

Chapter 3

Prior Knowledge

Whilst conceptualising the project idea, there is huge importance in knowing the solutions and methodologies are already in place to tackle the apparent technological problem, in our case, navigation and specifically in museums. It is also important to understand the stakeholders and the interest they have in the development of the application.

3.1 Current Solutions & Competitors

The market of indoor museum navigation has become more competitive in recent years with more solutions being submitted due to a growth in indoor navigational research. Most current solutions on the market cater very well for a basic navigation of large public spaces, but will fail to display an even proportion of navigational and interactive content with well-presented data. Through the use of augmented reality, the concept can provide an interactive navigation solution for museums and exhibitions.

Since most museums and galleries use a portable audio guide, user experiences can be vastly improved by the use of a phone. Currently only a few solutions can be found; the Orpheo group [4] provide a unique app for each place meaning that their solution is somewhat cumbersome to regular museum users who would wish to have a hassle-free setup process. As we hope to appeal to museums and by virtue of this, museum-goers,having one app whereby the user can simply walk into a museum or exhibition and be greeted with relevant information to be a vital differentiating factor[5].

If a museum 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 set out to provide this, they lack important 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.

3.2 Studies on Museum Visitors' Behaviour and the Retail Experience

It was proposed by Flavia Sparacino [8] the categorisation of museum visitors into three main categories:

1. the greedy visitor who wants to know and see as much as possible;
2. the selective visitor who spends time on artefacts that represent certain concepts only and neglects the others;
3. the busy visitor who prefers strolling through the museum in order to get a general idea of the exhibition without spending much time on exhibits.

Based on this, excluding the busy visitors, museum visitors will find it beneficial to have a supportive application on their mobile devices to assist in their navigation around the museum.

Public spending on museums has declined by 13% in real terms over a decade, from £829 million in 2007 to £720 million in 2017 [9].

One of the reasons for the decline mentioned is due to the vast amount of information that is readily available online, if a museum visitor would like to know more about an exhibit of an event in history, they already have the answers on their phones. A visitor survey commissioned by V&A Digital Media and Learning departments and conducted by Fusion/Frankly Webb and Green, contains fascinating details about the way in which visitors use their mobiles phones in different contexts, their attitudes to digital content and services in the Museum such as WiFi. For example, a surprising result that challenges preconceptions of what the typical museum visitors actually do with their mobile devices: "Have you ever used your smartphone at a gallery or a cultural site to enhance your visit for any reason? (Sample size: 258)" This question yielded a surprising result of only 40% of interviewees answering 'No' whilst the remaining 60% answering 'Yes' [10]. This allows for consideration of additional features of the application such as an informative implementation that details additional information about a specific exhibit.

Chapter 4

Design

4.1 Importance of Design

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

4.2 Unified Modeling Language

An effective design strategies was carried out through the implementation of the UML, a powerful standard for creating various specifications the software system.

Our implementation of a use case diagram outlined the different scenarios in which a user would function the application. (Figure A.1). UML was implemented was 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 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. One main reason that the activity diagram was essential was that these diagrams are normally easily comprehensible for both analysts, and stakeholders. By producing these models, we were able to have a clear understanding of what the application does, and enabled us to visualise the application for the future.

4.3 Service Model

The following cases are born out of one important principle, convenience. The **lost** use case, for example, comes from the user that could be lost for whatever reason. The service we would provide 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 e.g. wall-maps or paper maps).

Model around two cases

Both cases have a linear-stream of logic:

1. The user enters within the radius of an environment (museum) modelled by the service.
2. The user's location is picked up once they give use permission to.
3. The user picks 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. The user is then displayed the route, and directed towards their destination via their camera.
6. The user is given curated suggestions on possible places they can go.

Chapter 5

Prototyping

5.1 AR Libraries

In order to identify libraries that are good for implementing AR on mobile devices, we divided this prototyping into three platforms to explore them, and built test applications to find out how they help with the project.

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 object/image, and displaying information about that object/image on the device. We used Vuforia, an SDK that enables recognition, and tracking of image targets, to build it. This library can be used for the exploration case in the use case model. Although, there is a limited amount of tools for locating user current location compared to Android.

ARKit (iOS)

We built a similar prototype to Unity on Apple's ARKit using Swift, 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 targets a flat surface. Compared to iOS, it is easier to log GPS location, although connecting the user interface to the scripts was more challenging.

5.2 UI/UX Designs

Chapter 6

Functional Specification

The main functional elements of our concept are:

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.

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.

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

5. The **user's camera can recognise artwork/objects**, and will display further information about the piece. There will be a storage area of current pieces in the museum so that the camera can query the information.

Chapter 7

Technical Architecture

7.1 Means of Software Development

SDKs

Google's **ARCore** kit gives us the ability to apply the AR element of 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. [11]

Platform & Languages

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

IDE

Android Studio is the IDE utilised in the project 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

Our application fits under the MVC 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 Technicalities of satisfying user-related questions

Questions

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

   In order for user to get from one point to another, it will use route calculation to calculate the quickest route.
   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 if it was used without.

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 address, but also real time location, 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.[12]

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

Chapter 12

Conclusion

Appendix A

Figures

A.1 UML Models

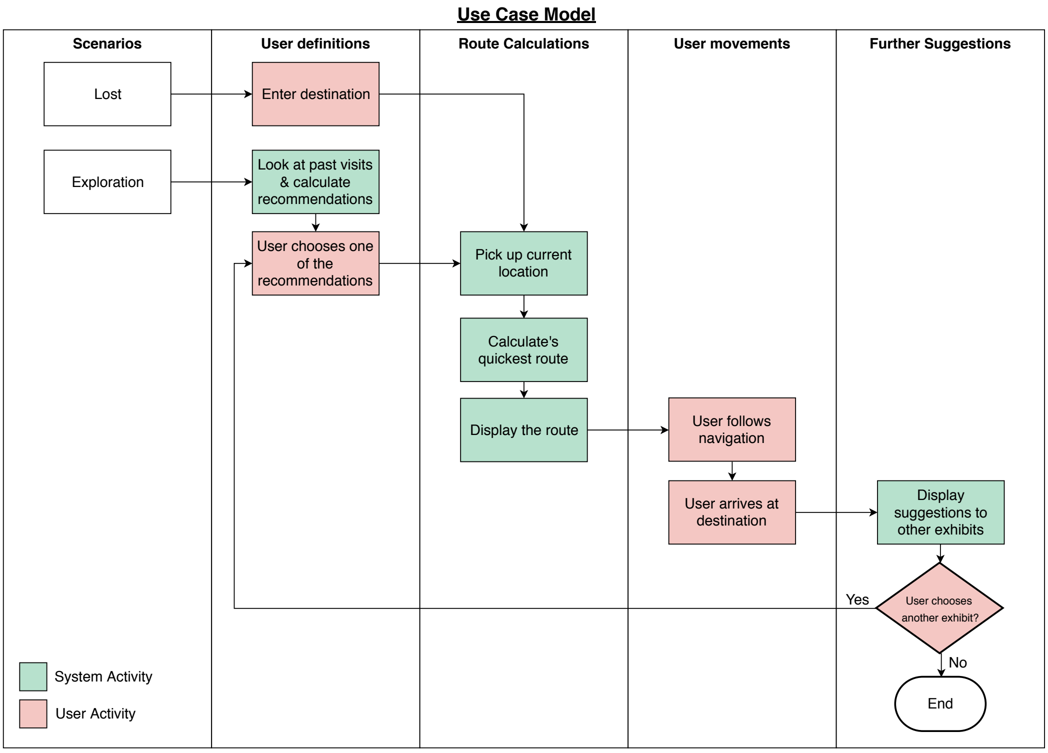

Figure A.1: Use Case Diagram

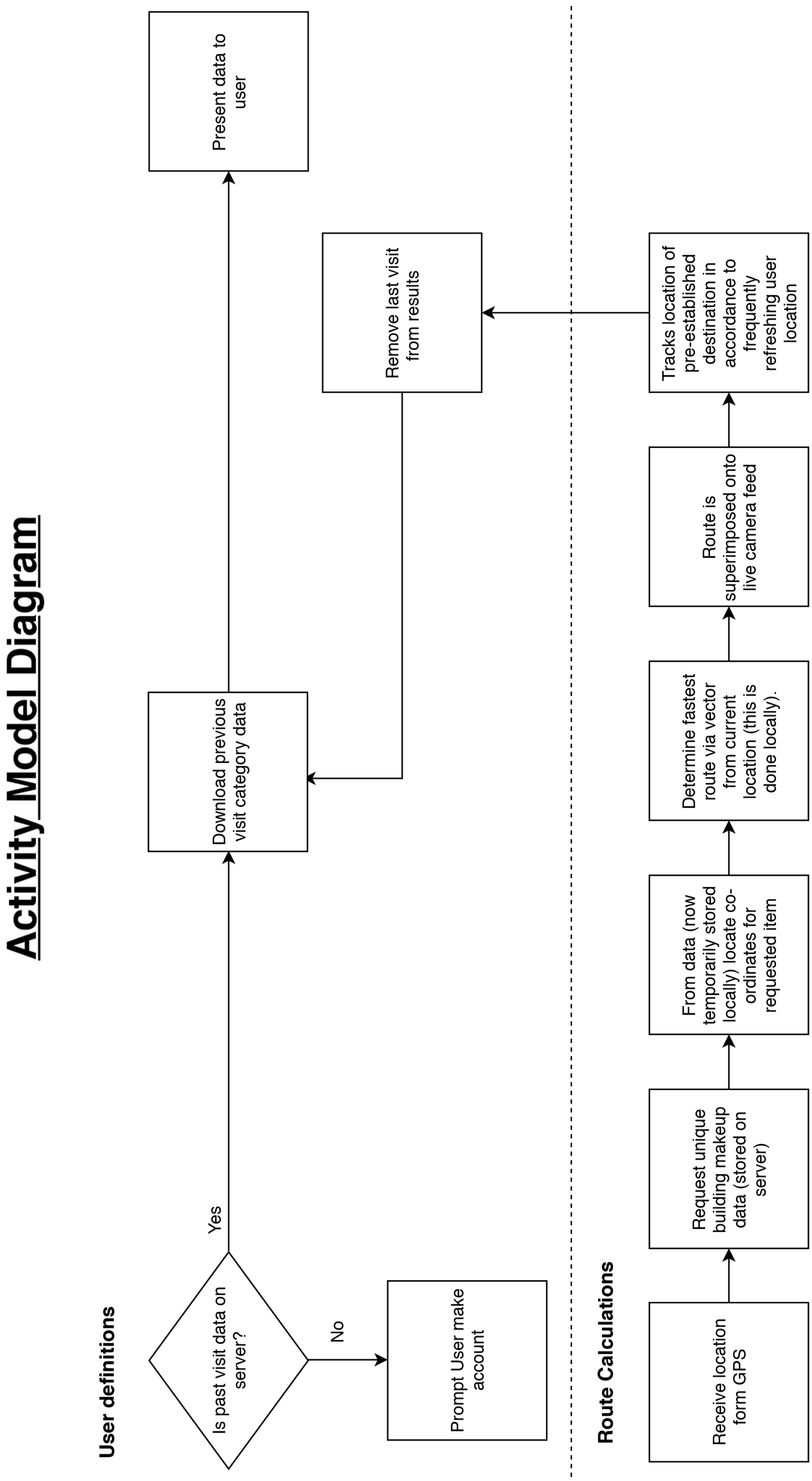

Figure A.2: Activity Model Diagram

A.2 User Stories

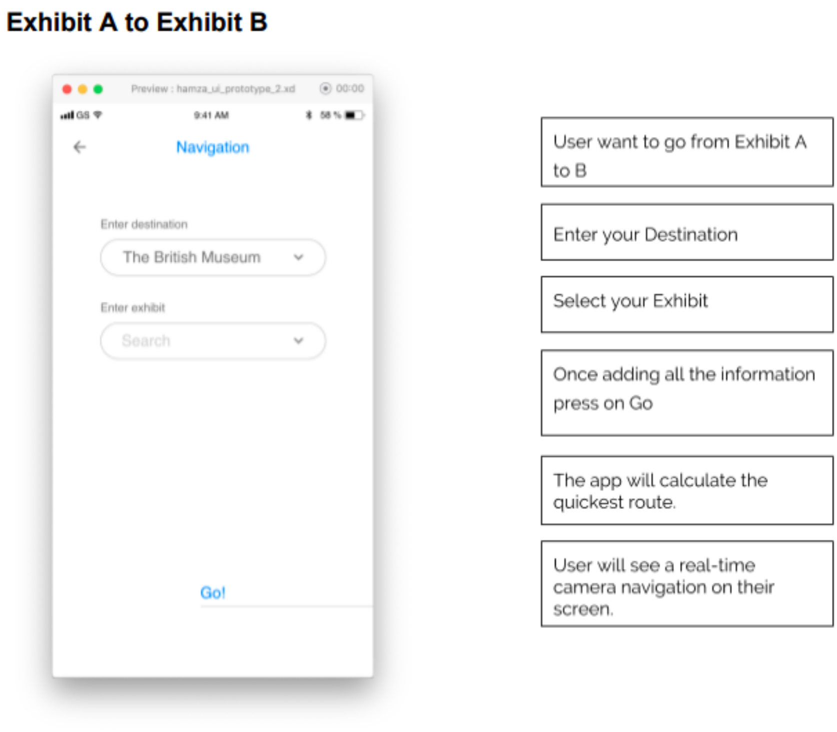

Figure A.3: Going from point A to point B

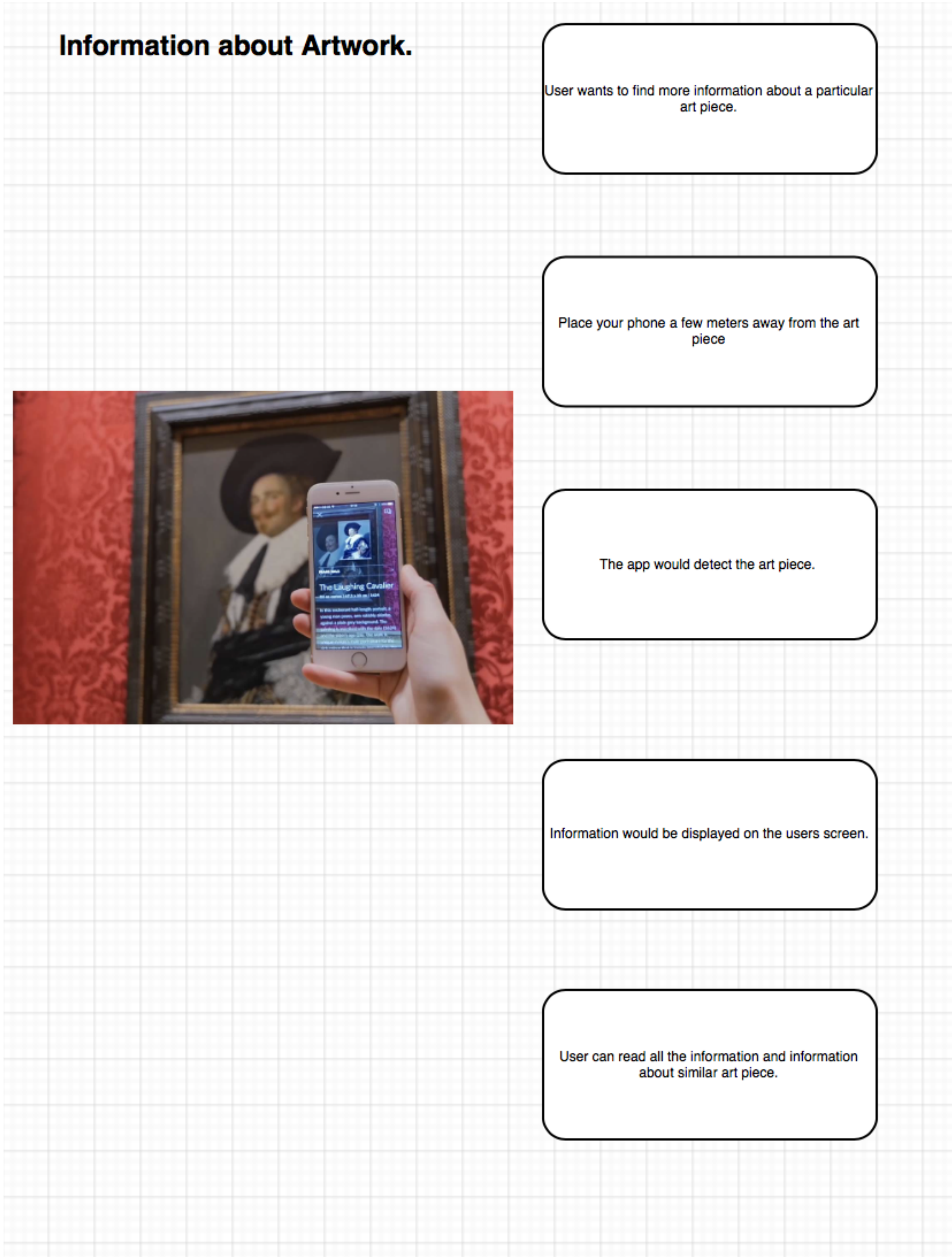

Figure A.4: Getting information from exhibition

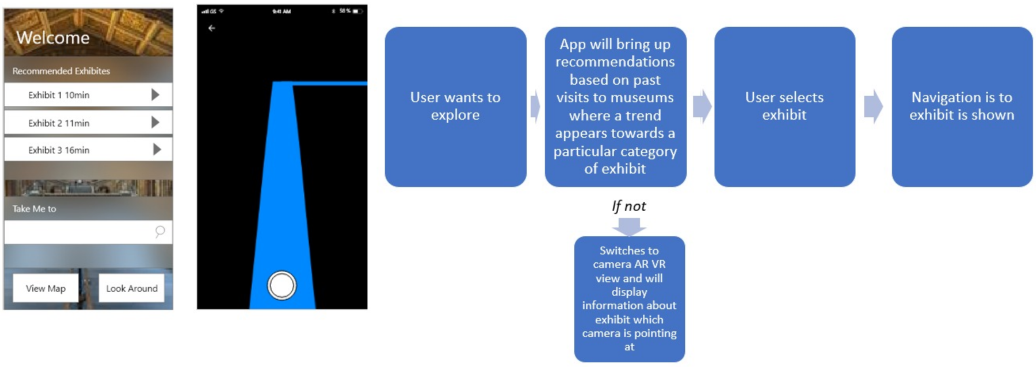

Figure A.5: Exploring the museum

Appendix B

Systems Requirements Specification

B.1 Purpose

B.2 Scope

B.3 System Overview

B.4 References

B.5 Definitions

B.6 Use Cases

B.7 Functional requirements

B.8 Non-functional requirements

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

Monday 13 November 2018

- Do research on Stakeholder

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

Friday 7 December 2018

- Submission of project tracking form

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

Appendix D

Current project tracking form

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