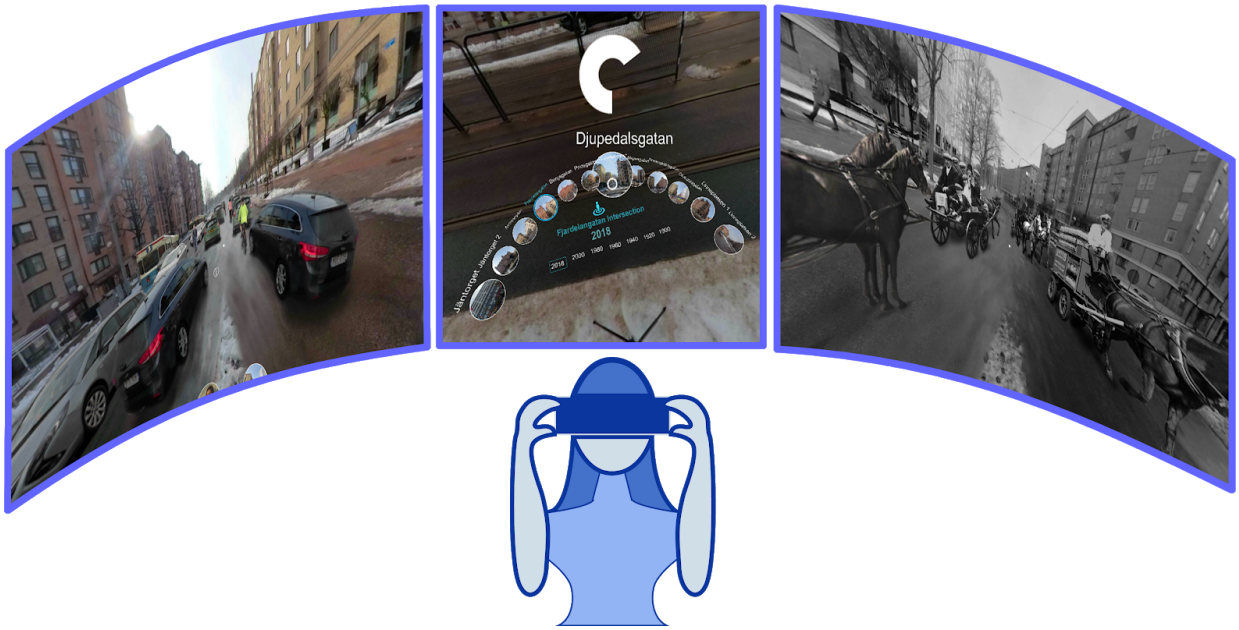

Biography of a Street

Design Guidelines for Retelling the History of a Street Through the Use of an Immersive Virtual Tour

Master's Thesis in Interaction Design and Technologies

Sophia Atif
Plamen Mateev

Department of Computer Science and Engineering
Chalmers University of Technology and University of Gothenburg
Gothenburg, Sweden 2018

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Abstract

It's a challenge to present historical facts in an appealing and memorable fashion, especially to people who are not very interested in the history to begin with. Citizens in the 21st century can also feel the impacts of good urban planning done by urban planners in the past, increasing the appeal of exploring and analyzing the history of a street. With the surge of technological improvements to virtual reality, and to its affordability and accessibility, it's a potential avenue for exploring history in an immersive and interactive medium.

This thesis work aims to provide guidelines and a framework which designers can use to retell the history of a street - using interactive historical content, user experience design practices and artistic representations. A virtual tour prototype, based on the street Linnégatan in Gothenburg, Sweden, was created and used to evaluate users' feedback over four iterations. The highlight of the prototype is the "Alternate History Concept" where users are given an option to change a critical urban planning event in the history to see its effects in the future.

After a literature analysis and user evaluations, the results indicate that user experience designers could follow guidelines that can help them create memorable and immersive historical virtual tours. Additionally, the process that was used to create the prototype could be used as a framework for creating immersive and interactive virtual tours.

The report details the theory and methodology used, the design, implementation and testing phases, as well as provides insights into potential use cases and future work. Certain concerns and pitfalls related to the technological tools that could be utilized are also discussed.

Keywords: User Experience, UX, VR, Virtual Reality, Linnégatan, Virtual Tours, 360 Tour, Historic Virtual Tours, Alternate Reality, Urban Planning

Acknowledgements

First of all we would like to thank Cybercom for providing us with the necessary tools and technology to carry out our research. We would also like to thank our supervisors for guiding us throughout the thesis period.

We would like to give a special thanks to Martin Emanuel for sharing the novel idea of Biography of a Street, it was an immense pleasure for us to work on this idea and do a formative design research which resulted in an interesting prototype.

We thank all the testers at Cybercom and Chalmers who tested our prototype in its various stages and gave us valuable feedback, without good feedback we would not have managed to iterate the design so many times.

Lastly we would like to thank our friends and family for their encouragement and support.

Sophia Atif and Plamen Mateev

Contents

1. Introduction

History can tell us a great deal about how things came to be as they are right now and can give us valuable insight into the dos and don'ts when making important decisions. Most of history is being retold in the form of books, documentaries, museums exhibitions and stories. All of these methods convey the information of what happened, but they do not offer an immersive experience that leaves a mark upon the person who viewed it. With the advent of new developments in Virtual Reality (VR), and new powerful, affordable hardware, it is the perfect playground to try out immersive storytelling. History is bound to repeat itself if it is not studied well, but through the use of a realistic environment, a seemingly unimportant historical narrative can be taught in a very engaging and memorable way. With the knowledge of important historical events in urban planning, people can also see the effects of both good and bad urban planning decisions.

What if you read that a particular street in your city was built in the year 1900? You would shrug and forget all about it. But what if you could be there when it was being built? See how the workers were constructing the street, what they were wearing, how did it all look like or sound like? Did the buildings change from that period until now? A VR experience can encompass the answers to most, if not all of those questions and would leave a much more resonating message to the user. This effect can be used to emphasize seemingly minor moments in history that have had a gigantic ripple effect on our present.

With the benefits of VR and the power of history, this thesis aims to create guidelines for an experience that would engage users and make them consider the importance of good urban planning in the past and its effects on traffic and quality of living in the present. In the process, a framework for creating a virtual tour is also explained.

1.1 Background

The ever-increasing power of computers and hardware rendering systems enables the creation of visually rich and perceptually realistic virtual environment (VE) applications. An interesting study by Riva et al. (2007) has shown a strong link between emotion and presence by using virtual reality as a medium. The study proved that the feeling of 'presence' was stronger when the virtual environment involved emotions. The term presence and immersion relate to each other strongly in a way that both represent deep involvement. Virtual reality has proved to be a suitable tool for generating immersive environments (Riva et al. 2007), so in order to harness the

power of VR systems there is a great need for a well designed set of rules for interactivity within the VR experience.

More effort has been put into making the technical aspect of virtual reality systems at the same time comparatively little effort has gone into the user interaction components of VEs (Gabbard, 1999). Although usability engineering is a newly emerging facet of VE development, user-centered design and evaluation in VEs as a practice still lags far behind what's needed in order to create truly enjoyable virtual experiences.

When we talk about virtual reality, most of us tend to think about computer generated virtual environments. There are however other forms of virtual reality environments such as 360 degree photos and videos. 360 degree environments can be considered as subcategory of virtual reality. As compared to computer generated virtual reality environments, 360 degree media presents the opportunity to view the real surroundings as they look like in reality.

In this study we aim to explore virtual reality environments and mixed methods in order to develop design guidelines for an immersive experience of a biography of a street. We aim to explore various methods for creating interactive experience such as storytelling, 360 degree media, 3D models of interior of buildings and then validate these methods using various types of users tests.
This study was proposed by a historian Martin Emanuel[1] in collaboration with cybercom[2], these stakeholders coined the idea of Biography of a Street and what narratives could be derived through exploration of historical facts of a street. The selection of the street was also proposed by the stakeholders, the reason of the selection of Linnégatan perhaps lies within the rich history of the area in which it is situated, named Haga in the city of Gothenburg.
This thesis is a form of formatives research which aimed at designing an engaging experience. Formative research refers to developmental research that focuses on improving the theory for designing certain type of practice or process for the sake of learning (Reigeluth et. al, 1999).

1.2. Problem

Why a city looks the way it looks like is because of many decisions made in the past by policy makers, politicians and architects. Many european cities are facing challenges today in order to meet the sustainability goals which conflict with their current urban infrastructures. These conflicts are not superficial rather they go to the core history of planning (Campbell, 1996). Most urban planning decisions are taken by planning systems elected by the local community. These urban planning decisions are supposed to reflect the wishes of the local community and their needs (Socrates, 2012).

Most often the general public is made aware of the decisions through newspapers and articles after they have been finalised. During the recent years there has been a great trend towards

[1]https://www.chalmers.se/en/areas-of-advance/Transport/news/Pages/The-biography-of-a-street-a-step-towards-a-more-sustainable-city.aspx
[2] https://www.cybercom.com/

involving citizens early in urban planning through various means of participation. In order for a city to cope with its future challenges and to be able to stay up to date with global technological and economical challenges, the city governments need to include their citizens in the planning of future cities (Hanzl, 2007). Modern cities are working on more projects than ever in order to include their citizens into the process of urban planning.

We take an example of Japan - they have faced many challenges in the past like nuclear war, tsunamis and earthquakes and they have always created a better system (Garcia, 2016). They have been able to do so because they analyse their past systems and try to improve the systems while rebuilding the infrastructures. This study takes inspiration from the same approach and aims to show a rich picture of the past of the street. Rich picture refers to narratives set in the history that can be derived by historical and cultural material found in the form of pictures, sounds and information about the buildings and roads including interesting facts. While doing so this system will attempt to provoke its users into thinking about and answering certain questions like; why does the street looks like the way it looks like, what urban planning decisions led to construction of certain road lanes, what decisions need to be taken now in order to achieve the urban planning goals of a modern sustainable city.

The eleventh sustainability[3] goal by the UN known as "Sustainable Cities and Communities" is focused on making the cities sustainable, safe and inclusive. While the modern cities are planning and working towards achieving this goal, they face the challenge of including general public in their planning. There is a need for including citizens in order to have creative solutions (Hanzl, 2007). We believe having the historical factor can work as an anchor point between the past and the future of the city, we can include the general public in the decision making by showing them the past and making them reflect on the historical decisions, which should allow them to suggest creative solutions to today's urban planning problems. We focus on the first part of this goal by telling a rich story of a street. When we discuss the ways of telling a story of a street, the design of the system must make its users interested in knowing about the past of the street.

There exist many examples of immersive designs that tend to engage users who like history by showing virtual models of the past of a cultural heritage site, examples include virtual reconstruction of St Andrews Cathedral [4], Digital reconstruction of Ancient city of Agora[5], Acropolis[6] and many more. However, these reconstructions aim to engage the users already interested in history, those who are willing to know about the past of a popular archaeological site. Our aim on the other hand is to engage users who are not the history enthusiasts. By showing a rich story of a well known street that users have been to many times, we aim to let them view the street in a manner that they have never seen before. Such an experience through a virtual tour should result in a transformative experience. A transformative experience refers to an experience that changes the perception of the viewer about the topic they knew before, they are able to see things in a different way which eventually and ideally should lead to changes in

[3] https://www.un.org/sustainabledevelopment/cities/
[4] Exploring the Past with Google Cardboard, Digital reconstruction of St Andrews Cathedral
[5] 3D virtual Reconstruction of Middle Stoa in the Athens Ancient Agora
[6] 3D virtual reconstruction of Archaeological Monuments

behaviour (Paul, 2014). Such a system will let the users explore the site in more details because even if people pass through a street often, they seldom find time to explore it because of lack of time and sometimes lack of accessibility options.

Additionally, taking into account VR technology evolution, contemporary relevant literature (*key words: Virtual Tours, History, Interaction Design, Virtual Reality, Guidelines*) suggests that the area of providing a framework or guidelines for creating immersive historical virtual tours, specifically by user experience designers, has not been explored.

1.4. Research Question

This thesis is a pre study of a bigger project that aims to gather and present historical artifacts about a street. In doing so, the researchers aimed to extract historical trends that could connect the urban planning decisions, patterns of mobility, the property values and other socio-economic factors. This analysis can help historical researchers and urban planners forsee the future and be able to plan for sustainability.

We as masters thesis students have investigated how to present the historical data so that it can achieve the purpose of deep reflection about the urban planning. There do exist many proven ways of presenting the data however if the data is being presented in order to raise awareness and create the emotions of empathy, there needs to exist a more immersive way (Kors et al., 2016).

This thesis aims to investigate how this presentation could capture the audience's attention and be able to induce reflective thinking about the history of the place. The thesis is aimed at investigating what kind of technology could be used to create an immersive and engaging experience. Such an engaging experience should be able to tell a rich story about a place. In doing so we aim to investigate if a deeper reflective thinking about urban planning decisions could be induced, if yes what are the do's and don'ts of designing such an experience. Following research question was formulated in order to support the investigation:

"What are the potential guidelines designers can use to create an immersive and interactive historical virtual tour of a street?"

This thesis focuses on designing an experience which is achieved by materializing the ideas using the lo fi and hi-fi prototyping. However, this research does not focus on creating a scalable solution which has optimised performance, technically speaking. Our solution was created using Unity, however the solution cannot be used as a platform to create any type of virtual tour as it might cause performance issues and the target device to slow down. Thus this research should be referred to when designing a similar experience as it states the suitable technology and design guidelines for a specific setting, either, at a public exhibition.

1.5. Thesis Deliverables

The deliverables regarding the elicited knowledge and insights about the interactive immersive experience are presented in the report, with a suggestion for what kind of interactions and content should be used when designing such an experience. Insights gathered regarding what to consider when designing, where to present, what kind of platform to use and what kind of content supports the engagement are also presented in the form of recommendations. A design suggestion for a Biography of a Street, an android based VR experience is presented which has been created based on suggested recommendations.

1.6. Report Structure

The report is structured into chapters. Each chapter is described below:

1. Introduction, the problem area is presented, the scope of the thesis is introduced and the research question is established.
2. Related work explores the literature connected to the topic of VR. Discusses guidelines for designing interactions in VR, and virtual tours are also explored.
3. Theoretical frameworks that were employed during the construction of this report were stated in this section.
4. Methodology puts forward the different research and design methods that were used to carry out this thesis.
5. Planning chapter discusses the overall planning of the project.
6. Execution goes over the work process during the course of the project, detailing each iteration of the prototypes, as well as describing the tools that were used in creating the prototypes.
Part *7. Results: Design Guidelines* presents the findings of our testing phases in terms of new design guidelines for creating virtual tours.
Part *8. Results: Biography of a street* presents our results in the form of a framework for creating an immersive historical virtual tour.
In section *9. Discussion*, guidelines and recommendations for creating immersive virtual reality tours are suggested, based on our results.
Finally, in part *10. Conclusion* is where the summary of the paper is presented.

2. Related Work

In this chapter we discuss the technology and research that has been used in other projects which aim to shed light on exploration of historical places and boost tourism in popular cities. We also touch upon what virtual tours have been explored in literature, and some of the methods they

have utilized in creating them and that could be useful for our prototype development, and can potentially steer us in the right direction of answering our research question.

2.1. 360 Virtual Tours

Planning and management, marketing, entertainment, education, accessibility, and heritage preservation are six areas of tourism in which VR may prove particularly valuable (Guttentag, 2010). Attempts of creating virtual tours in the fields of tourism have gained increased popularity. Cities like Bilbao[7], Dublin[8] and New York[9] have virtual tours created using 360 degree media (Fig 2.1). According to 360-virtual-tour-company.com, virtual tour is an immersive way of viewing a place virtually, it places the viewer in the middle of an image that surrounds the viewer from all sides, covering the 360 degree view.

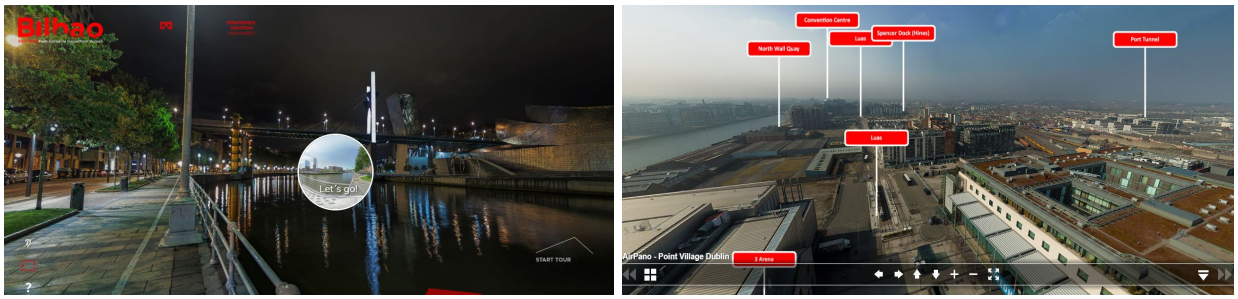

Fig 2.1 Virtual Tour Websites (Bilbao (Left), Dublin (Right))

Virtual tours are simulations in form of images of an actual place, when these images are viewed using web, they can be scrolled to view a place from one angle but lets the viewer experience the surroundings as these panoramas have unbroken view. When viewed in a headset, it provides a deeply immersive view. In order to create the 360 tours that let the users navigate from one spot to another, interactive hotspots are added. Once clicked they take the viewer to the next photo. Osman .A, et al (2009) created a virtual tour of a city in Malaysia that makes use of interactive hotspots in order to navigate, the 360 tour also has brief descriptions of the place in view. The study concluded with satisfactory results, however the indicated areas of improvement were, lack of visual feedback upon interaction with the hotspots, lack of 3D walkthrough and being able to closely inspect objects displayed in the 360 degree panoramic view.

These problems have been addressed in other studies. For example having 3D models in real pictures was studied by Al-Kodmany .K (2002). The study uses freehand sketches to create 3D models of buildings which were then embedded into the real images in order to get a feel of how the planned design of a building will look like in destination setting (Figure 2.2). Another study

[7] http://www.bilbao360walk.com/
[8] http://www.virtualvisittours.com/category/places-to-see-dublin/
[9] https://www.airpano.ru/files/Manhattan-New-York-Virtual-Tour/2-2

by Pletinck .D (2003) explores the methods of creating multiple narratives by providing the users with various themes. Since their system makes use of large database of information about archeological facts and historical information gathered in a period of 5 years, the viewers of the system can choose to explore this database by following trajectories of time, space or theme, following a story of their choice.

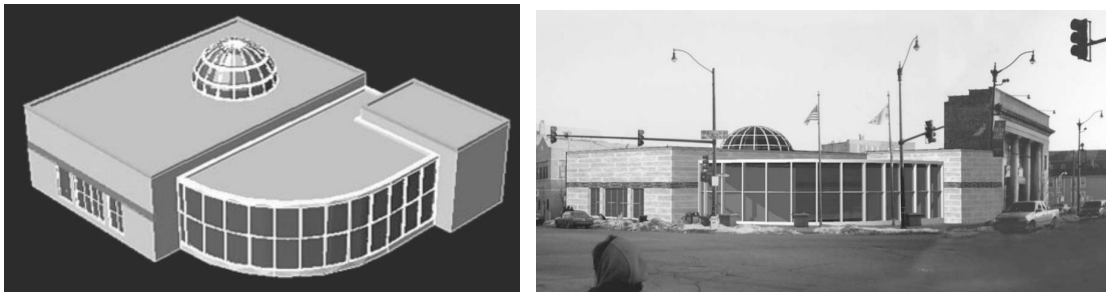

Figure 2.2: left; 3D model of building, right; 3D model on a photo

Storytelling is a well known tool being used in many institutions including educational bodies and design approaches (Brooks, 2010). It is a popular pedagogical approach in order to educate the audience. The concept of storytelling can be considered as a tool to convey a message effectively, it is used in education and user experience design for various purposes. Seeing a fact put into the right context changes its meaning (Brooks, 2010). We aim to use the storytelling method for its proven benefits in order to tell the story of a street.

2.2 Research Application Area

The main focus lies in the exploration of potential uses of virtual environments that enable the users to experience the times and scenarios they cannot experience otherwise. Examples of such scenarios include, but are not limited to, visiting old monuments, historical sites that are not accessible, virtually reconstructed cultural heritage sites, virtual tours of popular destinations and interactive journalism. Interactive journalism is explored by De la Peña et al. (2010), they have researched how virtual reality can be used for immersive storytelling to show the news. They do so by creating virtual representation of the scene where the incident happened, the user gets to see and hear the surroundings which creates the first person experience of the news.

Moreover, the application of virtual environments is also used in virtual reconstruction of old buildings, for example a virtual reconstruction of St Andrews Cathedral (Fig. 2.3) by Fabola et al. (2015), interactive storytelling in a virtually reconstructed cultural heritage site (Fig. 2.4) illustrated by Kwiatek & Woolner, (2009) and Pletinckx et al. (2003) are a few examples.

Figure 2.3: Virtual reconstruction of cultural heritage site, being viewed in a virtual reality application

Figure 2.4: "Storytelling about a past wedding at the church using virtual reconstruction, Kwiatek & Woolner (2009)"

While these examples lie in the area of virtual environments and creation of virtual experiences for the purposes of interactive journalism and historic architecture investigation, the main focus is on the computer generated virtual environments. On the other hand we will focus on the works that highlighted the guidelines for creating virtual experiences.

In order to create virtual experiences some early groundwork was laid out, in terms of designing immersive experiences in VR by Perez et al., (2015). They cover the six most important parts of a VR experience that need to be evaluated: interaction & functionality, pages (views), navigation system, panoramic view, sound, and finally, guidance and support. These guidelines are briefly explained below;

The *Interaction and Functionality* guidelines states that the general behaviour of the system is coherent with the actions of the user. The images are of high quality which gives the user a feeling of being transported to that place and the interactive content has a clear feedback.

The *pages* guidelines refer to having all the major interaction present on the main page and from their it should offer a good understanding of what to find where.

The *Navigation system* should be clearly structured and it should be evident which links should the user follow in order to get to a desired location in the system.

Panoramic View should consist of realistic images and should represent the view of the user from where they are standing.

Sound and voice over should reflect the actions being taken by the user thus having an overall synergy. The sounds and voice overs should be authorized by the user before the system is initiated.

Guidance and Support is an essential part of any software, the virtual tours should not be any exception. The support should include how is the system used and help should be accessible from any point in the system.

More work on designing for VR was presented by Sundstrom (2015), where a user test was conducted to see what participants would think about, react to and inquire about in virtual environment. The study comes out with a list of "do's" and "don'ts" that should be followed when creating a VR experience. Some of the "do's" include: thinking of how to display content, it should be set in the distance. Important content should be brought to the focus of the user, secondary should be on their peripheral vision. On the "don'ts" side, the study concluded that any movement could cause severe motion sickness and any rapid changes to the environment, especially outside the view of the users need to be avoided.

In another user study done by Newton (2016) a VR experiment is carried out to see what its effects on a user are, when they experience an immersive storytelling environment (Figure 2.5) in VR. The results state that immersive VR makes people "detectives". They will dig around for more information in a scene in VR, if the experience is immersive enough, and insignificant objects can become significant, e.g. a plate of cookies randomly put into the scene could invoke some sense of story (even though one was not intended). When the audience had limited visual information they would work twice as hard to make meaning out of every detail they saw. If something didn't jive with their expectations, it took them out of the experience. It sent them into detective mode, investigating the scene from a distance.

Figure 2.5: A cookie plate used to invoke a narrative and an element to get viewer in detective mode, Newton (2016)

Finally, VR could be used to promote a country's or a city's tourism, the benefits and guidelines are outlined in a paper by Sambanthan & Good (2013) where it is stated that VR could effectively be used to experience out of reach areas, or areas that are endangered and forbidden for public visits. Knowing the gaps in the research area, our work focused on designing an immersive, interactive, historical VR experience for a specific street. The potential benefits and uses of such a system are explored further in the following chapters.

3. Theoretical Background

In this chapter we outline the scientific theories and frameworks that we have employed in the making of this thesis work.

3.1. Concept Testing

Concept testing is a toolbox of methods used to ascertain the viability of a product with its target user group. As Bowman (2017) writes, it is mainly used as a quantitative method where users are asked to rate different measures of a product, mainly their perceived value of it. They are presented with several different concepts of the same product and the results from the study lead to the development of the best-received idea.

Concept testing can also be adapted for a qualitative approach, in the form of interviews, where designers can better extract behavioral and contextual insights while the user is testing the concepts. The concepts are usually presented in the forms of low-fidelity prototypes: wireframes, sketches, storyboards and it's advisable that the concepts are kept to a maximum of the three best designs there are to offer.

3.2. Inclusive Design

The practice of designing products while having people with disabilities in mind is definitely not a new one, however it's simply impossible to account for every kind of disability when creating something new (Newell et al., 2012). However, Abascal and Nicolle (2005) offer guidelines which human-computer interaction designers can utilize when attempting to incorporate inclusive design in their systems, to better accommodate people with disabilities. While these guidelines were created with web design in mind, they can be applied in other fields (Abascal, 2005).

- [10]Adhering to the Web Accessibility Initiative guidelines - for more easily accessible websites.

- Clarity, applicability and universality - uniform design across the whole system.

- Dynamic guidelines versus static standards - build your product in a way that can adapt to new demands in accessibility.

3.3. Research Through Design

Research through design is a fairly new concept introduced by Zimmerman et al. (2007) in the field of interaction design, derived from the fact that design researchers' scientific contributions were vague in the field of human-computer interaction.

The goal of research through design practitioners is to make "*a product that transforms the world from its current state to a preferred state"*, while adhering to a specific theoretical potential. The authors provide 4 main guidelines to ensure the final produced artifact has scientific merit: *process* (it must be described in detail)*, invention* (artifact needs to be a new invention)*, relevance* (why is the product an improvement)*, extensibility* (how can the final result be improved upon further).

While Forlizzi et al. (2011) and Solterman (2008) question research through design as a valid research method, Gaver's (2012) essay tempers those concerns by discussing the benefits of such an approach. He suggests avoiding research standardisation in this field and instead strive for exploration and speculation, as that can provide fresh, new and intriguing artifacts.

[10] Available at: http://www.w3c.org/wai/, last accessed May 14, 2018

3.4. Iterative Prototyping

The iterative design approach is widely accepted and used in many fields of design and development, bearing different names. For example the iterative user experience design approach has a close resemblance with Lean startup methodology for creating new businesses (Eisenman et al., 2013). The lean startup methodology is the new trend in creating successful new businesses. The approach suggests creating a hypothesis about a problem and proposing a solution, next talking to users in order to validate the existence of the problem in real life. After validating the problem, first prototype is created and taken back to users to get feedback, the results of the feedback are used to refine the prototype and the process of acquiring feedback and refining the prototype is repeated until satisfactory results have been achieved. This framework fits well with our task, as we take an exploratory approach.

Both the iterative user experience design and lean startup make the user a central entity around which everything else evolves. An early version of these frameworks is usability framework explained by B. Shackel (1991), Bennett (1972) and Eason (1982). This framework suggests that there are four entities of a system, environment, Users, Task and the tool itself. The constraints of the environment are taken into consideration while the tool enables the users to achieve their goals by performing certain tasks on the tool. The design of the tool should allow the user to be efficient while being comfortable with the tool.

The above mentioned frameworks state the user centered methods of developing systems. However, a detailed design approach is proposed by Jones (1992). He suggests divergence in the beginning of the design process in order to come up with various ideas. These ideas are then transformed in order to fulfil the requirements of designing the system. In the final stage, convergence is achieved by selecting the optimal ideas. In this study we combined the Jones model with the aforementioned frameworks in order to come up with various ideas of visualizing the past of a street, and evaluated these ideas based on their viability and finally created prototypes of varying fidelity. In the end, the prototypes were tested by users and ran through iterations of improvement and user evaluations.

3.5 Guidelines for Virtual Reality and Virtual Tour Graphical User Interfaces

When creating a prototype for a head-mounted display, with an interactive graphical user interface (GUI) system, it is important to follow already established guidelines for a desirable user experience (UX). Fröjdman (2016) conducted a case study, using a movie browsing VR

interface and has concluded that there are seven major VR GUI UX guidelines, designers should try to follow.

1. Place the graphical user interface so it is comfortable to explore and interact with.
2. Place visual feedback to selections within the immediate interaction area.
3. Keep information dense areas interaction - free.
4. Use dwell times (gaze times) of various lengths.
5. Avoid using time - limited information.
6. Never force users to interpret information in movement.
7. Use standards and affordances to minimize the cognitive load.

Veering off of these guidelines could cause the user to experience motion sickness, headaches and double-vision (Fröjdman, 2016). Additionally, we focused on implementing Perez et al., (2015)'s six most important aspects of a virtual tour experience correctly. They are: interaction & functionality, pages (views), navigation system, panoramic view, sound, and finally - guidance and support.

3.6 Interaction framework in VR

Alger (2015a), in his VR visualization guidelines proposed that a standard for VR content distribution should be established and adhered to. In his video, he shows the visual range of users in a VR experience, as well as where they would feel most comfortable interacting with objects within the environment and where they would cause discomfort. Figure 3.1 represents the comfortable movement ranges of users using head-mounted displays. Figure 3.2 shows how to optimally distribute content within a VR environment (Alger, 2015b).

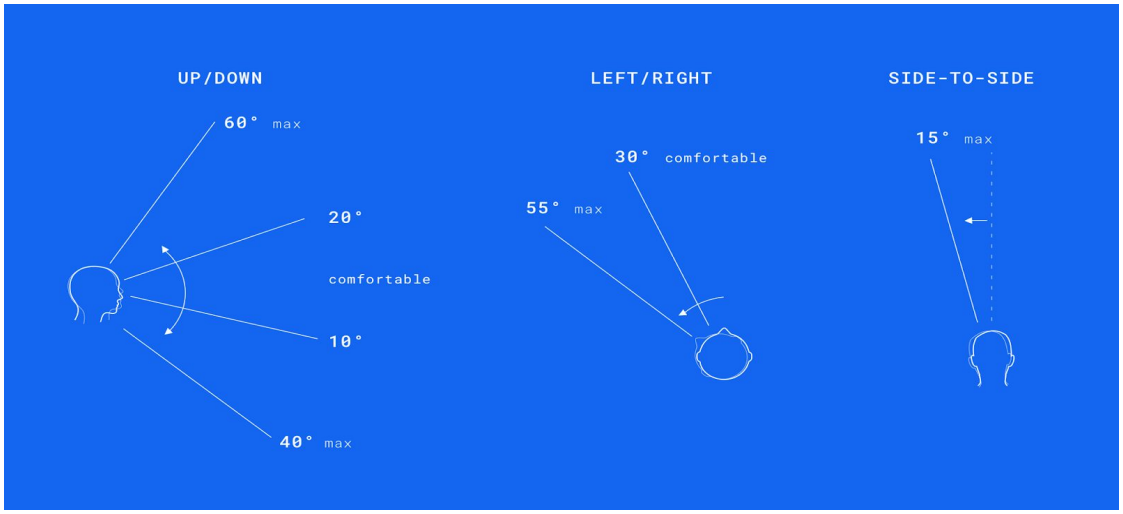

Figure 3.1: Alger's (2015a) optimal ranges of display within VR.

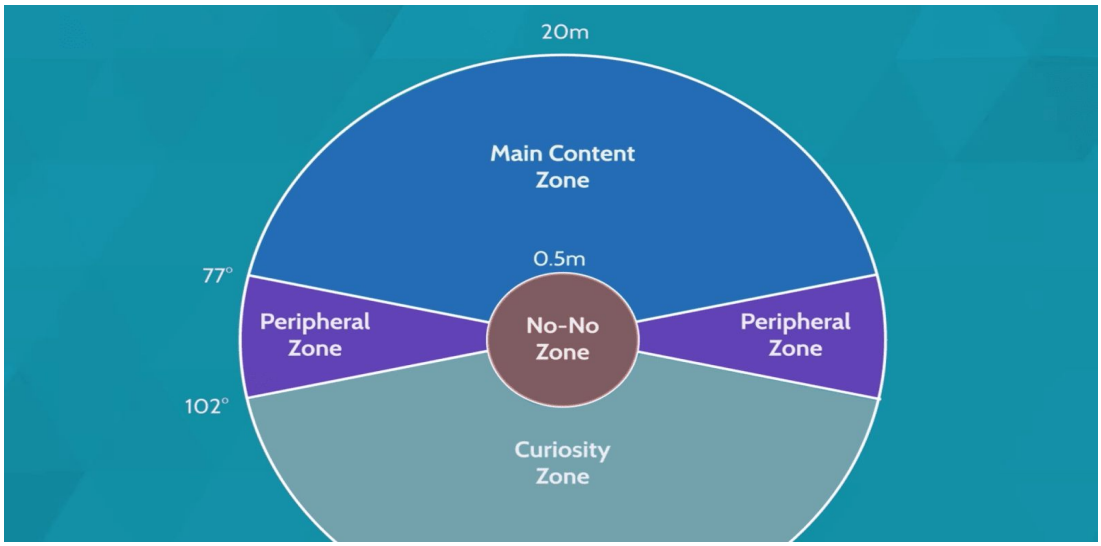

Figure 3.2: Alger's (2015b) optimal content placement in a VR experience.

4. Methodology

4.1. Qualitative Research

As described by Campbell (2014), qualitative research is focused upon extracting and analyzing data with an exploratory goal in mind. The main traits of qualitative research is that the data collection occurs in a natural setting, takes an interactive, humanistic approach and the final result is emergent rather than predetermined. Through the use of observations, ethnographies and interviews, researchers use data to develop themes and theories that can later help explain the phenomena that is being studied.

4.2. Literature Review

"To advance our collective understanding, a researcher or scholar needs to understand what has been done before" - Boote & Beile (2005).

Literature reviews aid authors in expressing the current accumulated knowledge on a given subject. Making sense of the presented state-of-the-art is usually chaotic unless aided by some form of framework or a narrative that the authors wish to express (Webster & Watson, 2002).

Thus, presenting literature relevant to a designer's subject is useful when determining what has been done so far, what has worked and what has not worked in terms of desirable user experience. A literature review can be used to assess and expose potential areas of interest that could be studied or further expanded upon. It can also be used to put theories into practice through the use of interactive high and low-fidelity prototypes.

4.3. Interviews

Interviews are one of the main tools in a qualitative researcher's toolbox (Campbell, 2014). It's best used in qualitative research, where the data is of exploratory nature. However, according to Adams and Cox (2008), it can be a very time-consuming process, both when conducting and analyzing the results of the interviews.

Depending on how rigidly constructed the interviews are, they can be *structured*, *semi-structured* or *unstructured*. The more structured the interview is, the less relaxed and comfortable the interviewee would be. Typically, semi-structured interviews are desirable if the researchers are

looking to extract as thorough information and freeform opinions as possible from the participants (Adams and Cox, 2008).

4.4. Questionnaires

A questionnaire is usually used when large quantities of data are required, typically sampled from a large population size, in order to support or refute a hypothesis, based on statistical and numerical analysis (Campbell, 2014). Depending on the structure and length of the questionnaire, and the substance of the questions, they can be used in a qualitative manner (Adams and Cox, 2008). For a questionnaire to be tailored to the exact needs of the researchers, they need to carefully consider these questions beforehand:

- Why are the questions being asked?
- Who are the results for?
- Will the answers help prove or disprove a hypothesis?
- How will data analysis be carried out after the results are in?

While interviews provide more in-depth data on a subject matter, questionnaires could be used to probe for the general "feel" for the topic at hand in a large sample size (Adams and Cox, 2008).

4.5. Prototyping

Prototyping is the natural way of transforming an idea into a working concept. It is vital for conveying a designer's initial interpretation of a design challenge. It generally comes in two major categories: *low-fidelity* and *high-fidelity* (Benyon, 2010)**.**

High-fidelity prototypes are produced using software and are typically close to what the finished product might look like and usually provide a high degree of interactivity. It's a double edged sword, however, since users viewing the high-fidelity prototype can believe that this is the final version of the product, and it might give off bad impressions if not everything is perfect (Benyon, 2010).

Low-fidelity prototypes are usually made out of paper, and represent the bare minimum of what the final product would be. They are quick, easy and cheap to produce, and thus offer great flexibility when it comes to rapid testing and evaluations (Benyon, 2010).

4.6. Usability Evaluations

Usability evaluations are tests which are tailored to determine how easy and pleasant to use a system is (Cockton, 2012). The methods with which to determine these metrics is usually much dependent on the system that is being evaluated, one thing is constant though - any interactive system is subject to usability evaluations.

Some example criteria of usability evaluations, as proposed by Cockton (2012), could be *fast-response, user control and freedom, recognition rather than recall, flexibility, efficiency of use, user interface aesthetics, learnability* and *accessibility.*

4.7. User Journeys for Coherent Experience

User journeys are typically a collection of steps, which depict a scenario where the user interact with the product that is being designed, as stated by Mears (2013). A user journey aids in 4 major areas when constructing a prototype:

- Demonstrating the vision for the project in the future, which could be used for requirements gathering in the start of a project.
- It can be used to better understand how users would behave when interacting with the prototype and what they might expect from it.
- Proposes and identifies potential initial and high-end functionalities of the prototype.
- Helps designers establish a suitable interface for the product.

4.8. PLEX cards for engagement

The Playfulness Experience (PLEX) cards, developed by Lucero et al. (2014), introduce the power of video games and their ability to motivate people to reach their goals, through playful elements. Each PLEX card represents a playful framework, from which a designer can choose to inject into their experience. There are a total of 22 cards, with titles such as “Humor”, “Exploration”, “Discovery”, “Simulation”.

Through conducting three case studies, the authors have established that the PLEX cards are a suitable evaluation and brainstorming tool for creating engaging and memorable user experiences.

4.9. Design for Rich Experiences

Fokkinga and Desmet (2013) argue that some of the most powerful memories that we form are the ones invoked by powerful emotions, and usually those are negative emotions. They propose a framework from which a designer can choose to adhere to in order to elicit certain emotions from their users.

Every emotion is governed by a specific protective frames:

- The detachment frame - an example of this frame would be to present readers with a statistic of a disaster, rather than a picture.

- The safety-zone frame - this frame distances the user from the source of negative emotion, so they can experience it from a "safe zone".

- The control frame - the user is granted gradual control over their exposure of the negative emotion.

- The perspective frame - it gives the user perspectives into the benefits of changing or overcoming a negative stimuli.

These frames can be used as guidelines by designers to create rich experiences (Fokkinga and Desmet, 2013). The authors argue that with the aid of these protective frames, a negative experience can be converted into a rich and engaging experience. Some of these rich quality experiences can be: "Unreachable" or "Sentimental", where users look upon past days with nostalgia and longing, and a wish to relive the past.

4.10. Gestalt Laws

Gestalt laws is a set of theories originated in the field of psychology (Chang et al. 2002). These laws have been used as guidelines for designing instructional screens. Chang et al. (2002) identified laws for computer screen interface design. These laws are industry standard for the interface design and are widely accepted. The 11 most important laws are listed below;

1. Law of balance or Law of Symmetry:
   An equilibrium in the design should be achieved by placing the objects at equal distances while a chosen axis is made an anchor point.
2. Law of continuation:
   The eyes tend to follow a path found in a visual design, thus the continuity should be maintained.
3. Law of isomorphic correspondence:
   We tend to interpret a visual representation based on what context is it presented to us.
4. Law of Closure:
   Our brains interpret open shapes as incomplete and try to fill the missing spaces.
5. Law of focal point:

In a visual representation, our eyes are first drawn to a focal point which then makes us follow the

6. Law of figure ground:

Every picture has a background and a foreground, our eyes perceive the the ground which has meaningful details. If a picture has two backgrounds, our brain will interpret only the figure that our eyes are focused on.

7. Law of good form:
   A stimulus will be interpreted into as good form as can emerge from the presented content.
8. Law of proximity:
   Elements presented close to each other seem as one group
9. Law of harmony:
   Congruity exist among the elements of the same design.
10. Law of similarity:
    Objects of similar shape are grouped together
11. Law of simplicity:

When the content is presented, we tend to simplify it in order to perceive it better. Simplification works better if the graphical content is already presented in some order.

5. Planning

The project was planned to be conducted over the period of 20 weeks. It started in the late January 2018 and was completed by the end of May 2018. A time plan was created that consisted of the following four step process including Background Research, Ideation and Planning, Exploration of Suitable Technology Platform and Iterative Prototyping and Testing.

The *Background Research* consisted of gathering information about the subject and related works by reading up the related scientific publications. During this phase we made use of two

methodologies, *Literature Review* and *Questionnaire*. The literature review was done by reading and summarising the published research related to virtual reconstruction of old monuments and design and development of 360° virtual tours. We also made use of Questionnaires in order to gather insights about user's needs and wishes about viewing the historical content.
As a result, a formal Proposal was produced which included the research question. This phase also included gathering of the data in the form of pictures and documents from the Gothenburg Museum archives.

In the *Ideation and Planning* phase, we made use of the brainstorming methods, such as *mind-mapping*, to come up with ideas in order to materialize the concept. We also made use of the *Interviews* and *Qualitative Research* methods in order to get more ideas. These ideas were categorised based on their feasibility which was dependent on the availability of historic data. This phase also included communication with the stakeholders. As a result, a planning report was produced which included, background research and a plan for conducting the thesis project. The ideation was not limited to this phase only, it continued in parallel with Evaluation of suitable technical platform and Iterative prototyping phase.

The *Exploration of Suitable Technology Platform* included testing at least three platforms to create the basic idea of prototype. We used high fidelity *Prototyping* methods in the form of an immersive virtual reality experience. Since the aim was to design for immersive experience we refrained from using low fidelity prototyping methods, such as paper prototypes, as the result of *Usability Testing* method revealed that the quality of the immersion was low. However we used a web based prototype (which in our case is considered a *low fidelity* prototype, but by definition it's still high fidelity) to test the idea of the historic virtual tour, later we moved to developing using the Unity Engine.

In the beginning we used forge.js to create a virtual tour, in parallel Panotour pro was tested by creating the same web based prototype. As a result we found out that panotour pro offered the same functionality and it was quicker to produce results. Thus we polished the Panotour pro prototype to communicate the idea of virtual tour to the stakeholders. Later this prototype was tested with a headset to achieve immersion - where it failed, and we switched to a more powerful platform, the Unity Engine. At the end of this phase, we learned how to create virtual tour and use it with a headset.

The final *Iterative Prototyping and Testing* phase consisted of various prototyping iterations followed by user tests, evaluation of user test results and improvements of the prototype.
During this phase we made use of various methods like creating *User Journeys, PLEX cards for engagement, Designing for Rich Experiences and Gestalt Laws for designing interactions*.

As this phase was continuous and could go on for a long time, we had set certain criteria which if fulfilled by the prototype, it will be the final version. The criteria included having an immersive view of the street, having interactive content in the tour, having sufficient navigational interactions and an experience that makes the audience reflect on the urban planning decisions. The final test confirmed the fulfilment of the goals. Figure 5.1 shows the plan graphically, each aforementioned phase is broken down into smaller tasks.

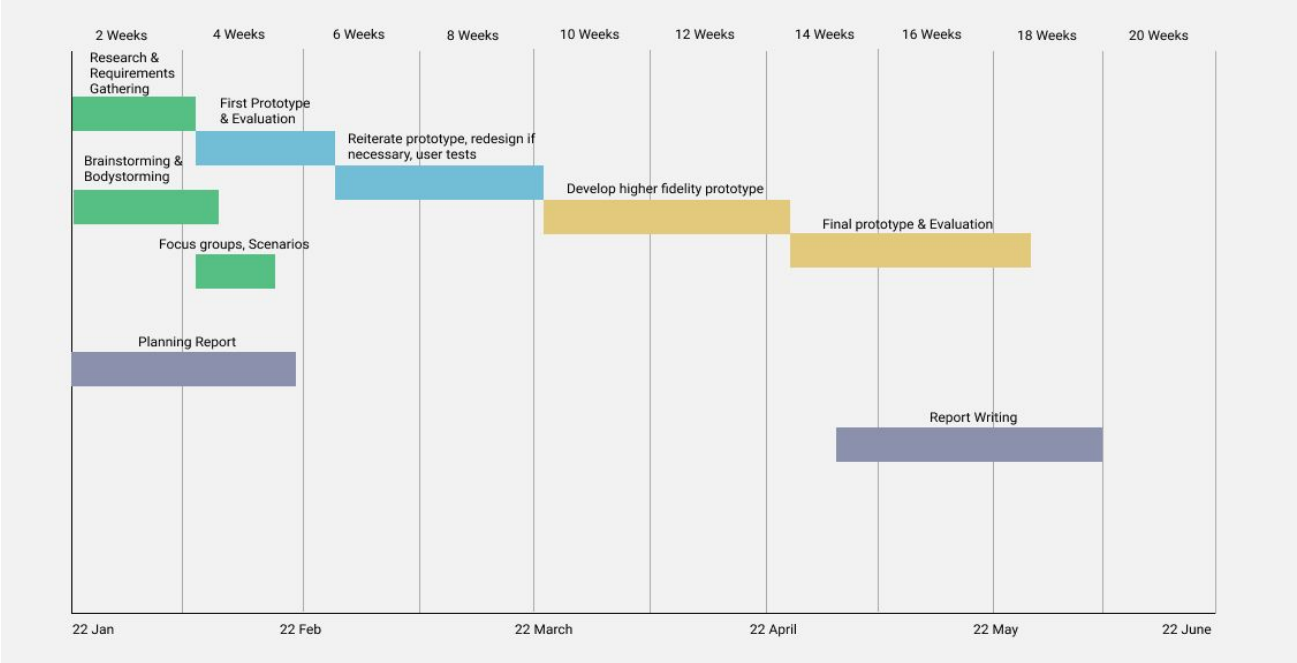

Figure 5.1: Time Plan

6. Execution

In order to describe the work process involved in the making of the various stages of the prototype, it is first necessary to introduce and define the tools, software and process that were used in creating it - doing so will provide clarity into why this development path was chosen for this project.

6.1. Design Process

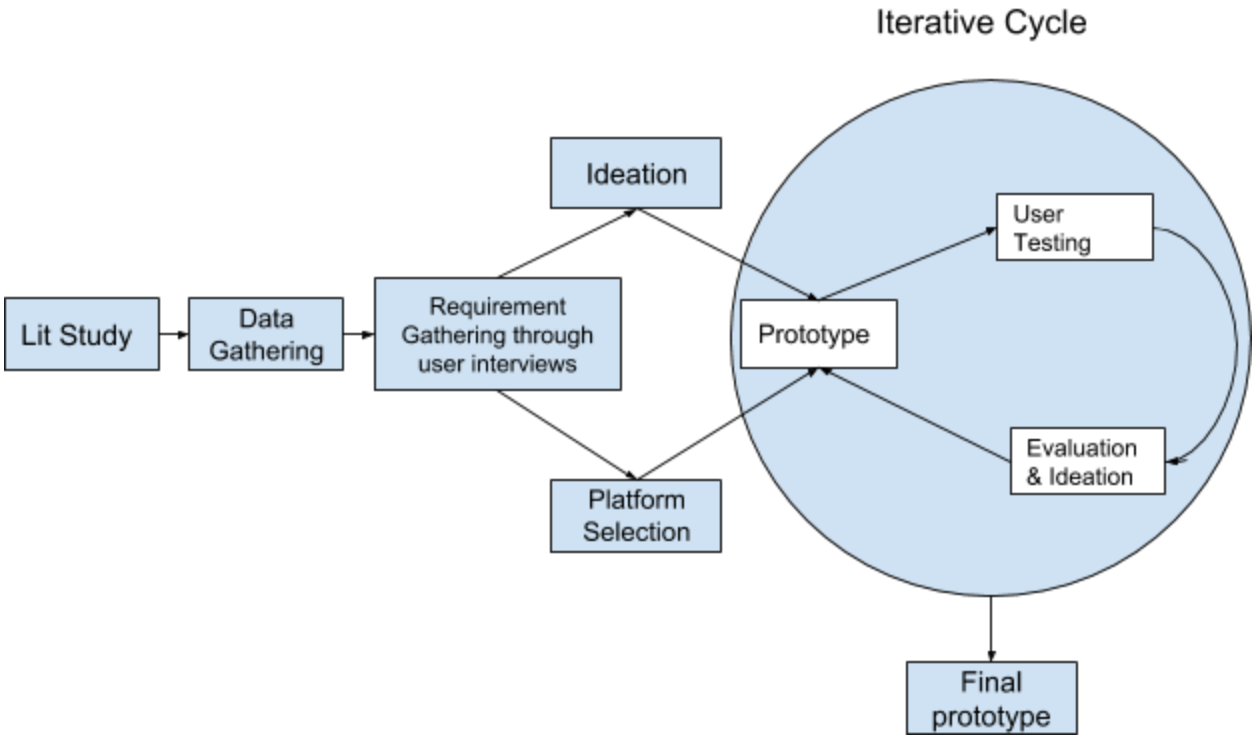

Figure 6.1: The overall design process that was followed during the course of the thesis.

The design process first began with an overview of what relevant literature has discovered in the topic of immersive VR experiences, virtual tours and visualizing data in VR, and what were the potential unexplored zones. Next we established contact with potential users and performed initial user studies and requirement gatherings. The next phase was to select a suitable platform on which to develop the prototype and to come up with ideas of how the prototype should work and look like. Finally, we entered the cyclical phase of our process - the iterative cycle; where we built, tested, evaluated and repeated the same process over the course of four major iterations.

Most importantly, we used Perez' (2015) VR GUI guidelines as a baseline for designing a virtual tour and with the accumulated feedback over the four iterations that we performed, we attempted to expand upon them and tailor them more towards our research question.

6.2. User Journey

In order to visualize our concept and make it easier for others to understand what we aimed to achieve with our prototype, we constructed a simple user journey that illustrated the steps that a typical user of our artifact would take to use it. Below are the visualizations.

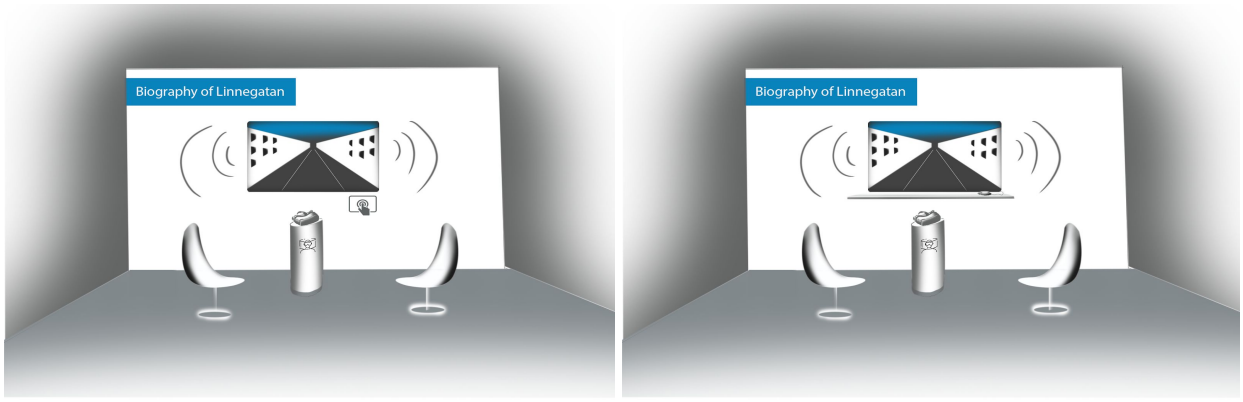

Figure 6.2: How our prototype in VR would look in a museum setting with a touch screen and/or headset (Left) and without a touch screen (Right)

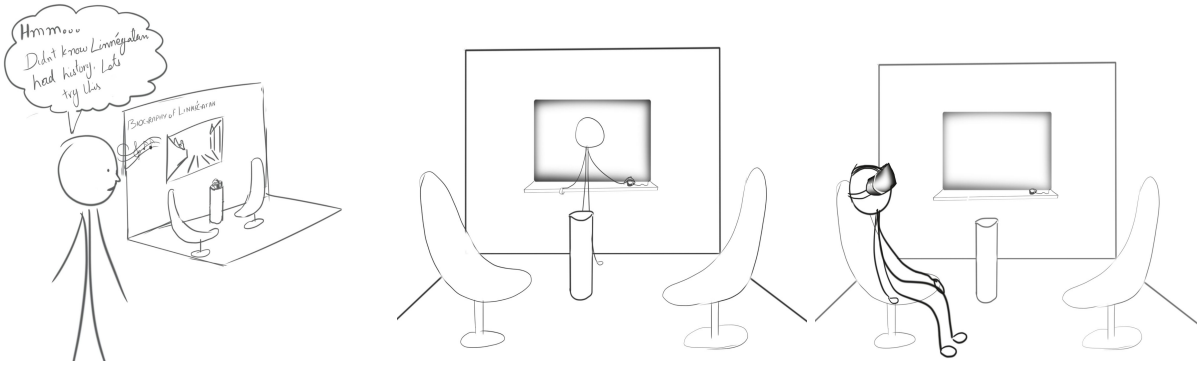

Figure 6.3: User sees our prototype in a museum exhibition and proceeds to interact with it

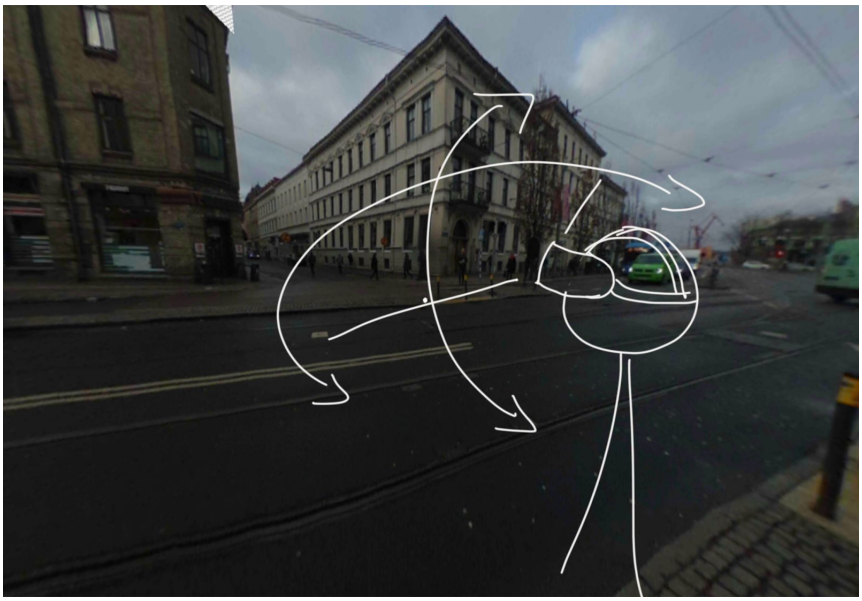

Figure 6.4: User in the VR experience

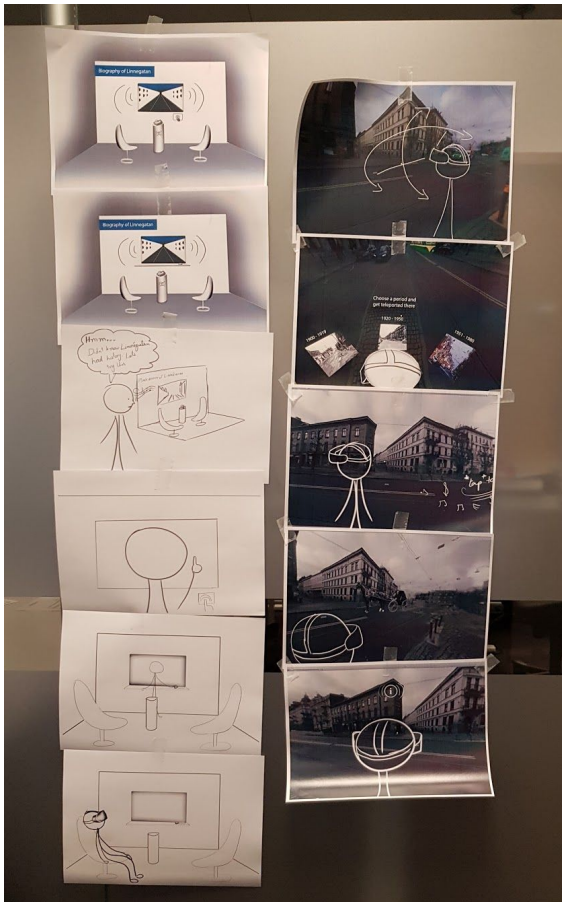

Figure 6.5: Complete User Scenario

6.3. Tools

In this section we outline the tools that we chose to work with after having done a pilot iteration (First iteration) to determine the best approach for our goals.

6.3.1. Unity Engine

[11]Unity is a game engine and developer platform, developed by Unity Technologies, which can be used to build three and two-dimensional video games, simulations and virtual reality environments. It can be utilized to create products for computers, mobile phones and video game consoles. Its primary coding and scripting language is C#. The Unity engine provides developers with a visual representation of what they are currently building and they can directly insert assets (textures, 3D models, animations etc.) into the 3D world, while providing scripts to manipulate

[11] Available at https://unity3d.com/ , last accessed May 15th, 2018.

the behavior of the assets, this makes it easy for even non-experienced programmers to effortlessly and quickly create high-fidelity prototypes of their final vision.

6.3.2. Oculus Gear VR

[12] The Oculus mobile platform is a framework for developers to deploy their VR experiences on. It comes in two varieties: the Oculus Rift Headset, which is connected to a computer, and the Samsung Gear VR, which only requires a post-2016 Samsung smart phone. The Gear VR also comes with an optional controller.

The main appeal of the Samsung Gear VR is that it is relatively inexpensive, compared to other forms of VR, as it only requires you to have your mobile phone as an extra accessory (as opposed to a very powerful personal computer) and the cost of the actual headset is low, making the entire platform far more accessible to the general public. Being a mobile VR platform, developing and testing VR applications on it is cheap and fast. It also provides enough power for the VR experience to be on par with that of computer-powered VR headsets.

6.7 First Iteration

The thesis comprises of two parts, the design of a system and extensive user testing in order to evaluate the usability of the system. The results of the user evaluations serve as the academic backbone of the thesis. The workflow followed a general method of "Research through design", expressed in the essay of Gaver (2012), i.e. our prototype was created for a specific purpose, and potential theories emerged from its use. The main benefit of using this approach was that we were free to change directions with our iterative prototypes and explore new ideas and solutions that supported our research questions.

6.7.1. Idea Generation

Before work on the prototypes began, we set out to investigate who would be interested in a historical VR experience. We conducted an initial pilot survey which received 36 responses, but turned out to be too broad and results were inconclusive (attached in Appendix A). We realized that users would better grasp the idea we were asking them about if we created a tangible and concrete prototype for them to test and then find out what their thoughts on the whole process

[12] Available at https://www.oculus.com/gear-vr/ , last accessed on May 15th, 2018

were. We developed our initial pilot prototype using a software called “Panotour Pro”[13], which can quickly and easily create interactive, but simple 360 degree tours that can be published on a website.

6.7.2. Prototype Development

In order to create the tour, first a few 360 degree pictures were taken at Linnégatan. We then created two versions of a virtual tour of Linnégatan. One using open source [14]Forge.js and the other using a paid software Panotour Pro. Two versions were created in order to evaluate the platforms, but both versions looked visually the same. Since having a web based virtual tour is just a first step towards creating an immersive tour, we evaluated both platforms on the bases of being efficient in terms of creating a quick prototype. While Forge.js gives more freedom, it takes more time to code. Panotour Pro on the other hand has some limitations but it was great at rapid prototyping. We then added old pictures, animated information about a building, web content and visualisation of traffic data of cars and trams using Panotour Pro.

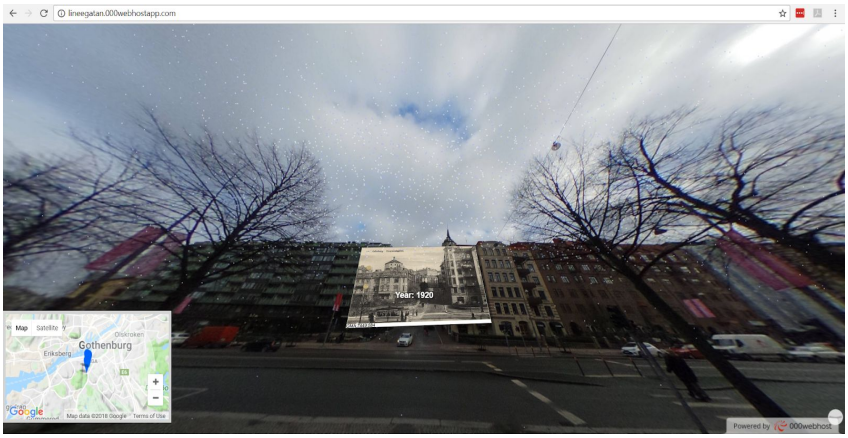

Figure 6.6: “360 photo as part of virtual tour at Linnégatan, Djupedalsgatan ”

[13] http://www.kolor.com/panotour/
[14] https://forgejs.org/

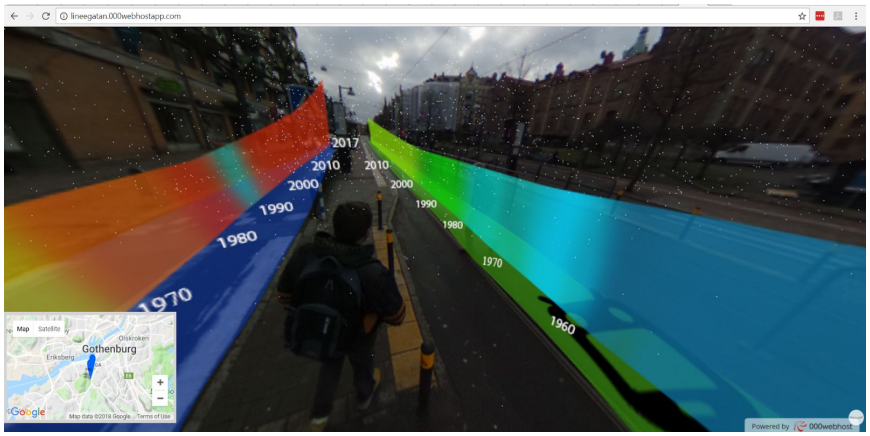

Figure 6.7: "A possible way of visualising traffic density data for cars and trams"

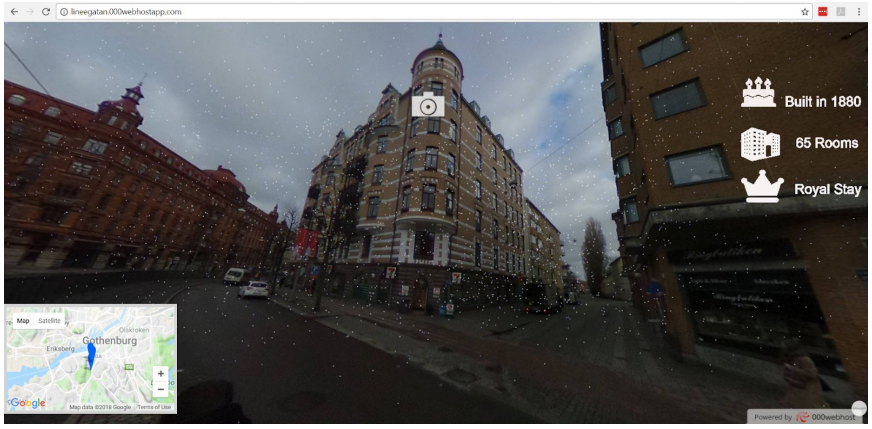

Figure 6.8: "Animated information about a building, an example of storytelling in early stage of prototype "

However, we soon found out that the Panotour Pro tool was cripplingly limited when it came to implementing the tours in VR and that Forge.js just simply took too long to show results. We needed new options, and the next best thing was the Unity Engine[15]. With Unity, we were able to create interactive 360 tours both in mobile VR and on desktop with all the interactivity intact (developed in the second iteration).

6.7.3. User Tests

After showing our pilot prototype in Panotour Pro to five (Appendix reference), including a demo of it with members from Cybercom Group[16], the Gothenburg Traffic Agency[17] and the Building Administration Agency[18] in Gothenburg, Sweden, we had received initial feedback that

[15] https://unity3d.com/
[16] https://www.cybercom.com/
[17] https://www.goteborg.se/trafikkontoret
[18] https://www.goteborg.se/wps/portal?uri=gbglnk%3A201632020213512

it was an interesting concept and definitely needed to be explored further. With our initial prototype in mind and the feedback from the meeting, we set out to get more information on what people would want out of a system like ours. That meant we needed to establish concrete target groups and set goals for our prototypes. We followed the approach suggested by Wadsworth and Yoland (1997) of just talking to people .

6.7.4. User Test Analysis

We conducted 4 unstructured interviews with people within the industry, students and random adults (Appendix B). We were lead to conclude that our focus user group will consist of people aged 25-60. This age group will be subdivided into two more groups, 25-40 and 41-60. The reason to do so is that through our design we want to get the younger group interested in the history of the street and, as a secondary effect, make them more aware of the benefits of smart urban planning and its effects on the city. The age group that is between 25 and 40 years old is more suitable to test an upcoming technology like immersive virtual reality that we intend to use in the project. However, we want to include the older age group in order for them to guide us in designing a system that is able to bring back memories. Unfortunately we were unable to receive initial feedback from the older age group. The initial feedback from the group that is between 25 and 40 years old was gathered in the form of unstructured interviews (Appendix A). This interviews session was then analysed using the thematic user interview analysis (Braun, V. et al. 2006 & Blandford, A. 2016). Thematic interview analysis resulted in a set of modes that identified the desired platforms and modes of showing the history (Appendix C). The important findings from that session are mentioned below:

- People regard hygiene highly when using objects available for public use: if the headset was used in a public setting, it needed to be either wiped after each use or to make sure there are disposable paper towels for the next person to use.

- Participants were generally excited with the concept of VR, however 4 out of 5 then suggested that the concept seemed more fitting for an Augmented Reality (AR) experience. Given the additional questions of "*How likely are you to use your smartphone in public, to view unknown buildings in AR?*", coupled with "*How likely are you to pre-download an application for a specific AR street experience?*", people quickly came to the conclusion that they would not be very inclined to go through all the steps, just to view extra information about a building. Further supporting our initial idea that the experience we are creating is best suited in a museum setting, where people would be much more interested in experiencing it and comes without any preparation on the user's part.

- Potential users reported they might feel hesitant to use a VR headset in public due to fear of looking foolish. This is a concern we felt would subside once users see others using the system. Or, alternatively, provide users with a small room where they can explore by themselves.

The initial user studies provided us with some overall points to consider when designing a VR experience in a public setting and that indeed, a VR experience is the right way to go with our concept in mind, but we also needed to think about the content of the experience - what's interesting and engaging?

6.8 Second Iteration

The second iteration increased the fidelity of the prototype, now in an actual head-mounted display, using a mobile device.

6.8.1. Idea Generation

After establishing target groups and a goal, we recreated our initial Panotour Pro tour into a 360 VR tour experience in Unity, for more interactivity and more creative freedom on our part.

Our first true VR experience prototype did not have much content, but aimed to display the capabilities of the Unity Engine. We decided to introduce different modes of interactions, to get a better feel for what users find natural (immersive) and what they find out of place. We also used a mind-mapping[19] brainstorming technique during the ideation phase to come up with potential future content (Figure 6.9).

[19] Mind-Mapping brainstorming technique:
https://www.adelaide.edu.au/writingcentre/docs/learningguide-mindmapping.pdf

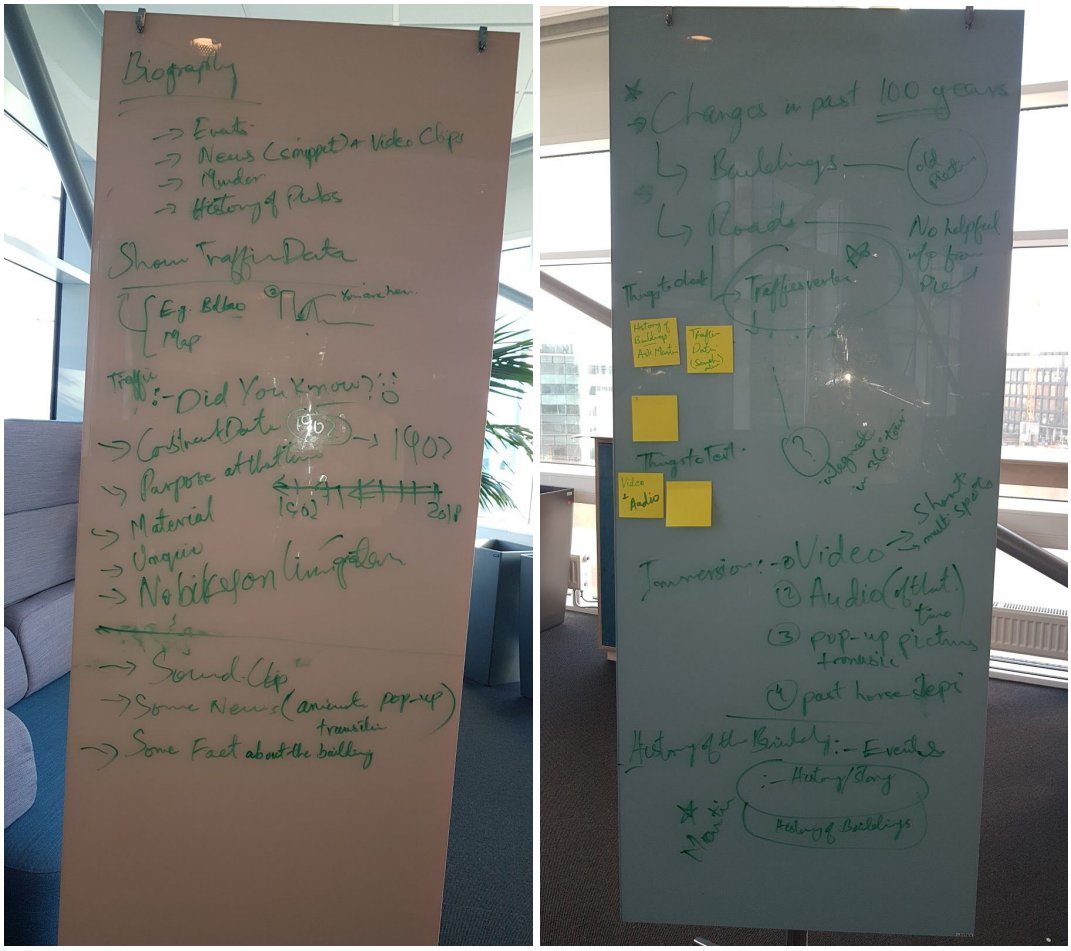

Figure 6.9: Mind-mapping brainstorming session

6.8.2. Prototype Development

The information sign, the text on the wall and the tram sprite in Figure 6.10 are the three types of interactions that we created and tested out. Additionally, we followed the UX guidelines for GUIs in VR by Fröjdman (2016) by making sure we included gaze interactions and feedback (progress bar, Figure 6.11), a target reticle in the middle - so the users know where they are pointing at, and placing interactive objects at a comfortable length. We also made sure the objects were within comfortable head movement, as suggested by Alger (2015a).

What the prototype offered in terms of content was:

- A very simple 3D Model space, accessed by looking at the text on the building. This was to show users what a 3D environment feels like in VR and it provided ways of displaying rich media for a particular spot in the tour, provided there was enough information and assets for the location.

- Teleporting the user from one street to the next, this was to test the users' sensitivity to motion sickness, it also allowed us to explore different modes of transporting the user around the experience.
- Providing the user with information in the form of floating text next to a building, via looking into the information icon. This aimed to receive feedback on the modes of information the users would like to experience.

Figure 6.10: Initial Unity VR prototype

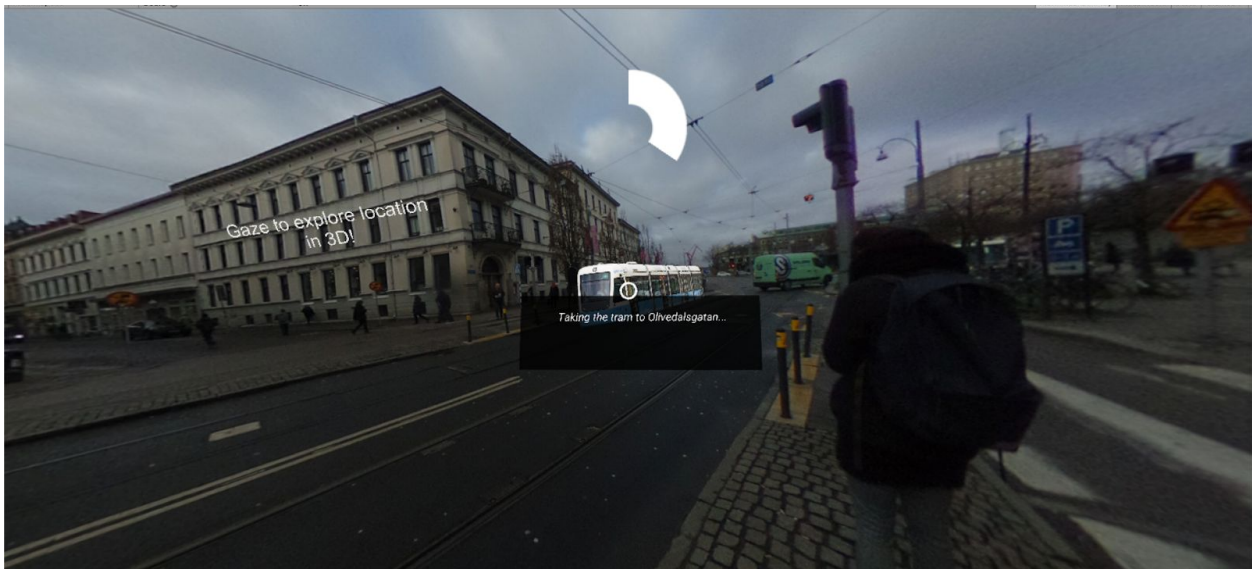

Figure 6.11: Interactions within the experience. The user is looking at the tram and it's "transporting them" to a new location within the tour, when the progress circle at the top completes.

6.8.3. User Tests

We next tested the prototype, with a Gear VR headset and a Samsung phone in it, with 5 individuals. 2 of the participants had previous VR experience and they were all between 23 and 35 years old. The tests and prototype content was aimed at an average of 3-5 minute experience. They were encouraged to think out loud to give us as much feedback as possible. We were mainly testing for motion sickness and overall feel of the experience. They were instructed to visit the 3D space, return and look check the building for more information, and finally take the tram to a new location. After the test was completed we asked additional questions, in the form of an informal interview, which probed into finding out where, when or how they would like to use a system like this.

6.7.4. User Test Analysis

The summary of the testing (Appendix E) was:

- No motion sickness experienced in any of the participants.
- The experience felt novel and unique, due to the interactions and especially because of the 3D Model world-space.
- Participants felt unmotivated to explore on their own, they felt like they needed a goal.
- 2 Users suggested that this prototype would not interest them on its own, but if it was a part of a bigger application (e.g. Google Maps, Tourist application) that they would definitely be more inclined to use it.
- Quality of the pictures was low.
- Think about adding a voice that reads for the user.

Based on feedback from the testing session (in particular the feedback about the lack of a goal) we refined the prototype further, adding an option for the user to make changes in history, since the main con of our experience was that it had been lacking a direction or a goal. If the users were introduced to decision making, they would have to consciously interact and engage with the prototype, giving them a sense of purpose. As described by Rosenfield (2002), "*The presentist character of alternate histories allows them to shed light upon the evolving place of various*

historical events in the collective memory of a given society". The concept of introducing alternate history to factual historical events, and then providing users with the visual aftermath of the alternate history events will strengthen the memory of the given event (Rosenfield, 2002).

We also received other ideas for giving the tour a goal or direction by gamifying it. Some users suggested that we hide easter eggs in the tour and give users some hints so that they go around looking for clues and find the eggs. However we did not proceed with this idea because users also suggested that they might get too involved in chasing the goal and will miss the point about the history. Thus we skipped the gamification and stayed with playful experience by letting the play with the history. We chose to change the en´vents that have already happened by choosing to not let them happen instead of introducing something completely new because its comparatively easy to take out a something from the history than to add somethings new. We do understand that the implications of both variations are complicated but we found the earlier one comparatively simpler.

Fokkinga & Desmet (2013)'s framework for designing for rich experiences helped us to outline the information and visuals that our prototype should contain to elicit emotions. Typically negative emotions leave a lasting impression on the user, which would help them better reflect on their experience (Fokkinga & Desmet, 2013).

If our experience was supposed to induce a feeling of longing and sadness of bygone days, of dreaming of what the future could be - if something in the past didn't happen the way it did - then our content needed to fit with the rich quality of "The Unreachable". Why would we want to elicit such emotions? At their base, they are negative and thus, as mentioned previously, tend to leave a more lasting impression. "The Unreachable" quality is described as where people see an object or a scene that makes them experience dreaminess - "*a calm state of introspection and thoughtfulness*" (Fokkinga & Desmet, 2013). In order to provide this state, our prototype employed a "control frame", also explained by Fokking & Desmet (2013), where users are given varying degrees of control in their interactions within the experience. We used this to ensure users could guide their journey and what they saw or heard was because *they* wanted to do it, that way, they can feel the weight of their decisions and consequences of said decisions.

 **The unreachable**	A bittersweet desire for something that is currently or permanently out of reach.	**Longing**: To experience a strong and painful desire for someone or something that is out of reach **Dreaminess**: To enjoy a calm state of introspection and thoughtfulness	*Profoundly desirable* People perceive an object or event as more deeply desirable and significant – as something worth investing time in.	*Dreamily passionate* People become more passionate about an object or event, but in a passive, dreamily way.	*Inaccessible object or concept* e.g., an inaccessible object (e.g., an expensive sports car, the unobtainable piece of a collection), environment (e.g., home, an exotic place), event (e.g., being with a certain person, longing back to one's own childhood), a missed opportunity, etc.	- Control frame *(and/or)* - Detachment frame

Figure 6.12: Fokkinga & Desmet (2013)'s Unreachable rich quality description.

To further help us ideate on how to elicit feelings and emotions from users, The "Playful Experiences Cards" (PLEX) cards and their usage, outlined by Lucero et al. (2014), were a suitable tool to use. The PLEX cards that were used in the following prototypes and what best matched our goals were the cards for "Discovery", "Exploration" and "Simulation" (Figure 6.7.1). We have incorporated these design guidelines in our prototypes. Discovery - where users found something new or unknown, exploration - users investigated objects or situations and simulation - where everyday life was simulated, no matter what point in history or present it was.

Figure 6.13: The PLEX cards for Discovery, Exploration and Simulation (Lucero et al., 2014)

With the feedback gathered from the second iteration, the rich experiences framework (Fokkinga & Desmet, 2013), and the PLEX cards (Lucero et al., 2014), we started work on the "Alternate History Concept", which is discussed more in depth in the 7th and 8th section of the report and is ideated and tested upon in the next iteration.

6.9 Third iteration

The third iteration was used as a pilot for our "Alternate History Concept" and increased the overall fidelity by adding new interactive content and media.

6.9.1. Idea Generation

Our core views on what the prototype should do and convey stayed the same, but with the help from the feedback from the last testing sessions, we looked to existing VR applications and Unity assets on their store page to see what people were finding attractive (i.e. paid money for and rated highly). We brainstormed and discussed ideas for how the "Alternate History Concept" should be executed. (Figure 6.14).

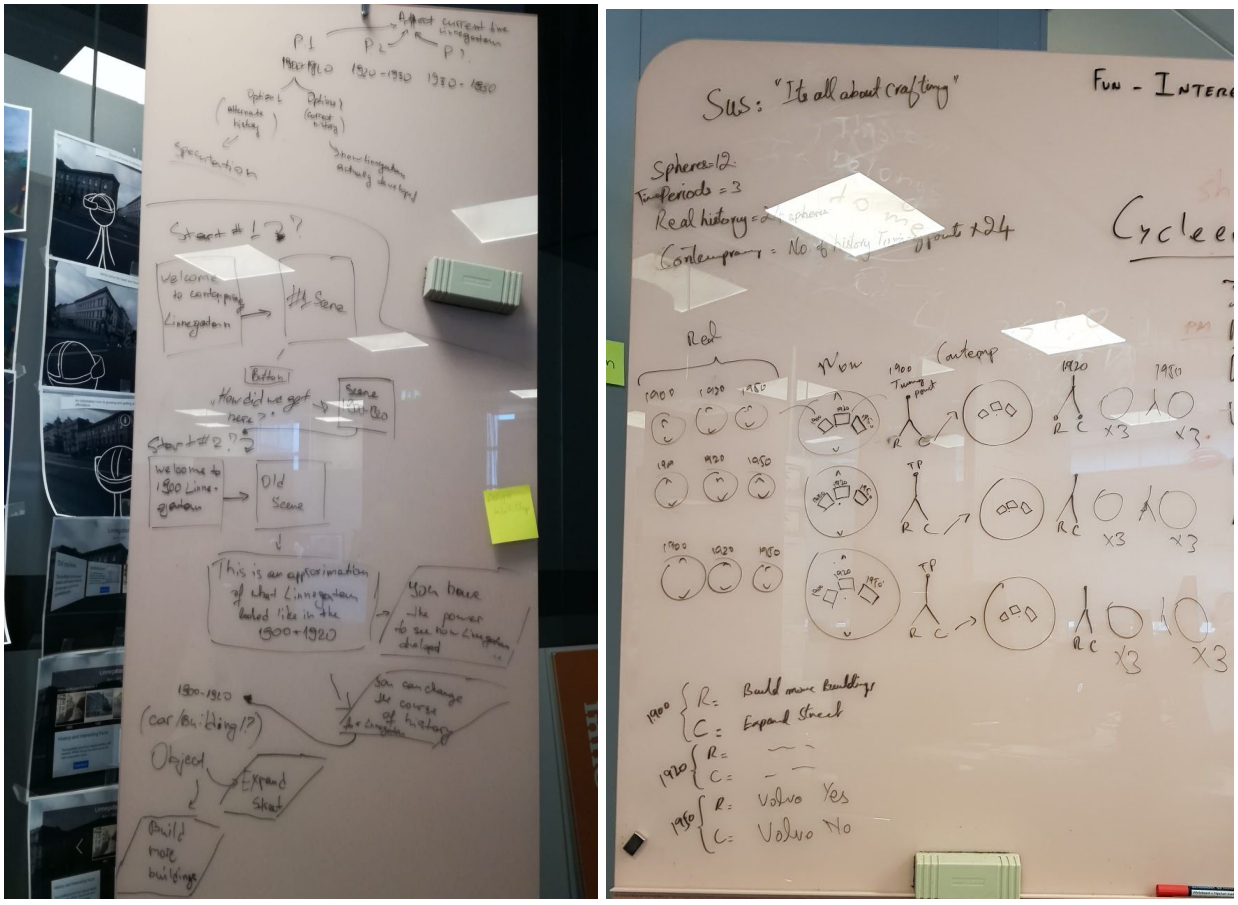

Figure 6.14: Alternate History Concept brainstorming session results and process

6.9.2. Prototype Development

The third iteration of the prototype expanded greatly in terms of content. From being able to only go between two street intersections across the length of Linnégatan, users could now freely move between 12 intersections, encompassing the whole street. New, higher quality 360 degree photos

were taken and used in the prototype. Our initial photos were of a 1920x1080 pixel resolution, which results in an actual 640 x 320 80s-era computer monitor resolution, when users look at them with a head-mounted display (Redohl, 2017). Hence, our newest pictures had a resolution of 3840 x 2160, which would translate to what users are typically used to seeing on their current computer monitors (1920x1080).

Next we added slight and subtle animations to interactive objects, to make sure users knew they could interact with them. The animations consisted of the objects pulsating slowly (expanding and shrinking in size, based on a looped time). Ambient sounds were added to the streets and music was added to the screen that showed Linnégatan during the 1900s. The music and sounds were selected to be time-appropriate. Voice overs, using a text-to-speech program, explaining what the users were doing was also introduced, as a test to see whether text and audio would work together, due to a suggestion from the previous test.

The spot chosen to show the past was Olivedalsgatan, due to sufficient accurate historical material that we had found, from the city archives[20]. In order to bring the historical photos into VR, we used Adobe Photoshop[21] to greyscale the photo, remove all vehicles, transform people and the location to look like they belonged in the 1900s - by using the 360 degree photos we took of the current Olivedalsgatan as a base.

Finally we introduced our alternate history concept in the form of an interactive "Time Machine" object, that when interacted with, provided users with a choice to either change history, or just witness history as it happened (Figure 6.15). The idea was to give the users a choice, so that they could perhaps see how the street first looked like in the past, and then maybe be inclined to tamper with history. When in the 1900s view of Olivedalsgatan, users were given information about the state of the street via newspapers. The newspapers themselves could then be interacted with in order for the user to choose either not to build a bike lane and see the effects of that decision in the future, or choose not to build tram lines and see the outcome of that.

[20] https://riksarkivet.se/goteborg Last Accessed 22th May, 2018.
[21] https://www.adobe.com/se/products/photoshop.html

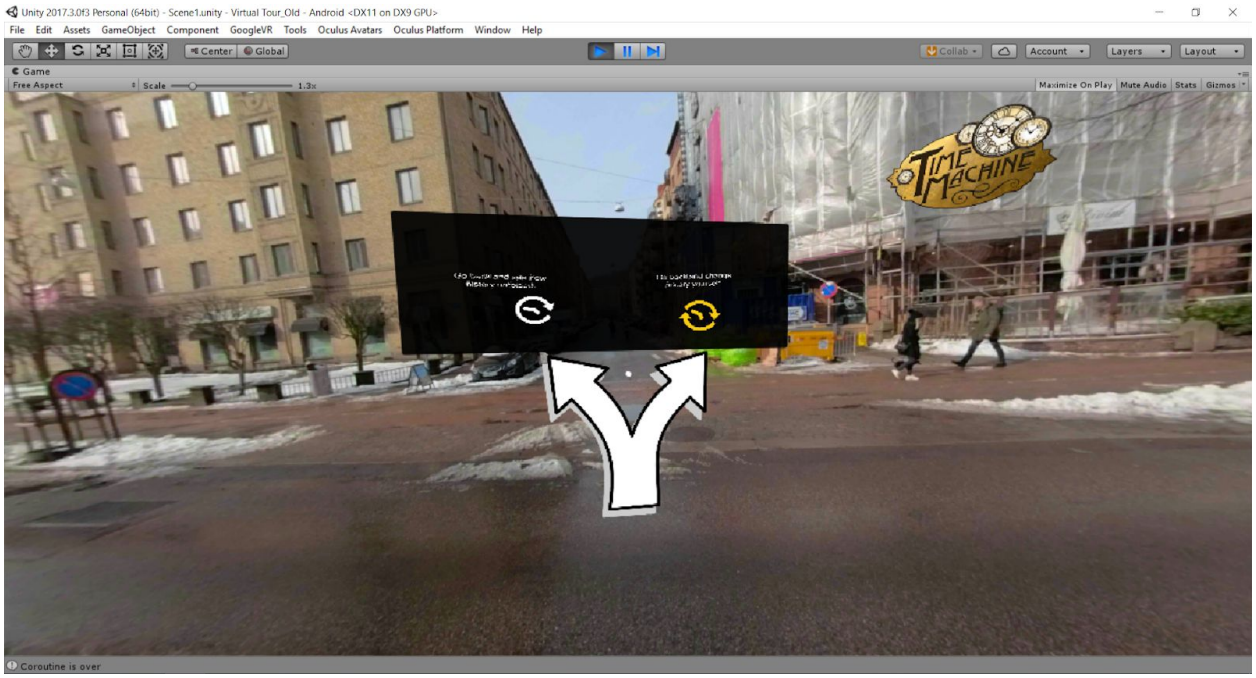

Figure 6.15: Users can make a choice to see history as it happened or they can tamper with historical events.

6.9.3. User Tests

Our testing session consisted of 4 new individuals, who were randomly selected, but within our younger target group. The testers had not previously experienced Virtual Reality. The content and tests were intended to be done in no more than 10 minutes. This test focused on evaluating methods of immersion. Feedback was received in 3 major areas, via a questionnaire (Appendix F) in the end - user interface, tools of immersion (voice overs, sounds, music, etc.) and finally the takeaway (did they consider good city planning and its results after experiencing our prototype?). Users were told to explore the “Time Machine”, but otherwise were given freedom to explore on their own accord.

6.9.4. User Test Analysis

The outcome of the test is summarized as:

- Users felt immersed in the system.
- The UI was intuitive and easy to navigate and use.

- Most said that they were much more interested in historical events in their city after having the VR experience.

- Sounds and music were main components of users' immersion in the system.

- Voice overs, provided by text-to-speech were regarded as annoying, unnecessary and broke users' immersion. This could be due to the text-to-speech quality or just due to it feeling unnecessary.

- None of the users read and understood the concept of alternate history, they did not understand what they were changing and the information provided via newspapers was generally ignored. Hence, users did not feel like the prototype had anything to do with raising awareness of the importance of good urban planning.

- Apart from Olivedalsgatan, every other intersection of the street felt empty and neglected in terms of content.

- Good urban planning became obvious to the users only after they were asked about it, they did not consider it while testing.

After receiving both positive and negative results (Appendix G) from the test, we set out to fix issues and annoyances, and add new functionalities that aimed to further increase immersion and focus on the takeaway message of the prototype.

6.10 Fourth iteration

The fourth iteration refines the "Alternate History Concept" and takes the fidelity of the prototype almost to its final vision, adding multimedia content to almost every place in the virtual tour and making time travel and spatial navigation possible.

6.10.1. Idea Generation

For the final prototype (of course, you can never truly be satisfied with your prototypes, but the word "final" here is in terms of time constraints) we needed to come up with a lot more interactions in order for the product to feel less empty and more engaging - perfect opportunity to utilize the old historical photos we had previously found in our pre-study. We also came up with different ideas for users to realize the weight of their decisions when it came to the alternate history interactions, by taking cues from other entertainment mediums such as video games. For

example, we transport the users to an entirely new area, with distinct music to show them that what's happening is important and they should be paying attention. (Figure 6.16)

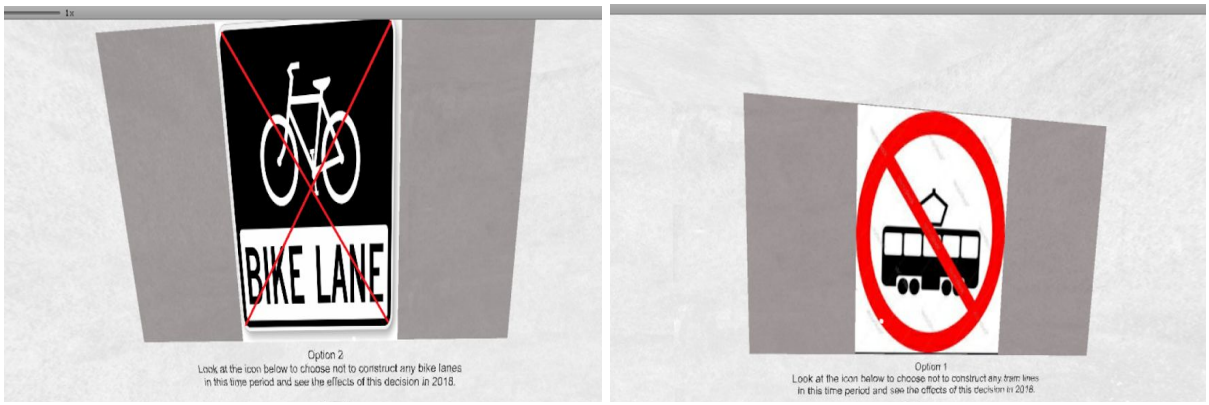

Figure 6.16: New environment where users are meant to make decisions

6.10.2. Prototype Development

The final prototype added some piece of content to 10 out of 12 intersections in the form of interactive photos and videos, historical and traffic information, as well as information about upcoming popular events in some hotspots on the street. (Figure 6.17)

Figure 6.17: Examples of new interactive rich media. Video introduced in an immersive way via an old TV (left). Old picture of the same building in the 1900s, to make comparisons (right)

A new navigation system was introduced (Figure 6.18), where users could travel freely in both time periods (from 1900 to 2000, in 20 year intervals) and places. This was done by utilizing the Adobe Photoshop technique that was used in the third iteration, albeit in much less detail, due to resource and time constraints. Time-appropriate music and ambient sounds were present for every time period of Olivedalsgatan (intended for all time periods of all intersection, not implemented due to time and resource constraints).

The alternate history component was redesigned. Making a choice that changes history is made more impactful with the use of sounds, music and an entirely new room where users make their

choice, in order for them to have the time to absorb and feel the agency of their decision. A more complete version of the final prototype is presented in section 8. Biography of a Street.

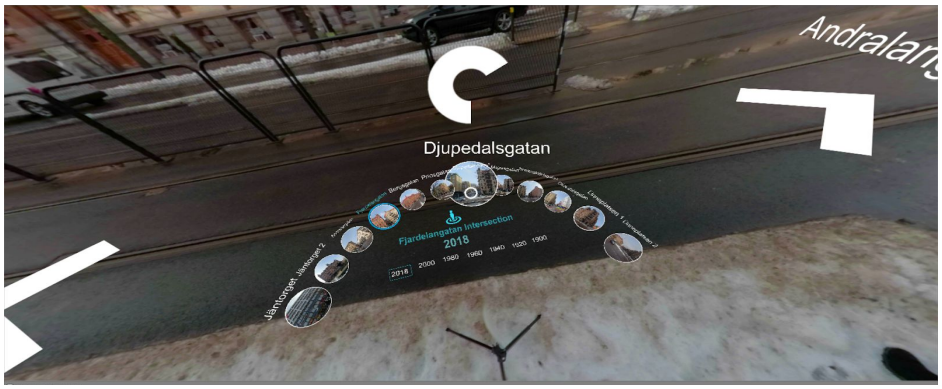

Figure 6.18: Navigation system: users can select time period of their current street at the bottom. They can jump between different street corners using the circular images.

6.10.3. User Tests

The new setup that we had (Figure 6.19) allowed us to better see what users were experiencing and we were more able to navigate them during the experience, if necessary.

Figure 6.19: Testing setup, laptop shows what the test subject sees.

Finally, one last test was performed. There were 3 returning test subjects from our second iteration, and 5 new test subjects, who were not experienced in virtual reality. The tests had a minimum test time of 10 minutes, and participants were allowed to continue to explore if they

wished to do so. The increase in time between iterations was to determine if motion sickness would appear with extended use of the system.
This time, we gave no strict directions. After the test, they were given a questionnaire that pertained to finding out their impressions on the user interface, immersion and overall feel of the prototype. In addition, they were asked to provide any additional feedback for improvements, things that they felt did not belong in the prototype, or things that were missing from it. The reason for coming back to old test subjects was to measure their perception of overall prototype improvement or its decline, compared to the iteration that they experienced.

After these tests were conducted and then analysed, an unexpected opportunity opened up - we got a chance to present our prototype at Gothenburg Tech week[22]. Due to the spontaneity of the event we were not prepared to explicitly gather data in a controlled environment and we did not have the opportunity to properly conduct an interview after the users had tried the prototype. However, we still received some valuable insights, which are discussed in the 9. Discussion section. There were a total of 21 participants, ranging from 25 to 60 years old with various technological backgrounds.

6.10.4. User Test Analysis

Our final round of feedback yielded that:

- Overall users felt immersed in the system (average score of 3.71 out of 5).
- 6 out of 7 participants noted sounds and music as being the top reason for immersion.
- Since lower resolution images were used when showing older time periods, people lost their sense of immersion when experiencing them.
- Old interactive pictures were pointed out as being the best reward for exploration.
- Curiosity was the most experienced emotion during the test.
- With an average score of 4.28 out of 5, users agreed that, overall, the experience provided an adequate biography of a street.
- Most of the users found the UI responsive, understandable and easy to use, but were only slightly better than neutral (a score of 3.42 out of 5) when it came to an immersive UI.

[22] Gothenburg Tech week: https://gbgtechweek.com/

- Navigation menu felt confusing since years were visually (but not intentionally) corresponding to streets.

- Placement of navigation UI was not desirable.

- People felt like the prototype could benefit from the use of controllers, in addition to the gaze interactions.

- Some of the gaze interactions felt too slow for experienced users.

More detailed analysis of the responses from the questionnaire that was used to assess our final prototype can be found in Appendix H. More in depth analysis is provided in Appendix I and J. Our main findings after all four iterations are presented in the next section: 7. Results: Design Guidelines.

7. Results: Design Guidelines

This study aimed at finding out the best possible way of showing history of a street. By exploring the history of a street, many factors get highlighted such as urban planning, the mobility patterns, historical landmarks and socio economic trends over a long period of time. As a result of the research process, we are able to deduce the guidelines for designing such an experience that could highlight aforementioned factors. These guidelines are meant to help a designer create an engaging experience to showcase the history in a critical manner.

We used virtual tour design guidelines by Perez' (2015) as a base to create the historic virtual tour and expand on those guidelines. With the help of iterative prototyping and user interviews, we were able to identify some key elements that should be kept in mind while designing virtual tours and reflective thinking about the urban planning. These elements got highlighted while we searched for a way to design an experience that could engage the users. The below mentioned areas are not where we were actively looking for guidelines but instead they got emerged along the way while designing engaging experience that could also highlight the importance of urban planning. The design guidelines cover six major areas:

1. Platform Selection
2. Location of Exhibition
3. Interactive Content
4. User Interface

5. Participatory Narratives
6. Guidance and Support

The guidelines are mentioned below and their details follow in the chapter.

- Choose the technology Platform depending on how the target audience should be reached
- The system that aims to raise awareness or instigate interest should be easily accessible
- Virtual tours are interesting if there is plenty of informative content to interact with
- Simple Gaze based interactions work best for a virtual tour system displayed in a public setting
- The interactive content in a virtual tour environment must have clear affordances
- Give the user enough time to take a decision in a gaze based interaction environment by providing a progress bar
- The gestalt law of proximity still applies when designing a navigational menu for time and space
- Virtual Tours are engaging if they have participatory narratives
- Help the users by introducing the method of interaction and what to expect from the virtual tour

7.1. **Choose the technology platform depending on how the target audience should be reached**

The first session of interviews along with the first prototype evaluation gave us ideas on how the audience would prefer to view the historical information. The answers were mixed. Some people wanted to use their phones while walking in the city, some were not interested in history at all so they preferred a museum setting where they will be willing to try out a historic experience because of the relevance to the surroundings. Some wanted Sci-Fi inspired solutions that are powerful enough to show everything in Augmented Reality (Appendix). However their suggestions did not match with their willingness to try out the platform if they were presented with the opportunity (Turner et al., 2008). The reason is that the experience offered by a system or product greatly depends on the context in which it is being used, it is known as contextual user experience design (Obrist et al.). As discussed by Obrist et al., the user interface design of a product is influenced by the context in which the product is being used. The user's emotions and circumstances along with spatial and temporal characteristics of the product are few of many factors that influence the user experience. In their study, they characterized various contexts like 'Context Home', 'Context Car', 'Context Shopping' etc. Similarly, we are convinced that

‘Context museum’ is a suitable context to design for in order to achieve the goal of capturing and retaining user’s attention towards historical content.

In order to visualise and demonstrate the vision of the system, we created a user scenario that helped us identify the important elements of the system and helped us communicate the context in which the system is utilised the best.

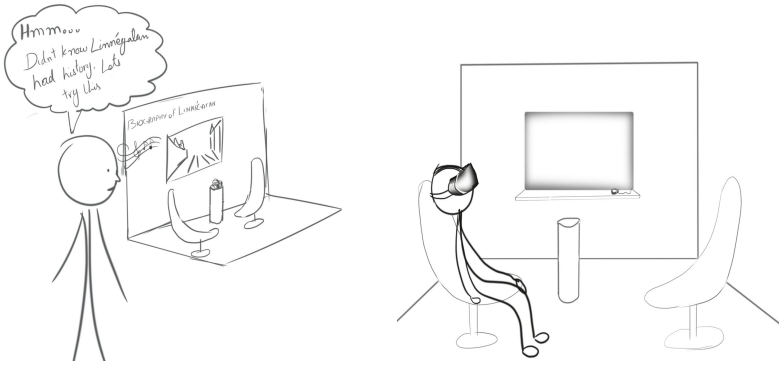

Figure 7.1: User Scenario; User sees the explanatory video in a museum exhibition and proceeds to interact with it

This concept provides a way to attract the users. The screen displays what the VR experience has to offer. It will recommend the user to try on the VR headset placed next to the screen for a better and immersive experience. The combination of both of these technologies makes the system an attraction that gets the audience intrigued. The virtual reality headset proved to be a platform that would attract the attention of most of the audience that we interviewed. The reason for such high acceptance of VR for historical applications was that it lets the user be part of the time and place they get to visit in the virtual reality.

When the prototype was displayed at the Gothenburg Tech Week, we found out that if a user was trying out the prototype and other could see what he is seeing on the screen, it attracted more audience and the experience became a collaborative experience. Thus the recommended way is to have an introductory video and a screen that shows what the user is seeing.

7.2. **The system that aims to raise awareness or instigate interest should be easily accessible**

Several ideas were presented and discussed about the best platform to showcase the project in order to reach the audience, however two places/platforms were evaluated in detail which are discussed below.

7.2.1. App Store

Like mobile applications, there are app stores for VR applications like WITHIN, Cardboard and Oculus. In order to reach maximum number of audience, app store would be a great place. However, since the project is about history, the majority of users who are already interested in the history are elderly. The VR app store being a new platform does not have a good number of user base of history lovers. The AR and VR device owners and users are aged below 35 (statista, 2017). In the light of interviews, we are convinced that the young user base of the AR, VR platform not willing enough to try out the historical applications at home.

7.2.2. Museum

Museums are well known for showcasing history in an engaging way by displaying the historic artifacts. When visiting the museums, users turn into explorers and visit every artifact with an inviting mind for new information. Museums specialise in displaying content in order to capture the attention of visitors. As mentioned by Devine et al. (2018) technology is being improved continuously and its creating new opportunities for the museums to attract new audience. With museums getting better equipped with technology they seem to be the most suitable places to display a project about history. This idea was also confirmed by the user interviews. Users who were interviewed said that they would only try out the Biography of the Street if it is displayed at a museum or a similar exhibition.

7.3. Virtual tours are interesting if there is plenty of informative content to interact with

The main aim of the project was to find a way to present the historical artifacts. These artifacts included old photographs, documents, urban development decisions and planning diagrams of the buildings.

7.3.1. Photographs

Our study highlighted that users were most interested in the historic artifacts if they were easy to compare. For example, if the old photographs were presented in a 'Then and Now' way of comparison, they provided a better context and they were more interesting than being presented on their own.

7.3.2. Historical Documents

Similarly the documents containing important decisions will hold less interest for the audience as compared to narration the purpose of those decisions. We prototyped the decision of building tram line and bike lane at Linnégatan, how the street looked like before they were built, what was the effect of building those and how could it affect the present if they were not built. In other

words, an experience will be truly engaging if the historical information was used as a script to create the reflective experience of the past.

The historical documents also contain information about the buildings. This information can consist of the year the building was built in, interesting facts about the building and how was it used. Keeping in mind the Gestalt law of proximity (Cooper, 2014), this information was made available on demand when the user looked at the information icon (i) placed on the building.

7.3.3. Sound

The feeling of being at a place will involve all the human senses, sight, sound, temperature and smell. The VR can achieve two of these so far, sight and sound. Having the ambience sound of horse steps was widely appreciated by the test users. The sound was equipped with stereo effect which resulted in increase or decrease of the level of sound when the user turns head, it feels more natural. The sound of traffic and chattering are examples of other types of sounds that we used to achieve a better level of immersion.

Overall, more content in a scene is appreciated by the users as it keeps the engagement levels high. However, the scene must not be crowded with a lot of content as it takes away the attention from the scene itself.

7.4. Interface Guidelines

The virtual reality applications consist of two main components namely, the virtual environment and the interface. The interfaces in the Virtual reality environment are mainly based on controller interactions. Usually when the button on the controller is triggered, a menu pops up which contains the Graphical user interface and the subcomponents of the interface. This interface normally consists of at least two levels of menus. The main difference between the regular 2D menus and the 3D or Virtual reality menus is that the can be presented in 3 dimension. Which creates more ways of presenting the interface. Generally the VR applications contain a curved menu which pops up when the user interacts with the controller.

7.4.1. Simple Gaze based interactions work best for a virtual tour system displayed in a public setting

For this project we abstained from using a VR hand held controller as our interviews and first prototype evaluations showed that the gaze based interaction was intuitive and users did not feel

the need of having the controller. Some users even stated that having a controller would have made the interactions complicated.

As the project was being developed for public place that is museum, the audience would comprise of all ages. Such a large group would consist of people with varied experience of the VR technology. It presents its own challenges and opportunities. The visitors might have quite a lot of experience with the VR technology or this project might be their first experience with VR. In order to facilitate both extremes, the simplest and most intuitive interaction mode was used. The gaze based interactions are easy and intuitive. The need of having a controller is eliminated if the interface is designed in such a way that it works well with the gaze.

7.4.2. The interactive content in a virtual tour environment must have clear affordances

The prototype testing provided with the insight about the gaze based interactions. First, the interactive objects must have affordance. A virtual environment where everything is colorful, using certain colors to highlight the object's affordance will go unnoticed. The study found out that motion was a good way of showing affordance. The interactive objects had pulsing animation, which made them stand out in the virtual environment and clearly showed the affordance. Such interactive objects were used as hotspots, menu items and multimedia holders. The user would look at the object and it would open the multimedia content. However, in order to close the media user had to look at the icon again which was not intuitive and the users highlighted this issue. Thus the design should follow the industry standards for UI and add a cross button at the top right corner of the media whether it be a chart, photo or a video.

7.4.3.Give the user enough time to take a decision in a gaze based interaction environment by providing a progress bar

If the object was a hotspot, the user would be taken to another point on the street. The interaction model worked well for the multimedia, however in the case of hotspot, the interaction was too fast. Even if they would hover over the object, they would be instantly taken to the new scene. This problem was resolved by adding a time loading spinner. The user looks at the object and the hover text appears which explains what would happen if the interaction is completed. The interaction completion time of 1.5 seconds was sufficient loading time. Further refinement of the prototype resulted in addition of progress bar on each interaction as it also provides a way for the user to take their time to decide and change their mind about completing the interaction, for example if they really want to open a picture or get transported to another location.

Moreover, user interviews highlighted an interesting fact about the interaction with the multimedia content. When the interaction is completed, the multimedia, i.e photos, videos or news open with an animation. This adds to a pleasant experience.

7.4.3. The gestalt law of proximity still applies when designing a navigational menu for time and space

The purpose of having a historical virtual tour is to be able to visit various locations easily, have better accessibility and more freedom while avoiding the hassle of finding the way. In order to facilitate this idea, 2 types of navigations were added, hotspots in the form of arrows bearing the name of the location it leads to and a menu at the bottom. The hotspot can take the user to the adjacent locations only, i.e. forward or backward on the street. The menu at the bottom consisted of all the locations available so that the user can jump between the locations that are not directly connected. This bottom menu was a set of pictures representing the location in the form of circle arranged in an arc. The arc shape at the bottom made it easy to rotate the head for interactions.

Since this tour is spanned over space as well as time travelling, the navigation needs to include both dimensions. This would mean for each point on the street there were several options of time travel. The time travel navigation consisted of interactive text representing the year, aligned in the form of arc. This arc was placed below the location arc.

However, the user testing revealed that the locations arc and years arc were easily confused because they didn't follow the proximity principle. The years corresponded to the different time period of the current location where the user is. However, the users got confused because it seemed as if each year was corresponding to each location on the menu. Thus the years should be aligned so as they are placed closer to the text that shows the current location and year where the user is at the moment. This would mean the location arc is placed at a safe distance from the years. Fig 7.1 a and b shows the confusing and improved 2 dimensional menus respectively.

Fig 7.1(a) Initial 2 dimensional navigation

Fig 7.1(b) The improved menu for 2 dimensional navigation

As the year/time navigation is relevant to the location, the user travels back in time of the location he is currently at and vice versa. For example at Fjardelangatan, if the user goes to the period 1900, he gets to the 1900 Fjardelangatan, however if he is at 1900 Fjardelangatan and chooses to go to Andralangatan, he should reach Andralangatan in 1900. Similarly, if the user is at andralangatan in 1900 and chooses the right arrow (hotspot) that takes him to Jäntorget, he should reach Jäntorget in the 1900 and not in 2018. This result was derived from the user testing because when the users were in the 1900 Fjardelangatan, and chose to go to any other location, they were taken to the 2018 version of that location which was unexpected for the users. Thus the time state should be retained when the location is changed.

7.5. Virtual Tours are engaging if they have participatory narratives

This study aimed at creating an engaging way of showing how the history unfolded and the impact of historical events on today. To know the history is to foresee the future. We used the

same idea in order to highlight the historical events. A time machine object was added to the scene (Fig. 7.2). This time machine will allow changing the history or playing with. As argued by Fokkinga and Desmet (2013), a memorable experience is something out of the ordinary. Our design decision was influenced by Fokkinga's ideas and we aimed at creating an experience that would take the user back in history, let them manipulate the history and then show them the result of their manipulation. The aim was both to make it a memorable experience and make the user reflect on the importance of the urban planning decisions made in the past. It can be argued that predicting the impact of a change in the past on the future cannot be straightforward and simple. If one thing is changed it would impact quite many or possibly everything that happened afterwards, thus what we predict might not be the truth or exact representation of the social and environmental situation. However, exaggerating some facts to spark the interest is mentioned in the guidelines for designing for science centers.

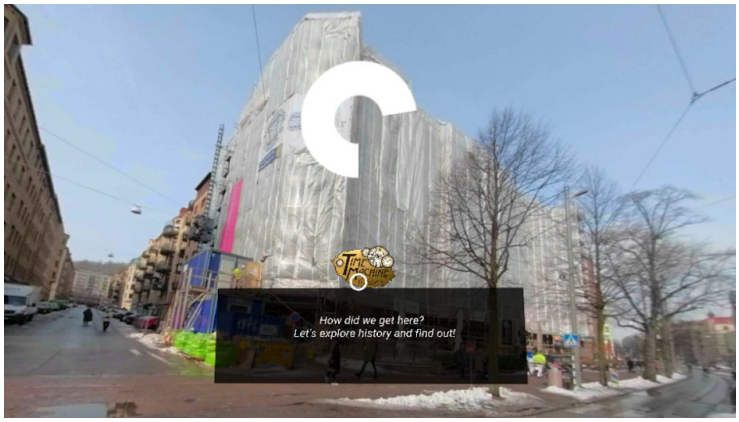

Fig: 7.2 Time Machine Object That takes the user back in time and offers changing the history

The initial design consisted of the same time machine object, clicking on it opened a menu containing 2 choices, 'View as the history unfolded' and 'Go back in time and change the history'. After testing this prototype, an insight was gained about the design which revealed that even though users were making the choice of changing the history, once they got to the changed future, they didn't realise that its a result of a choice they have made. The second iteration for this concept consisted of a white room with choir sounds to give a feeling of 'playing God', this new and changed surrounding should make the user remember and associate this particular environment with making a choice or changing something and have the expectation of seeing different result. The choice making rooms were tested and the users understood the whole concept and appreciated it. They also liked the feeling of playing God, thus it was made part of the final prototype.

7.6. Help the users by introducing the method of interaction and what to expect from the virtual tour

The prototype was tested at various times and in at least two different settings. The first setting was the user testing session which took place at the quite workplace and at the school's calm study room. Users who took part in this setting were first told what do they need to test and what should they do once they are inside the virtual environment. In other words they were guided before entering the virtual environment. Even though they were guided beforehand, in the first go they took a few minutes to figure out what should they do and what objects should they interact with. The second setting was a tech week exhibition where various projects were displayed and were being demonstrated. Our project was displayed at a booth that included a screen that showed the introductory video of the project and infront we had the headset placed on the table. The visitors who were interested in the project were first briefed about the project and then were told to try the prototype by wearing the headset. As compared to the first setting the pre trial guidance for the virtual experience and how to interact with the prototype was minimal. As a result users were spending very little time inside the experience. When inquired about the reason, they said they couldn't find much to do and were reluctant of spending much time.

We then started guiding users about what to do as hints that would help them explore the virtual environment better. As a conclusion, we recommend having a way of guiding the user about the virtual tour.

The guide should include the following.

1. Introduction to the project and its purpose.
2. A tour guide which should include what things should be explored. For example, in the case of Biography of Linnégatan, users should be presented with a map that shows which spots contain what sort of interactive content.
3. A guide about how to interact with the objects and what to do in case of something going wrong and getting unexpected results.

7.7. General Recommendations for VR in Public Spaces

Generally the publicly displayed projects use some kind of medium to communicate the idea of the project, in the form of a poster or a banner. However, as the VR is a comparatively new technology, it should first be introduced to the users to show what should they expect when they try out the headset. As VR takes the user into a virtual world, visually disconnected from the real world, the intimidation of not knowing what to expect should be minimised. A movie of what they will see in the VR is found to be helpful. If the user does not want to try the headset, they

should still be able to interact with the system. So we suggest that a shorter but interactive version should be displayed next to the headset in order to attract the audience and give them an idea about what to expect in the virtual worlds.

The user interviews highlighted an issue of hygiene when it comes to trying out a device that has been put on other people's faces. Some users said they will not try out any other person's headset because the device touches entire face. A female user said she was scared to put the device because she was afraid the makeup on her face with make the headset dirty. The device can also smudge the makeup. When asked, the users said that they will be more willing to put on the device if it have some sort of fresh cover on the device. We suggest and strongly recommend having disposable headset covers for the headset that could be changed for each user.

8. Results: Biography of a Street

In this chapter a suggested design for the 'Biography of a Street' is presented. The design is described by screenshots of the Virtual reality system and explanations of how the system functions. This system can be used as a framework to design an interactive and immersive virtual tour of the history of a street.

8.1. The Tour Locations

The system consists of 12 locations at Linnégatan, named Järntorget 1, Järntorget 2, Andra Långgatan, Fjärde Långgatan, Bergsgatan, Prinsgatan, Djupedalsgatan, Majorsgatan Nordenskiöldsgatan, Olivedalsgatan. Linnéplatsen 1 and Linnéplatsen 2. These locations are intersections of other streets connecting with Linnégatan. The user can navigate between these locations using the bottom navigation, or left and right arrows shown in fig 8.1.

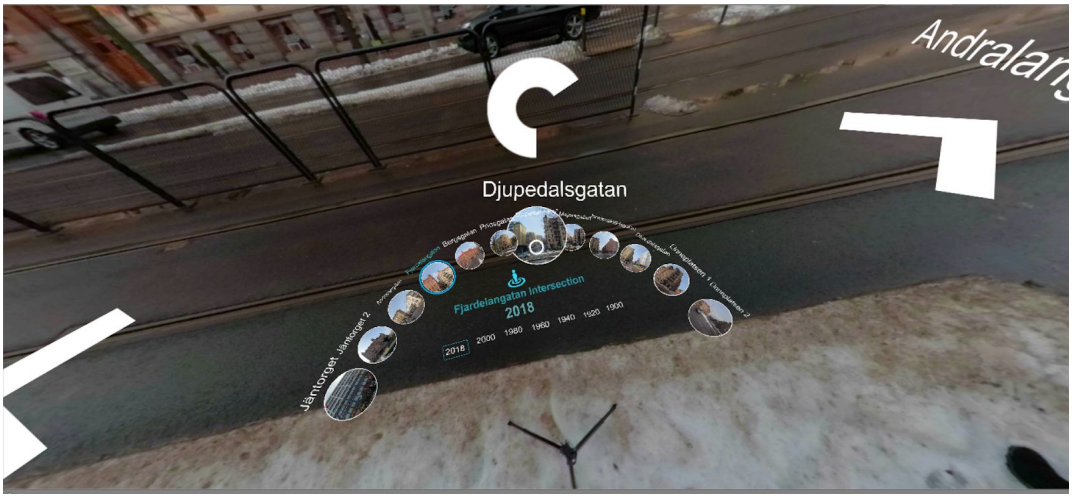

Fig 8.1 Navigation Menu and Navigation Arrows

Every location is a 360° picture wrapped on a sphere and the user is placed inside so it feels like they are at the location where the picture was taken. Every location has interactive multimedia content placed on the buildings. When the user looks at the info icon, the multimedia is opened with an animation.

Olivedalsgatan is one of the twelve locations in the tour which contains slightly more content other than the photos, building information and video. This additional content consists of a news stand and a time machine. Eventually every location on the tour should have all the interactive content that is placed at Olivedalsgatan, but wasn't replicated at the rest of the locations because of the narrow scope of the thesis.

8.2. Multimedia Content

In order to show the past of the street, old photos of Linegatan were placed at the positions where they were originally taken at. This provided a comparison of how much has changed over the years. Fig: 8.2 is an example of such photo.

Fig. 8.2 Old photo of Djupedalsgatan placed at Djupedalsgatan in the virtual tour

The multimedia also included data/interesting information about the buildings (Fig 8.6 (a,b)), video of Järntorget Square from 1960's (fig 8.3) and data about the events going on at Slottsskogen, which is a park located right next to Linnéplatsen and hosts yearly events popular throughout the city of Gothenburg in Sweden.

Fig 8.3 Video of Järntorget from the period of 1960's displayed at the Jäntorget Square in the virtual tour.

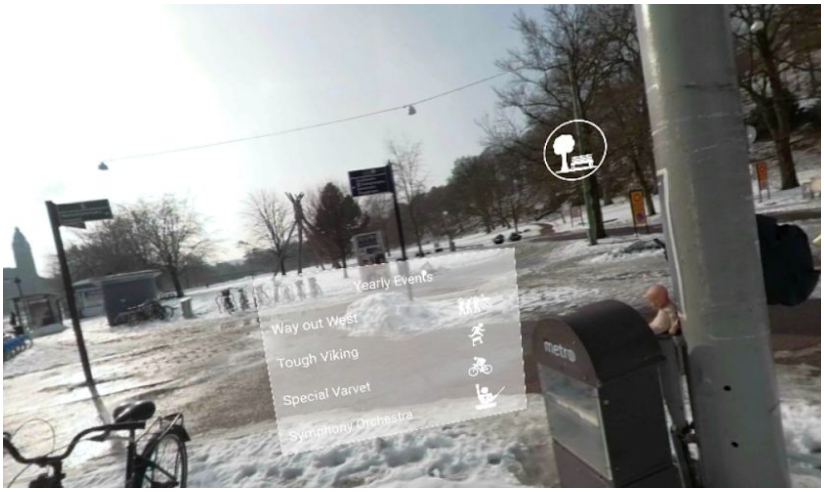

Fig 8.4: Slottskogen Yearly Events

The content also included news for each period. Fig 8.2 (a,b) shows an example of newsstand and news paper that fly out of it. These news contain information about the events that are going on in the respective time periods.

The tour locations also have information about the road usage statistics which include dummy data about the number of horse carts, cars, trams and bikes per day (Fig. 8.4). The horse carts information is only available at the time periods older than 1940.

Fig 8.5 (a)

Fig 8.5 (b)

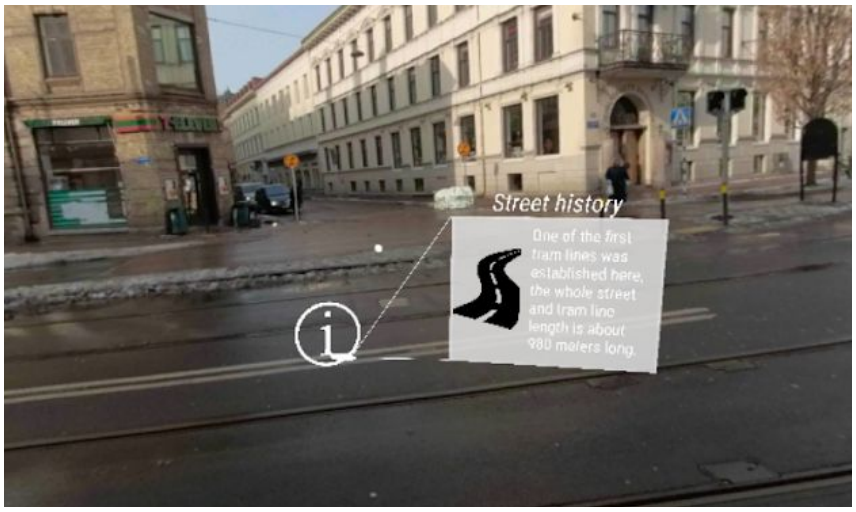

Fig 8.6 (a)

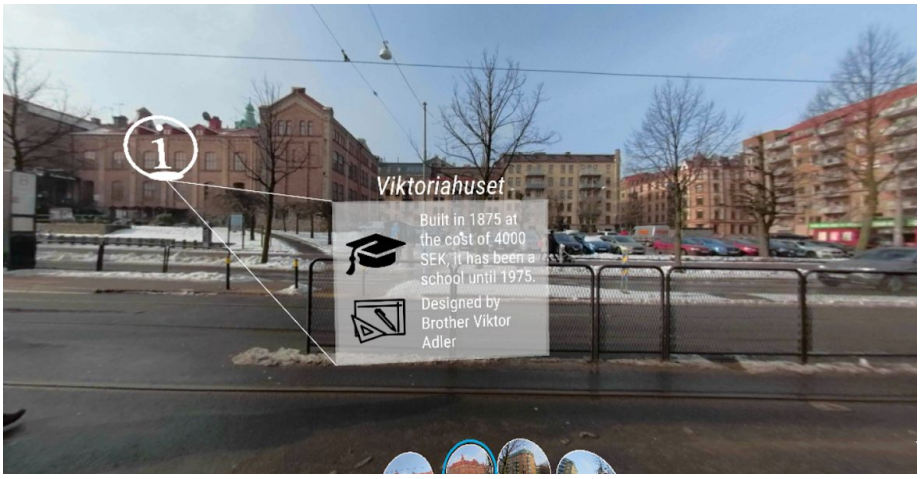

Fig: 8.6 (b) Interesting information about the historic building

8.3. Time Navigation

The bottom navigation available at each tour location has the functionality of taking the user to previous time periods. The reason for having at least ten years gap between each period is to highlight the major changes made on the street. This project's aim was to create a framework for showing the historical data, however for the lack of data and shorter scope of the project, the bottom navigation for time travelling only includes various visual effects applied on the 360 photos in order for them to look like old photos. For example the photos from 1960 have a pinkish finish because of the chemicals used at that time to develop the photos. Over the time these photos faded, giving them the signature 1960's affect (Turner, 2010). To achieve the same affect, the 360 picture taken of today's Linnégatan were photoshopped. The same goes for the 1980, 1940, 1920 and 1900 photos, all periods were given a version of black and white effect. Only the time traveling available at olivedalsgatan has more detailed affects. The road was photoshopped in order to remove the tram tracks and separate car lanes (Fig: 8.7 (a,b)). For each period the cars of the respective time have been placed on the 360 photos, making them more related to the corresponding time period (Fig. 8.7 (c, d)).

Fig: 8.7(a) Removed Bike lane

Fig: 8.7(b) Car lane replaced with pedestrian lane

Fig 8.7(c) Photo editing of the 2018 360 photo, to make it look like an old image

Fig 8.7(d) Old cars at Linnégatan

8.4. Alternate History Concept

Olivedalsgatan contains an interactive time machine object (fig 8.9). Although the bottom navigation allows the user to do a time travel, this time machines lets the user go back in time and change manipulate the history.

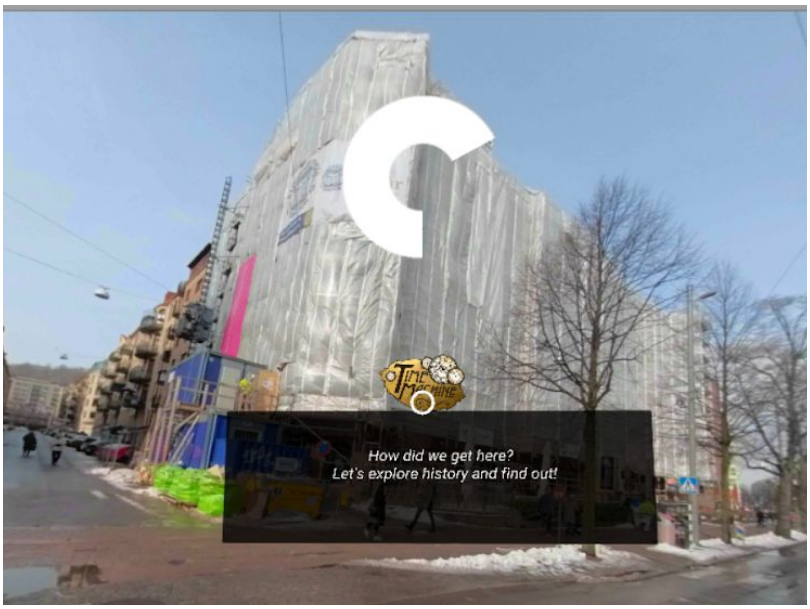

Fig. 8.9: Time Machine at Olivedalsgatan

Manipulation of the history is achieved by taking the user to a white room where they can make choices. The first room lets them choose between, 'Viewing the history as it unfolded' (Fig 8.10(a)) and 'Going back in time and changing the history' (Fig 8.10(b)). The first option takes them to the 1900 olivedalsgatan, where they can see what was going around, check news and use the bottom navigation to travel back and forth in time.

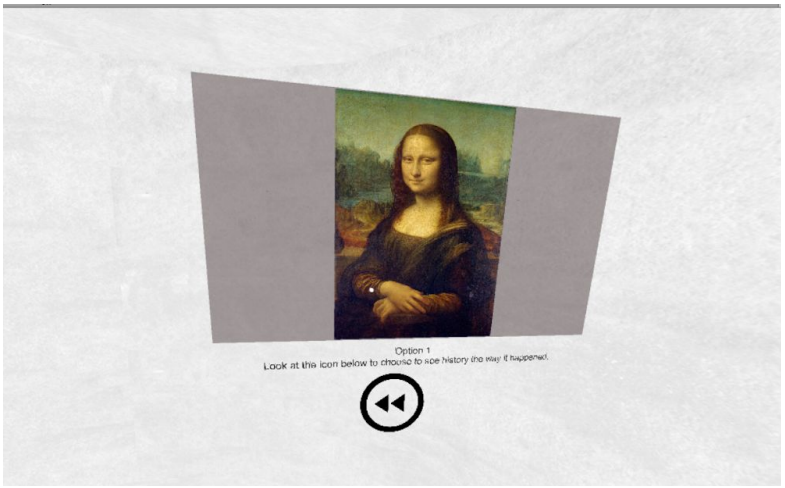

Fig: 8.10(a) View as the history unfolded option.

If the user chooses the option ‘Go back in history and manipulate it’, they are told to look for crack in time.

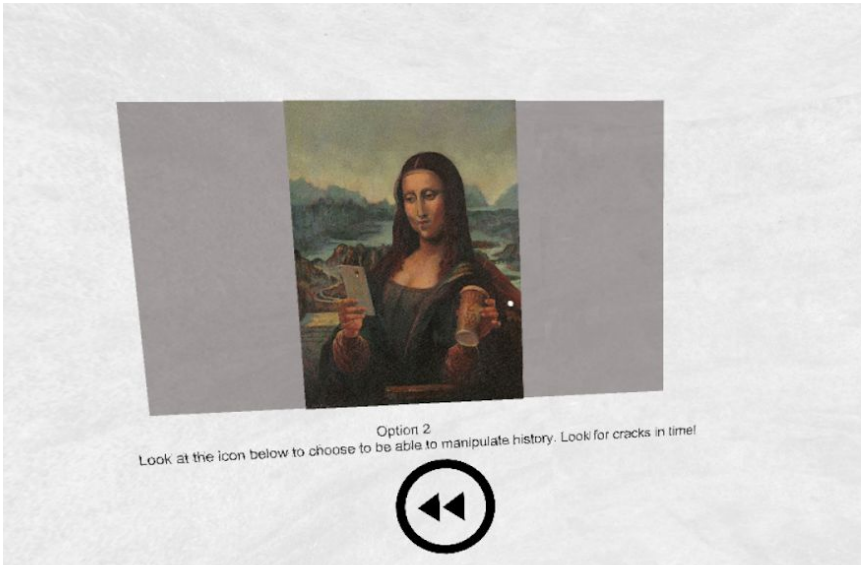

Fig 8.10(b) Change the History choice

The user is then taken to the olivedalsgatan at 1900. This time they see a crack on the ground, bearing a label ‘A crack in time’ (Fig 8.11).

Fig 8.11: Crack in time

Looking at this crack in time takes the user to another choice making white room. Since this crack exists in the 1900s, the user gets to change the events that were happening in the 1900s. The highlights for Linnégatan at that time were the construction of tram lane and bike lane. Thus user get to change this by either opting for not building the bike lane or not building the tram lane. The choice room is shown in fig: 8.12.

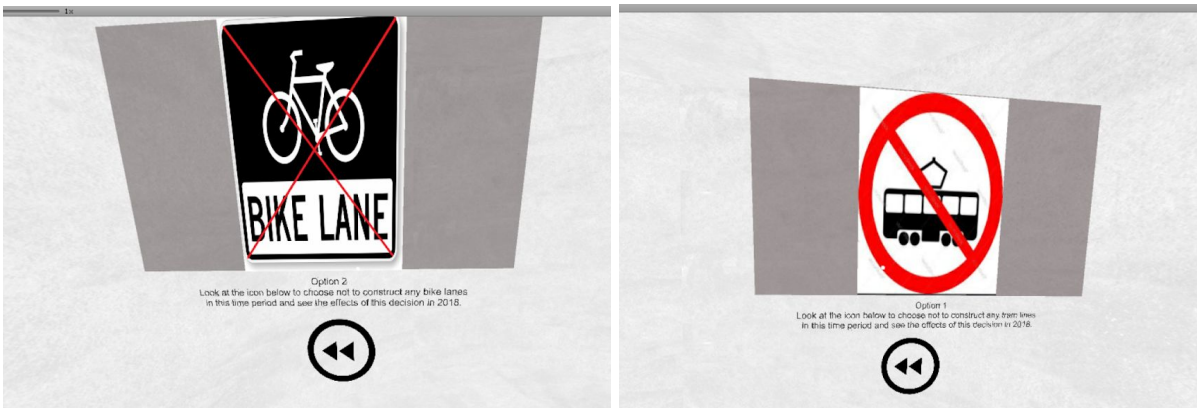

Fig: 8.12 The choices for changing the history, not building bike lane (left), not building tram lane (Right)

Depending on what the user chooses, they get to see the effects of their decision on today. They get to see how Linnégatan would have looked like if their choice bike lane was not built or tram lane was not built.

Fig. 8.13 shows the effects of not having a separate bike lane. Everyone would drive on the same road no matter if its a car, a bus or a bike. This would cause more accidents, more car traffic and less bike riders. The information on how this could have been the reality is retrieved by looking at the traffic patterns of less developed countries like India and Pakistan.

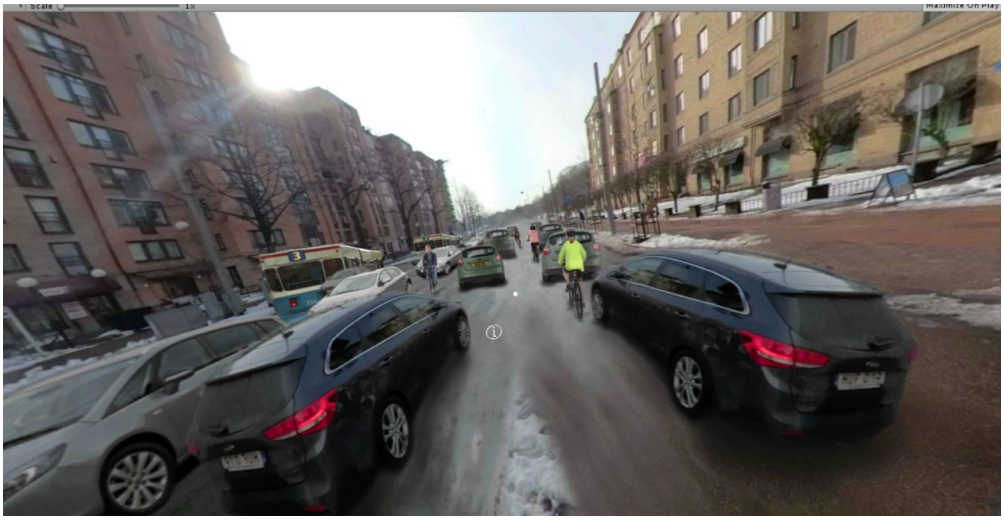

Fig 8.13: Alternate reality for Linnégatan in 2018 if bike lane didn't exist.

Fig 8.14 The dummy data for traffic count if bike lane didn't exist.

Figure 8.14 shows the effects of choosing not to build a tram lane. There would be more cars because of the lack of public transport. Having more personal traffic would add to the pollution, the effects of which are visualised using added smoke and a darker color of the sky.

Fig 8.15 No tram line visualisation

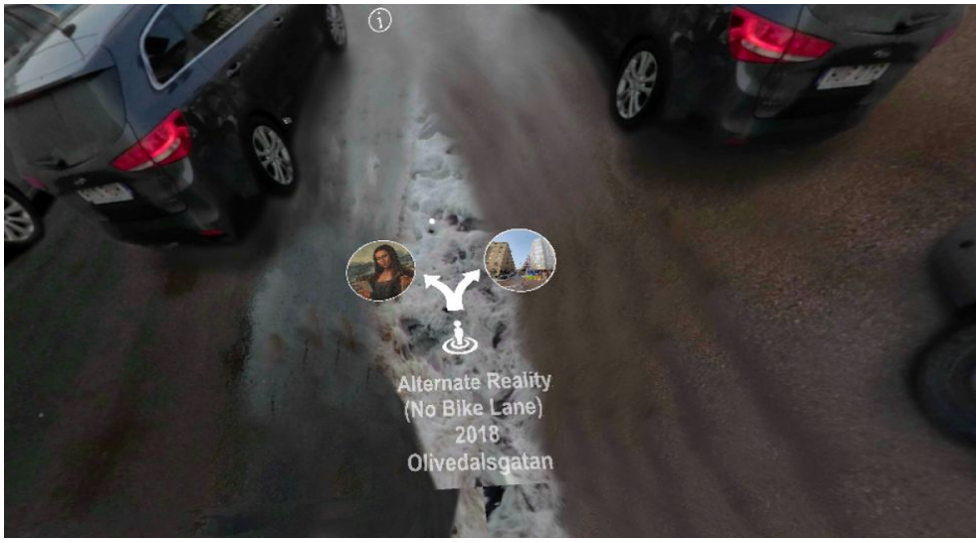

Fig 8.16: Menu for switching between alternate reality and actual reality

In order to provide the users with a way of comparing the alternate reality with actual reality a special bottom navigation is added on the alternate reality locations. It also lets the user go back to the choices screen and choose another way of manipulating the history (Fig 8.16).

8.4. 3D representation of the inside of a Building

The prototype also includes a 3D model of a building. The idea was to be able to utilise the building information like drawings, renovation data and other architectural information in order to be able to provide the user with an additional insight into how the interior of the buildings used to look like in the old times. In order to get there we added a 3D glasses object in the scene as shows in the figure 8.17.

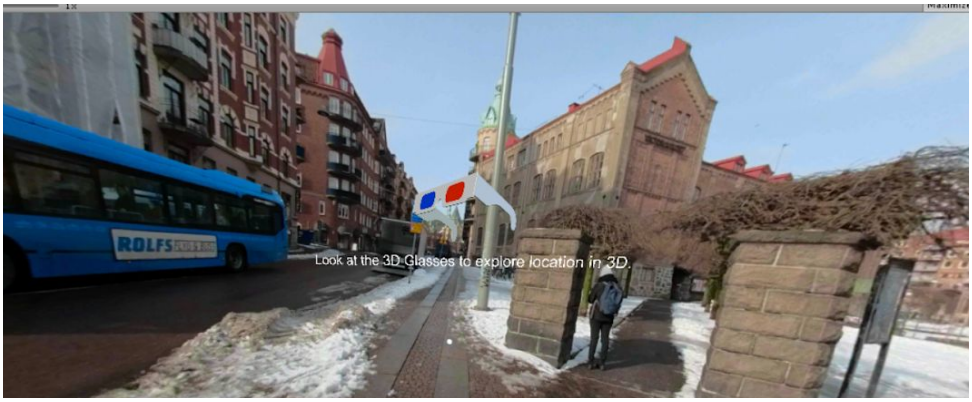

Fig : 8.17 3D glasses Object that lets the user explore the 3D environment of the inside of a building

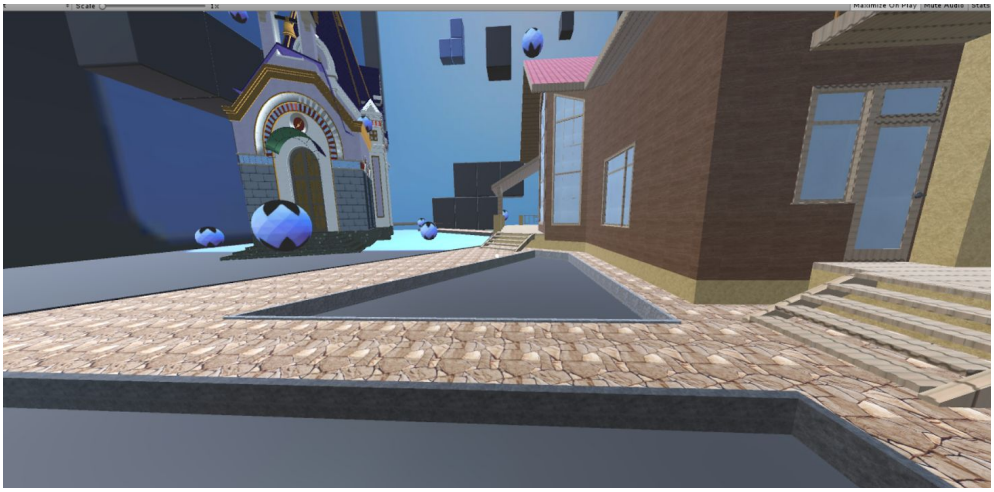

Fig : 8.18 3D environment SHowing a church

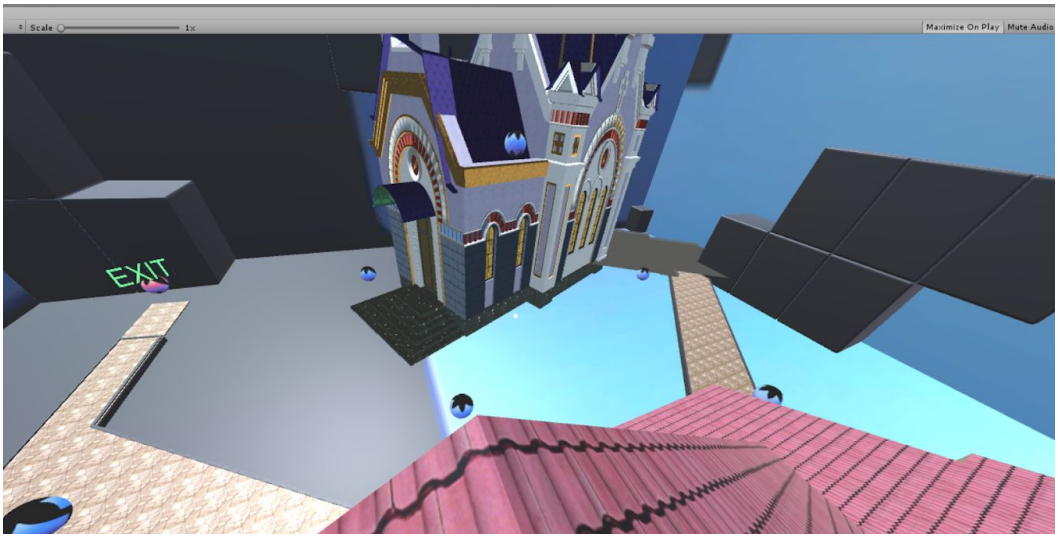

Fig : 8.19 (a) View from the building's top

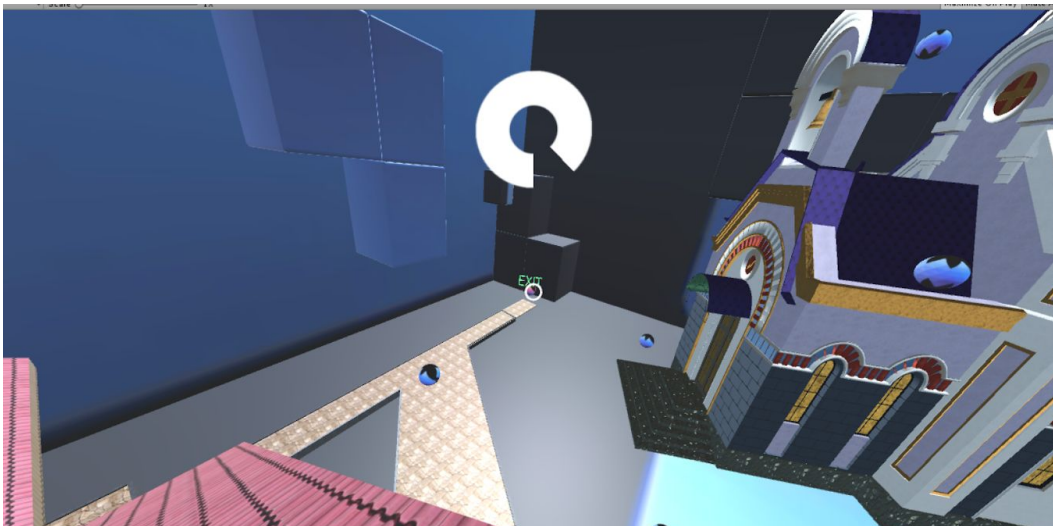

Fig : 8.19 (b) Exit the 3D scene

We wanted to find a way of showing the historic data about the buildings that we found at the city archives for building of Gothenburg in Sweden (Stadsbyggnadskontoret). We found building renovation documents that contained building map drawing and front view of the buildings. These drawing can be used to reconstruct the version of a building from the old times as specified on the historic documents. To test the concept about the reconstruction we created a test 3D environment which the user can enter into from the 360 virtual tour. The purpose of this integration was to test how the user would react to change of surroundings and also if this reconstructed environment would make any impact on the users regarding their interest about the history of a building.

We used sounds and a way to move in the virtual environment. The little pulsing balls take the user to the next spot in the VE. The most interesting feedback was about getting on top of the building, it gave the users a new perspective of viewing the building. Thus a view from top will make an interesting choice for future works. The overall result about the 3D environment was interesting because the users had more freedom to move in VE. They also appreciated this VE because of crispiness of the image quality which was not as great in the case of 360 VE.

9. Discussion

This study was aimed at designing a concept which can use the historic data about a place to write its biography. We combined and tested various technologies like 360 degree photos, 3D models, virtual tours with interactive content, space and time navigation to create an immersive biography of a street. We introduced a concept that is about playing with history: to change key events in the past within the virtual tour. This creates two opportunities, highlighting the importance of key events related to urban planning and a way to make the audience remember when did the important events occur. These ideas were prototyped and tested with audience of various ages. After conducting interviews and evaluating the prototype, it was suggested that such a system should be displayed at a museum. For the optimised user experience, the contextual user experience design should be considered which refers to testing the suggested system at a museum.

9.1 Field Testing Feedback

Unfortunately, due to poor cooperation with museum organizations, we could not test it at a suitable site, instead this prototype was tested at Gothenburg Tech Week 2018, albeit without foreplanning. At the exhibition, we got to compare our simple to use prototype with the more high end looking HTC vive[23] virtual environment system, which used hand controls. The users took time to understand the use HTC Vive because of its complicated hand held controllers and struggled with it, our prototype was straightforward and intuitive to use. We also got to test our prototype with older audience, although the younger user base did not feel any dizziness, the audience older than 50 years did feel mild dizziness. Our tests did not last longer than 5 minutes thus we cannot claim with surety as to our prototype does not cause any dizziness, for the future work the prototype needs to be tested for longer periods.
Even though we did not have the opportunity to properly record the information we gathered during the exhibition (and subsequently did not count it toward the actual results of the report), we were provided with valuable feedback and potential use case scenarios that were suggested by people who tested the prototype.

The prototype still needs to be tested for the location it was designed for, as it will bring better insights about the overall design. While we focused on creating an engaging user experience, the sub domains like interface design was focused in detail as well. The interface was intuitive to use and required no prior experience of VR or any training.

[23] https://www.vive.com/eu/

9.2 Prototype Fidelity

In order to show the past of the street, the 360 degree images of 2018 were photoshopped and made black and white. This might not have been the best solution to test a concept as it can be considered a low fidelity prototype, however the high fidelity prototype would involve much more expensive 3D rendered environment of the past years constructed though the historic data. It can also cause issues with mobile phone performance, depending on the amount of details in the 3D models. Thus it can be said that there is a tradeoff between having a low fidelity prototype for a proof of concept to iterate faster and a great user experience with the low fidelity prototype.

The interviews and tests showed that the 360 degree photos were not as immersive as the 3D virtual environment. The reason could be lower quality of 360 degree photos as compared to virtually rendered 3D environment. Also seeing 360 degree images of Linnégatan and expecting that things will move like in real life but they didn't, might have taken away the immersiveness factor.

9.3 Prototyping Tools

For the first iteration of prototyping, we used two different tools, forge.js and Panotour Pro. Both tools could create a similar prototype but with different learning curve and the time required. However, forge.js is a free javascript library which gives more freedom to create the web based virtual tours. On the other hand, Panotour pro is paid software with a nice user interface which makes it easy to use plug and play kind of tool.
The shortcoming of these tools was that we couldn't import the outcome and use it in a virtual headset. Perhaps there are more complex methods out there that make it happen. Instead of looking for those methods we chose to use Unity which is a more popular virtual reality development tool. It has well documented help and since it is more popular, the help is readily available on the internet. Unity uses C# or Unity scripting as scripting languages.
During the prototyping process with Unity, we faced certain issues. When the interactive items are placed in the virtual tour, how the look like can be checked in the editor window of unity, however when the prototype is put into the mobile device and inserted in the headset, the result looks slightly different from how it looked like in the editor. The reason is that the editor shows a 2D result and fails to convey the complete picture of how distant the object might feel in the VR headset. If the environment is completely 3D unlike in our case where it was a mix of 360 degree photos and interactive 2D sprites, it is easy to have an idea about the distances of the objects relevant to each other and the environment. In our case of 2D sprites placed on top of 360 degree

photos, it is difficult to get the idea of the distance of the objects relevant to the 360 degree surrounding which is basically a sphere wrapped with the 360 degree photo (Fig 9.1).

Most of the times we had to perform several iterations until the interactive object felt at the right distance. This was problematic because the process of testing the prototype in the headset consisted of creating the build, exporting it to the mobile device, then installing the app in the device, followed by insertion in headset and waiting for the loading time of the application in the headset.

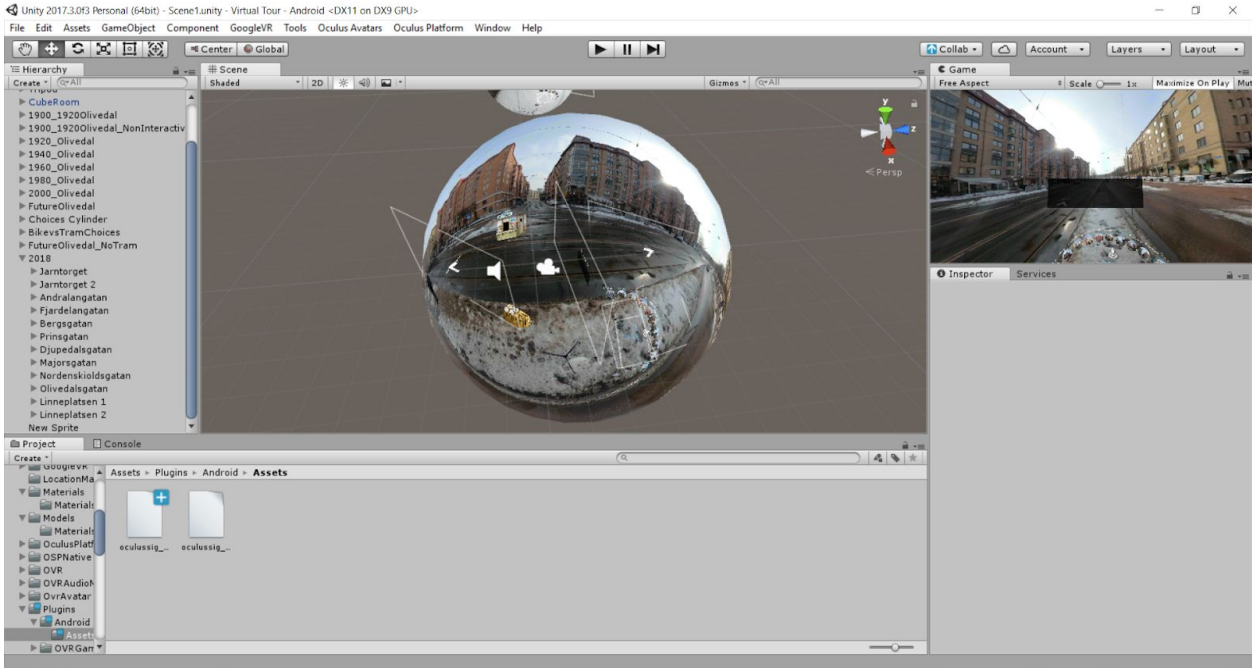

Fig. 9.1: Unity Editor; Sphere wrapped with 360 degree photo and interactive objects inside

9.4 Platform Issues:

We chose to use mobile based virtual reality headset for 2 reasons, first it was cheaper option with the best quality immersive experience results and second that it was an easy to use device. However we understand that using such a device in a public setting can have its issues.

First, when the mobile runs out of charging, it needs to be taken out of the headset and charged, thus either the experience gets interrupted until the mobile recharges or the mobile needs to be replaced with another one with the application already installed in it. The mobile cannot be charged while still inserted in the headset because the same port is used for charging (Fig 9.2).

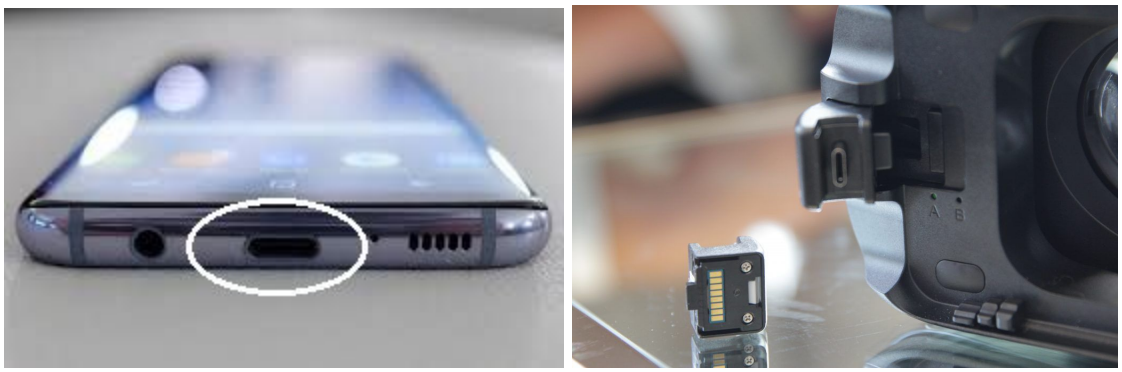

Fig. 9.2: (Left) Samsung phone charging port, (right) Gear VR port where the mobile is inserted

Secondly, if the headset with the mobile device is placed in public without any security, there are chances of the mobile device being stolen.
These issues can be resolved by using a headset device like HTC Vive or similar which get connected to a computer system instead of a mobile device. If the gaze based interaction model is used, we believe that our system can run on these devices as well and won't alter the overall experience. However, we have not tested the system with any other device, thus further work needs to be done in order to find out how reliable other headsets can be.

9.5 Alternate solutions

While we did go down the road of mobile VR, 2 other directions can be taken to develop a biography of a street, all 3 would fit within a museum-like setting.

The first is a web-based solution, which provides a familiar mode of interaction in the form of kiosks, where users can explore the history of a street freely. That of course, is less immersive, and in turn would most likely not leave a lasting impression on the user. However, it is a relatively cheap solution and requires little to no curation while on display in a museum setting. One of the main issues with mobile VR in a museum setting is curation - there might be a need for another person to take care of the equipment. The battery of the phone might get discharged mid-exhibition, for example. That would create unnecessary hassle and increase in costs - we have not explored the implications.

The second alternative is a full VR experience, using the most powerful headsets. That would provide the possibility for much higher fidelity experiences. The learning curve and the initial anxiety that overcomes people when they are faced with a new challenge is something that is difficult to be solved. The matter of price is also another concern. To put it in perspective, to acquire all the hardware required for a smooth VR experience is about 2.5 to 3 times greater than that of mobile VR. Additionally, you are required to use a relatively big empty room in order to operate smoothly, due to the need of motion sensor set ups.

As far as the price is concerned, we focused on the lower priced device as the thesis budget was limited, however once the solution is approved by a museum or an exhibition, either the project is funded, the budget will no longer act as a measure to choose the device.

9.6 Learning Through a Historical Virtual Tour

The thesis sent out to create a virtual tour which can be used as a tool to learn the history of a place. However, we did not have any specific requirements about the learning experience with which we could measure how successful this system has been in actually teaching something. Our user tests highlighted that users were more interested in the urban planning after taking the tour but if they learnt a lot or too little is unclear and was not covered by our research. Further work needs to be done in this area in order to find out how successful such a tool can be for teaching purposes.

Since our collaboration with the city museum didn't work out, we couldn't ask them specific questions regarding learning and how to design to teach about history. In order to find out more about creating content for learning, museums can be helpful. As by talking to museum experience designers, it can be found out what criteria they use to consider some artifact or project suitable for learning. More literature research and background research about museum designs and museums as places for learning can be a good starting point.

9.7 Potential Use Cases

Other than exploring the biography of a street, the prototype we have developed, along with the derived guidelines, can be utilized in different domains.

A first example of going in a different direction would be if this solution was tailored for an architect or an urban development organization. The stakeholders would be able to navigate through the history of a specific location and note the style of architecture, potential available space for expansion, and making sure new construction plans are in accordance with what already exists or improves upon old designs.

Secondly, it could be used as an archiving tool. In particular, it could be used to recreate workshops or lessons. If a 360 degree photo or video were taken during those events, interactive media could be used to immerse the user into the tasks and provide almost a first-hand experience. It would be an invaluable tool for those who cannot either afford to travel to the designated destination or those who simply missed the opportunity.

A third use case could involve creating an online virtual store. Users would explore the store's contents in an immersive environment, and depending on the type of store and its inventory, could perhaps make more informed decisions about their purchases.

Provided that the solution is also integrated with communicating with the internet, it can potentially serve as an information tool about a specific place, not far from what Google Maps [24] does right now - just way more interactive and more immersive.

Finally, it can be utilized as an exploratory and educational tool. For example - explore the International Space Station and learn what all the gizmos and gadgets do up there. How does a workstation of a pilot look like? Perhaps learn the essential set ups of world-class chefs? How and what do the offices of the most influential people in the world look like?

The possibilities are there, the main issues are: who *needs* a tool like this? We believe that is up to the organization to decide. But our results point to the fact that it has merits when it comes to memorability and familiarization of a topic, and a novelty factor, which can be utilized.

9.8 Future Work

If we were to continue working on this project, we will start by creating the 3D models of the buildings or look for 3D models that have already been created by the city building organisation and add them to the tour. As we saw with the user tests that users really liked the feel of the 3D church as it gave them the freedom to view the building from an unusual top angle and also the 3D models worked as the insides of a building. We believe that the experience can become even more engaging if the users are offered to peek inside the buildings and see how the interiors of the buildings changed over time. What household items have been used throughout different times in the history. By doing so we will be able to shed light on the lives of the residents of those buildings and speculate how their everyday life would have looked like.

If we were to expand this project, we would also like to include another historic area from perhaps a country that has more eventful past, for example Germany. By doing so we will get a chance to show how drastic the change has been and how did the urban planning helped these cities get modernised and cope with the challenges of modern life.

Moreover, the current prototype focuses more on the traffic changes and mobility patterns but not so much on the buildings. In future, provided that enough data about the traffic and buildings

[24] https://www.google.com/maps

is gathered, a more elaborated picture of the history of the buildings as well as the traffic can be painted, resulting in a comprehensive biography of a street.

9.9 Ethical Considerations

The alternate history concept was used in the project in order to emphasize the importance of urban planning, however we understand that the impact of changing something in the past onto the speculated future cannot be as straightforward as shown in the prototype, it is much more complicated and requires detailed analysis. For example when the user chooses not to build the bike lane, would the street really become crowded? would there be frequent accidents? Perhaps choosing not to build a bike lane changes many things in the future and the future branches out in a way that having a lot of accidents is only one option amongst several other branches of the possible futures. We have only simplified the speculated future in order to make a point and do not claim that the speculated future is truthful.

If this idea of alternate history is to be used in the future, it should be specifically stated and made clear that the possible outcome is only one of many other futures that might have occured and depends on many other events that happened in the past and made the current future (today) a possibility that we see today.

10. Conclusion

This master's thesis work aimed to explore and find the best guidelines user experience designers could use to create immersive and memorable virtual tours, with the hopes of showing the effects of good or bad urban planning.

As the backbone of the thesis, a fully functional prototype was created - a virtual reality experience of the street "Linnégatan" in Gothenburg, Sweden. After four iterations of the prototype and subsequent evaluations, several guidelines for creating immersive virtual tours emerged. The guidelines that were derived were in these major areas:

- How to assess the appropriate platform, based on your requirements
- How to select a suitable location to host the experience for maximum interest
- How to choose the modes of interaction, best suited for your target user group
- How to implement interactive content for positive reactions
- How to get users engaged in your experience
- How to provide guidance and support so users don't get lost and confused

Relevant background work was analyzed in the first part of the thesis, based on guidelines for virtual reality interactions, and tours which explored history and historical monuments. Combining existing literature with methods such as “research through design” and well known qualitative data collection methodologies (interviews), yielded a solid groundwork for the prototype. Utilizing high fidelity prototyping techniques, user studies and evaluations - the final version of the prototype was established. Finally, an analysis of the results over the course of multiple prototype iterations, following an iterative design approach is presented.

Even though the prototype was meant to be used in a museum environment, it was not possible to carry out field tests. Feedback from users, however, suggests high flexibility when it comes to the potential usage scenarios of a virtual tour experience. The guidelines derived from the user tests, and the prototype creation process that was described, could be utilized as a potential framework for designers who wish to create immersive virtual reality experiences. Future work could explore new potential use cases for the prototype, recreate the experience for a more historically eventful street, or a street with broad historical urban planning decisions. The guidelines derived from this report could be evaluated as well.

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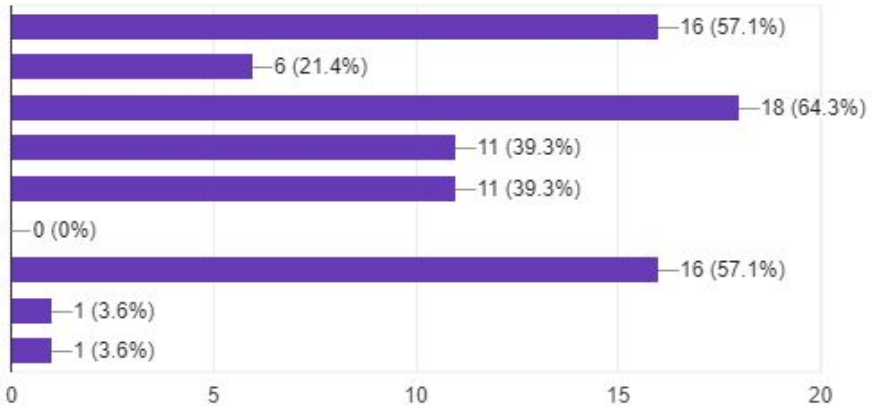
Appendices

Appendix A: Questionnaire

This questionnaire was used to conduct survey as a way of doing initial research about the user preferences. The questionnaire was aimed at gaining insights about people's interest level in the history, how people would like to experience the history and where.

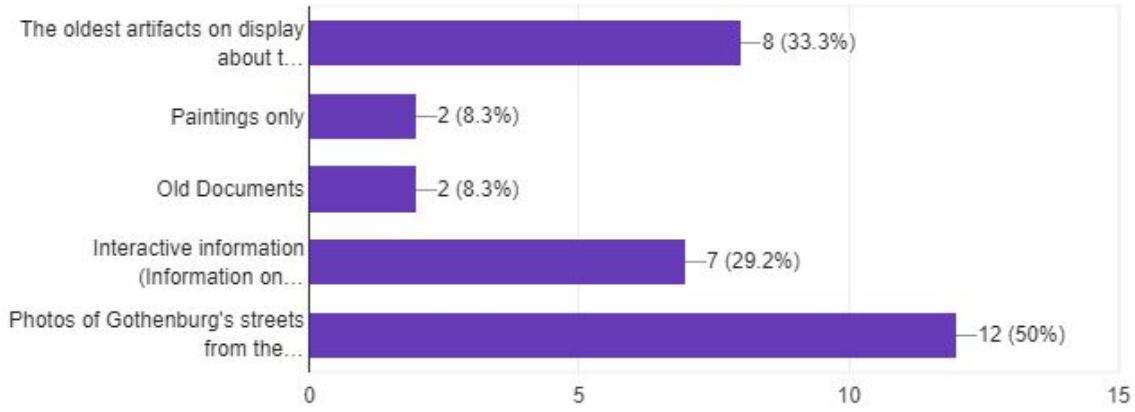
Question 1:
Why do you go to City Museum(s)

a. I'm interested in finding out why does Gothenburg look like the way it looks like today
b. I'm interested in the local artists of Gothenburg
c. Im interested in the city's culture
d. I'm interested in the city's architecture
e. To see old artifacts
f. To take the kids out
g. To know about history of the city in general

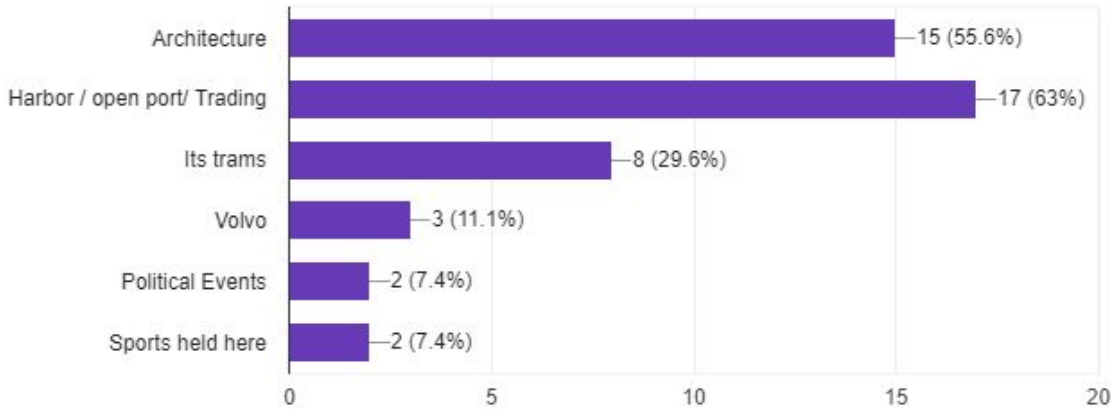


Responses (Top to bottom - a to g)

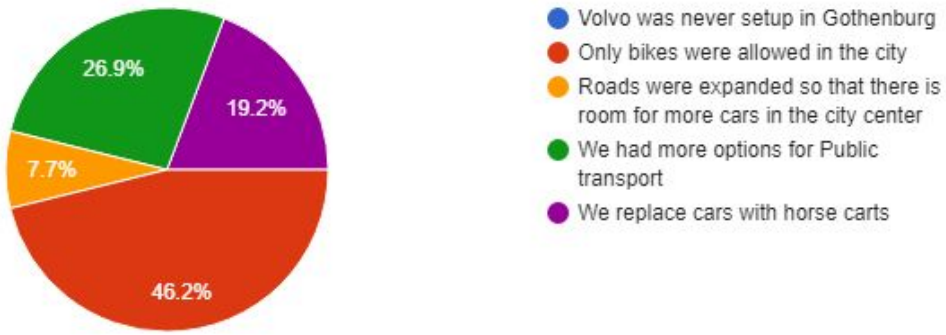
Question 2:
What is the most memorable thing you experienced your last museum visit



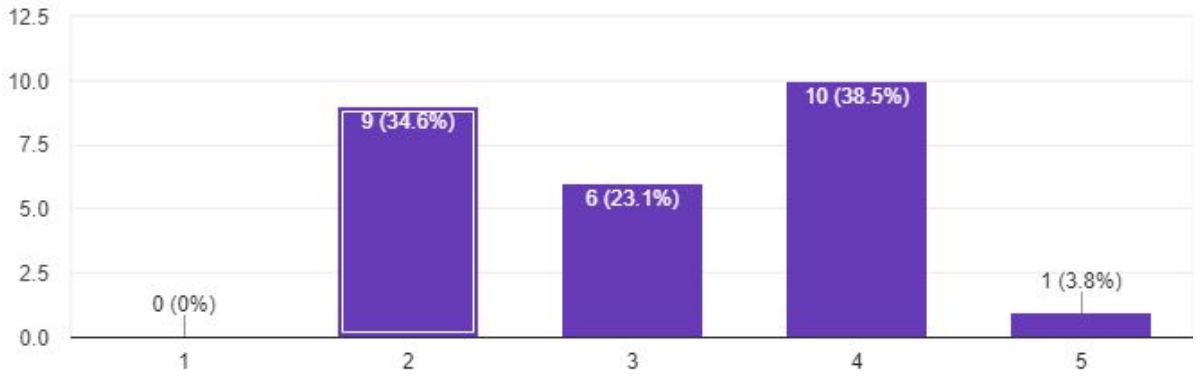
Question 3:
What do you admire the most about Gothenburg's History



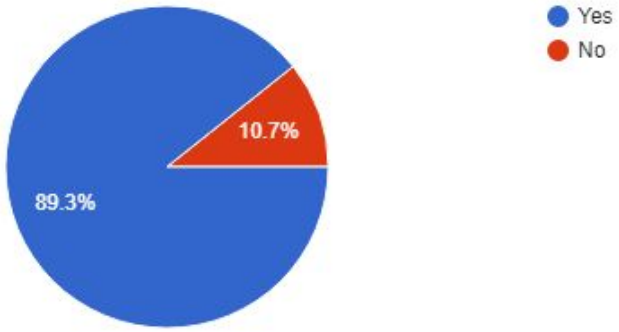
Question 4:
I think Gothenburg's Traffic situation would be different if



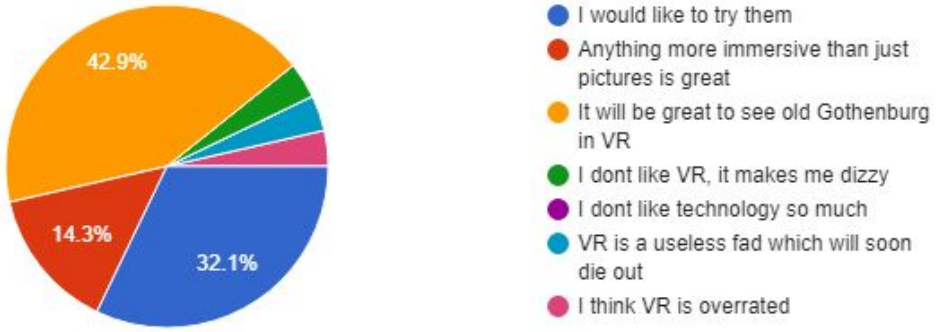
Question 5:
Gothenburg's Traffic today is:



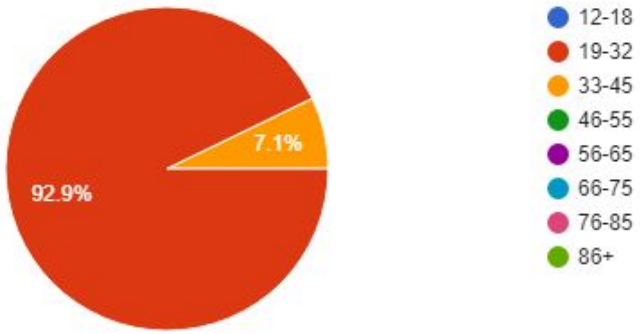
Question 6:
Have you tried any Virtual Reality Headset?



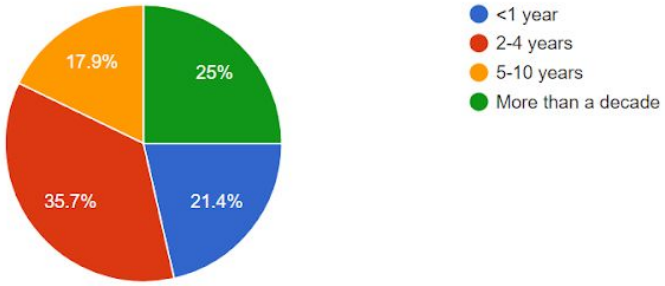
Question 7:
Do you think museums should include VR (Virtual Reality) tours as part of their exhibitions?



Question 8:
My Age



Question 9:
I have Lived in Gothenburg for:



Appendix B: User Interviews (First Iteration)

Mode: Interviews only
Purpose: Early interviews in order to validate the idea and find the best suitable platform and place to showcase the project.

1. Interview Questions for a semi structured interview

1. Considering google street view as a base, how would you improve the experience in order to show the history of the street?

   Q. What information would you like to see?

2. What kind of platform would you like to try this on, Something web based, on mobile or wearing a headset?
3. How would you like to try it?

Q. What if there is queue at the museum.

Appendix C: User Interviews Analysis (First Iteration)

Mode: Thematic User interview analysis

User: #1, #2, #3, #4
Theme: Location: #1, Platform: #2, Mode of Viewing History: #3, Engagement: #4
Mode: AR: #1, Mobile: #2, Museum: #3, At Home: #4, Timeline: #5, Web App: #6, , Interactive Objects: #7, VR headset: #8, Cinema: #9

Idea	User	Theme	Mode
Add a timeline to go back and forth in history of the street	#1, #3, #4	#3	#5
Add interactive objects for better engagement	#1, #4	#3, #4	#7
View the street using mobile AR	#2, #3, #4	#2, #1	#1
View the project at a museum	#1, #2	#1, #2	#3, #8
View the project at home on web or mobile	#1, #3	#2	#9, #2, #6
Explore history of the buildings	#1, #2, #3	#4, #3	#7
View the street during different seasons	#3, #4	#3	#5

Appendix D: Prototype testing and User Interviews (First Iteration)

Mode: user test followed by Interviews
Purpose: Early testing of the prototype, the prototype included 360 tour of 2 locations, having interactive content and also 3D environment for comparison. These user tests were followed by user interviews.

1. Which one was more immersive? 360 or 3D scene

    a. How did you feel about the sound
2. What do you think about the interface for transitioning between the periods
    a. How would you improve it
3. How would you like to see the feedback from the system whenever you interact with the objects

4. What do you think about the back rewind button?

    a. Where do you think it should be located
5. What if the button could take you to a bar and every time you go to next or previous period you have to go to a bar?

6. What else did you find engaging and interesting and how would you improve it

Appendix E: Prototype testing and User Interview Analysis (Second Iteration)

Mode: Thematic User interview analysis

User: #1, #2, #3, #4, #5
Theme: Immersion: #1, User Interface: #2, Interaction Feedback: #3, Time Travel: #4, Engagement: #5
Mode: 3D Environment: #1, 360 photo: #2, Sound: #3, Rewind Button: #4, Social Bar a mode of time travel: #5, Loading Icon #6, Controller #7

Idea	User	Theme	Mode
Using 3D Modeled Environments for better immersion	#1, #2, #3, #4, #5	#1	#1
Using audio stimuli for better immersion	#1, #2, #3, #4	#1	#1, #2, #3
Interacting and loading into new areas need to be slowed down or sped up depending on the interactive object	#1, #3	#2, #3	#6, #2
Users need to be guided to see old time periods within the prototype	#4, #5	#2, #4	#2, #4

Icons associated with going back (e.g. rewind button) felt intuitive and easy to understand	#1, #2, #4	#2, #3, #4	#2, #4
Going to a separate environment to choose time periods did not seem like a good approach	#2, #3, #4	#4	#5
Users need to feel a sense of direction and purpose; they need a goal	#1, #4, #5	#5	#1, #2
Users did not feel the need for a controller	#1, #2, #3, #4, #5	#3	#1, #2, #7
Using voice-overs in conjunction with text	#4, #5	#2, #3	#1, #2, #3
Use high resolution pictures	#1, #3, #4	#1	#2
Application integration within other applications, to induce interest	#1, #2	#5	#1,#2

Appendix F: Prototype Testing and User Interviews + Questionnaire (Third Iteration)

Mode: Third iteration of prototype testing followed by user interviews with the help of questionnaire presented below.

UI

1. How do you feel about the mode of interaction? (i.e. Gaze)
    a. It was intuitive
    b. It took me some time to understand it
2. Was it easy to know which objects are interactive?
    a. Yes
    b. No

3. What do you think about the movement of the interactive objects?
    a. It was ok
    b. It was annoying
4. What do you think about the time machine object?
    a. It was easy to find

Yes No

b. I understood what is it supposed to do

Yes No

C. It could have been better by having…

_____

3. Any suggestions on ways to show the news?

Experience

1. In your opinion, how immersive did the experience feel?
   1-Not immersive ::::: 5-very immersed

   1 2 3 4 5
   ○ ○ ○ ○ ○

2. Which aspects helped you feel more immersed?
   1-Did not help::::: 5-Helped a lot

   1. Sounds

      1 2 3 4 5
      ○ ○ ○ ○ ○

   2. Voice Over

      1 2 3 4 5
      ○ ○ ○ ○ ○

   3. Music

      1 2 3 4 5
      ○ ○ ○ ○ ○

   4. Interactive 3D User Interface

      1 2 3 4 5
      ○ ○ ○ ○ ○

   5. Looking around in a 360 photo

      1 2 3 4 5
      ○ ○ ○ ○ ○

   6. Exploring a 3D building

      1 2 3 4 5
      ○ ○ ○ ○ ○

3. Suggestions for more immersive aspects? (Other than music) (Descriptive answer)

4. How did you feel about the alternate history concepts as a guide of the whole experience?(Descriptive answer)

Urban Planning

1. Has playing around with alternate history affected your perception on the importance of good city planning? (Descriptive answer)

2. Has playing around with alternate history affected your interest in historical events in your current city? (Descriptive answer)
3. If you were to rate your interest in Linnegatan's history before this VR experience what would it be? 1 - not interested ::::: 5 very interested

1 2 3 4 5
○ ○ ○ ○ ○

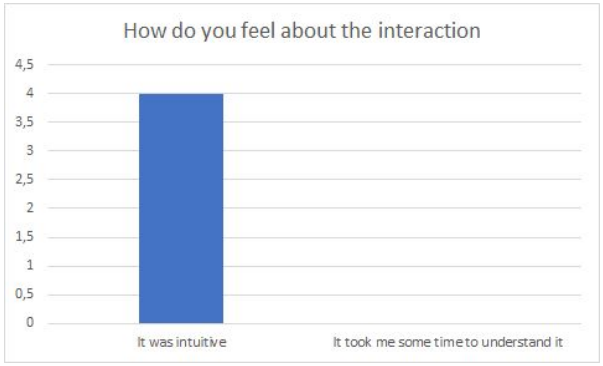
4. If you were to rate your interest in Linnegatan's history after this VR experience what would it be? 1 - not interested ::::: 5 -very interested

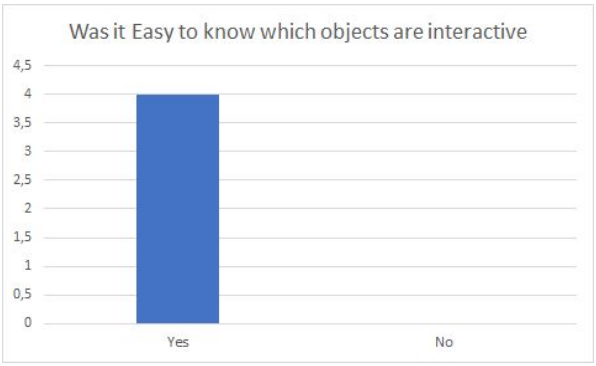
1 2 3 4 5
○ ○ ○ ○ ○

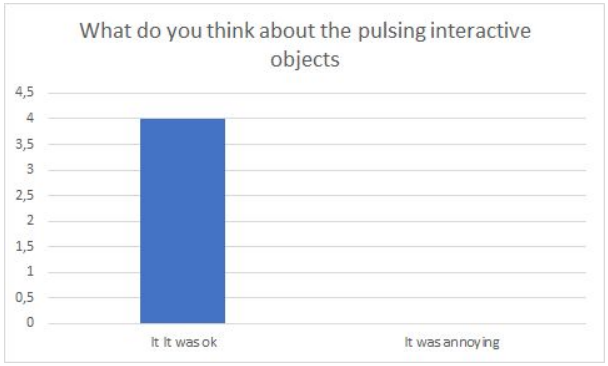
Appendix G: Prototype Testing Analysis (Third Iteration)

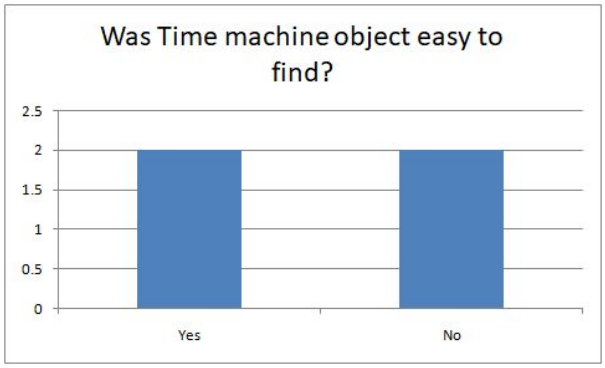
Below is the analysis of test results, it was performed by four participants.

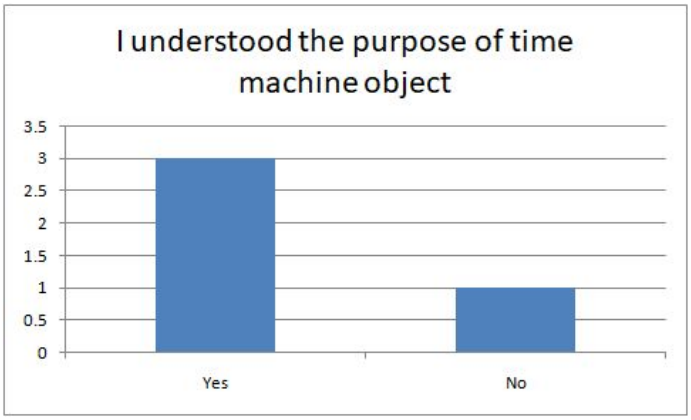
UI



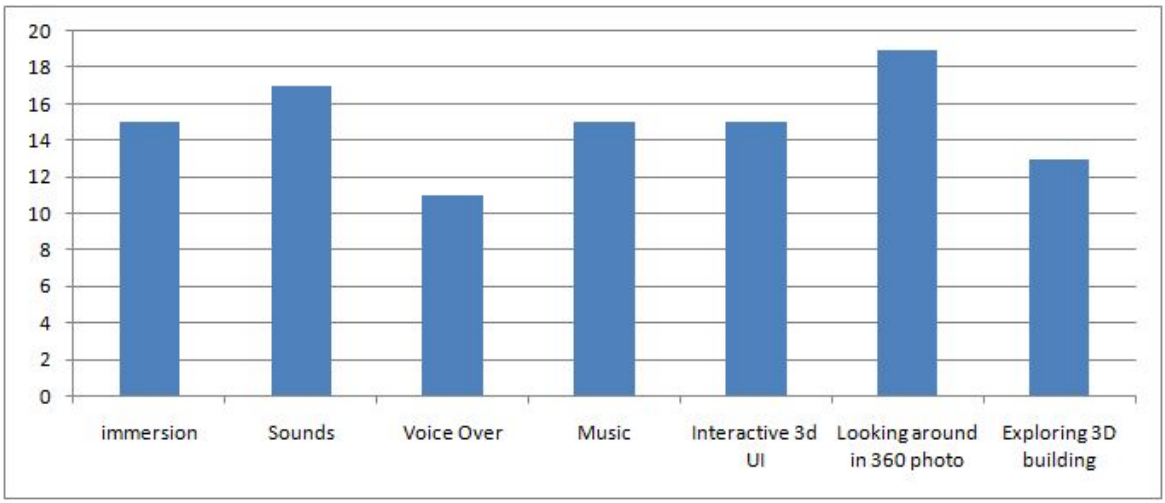







I understood the purpose of time machine object
3.5
3
2.5
2
1.5
1
0.5
0
Yes
No

Experience


20
18
16
14
12
10
8
6
4
2
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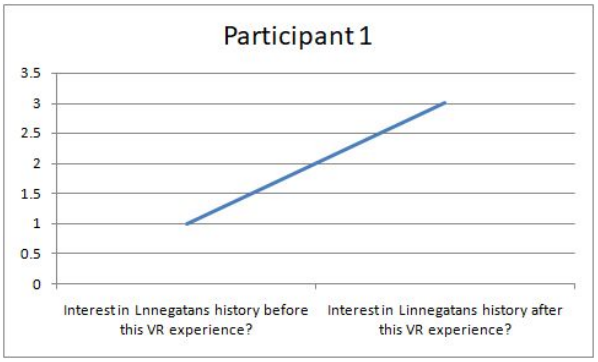
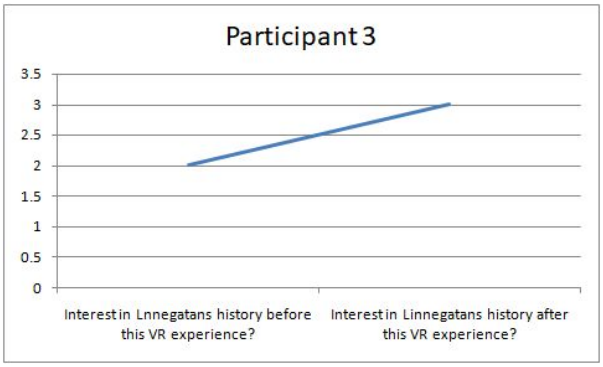
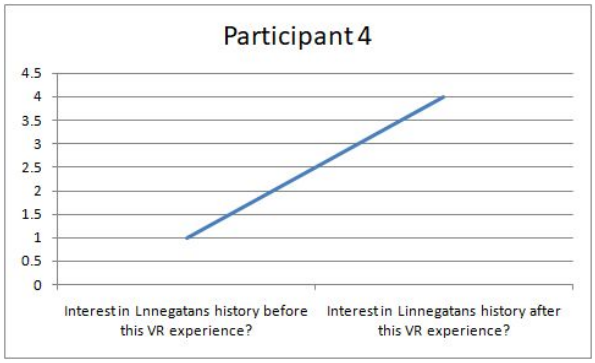
immersion
Sounds
Voice Over
Music
Interactive 3d UI
Looking around in 360 photo
Exploring 3D building


Participant 1
3.5
3
2.5
2
1.5
1
0.5
0
Interest in Lnnegatans history before this VR experience?
Interest in Linnegatans history after this VR experience?


Participant 2
2.5
2
1.5
1
0.5
0
Interest in Lnnegatans history before this VR experience?
Interest in Linnegatans history after this VR experience?





User: #1, #2, #3, #4
Theme: Alternate History: #1, Time Travel: #2, Narration: #3, Interactive Content: #4
Mode: Urban planning: #1, Timeline: #2, News: #3, Animations: #4, Information Text #5, Choices #6

Idea	User	Theme	Mode
Information provided by voice-over was distracting	#2, #3, #4	#3, #4	#5
Alternate history concept needs to be emphasized and clarified in the prototype	#1, #2, #3, #4	#1, #4	#5, #6
Alternate history concept is a good way to point out a critical event in history in a memorable way	#1, #2, #3	#1	#5, #6
There needs to be a way to navigate through time periods (through a scrollable timeline of some sort)	#3	#2	#2, #5
Animations and moving objects add to clarity of what's interactive	#3	#4	#3, #4
Interactive objects that can to be read need to be presented close enough to the user for them to read, but to also understand there are more than one.	#4	#2, #4	#3, #4

Good urban planning is only obvious to the users only in hindsight	#1, #2, #3	#1, #2, #4	#1

Appendix H: Prototype Testing and User Interviews (Fourth iteration)

Mode: user tests followed by Interviews
Purpose: Last session of formal Testing of the prototype, the prototype included 360 tour of 12 locations, having interactive content, music, sounds, interface for traveling to other location and time periods, and also 3D environment for comparison. These user tests were followed by user interviews.
Following is the result of questionnaire filled by users after testing the prototype.

Immersion

1. How well did the experience succeed in making you forget about the real world? (1: I did not forget the real world - 5: I was completely immersed in the tour)

   1 2 3 4 5
   ○ ○ ○ ○ ○

2. Which aspects of the experience helped you focus on the world in the headset?
   - ☐ Sounds
   - ☐ Music
   - ☐ Interactive objects
3. Which aspects of the experience made you lose focus from the world in the headset?
   - ☐ Low resolution images
   - ☐ Not enough interactions
   - ☐ No motion
4. How do you feel about the rewards of exploration? (History snippets, old pictures, movies), rate in terms of interest - 1 not interesting - 5 very interesting

History snippets: 1 2 3 4 5 ○ ○ ○ ○ ○

Old pictures: 1 2 3 4 5 ○ ○ ○ ○ ○

Movies: 1 2 3 4 5 ○ ○ ○ ○ ○

5. What emotions, if any, arose during your exploration? ()

UI

1. How did you feel about the user interface that controlled navigation, in terms of:

   Ease of use 1 2 3 4 5 ○ ○ ○ ○ ○

Clarity (Affordance) 1 2 3 4 5

Responsiveness 1 2 3 4 5

Immersion (how “natural” did it feel?) 1 2 3 4 5

2. Did you feel like you had the necessary controls to navigate freely in the experience in terms of **time**?

   No | 1 2 3 4 5 | Yes

3. Did you feel like you had the necessary controls to navigate freely in the experience in terms of **place**?

   No | 1 2 3 4 5 | Yes

Overall feel

1. How suitable do you feel the experience is to explore the history of a street?

   1 2 3 4 5

   (Optional) Reason : _____

2. How suitable do you feel the experience is to explore a street?

   1 2 3 4 5

   (Optional) Reason : _____

3. Having google street-view in mind, do you think this experience offers more in terms of:
   - Exploring a street

     Yes ☐ No ☐
   - Getting better information about a street

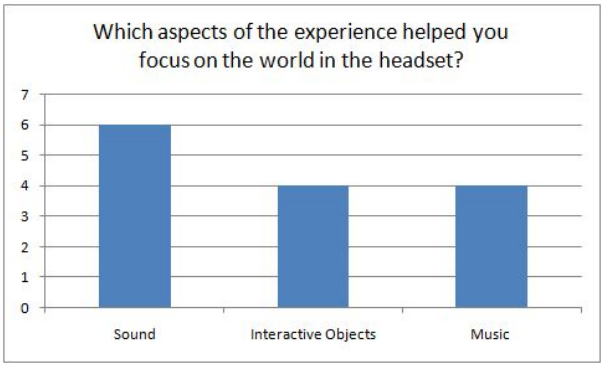
     Yes ☐ No ☐
   - Feel like you are visiting the street

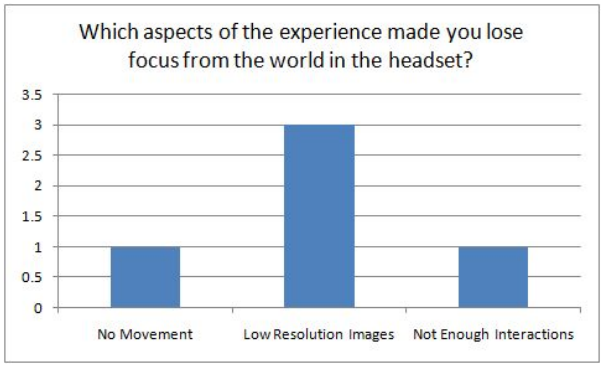
     Yes ☐ No ☐

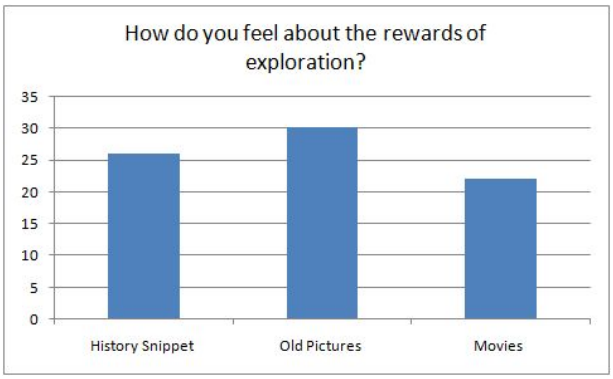
Appendix I: Prototype Testing and User Interviews (Fourth iteration)

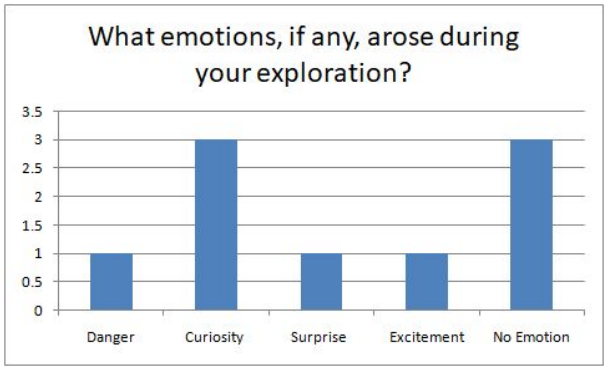
Below is the analysis of test results, it was performed by seven participants.

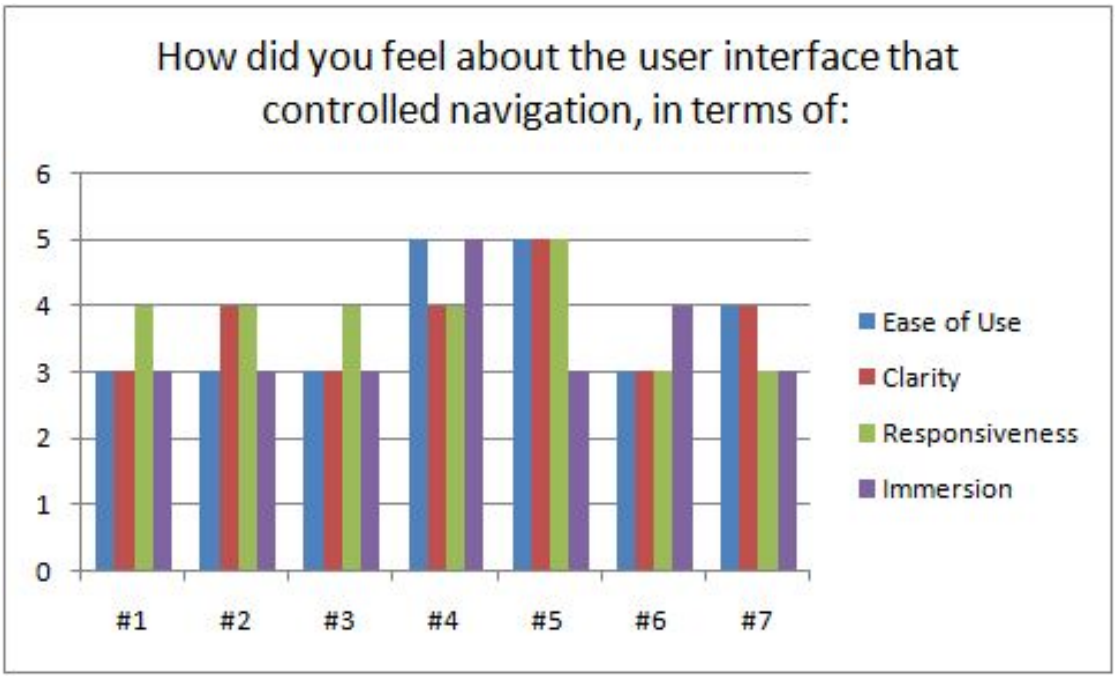

How well did the experience succeed in making you forget about the real world?
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7

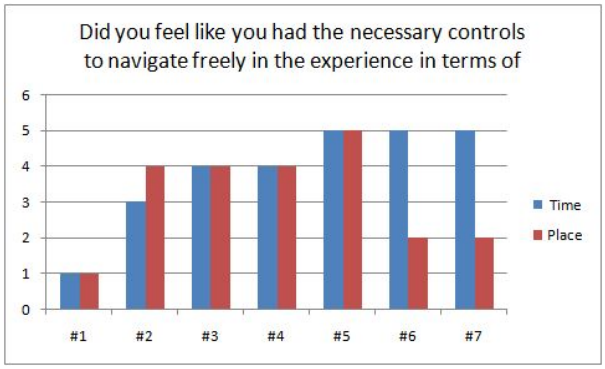

Which aspects of the experience helped you focus on the world in the headset?
7
6
5
4
3
2
1
0
Sound
Interactive Objects
Music


Which aspects of the experience made you lose focus from the world in the headset?
3.5
3
2.5
2
1.5
1
0.5
0
No Movement
Low Resolution Images
Not Enough Interactions

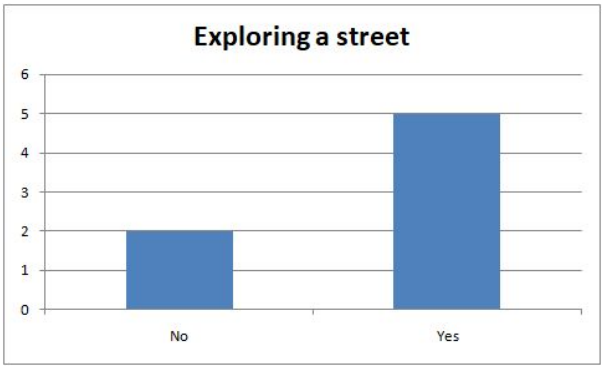

How do you feel about the rewards of exploration?
35
30
25
20
15
10
5
0
History Snippet
Old Pictures
Movies

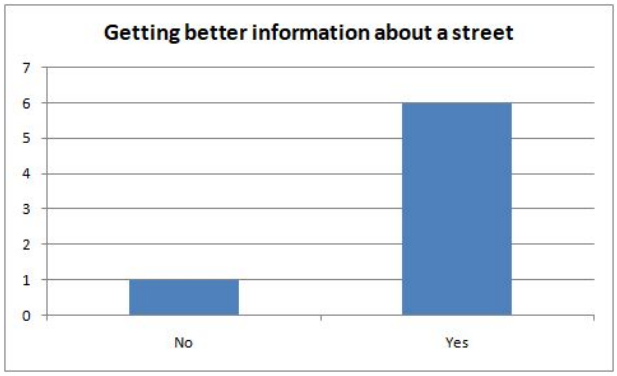

What emotions, if any, arose during your exploration?
3.5
3
2.5
2
1.5
1
0.5
0
Danger
Curiosity
Surprise
Excitement
No Emotion

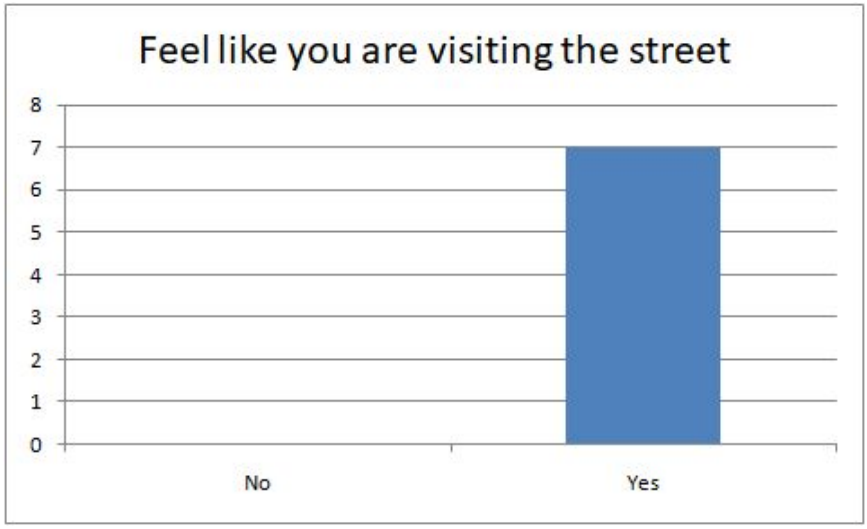




Having google street-view in mind, do you think this experience offers more in terms of:







Appendix J: User Interview Post-test Analysis (Fourth iteration)

User: #1, #3, #5, #6 (users #2, #4 and #7 omitted - did not provide additional comments)
Theme: Confusion: #1, Low quality: #2
Mode: Navigation: #1, Interactions #2

Idea	User	Theme	Mode
Do not align years with the pictures in the navigation menu. Confuses users.	#1, #5, #6	#1	#1, #2
Provide higher quality 360 degree pictures, as long as mobile phone performance does not drop	#1, #3	#2	#2

Provide short instructions to the user that they only need to look at objects to interact with them.	#1, #3, #6	#1	#1, #2