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Investigation into the Impact of Using Virtual Heritage to Depict the Historical City of Al Madinah

A Thesis Submitted to the University
of Kent
for the Degree of Doctor of Philosophy
in Electronic Engineering

By
Walaa J. Alharthi
June 2015

Abstract

Al Madinah, in Saudi Arabia, is the second most holy city for Muslims throughout the world and has a long and rich heritage. However, most of the historical and traditional buildings, city walls and holy places have been replaced with modern structures. But, there have been several attempts, many by individuals, to preserve the heritage of Al Madinah.

This thesis took an in-depth look at the history of Al Madinah, with emphasis on a 3D virtual environment which was produced as part of this project and inspired by a 3D model depicting the historical city of Al Madinah.

First, this research examined the documentation of the historical city and identified its limitations by visiting location museums and evaluating the display mediums concerned with the heritage of Al Madinah. To contrast the traditional methods employed in local museums, eight museums in the UK were visited to explore their use of technology and digital devices.

After these two initial steps, the main contribution focused on developing an effective installation to present the heritage of Al Madinah using first hand material. The Madinah Virtual Heritage (MVH) installation was developed in two main stages and tested for its usability. MVH provides a virtual reality experience by using an affordable head-mounted VR display, which would be especially beneficial for local museums with limited budgets. This thesis gives an overview of how to create a virtual heritage environment, and the principles can be applied to other fields. The findings show that there are limited resources available to understand the heritage of Al Madinah, especially because local museums are self-funded and use traditional media and redundant displays. The use of 3D is a possible solution to reconstruct the demolished buildings. Virtual reality brings interactivity and engagement to the installation, which could be used in local museums as it is now available in head-mounted format at an affordable cost.

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List of Acronyms

CG: Computer Graphics

FB: Face Book

MUD: Multi-User Dungeon (original) Multi-User Dimension and Multi-User Domain

MVH: Madinah Virtual Heritage

PBUH: Peace Be Upon Him

QUIS: Questionnaire for User Interaction Satisfaction

SUS: System Usability Scale

VR : Virtual Reality

CHAPTER 1

Introduction

1.1 Background

The city of Al Madinah is the second holiest city for Muslims around the world, located in the west of Saudi Arabia. Its religious value is due to its role during the first era of Islam as the capital city of the Islamic empire. Al Madinah Al Munawwarah was the new name of Yathreb, which means the lightning city. This name was given by Prophet Mohammed (PBUH) after he was driven out from Mecca, where he used to live. Al Madinah became a destination for every Muslim, and has remained so right up to the present day, as it has the grave of the Prophet Mohammed (PBUH) who died c. 8 June 632. The city has had a rich heritage since that time. But most of the old buildings, walls and holy places have been replaced by modern architecture. According to an estimate by the Washington-based Gulf Institute, more than 95 percent of the buildings that were around a thousand years old have been demolished in the last 20 years([Abdo, 2015](#)). The new generation has limited knowledge about the history

of the city, especially its architecture and how it affects the social life of citizens (Kaki, 2007, 2001). In addition, the development of the city has been rapid, and new buildings have replaced most traditional ones.

How can some aspects of the heritage that have been lost be retrieved? In recent years, virtual technology has been widely used to represent and clarify ideas related to different aspects of history.(Refsland et al., 2000; Rua and Alvito, 2011)

Virtual heritage is one of the aspects that has benefited from this technology, particularly 3D modelling. There are several ways of creating 3D models in virtual heritage; augmented reality and virtual reality are the new trend for researchers and developers. (Addison, 2000; Wojciechowski et al., 2004; Noh et al., 2009)).

While augmented reality allows one to view virtual objects on-site, in the way Google Glasses do, virtual reality simulates an environment for people viewing it on a computer off-site (Mendes et al., 2010)

The use of virtual heritage is common in the context of museums, archaeology and architectural heritage, with multiple methods to create it, such as image-based 3D modelling and 3D modelling based on laser scanning, each of which has its own features. The successful use of both methods requires special equipment and teamwork to set up a system. However, recently the use of virtual reality equipment has become more affordable, and developers kits have come into the market; this has given more researchers in the field of 3D modelling and virtual environments a better chance to develop successful projects.(Prasolova-Førland et al., 2008; Masci et al., 2012)

Museums have benefited from this technology, especially in terms of presenting or exhibiting the heritage of a specific historical period. For example, the interactive museum This Old Digital City (TODC) was created to represent the virtual heritage of Cedar Rapids in the United States during the first and third decades

of the 20th century, and presented in museums ([Hogan, 2000](#); [Cremer et al., 2000](#); [Severson and Cremer, 2002](#)). Some studies have covered these benefits; another example is the reconstruction of the historical city of Kawagoe in Japan from an antique map ([Suzuki and Chikatsu](#)) This example and others are discussed in the literature review in Chapter 2. This thesis explores the possibility that applying 3D technology to generate an installation that represents Al Madinah during the historical period of 1850-1950 (the installation design having been inspired by a scale model of the city as it was in 1926) would give the public an opportunity to learn about the history of the city in an entertaining way, and would also support the educational role of museums as regards the city's heritage.

1.2 Problem Statement

The modernisation and urban development of Al Madinah has been rapid, leaving very little documentation about the past ([Alsafdi, 2007](#)). Nevertheless, there have been several attempts, many by individuals, to save the heritage of Al Madinah.

There are many researchers who have focused on Al Madinah's development. The period that is most covered spans the 6th and 7th centuries CE, associated with the beginning of Islam and the subsequent rapid spread of the religion. For instance, the most well-known physical structures that are part of Al Madinah's history include Al Masjid Al Nabawi and the Qubaa mosque, both of which have been refurbished regularly. Although these mosques are not in their original form due to expansion, the changes over time that they have undergone (especially in the case of Al Masjid Al Nabawi) have been well-documented. In contrast

to this, some other periods have been less well-documented. (Al Hussien, 2003; Dhaish, 1999) For example, in my research I have found only one academic paper on the subject of early to mid-20th century Al Madinah that documented the city and its significant landmark locations. (Alsafdi, 2007)

With the continued demolition of old Al Madinah, the original city layout has

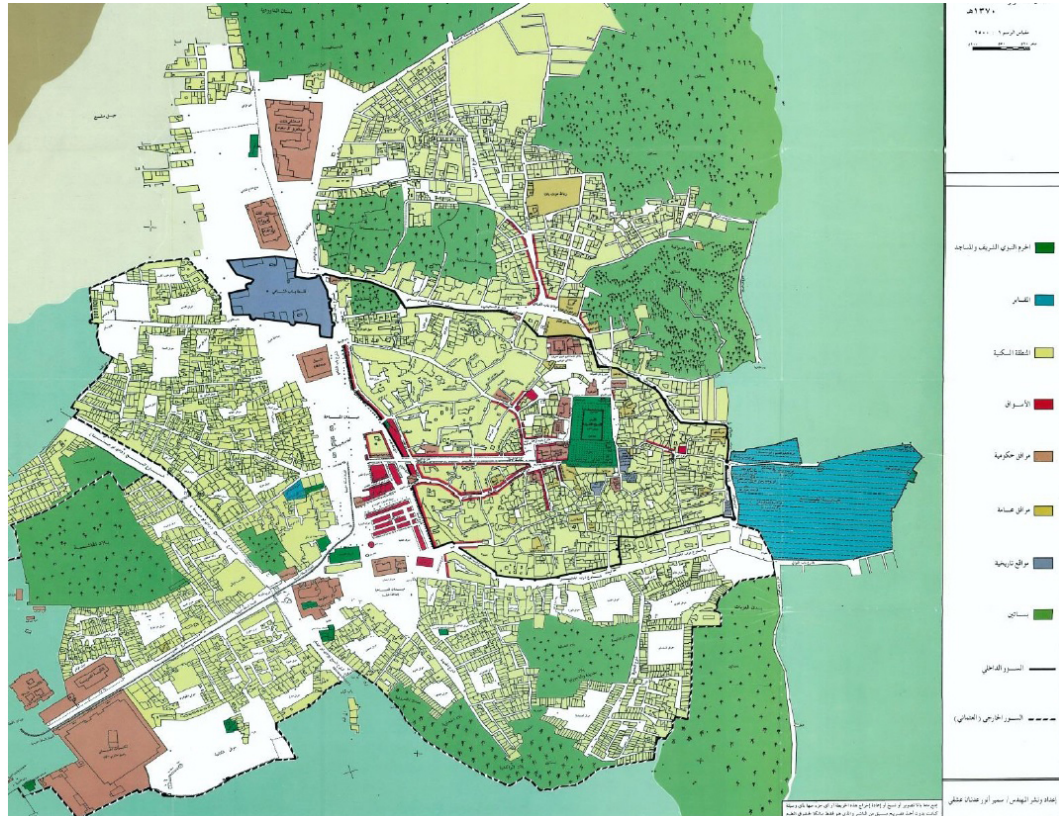


FIGURE 1.1: Map showing the layout of Al Madinah in 1950, (Alsafdi, 2007)

been obliterated, leaving mainly still images and memories. The Al Madinah city council did some research to resolve this issue, and undertook a project to document the city during the period between 1850 and 1950. This project, discussed in a research paper published in 2007, was the first to document Al Madinah of that period and was undertaken in collaboration with engineers, architects, archaeologists and researchers with history and architecture backgrounds (Alsafdi, 2007). This project covered the whole city, and built a scale model of the city with

all traditional places, including mosques, libraries and service buildings. The produced model was the main output of the project and it was the first model that represented Al Madinah during the period mentioned earlier. Although the research paper covered 100 years, the scale model is labelled as representing the Al Madinah of 1926. This project was done manually, using wood for constructing the model and then applying paint over it. The map drawn during this project has become the reference for museums to build their own scale models. Both the museums that I visited in my study had such models.

Although the above research has disseminated very important information, the fact that this information is accessible only to museum visitors limits the number of people who have a chance to explore the old layout of Al Madinah. More importantly, museums in Saudi Arabia are not a crucial landmark in the realm of education; regardless of their rich historical resources, the museums of the area have failed to have a strong impact or to play a serious role ([aljazeera Riyadh, 2012](#)). According to ([Almnai', 2014](#)), visiting museums is not a common activity among the people of Saudi Arabia; in her thesis, she found that there is a lack of technology use in museums, as well as in archiving and displaying. In addition, most of the museums use static display methods, which are based on traditional ways of displaying rather than the modern interactive devices which are now being used in museums around the world ([Almnai', 2014](#)). So, the use of modern technology in museums is an essential step in improving the current situation of museums. In my research, I aimed to produce a part from digital technology, and I chose to work with 3D and virtual reality to create a virtual heritage installation. There are several reasons for using technology in virtual heritage. First, the targeted heritage could be lost or destroyed, such as the Great Buddha of Bamiyan, Afghanistan ([Gruen et al., 2003, 2004](#)), which was

destroyed in 2008. Second, if a heritage site is ruined and the surviving parts have lost their characteristics, a 3D reconstruction can help to visualise the beauty of the original shape, for example, Dudley Castle, in the town of Dudley, West Midlands, England (Boland and Johnson, 1996). The third reason is for the documentation process, and to disseminate this knowledge widely and make it available to the public; this has become more common as there are lots of museums in the world that provide a virtual museum experience online. The use of technology in virtual heritage is based on three main stages: 3D documentation, 3D representation and 3D dissemination (Addison, 2000). One of the main issues in my research is the lack of the documentation of Al Madinah, and that results in extra work to collect first-hand data that can be used in the second stage, the representation stage, where the virtual sites are built based on the historical documentation. Again in this stage, the fact that most of the heritage sites have been destroyed limited the options to represent the data by using actual images, and the best option was to build 3D models using 3D software. The last stage is dissemination, and in this stage I considered the low budget of local museums; at the same time, it is important to build an implementation which provides historical information in an interesting and engaging way. So a head-mounted VR display was the best option to disseminate the work. To conclude, this thesis takes an in-depth look at a specific period in the history of Al Madinah, with emphasis on a 3D virtual environment which was produced as part of this project and inspired by a 3D model depicting the historical Al Madinah. The 3D virtual environment in this study represents the period between 1850 and 1950 by applying 3D modelling in order to present the information of that period in an entertaining way. In addition, it attempts to fill a gap by providing an installation that will aim to benefit not only local museums, but also all learners

who are eager to find out more about Al Madinahs heritage. Direct observation, participant observation, semi-structured interviews, and document analysis were the research tools applied to collect relevant data about that period.

1.3 Aim and Research Questions

The aim of this thesis is to investigate the use of digital devices that represent Al Madinah between 1850 and 1950 in a museum context, and to suggest ways in which information about this period of history could be better conveyed to the public. The thesis provides answers to the following research questions, under each of which is the action carried out to address the question:

1. How was the history of Al Madinah between 1850 and 1950 documented and which of these resources are currently available?

The thesis evaluates previous research and projects with the aim of documenting Al Madinah, and has located available resources for researchers of this topic. As further discussed in Chapter 3, I conducted research on Al Madinah to find out the answer to this question by interviewing researchers, archaeologists and local inhabitants of Al Madinah. I also visited local museums that dealt with the civic history of Al Madinah and evaluated the media they use to represent the information.

2. What are the types of digital devices used in UK museums?

The thesis responds to this question by means of an investigation exploring the digital devices currently used in UK museums; this includes understanding the subjects they covered and how they were set up. The study

was based on ten museums in the UK, and it used direct observation and note-taking, with map themes analysis based on these. The findings of this study show that display screens and projectors of different sizes and various purposes are widely used. The design of an installation can cover very specific objects and time periods, or can have a wider focus. The level of interactivity is not solid and varies from museum to another. The details regarding this are presented in Chapter 4.

3. How can an effective installation be developed to convey the heritage of Al Madinah in a museum context?

The thesis responds to this more open-ended question by presenting a virtual reality application that draws on research findings from previous studies. This application forms the first part of an envisaged larger project, which involved an interactive map representing Al Madinah between 1850 and 1950, and some of its key locations, with a virtual reality tour to discover the external landscape views around the city and explored a model of a Hijazi house. The development of the application and the user testing is presented in Chapters 5 and 6. The installation was tested in two phases. The first was based on the MVH1.0 and tested the usability of the installation; it received user feedback, which was acted upon. The second phase tested the virtual reality experience of MVH2.0 from the perspective of users.

1.4 Contributions of the Thesis to its Discipline

The key contribution of this research is the production of an effective application, based on new VR and 3D technology, which demonstrates the history of the city and can be used in a local museum.

The use of 3D modelling to produce historical information, especially for the purpose of recreating lost heritage, is new in the context of Saudi Arabia. The main contributions of the research can be enumerated as follows:

1. Collecting different kinds of available data and presenting them in an accessible, informal and entertaining way.
2. Understanding the use of digital media in museums, which includes a comparative study of the UK and the Kingdom of Saudi Arabia.
3. Developing a practical application as an example of how to preserve cultural heritage using VR; this will help museum owners in Al Madinah and interested researchers or developers and will get the public more involved and disseminate the information more widely.

1.5 Scope

The goal of this thesis is to rebuild the spirit of the city of Al Madinah from the past, and to provide information about the urban and architectural aspects of the physical appearance representation of the city. The thesis focuses on a virtual reality installation project inspired by Al Madinah from 1850 to 1950, which was chosen as the last era in history before the layout of Al Madinah

began undergoing changes at today's rapid rate, leaving almost no remnants of its rich heritage. This period of time was the late era of Ottoman rule and the early years of the Saudi kingdom. It was after this time, around 1951/1952, that most of the key locations and buildings began to be demolished.

1.6 Structure

- Chapter 1 provides the research context and lists the research questions and methodology.
- Chapter 2 reviews the different aspects of the topic of the research. The project focuses in particular on virtual heritage, 3D design and digital media in museums. Each aspect is discussed and explanations about how it relates to the thesis are given. Next, there is a discussion about using digital media in museums and a different way to present demolished cities in a museum. This in turn is followed by a description of the previous work done to document the context of the study - specifically the study Al Madinah in 1850-1950 ([Alsafdi, 2007](#)). This study attracted considerable interest, mainly from architects and archaeologists, but the scientific research on this topic was very limited.
- Chapter 3 presents raw data collected first-hand about various aspects of the subject by interviewing specialists and visiting local museums to discover what media they use to display the heritage of the city.
- Chapter 4 investigates the use of digital media in UK museums, and provides an analysis of research conducted in 10 museums in three different

cities: London, Canterbury and Liverpool. The findings lay out the different methods used by museums to present data in digital form.

- Chapter 5 discusses the development of the application. This chapter presents a framework for developing a digital application based on old maps and photos. It also describes the process of classifying the collected data into different forms (descriptive data, old photos, books, narratives) and discusses how these can be converted into 3D forms and then used in different ways. The process of the design and development of the application is then discussed, along with a description of the usability test for MVH1.0.
- Chapter 6 includes a discussion about the development of the MVH2.0 application, based on the previous usability test of MVH 1.0, and with the addition of virtual reality features by using a head-mounted VR display.
- Chapter 7 discusses overall findings, focusing on the implications and limitations of the research, and points towards further work that could be carried out in this field.

1.7 Methodology

This section explains the methodology that has been used in the research. As the research aim is to make an engaging, effective and informative 3D graphics application about Al Madinahs heritage that can be displayed in a museum context, the work has been done by using qualitative methods in addition to the practice-based method. The qualitative method allowed me to deeply explore the nature of museums and how they function in different cultures (Verd, 2004). The practice-based method was applied to build the implementation and test it in the first cycle, use the feedback on this to develop another version and test it, and finally use the feedback from the two cycles to produce a suggested framework for further development (Candy, 2006). The research takes an in-depth look at the historical city of Al Madinah. Several research methods were used: semi-structured interviews with local museum owners and elderly local inhabitants; direct observation, participant observation and document analysis to collect relevant data about that period; and, later on, an investigation into the possibility of using 3D graphics in museums to display the heritage of Al Madinah. The research went through five phases, during which various research methods were applied. The choice of method depended on the purpose of each phase. Among the various methods, participant observations and semi-structured interviews were the main tools utilised to collect most of the relevant raw data. The nature of the qualitative data allowed me to adopt and use several methods in order to gain an in-depth understanding of my research context, such as semi-structured interviews and observations. The collected data was used to provide a 3D VR installation. During this phase, practice-based research was adopted and a variety of software was used, including Autodesk Maya, Unity3D, Adobe After Effects

and Photoshop in an experimental fashion. Designing the implementation was based on the investigation conducted by the researcher on the use of displayed digital devices in UK museums; this was done in addition to drawing on my existing knowledge of 3D design as a 3D computer artist. The 3D virtual environment named as Madinah Virtual Heritage (MVH) had two versions, both of which were tested. MVH1.0 was tested for its usability as the first stage of the development, then MVH2.0 was tested again with the focus on engagements as a virtual reality tool. The results of the practical research method provide a framework for the production of a 3D environment based on retro references to be used as a virtual reality environment.

In conclusion, the first phase explored the existing data available about Al Madinahs heritage, and critically examined the way it is currently being displayed in a museum context through different mediums of display. In the second phase, the use of digital devices in UK museums was investigated; this included a comparison with how historical information is displayed currently in Al Madinahs local museums. In the third phase, the Al Madinah Virtual Heritage (MVH) implementation was designed; it was then built using several types of 2D and 3D software. The fourth phase tested the usability of MVH1.0 and received feedback from users. The fifth and final phase involved the improvement of MVH2.0 based on this feedback and the addition of using virtual reality with the aid of a head-mounted display. While the qualitative approach was mainly used in phases one, two and four, practice-based research was applied in phases three and five.

1.8 Research Methods

As the research required an exploration of the historical and cultural background of a city, it was important to obtain largely descriptive data without being constricted by specific questions and answers. This research phase was conducted using a qualitative approach. In his book about media research methods, ([Gunter, 1999](#)) suggests using a qualitative approach when interpretation is more important than measurement; an example is a media-related study looking at impact, reaction and behaviour. The primary reason to communicate by using words instead of numbers is to focus the project on people and their interests, their ways of thinking and their interaction with the ideas that build up their own world. In addition, some essays mention that qualitative research is context-conscious, where the culture is the ultimate context that people interact with ([Löfstedt, 1990](#)). The contextual background, Al Madinah in the 1950s, plays a significant role in the research, where the local people in Madinah interact with the data. Different methods were used in the research: semi-structured interviews, observation, document analysis, media recording and questionnaires. The research data was collected by using the following methods:

1.8.1 Semi-Structured Interviews

Semi-structured interviews combine the advantages of both structured and unstructured interviews. There are two main reasons for using semi-structured interviews to answer the first question in the research, about the history of Al Madinah and the documentation process related to it. First of all, this method

allowed me to explore interviewees feelings, thoughts and memories. The interviews were conducted with local inhabitants of Al Madinah who lived there during the 1950s and have information about that time that are derived from personal memories or from their parents descriptions. The semi-structured interviews gave the participants the opportunity to talk about their past and how life looked at that time. It also provided the interviewer with an opportunity to determine which parts of the interview are most important (Cohen and Crabtree, 2006). At the same time, the researcher was able to refer to the semi-structured interview schedule and ask related questions at the right time, so that participants did not waste time by talking in too broad terms or about something irrelevant to the studys needs. The semi-structured interviews provided a balance between the interviewee and the researcher in order to share knowledge, experience and ideas, as well as to enjoy the interviews. The second reason was to gain knowledge from the interviewee. When the research on the available data on Al Madinah was conducted, I faced difficulties in finding resources. Some of the main resources were archaeologists, who typically have information that is not included in non-specialist books. The semi-structured interview provides a chance for this knowledge to come out, allowing the researcher to choose information that is more directly related to the research topic. During the first phase, I managed to have seven interviews with two architects, an archaeologist, a lecturer in media, and three elderly ordinary local people.

The interviews in phase one focused on details of Al Madinahs heritage, its situation today, and sadness about the loss of this heritage. The other semi-structured interviews conducted in phase four were followed by the testing of MVH1.0. Eighteen participants were interviewed in order to explore their knowledge about Al Madinah in general and its past heritage in particular, and to learn about the

sources from where the interviewees gained this knowledge.

1.8.2 Observation

To collect data in its natural environment, (Gunter, 1999) advises researchers to make use of the advantages of observational research. Two types of observation were applied in this research in order to facilitate data collection throughout the phases: direct observation and participant observation.

1.8.2.1 Direct Observation

Direct observation is a valuable method for collecting evaluation information (Patton, 1990). Direct observations are useful when the researcher needs direct information. This kind of observation is not based on peoples reactions; instead, it provides an opportunity to document activities, behaviour and physical aspects of the participants (Taylor and Bogdan, 1998; Gunter, 1999). Such observations were conducted in the first phase during visits to the surviving old buildings in Al Madinah (some of which were demolished two years after my visit), and to local museums in the city.

1. Building Survey

There are very few surviving old buildings in Al Madinah, as most of these buildings were removed to make room for more modern structures. I did a tour of those buildings during the course of an interview with one of the archaeologists. This was an opportunity to link written and oral information

with reality and visualise it in context. There was also the benefit of gaining ideas in a technical sense to create 3D models of 1950s buildings in Al Madinah, using photographs taken during this occasion as reference. Additionally, some images were used to give a more authentic texture to models. For example, one of the four different locations observed was the ruins of a fort built over 1400 years ago; the images from this location were used in the production stage as texture material. Two other empty buildings examined had the internal and external structure of the traditional Hijazi house. The *Al Seeh* neighbourhood was the fourth location I visited, and the last to have survived. Although several houses with inhabitants still stood, the empty ones had already been demolished. Workers from other countries were living in this area in very harsh circumstances that matched the condition of the buildings. Some of the images from here were used as texture for 3D models.

2. **Al Madinah Museums**

Visits to the museums in Al Madinah had two main purposes. The first was to collect information about the heritage of Al Madinah; this included historical information and information about the physical objects which were available in the museums. Both the museums permitted photography during the visits, and the photographs thus taken were used as a reference for building 3D objects such as furniture and indoor utilities. The second purpose was to explore the display medium in museums. Al Madinahs museums were the primary resources for my collected data about the cultural heritage of Al Madinah, especially with regard to props and old photographs from that period. All the museums I visited are self-funded; the owners are motivated by their love of the city to preserve its heritage,

to encourage people to visit and share knowledge, and to introduce the culture of the museum to visitors and pilgrims.

1.8.2.2 Participant Observation

Participant observation is where the researcher immerses herself in a social situation as a participant in order to more accurately determine the nature of the situation (Moyles, 2007). Such observation was done in the second phase of this research, where an explorative study was conducted in UK museums to gain a deeper understanding of the different digital implementations and representations of data in digital format that are being used in a specific museum. The aim of visiting some museums in the UK was to examine the usage of digital devices in a museum context and to be a participant observer, trying different devices and comparing them to discover the strengths and weaknesses of each. The second phase was essential after the raw data collection, since it gave the researcher the confidence to design her own implementation after investigating the available implementations in museums.

1.8.3 Document Analysis

Visual documents such as photographs and books are very important tools for visualising the city of Al Madinah. Books vary in content and time of publication. Most of the books were very hard to find, due to low demand. I borrowed most of the books, and some I received as gifts or rewards. Some photographs used are private and owned by Al Madinah citizens, and I made copies of these after obtaining their permission. Others were available online.

1.8.4 Screen Capture and Film Recording

Using a film record has the advantage of saving actions, and giving accurate visual information (Collier and Collier, 1986). Screen captures were done during the testing of MVH11.0 for tracking user behaviour while people navigated through the implementation. This led to the discovery of the strengths, weaknesses, opportunities and threats. Alongside this, a video camera filmed the process to record user reactions. In the second test, for MVH2.0, two video cameras recorded the experiment, but no screen capture was used. This was because of the difficulties in running the capture software in tandem with the Oculus Rift device. The two cameras were set opposite each other while the user sat in the middle in front of the desktop computer. Both cameras were important, especially in terms of gauging the virtual reality experience, while the user put on the Oculus Rift and started navigating.

1.8.5 Questionnaires

Questionnaires were used in the fourth phase, after users tried MVH1.0, to find out the usability of the implementation. The usability test was based on two formal usability questionnaires which were designed specifically to measure the usability of the implementation during the interaction between the user and the software. These questionnaires were in compliance with the System Usability Scale (SUS) and the Questionnaires for User Interaction Satisfaction (QUIS) guidelines. The SUS seeks users general impression about the system while the QUIS is more precise and includes five different parts to test. These parts test reactions to the software, screen, terminology, system information, and learning

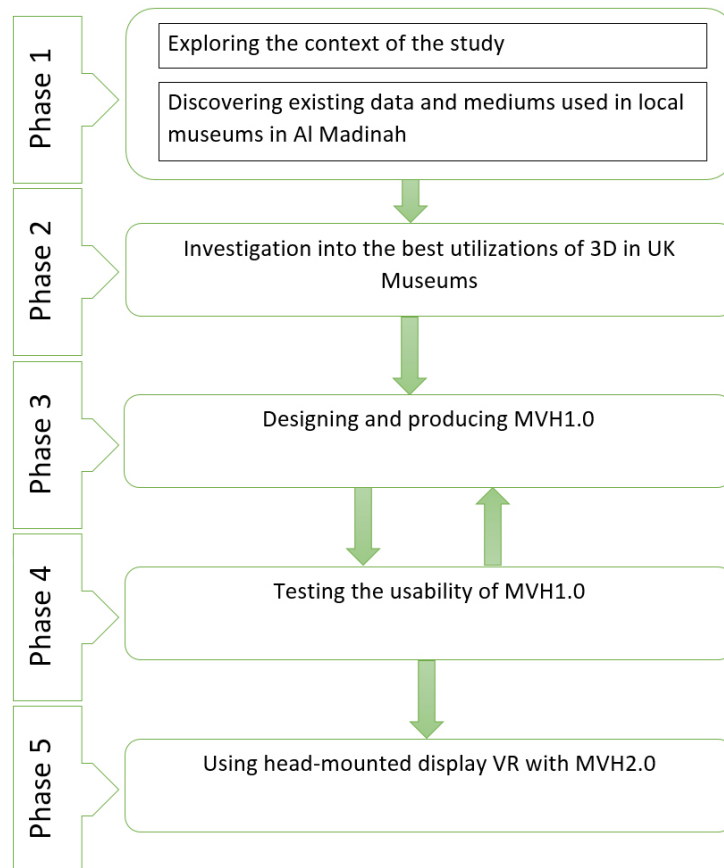


FIGURE 1.2: PhD Phases

and system capabilities. The questionnaires were given to the user for filling in after the test. Sixteen of the 18 participants did the questionnaires on the same computer, thus allowing them to be recorded online, while two participants preferred the paper questionnaire.

1.9 Research Phases

1.9.1 First Phase:

1.9.1.1 a: Exploring the Context of the Study

The aim of this phase was to investigate the context of the research and discover the existing historical information, photographs and maps related to Al Madinahs heritage. In order to achieve the goal of this phase, three tools were applied. First, direct observation was utilised; this provided the exploratory framework for the research. For this, I was accompanied by a professional as I visited old buildings and other places of interest to the research in Al Madinah in order to examine the condition of these surviving old buildings. This was necessary, as most of these buildings are located in unknown places, and it was vital to be able to visualise the traditional houses and the materials used in their making. Second, semi-structured interviews took place as a major tool in light of a substantial lack of necessary information in the data collected using the first tool. I managed to interview local archaeologists and local inhabitants. The interviews were in Arabic, as it is the native language in the city of Al Madinah, and the interviewees were given an information sheet and a consent form in Arabic, so that their consent to take part in the study could be obtained. The aim of the interviews was to collect information about Al Madinah in the 1950s and earlier, including historical information as well as data on social life. Although the interviews have not been transcribed, they were recorded with the interviewees permission. I have been listening to these from time to time and taking notes. Third, document analysis played a critical role in this phase, as it helped me to better understand

Al Madinahs heritage, especially with regard to the citys layout plan and how this plan affected the social lives of the inhabitants. The documents included textbooks, photographs in exhibitions, and original documents such as personal photographs and maps from different resources.

1.9.1.2 b: Discovering Existing Data and Mediums Used in Local Museums

The goal of the final implementation was for it to be used in a museum context in Al Madinah, for which it was necessary to become familiar with the existing museums and to investigate the availability of historical information about the cultural heritage of Al Madinah; two visits to museums were done for this purpose.

1.9.2 Second Phase: Investigation into the Best Practices in Using Installations in UK Museums

To determine the best practices in using installations in museums, visits to several museums in the UK were conducted and the current usage of 3D graphics in that context explored. In addition, other digital media and interactive devices used in museums were observed in order to gain a better vision of the use of graphics and technology in museums. This phase directly influenced the next phase by looking for the strengths and weaknesses of various digital devices in various museums.

1.9.3 Third Phase: Designing and Producing the Installation

This phase was based on previous research about the different implementations currently used in museums. In addition, a selection of images from specific locations collected in the first phase was used according to the popularity of the location and the availability of the references. Although all locations are important, I focused more on the history of walls, gates, the Prophets mosque and the main market street. Other key locations built as 3D are the army barracks, the Egyptian kitchen, the wireless station and the railway station. These four constructions have their unique features in terms of their buildings and the stories each has to tell. Different media were used in the implementation, including photographs, original sounds, new versions of some old songs, original video clips, and documents.

1.9.4 Fourth Phase: Testing the Usability of the Application

The aim of this study was to explore the potential for using virtual digital devices to engage people in learning about Al Madinahs heritage. MVH1.0 starts by playing 56 seconds of 3D video animation demonstrating parts of Al Madinah, introducing the user to what they can expect to find. After the video finishes playing, the main screen starts with two options given to the user: the first one is an interactive map, and the second one a virtual environment tour. The interactive map is a 2D map with 3D models, which represents the key locations in Al Madinah that the user can navigate through and get more information

about specific places. The virtual environment is based on a genuine plan of a traditional house in Al Madinah. Based on the plan, I built the 3D objects of the house using 3D software and exported them to the game engine to enable the virtual environment controller to operate. Eighteen participants were involved in the study, and all of them were able to read and understand Arabic, the language in which the implementation is done.

1.9.5 Fifth Phase: Using Head-Mounted VR Display with the Installation

In this phase, I developed the implementation based on the feedback from the first study and added a virtual reality experience instead of the virtual environment to produce the MVH2.0. Adding the virtual reality element made the experience more engaging to the player. In this study, I used the Oculus Rift device for this purpose. Although this device was launched as a developer kit, it was appropriate for this job. There are some limitations due to certain aspects of the device, including the need to use a specific desktop computer with Pro Unity3D software.

1.10 Conclusion

In this chapter, I have written about the great city of Al Madinah and its lost heritage, with not enough documentation concerning the huge demolition of the city which started in 1951 and destroyed most of the significant sites. With the technology of virtual heritage, the development of 3D virtual heritage was considered, and to achieve that, it was essential to start with collecting first-hand

data about the history of Al Madinah; this was done by interviewing local people from Al Madinah. The next step was to visit local museums in Al Madinah that represented the history of the city and to explore the display methods, as well as surveying some surviving historical buildings.¹ This was the first stage where I applied semi-structured interviews, observation, building surveys, captured photographs, and recorded videos. In the second phase, I conducted an investigation into the best practices in using installations in UK museums. This was essential to explore how historical data is displayed in a museum context using technology. The fourth phase was the process of developing MVH1.0, which was followed by testing the usability of MVH1.0, and making changes to develop MVH2.0, which used a head-mounted VR display. The next chapter will give an overview of virtual technology and how it has been used to save heritage.

¹Some of the historical building I visited on 2010 / 2011 were demolished a few months after my survey.

CHAPTER 2

Literature Review

2.1 Introduction

The objective of this thesis was to demonstrate how the lost heritage of Al Madinah could be reconstructed in an engaging way using 3D Technology, thereby enabling the public to learn more about the civic history of the city of Al Madinah.

This chapter provides insights into different approaches to 3D technology; it provides a definition of 3D technology and discusses its uses. Relevant research papers regarding the virtual world, augmented reality and virtual reality are presented, and the application of this technology in different domains, such as the social, medical, education and entertainment are considered. The 3D techniques used in the study of cultural heritage are investigated.

2.2 3D Computer Graphics

3D technology is used widely in many disciplines. The uses of 3D technology vary, including 3D printing, 3D camcorder and 3D television. This thesis focuses on 3D computer graphics and more specifically on the use of 3D to illustrate cultural heritage.

2.2.1 Virtual World

There are ambiguities around the use of the term Virtual World (VW) in academia. Bartle ([Bartle, 2004](#)) defined VW as an environment implemented by the computer, which is partly controlled by individuals. The earlier 2D VW was based on text and graphics, and then 3D VW improved on this by introducing 3D computer graphics ([Bell, 2008](#)). A number of characteristics define VW: generally, it refers to a persistent environment that can be shared by a network of people who are simultaneously represented by avatars ([Castronova, 2008](#); [Koster, 2004](#); [Bell, 2008](#)).

A number of different terms appeared in the research referring to VW. These included, virtual environment (VE) ([O'Connor et al., 2014](#)), immersive virtual world (IVW) ([Lee et al., 2013](#)), multi-user virtual environment (MUVE) ([Billingsley et al., 2013](#)), massively multi-player online game (MMOG) ([Steinkuehler, 2004](#)) and serious virtual world ([Billingsley et al., 2013](#)). The use of a specific term is driven by the purpose of that particular virtual world. Due to the ambiguities in using the terms for the virtual world, Girvan ([Girvan, 2013](#)) presented a classification of virtual world types based on research that covered 88 articles relating to the VW. Figure 2.1 shows Girvan's classification, which is based on

two main groups, one text based and one graphical.

The text- based group includes Multi User Dungeons (MUD), which is an early version of VW (Bartle, 2004). The graphical VW group includes both 2D and 3D. The 3D VW are now more popular. Sub-sections of the graphical VW can be goal oriented, or non-goal oriented. The goal-oriented group have tasks, which have to be achieved in a pre-designed environment.

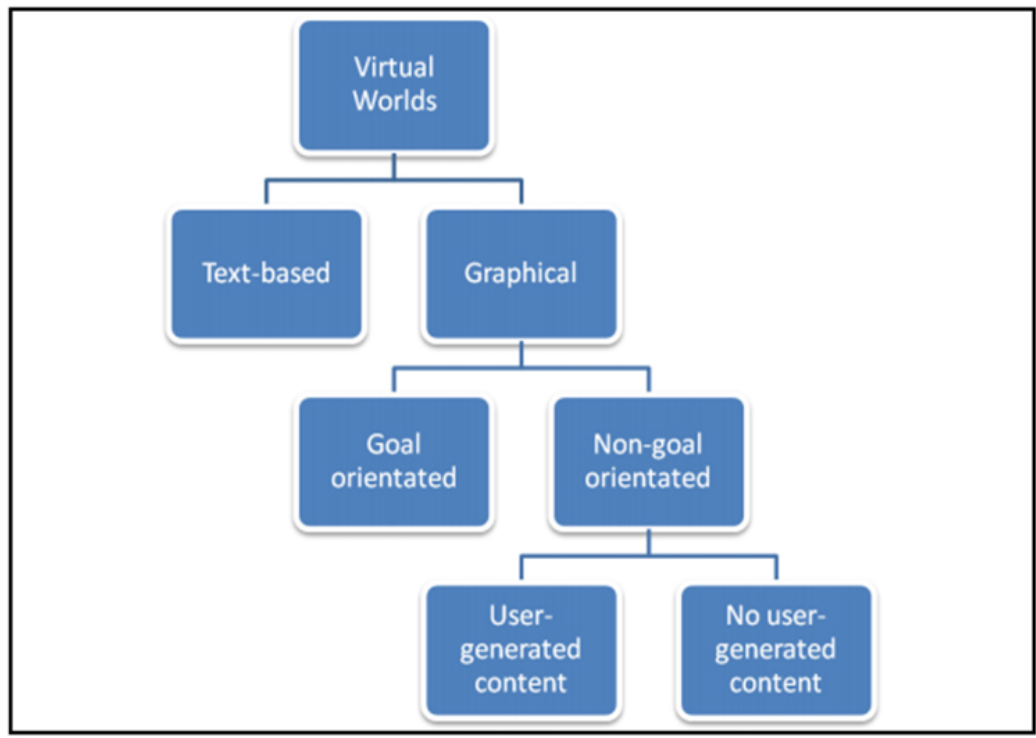


FIGURE 2.1: Classification of virtual worlds according to (Girvan, 2013)

2.2.2 Augmented Reality

Augmented reality has as many definitions as the virtual world does, but while the virtual world is about a crafted virtual environment, augmented reality (AR) portrays the real world enhanced by virtual content generated by the computer (Jung and Han, 2014). Many aspects of our lives make use of AR, such as archaeology (Papagiannakis et al., 2005; Eve, 2012; Dähne and Karigiannis, 2002),

architecture([Webster et al., 1996](#)), art ([Peterson and Fisher, 1955](#)), tourism ([Tian et al., 2013](#)), commerce([Tan Poh, 2013](#)), education ([Billingham, 2002](#); [Lee, 2012](#); [Kaufmann and Schmalstieg, 2003](#)), medicine ([Santhanam et al., 2004](#)) and entertainment([Furht, 2011](#)).

2.2.3 Virtual Reality

Virtual reality is defined in the Oxford Dictionary as the computer-generated simulation of a three-dimensional image or environment, which can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors. This artificial environment can vary in the realism of its appearance and purpose. Such environments are used in health care, the military, pilot training, nursing, therapy, surgery simulations, education and entertainment. The virtual reality is constructed through 3D images or scenes, and needs equipment to display it and make it interactive. This type of equipment has been developed since the late 1950s. The next section gives further detail about the virtual reality timeline.

2.2.3.1 History of the Virtual Reality Headset

Recently, virtual reality equipment has become more popular and more affordable for developers, researchers and gamers, owing to developments in the design of modern virtual reality headsets. Earlier, although the concept of VR was available 58 years ago, the high cost of the physical equipment meant that the number of studies using the technology was limited. In this section, an overview of the history of the development of the VR headset is given, with a description of how it has become more popular and cheaper.

In 1957, the Sensorama simulator first provided 3D images combined with vibrating seats, artificial winds, smells and sounds for added sensory stimulation. This was invented by Morton Heilig ([Gladstone et al., 2000](#)). This machine was used to simulate five different experiences: riding a motorcycle, riding a bicycle, riding a dune buggy, flying a helicopter, and doing belly dancing, [Figure 2.2](#)([Fisher, 1991](#)).

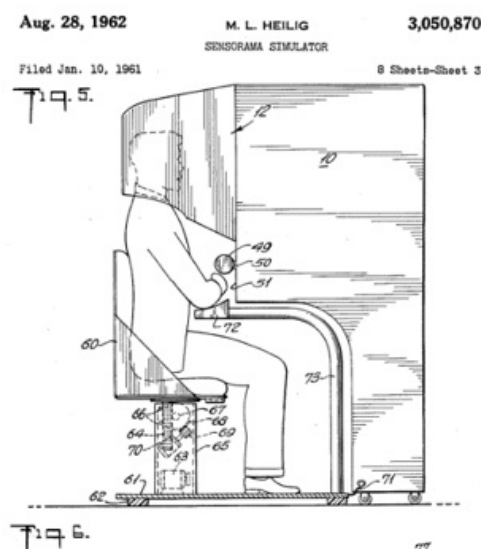


FIGURE 2.2: The Sensorama machine was the first virtual reality machine, 1957

Heilig failed to raise sufficient funds to continue with this project. He made a second attempt to create a head mounted display (HMD) in 1960, the outcome of which was the Telesphere Mask. This consisted of a headset that provided 3D vision and sound. Heilig's concept was called the Stereoscopic-Television Apparatus and it was patented (US patent number 2955156 A; year 1960). It was intended for individual use. In 1962, the invention was given the US patent number 3,050,870 ([Kollee et al.](#)).

In 1961, a head-mounted sight tracker was developed by Comeau and Bryan from

the Philco Corporation. This invention was the first functional HMD, and had a helmet attached with a magnetic tracker, connected to a remotely controlled closed circuit TV. This system was used to observe dangerous places from a distance (Ellis, 1995).

In 1963, Ivan Sutherland wrote a programme for SketchPad in his PhD thesis; this was the earliest Graphical User Interface (GUI), and it was a precursor to the modern Computer-Aided Design (CAD) software. In 1965, Sutherland introduced The Ultimate Display, which was a precursor for augmented reality. In 1968, while working as Associate Professor of Electrical Engineering at Harvard University, Sutherland created his first virtual reality and augmented reality with his student Bob Sproull. The HMD system was designed to be hung from the ceiling above the users head, for which reason it was called the Sword of Damocles (Caudell and Mizell, 1992; Feiner et al., 1997) Figure 2.3

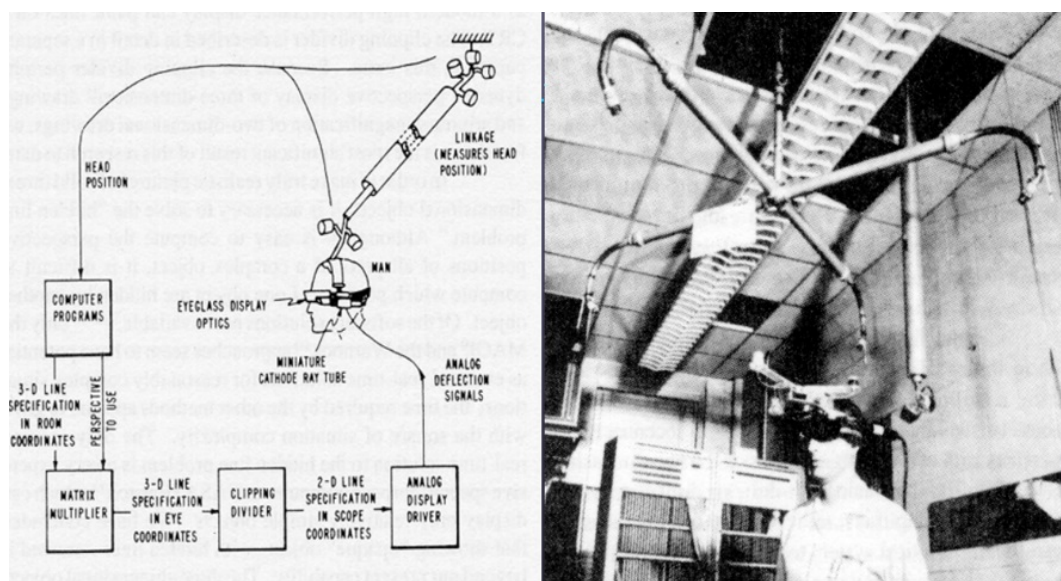


FIGURE 2.3: The Sword of Damocles, the HMD system developed in 1965

The Virtual Interface Environment Workstation (VIEW) developed by NASA

in 1985 combined HMD with data gloves. In the few years that followed, the flight simulator was the focus of research in this area. For example, the British Aerospace Virtual Cockpit was the first flight simulator used by pilots ([Abdul-Muhsin and Patel, 2014](#)).

VPL "Visual Programming Languages" research was founded by Jaron Lanier, resulting in various products, one of which was the eye phone [Lammers \(1986\)](#). The eye phone was an HMD device, and the company was the first to sell VR goggles and data gloves to customers. It is believed that Lanier is the pioneer of many virtual reality concepts that have become familiar terms ([Lanier, 2001](#)). The Virtuality group produced a series of VR machines with the support of IBM research labs in the UK. The devices provide stereoscopic vision and have a joystick for navigation. The first two devices of this kind were sold to British telecom research laboratories. The system supports a multi-player mode, and it has been sold in more than 17 countries as a gaming machine and played over 42 million times.



FIGURE 2.4: Developing Virtual Reality in video games

In 1993, Sega demonstrated its VR glasses, but they did not complete their project ([LaViola Jr, 2008](#)). In 1995, Nintendo created the virtual boy device, which is a 3D gaming console; however, it has not performed well in the market

(Boyer, 2009). In 2012, Oculus VR raised \$2.4 million by using Kickstarter to support a project to develop the first Oculus Rift device kit. By the end of 2012, the Oculus Kit had become available for developers. In 2014, Oculus VR launched the second development Kit, Oculus Rift DK2, which is what is used in this project (Oculus, 2012). Sony computer entertainment has now developed the Project Morpheus virtual reality headset, which is compatible with PlayStation 4 and PlayStation Vita (Avila and Bailey, 2014; Goradia et al., 2014).

2.2.4 Evaluation of 3D Technology

In this section, two different types of 3D technology are chosen for evaluation. The first is A Second Life as it is very popular for research purposes and has been used in different disciplines. The second is Oculus Rift DK2 as an example of a head-mounted VR device, which is new on the market and is used in this research.

2.2.4.1 Second Life as an Example of an Online Platform

Second Life is an online platform, which allows players to live in a 3D virtual world, build their own environment and interact with others by using their own avatar. Second Life is a game-based platform, and is used in education, art, science and for work solutions. This platform was a good research tool for this project in many ways, as a number of papers describe its use in testing 3D models. Second Life also provides a context for increasing student interaction in the learning process by stimulating their learning to extend beyond the classroom (Campbell, 2009). It is also used in the School of Psychology and Counselling at

Regent University in Virginia, USA, which provides online resources for their students. This complements what the students who study on-campus have in terms of facilities, assisting them to obtain the skills they need. The virtual environment of Second Life, which is widely used in universities and colleges, provides the opportunity for students to create a specific environment that meets their particular needs (Walker, 2009).

Minocha and Reeves (Minocha and Reeves, 2010) also discuss Second Life. They comment that Second Life attracts academics and has social and business applications. In their study, they look at designing learning spaces in multi-user virtual environments that focus on 3D learning environments within Second Life. Second Life was not used in this project, as the focus was on developing a model of old Al Madinah based on original images, but it will be considered for use in future work. During their data collection, Minocha and Reeves conducted online surveys, followed by semi-structured interviews. For this project, people in Al Madinah who have good knowledge of the context were interviewed. The interviews were semi-structured, with planned topics for discussion. Minocha and Reeves write about the importance of signs and paths in helping users understand the environment; these are concepts applicable to the digital devices used in museums.

2.2.4.2 Oculus Rift DK2 as an Example of a Head-mounted VR Display

Palmer Luckey invented the Oculus Rift and he founded the Oculus VR Company in 2012. Two years later, his company was acquired by Facebook for \$2 billion. Luckey built his initial VR device in his parents garage, in 2009 when he was 18 years old. At that time, he named it CR1. He improved the traditional 40 angle

of the viewing span to a 90 angle. He tested with 3D vision and with a wider field of view, and posted his updates to the MTBS3D forums ([Boffoli et al., 2011](#); [Iozzio, 2014](#)).

In 2013, the company started shipping the Development Kit1 to developers all over the world. In March 2014, Development Kit2 was announced, and it was first shipped in the same year. The Kit used in this project was ordered in June 2014, and received in October 2014. In December 2014, the Gear VR was launched with Samsungs collaboration. The Gear VR has the advantages of a wireless head tracker and a game pad, but it has to be used with a Samsung Note4 smart phone, unlike the Oculus Rift Kit, which can be set up using windows, Mac or Linux ([Desai et al., 2014](#)).



FIGURE 2.5: Oculus Rift DK2

2.3 Domains of 3D Technology

There is a wide domain using 3D technology. Large numbers of researchers use 3D in the fields of medicine, social work, the military, sport, architecture, archaeology and industry. The focus of this review is on its use in education and entertainment, and specifically in museums.

2.3.1 Education

The revolution in technology has had an impact on education. This impact influences distance learning and affects the way people communicate online. ([Wan et al., 2011](#)) emphasise the importance of social interaction in the learning process; therefore, when implementing a virtual environment in an educational context, it is necessary for instructors or teachers to make sure that the students engage in the learning process. ([Lester et al., 1997](#)) also talk about the huge increase in using animation as a pedagogical learning tool. Targeting schoolchildren whose average age was twelve, they found that in a sample of one hundred students, the childrens learning experiences significantly improved with the use of animation in pedagogy. Although children did not play any role in the research for this project, the final application will target museum visitors including children. In another study, ([Campbell, 2009](#)) trained his participants to use the virtual environment Second Life, produced by Linden Labs, and gave them time to become familiar with the environment. Such training is not part of this research since, although this project utilises a 3D virtual environment for educational purposes, it is not investigating training or teaching principles. This project is a non-formal learning application, intended for use in a museum context, while

([Silén et al., 2008](#)) played a formal teaching role, involving graduate students who learned material based on traditional classroom conventions. A training of that type requires the adoption of a new teaching technology, and Silen discusses the importance of the use of 3D visualisation in student-centred learning in a school of health and psychology, highlighting the main points of use in practice. As many the points related to visualisation were very relevant to this project, they are detailed here:

- Authentic 3D images and applications help students to gain a better understanding of spatial anatomy;
- High quality 3D visualisations can easily be produced and made available in health care education;
- Successful implementation of new visual technology requires teachers involvement in both planning and implementation;
- Students need time for an introduction to the new media in order to become interested in using them; and
- Virtual dissections based on authentic material add educational value.

([Silén et al., 2008](#))

In a paper by ([Jiman, 2004](#)), the importance of the medium of communication as the major tool in the learning process is discussed. For Jiman, students in both traditional and virtual classrooms have the opportunity to engage and ask questions. Moreover, the increasing involvement of technology in education can create high-tech educational systems, which will not be limited by geographical boundaries. Patil and Raman ([Patil and Raman, 2005](#)) discuss the significance of simplifying complex contexts in order to deliver them in an easy and joyful

way to children, especially children at the primary level. Their reference to creating a context from a historical period, whereby young children can enjoy learning, for example, about the 17th century, relates to this study as in it a historical period in Al Madinah will be presented in a way that, hopefully, will help children enjoy learning about it. In his paper, (Walker, 2009) talks about the use of virtual environments in distance learning and counsellor education among Human Service Professionals, where people in the field are trained to use the required skills. The use of 3D technology in psychology and counselling is not new as it had its roots in this field, although, in recent years, its use has rapidly diversified.

2.3.2 Entertainment

3D is used in many ways in entertainment such as in video games and online games. In this section, the focus of entertainment will be that in museums, as museums are the focus of this study.

2.3.2.1 Digital Devices in Museums

Digital museums are one of the media tools that are used to present information and recount the history of a certain period; their role is not only to preserve the heritage, but also to show and share it (Tang, 2005). Digital museums have rapidly increased in number in recent years and the public can access these via the Internet (Schweibenz, 1998). Digital museums are defined by (Chen et al., 2003) as large scale websites with interlinked webpages which may contain content elements as well as style elements providing the page presentation styles. In practice, several museums all over the world have put their collections into a

shared database in order to collaborate and this helps these museums to organise their objects (Marty and Jones, 2008). In addition, digital museums help people to learn about the history of exhibited items without having to visit a particular museum physically (Tang, 2005). Also, as (Patel et al., 2005) suggest, they enable conventional museums to display objects when they do not have enough space to display them physically. In order to produce a good quality digital museum, (Chen et al., 2003) suggest that certain criteria need to be met:

1. It must be feasible to produce exhibition pages based on digital archives;
2. It must be possible to generate several presentations easily for the produced page; and
3. It must be viable to modify the page easily and generate a new exhibition based on it. (Chen et al., 2003)

(Hirose and Tanikawa, 2010) emphasise the importance of presenting both objects and events on a digital museum site. Moreover, it is important to have links between objects in the digital museum. There are two ways in which these links can be formed:

1. By presenting the objects in systemic cohesion categorises;
2. By presenting the objects through a narrative approach (Tang, 2005).

The history of a city can thus be presented through a virtual environment, which reflects historical objects, and at the same time reflects the lifestyle of the period. Therefore, as a 3D virtual application, MVH (Madinah Virtual Heritage) will be shown in local museums in Al Madinah as a new approach to creating virtual

reality in a museum, while a simpler version of the MVH will be published on museum websites. Moreover, as (Chen et al., 2003) suggest, Al Madinah will be easy to access due to its virtual quality. The educational dimensions of the present research are in line with the statement of (Mei, 2004) that a digital museum is not limited to archiving existing materials. It provides the opportunity to make connections between exhibit items, their history and location in a learning process. In addition, a digital museum overcomes the shortage of feedback available in conventional museums, and moves towards more complex functions, allowing interaction with the digital devices and possible feedback. Hogan, Cremer and Severson (Cremer et al., 2000; Hogan, 2000; Severson and Cremer, 2002) all discuss their innovative virtual museum, which uses 3D to model an historical environment. The context of their model is relevant to the present project as both share historical contents. To create the This Old Digital City (TODC) project, a virtual history of Cedar Rapids in the United States was presented in two periods, the 1900s and the 1920s. Most of the collected data were historical, and Cremer and Severson both mention their data sources, which include the following:

- Photographs
- postcards
- newspaper images
- insurance maps
- city records
- blueprints
- reference books about building materials

- paintings

Accordingly, when starting to collect the data to create the Al Madinah environment, the researcher relied on photographs, old maps and drawings, city records and reference books. Furthermore, some elderly inhabitants of Al Madinah who had lived there during the 1950s were visited, as the social life of the people at that time was to be included in the project. According to Cremer and Severson, TODC has demonstrated additional educational benefits as the use of technology has encouraged students to become involved in research by using the museum archives and the city records to look for contents linked to specific buildings. An example of what was used in TODC as the historical context and the resulting virtual environment are presented in Figure 2.6



FIGURE 2.6: An old photograph (left) of and its 3D version (right) developed for the TODC project (598)

After the success of the TODC, the team wanted to engage more people. They developed their system further and provided more options for the visitors. After a year of working on it, this project was completed and the name changed to Time Quest for commercial purposes (Cremer et al., 2001). Time Quest uses three large screens 1.83 * 2.44, LCD projectors and mirrors to produce the virtual environment in a wide space that holds time machine seats for four adults or

six children. The main controller is attached to the front seat, and includes a joystick and buttons to explore the city. The direct cost of this interactive virtual environment was US\$300,000, half of which was used for the physical equipment (see Figure 2.7) (Cremer et al., 2001). This type of cost is not affordable for local museums in Al Madinah as they mostly rely on personal donations. With the revolution in the development of virtual reality headsets, the cost has come down and they are now available on a low budget. For example, the Oculus Rift DK2 used in this project cost US\$350.



FIGURE 2.7: The installation of TODC in progress at History centre (Cremer et al., 2001)

2.4 Use of 3D Technology in Cultural Heritage

The present project looks at the heritage of Al Madinah. The existing literature related to heritage typically discusses it as a set of attributes demonstrated through human activities; these include tradition, art, cultural evidence and narratives. As MVH aims to introduce people to their history, cultural heritage was interpreted as the legacy handed down to a group or society through physical artefacts and intangible attributes, some of which are man-made. In MVH, the heritage and physical spaces of Al Madinah are reproduced using Digital Heritage.

UNESCO's Charter for the Preservation of Digital Heritage describes the concept behind digital heritage preservation as follows: first, the conversion of human knowledge and its expression in digital form; second, an ephemeral presentation of the digital material, including different formats, such as audio, film, text and photographs; third, heritage is valuable and should be saved for future generations.

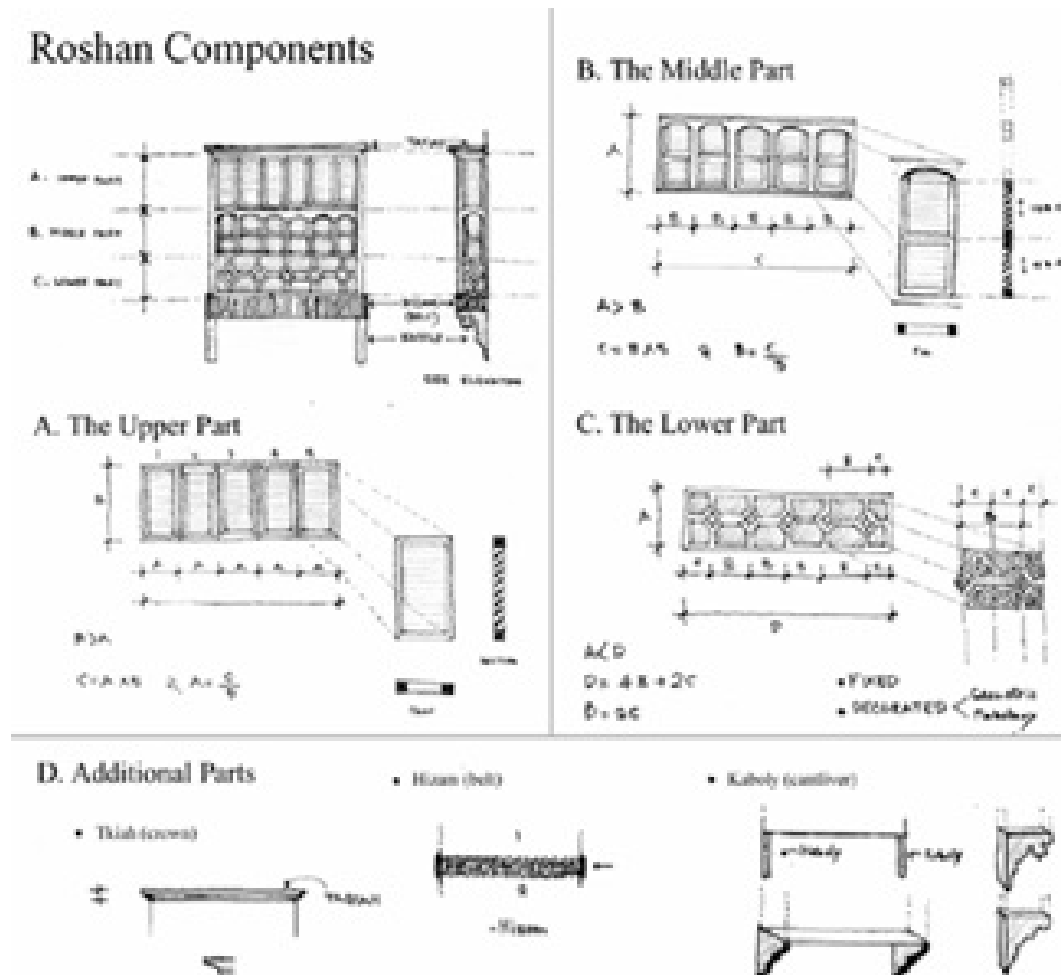
In using computers and related tools, humans are creating and sharing digital resource information, creative expression, ideas, and knowledge encoded for computer processing, which they value and want to share with others over time as well as across space. This is the evidence of a digital heritage. It is a heritage made up of many parts, sharing many common characteristics, and subject to many common threats ([Singh, 2010](#)).

Preserving heritage is essential and has been done throughout human history, starting with paintings, and later continuing through photographs. Now, technology provides us with the option of reconstructing heritage despite limited financial resources and making it available for a wider population to enjoy. The

term Virtual Heritage in the present study thus refers to a combination of Virtual Reality and Cultural Heritage. A Virtual Heritage interprets the history, culture, memories and past lives of a certain context, and makes them come to life again by producing them in a digital format. This study attempts to record some historical features of the Al Madinah area by representing them in 3D form. Recently, an increasing number of studies have focused on developing 3D heritage environments. Such research has mainly been conducted by research teams. The number of members in such a research team will depend on the type of project and the purpose of the environment to be constructed. Although a number of studies about virtual heritage have been published, it would appear that there are different methods for achieving the desired result. The method used in each piece of research relates to the background of the research teams themselves. For example, the research conducted by (Koshak and Gross, 1998) to preserve the heritage of Makkah used CAD software and was based on architectural methods and perspectives.

Therefore, documenting historical building is important. It preserves information for future generations to learn from the past. A rich architectural heritage provides future architects and planners with design solutions to various problems. In addition, many cities gradually lose their rich artefacts and history, as historic buildings are destroyed to make room for new projects

(Koshak and Gross, 1998)



The reasons for this kind of research are well explained in the above excerpt from Koshak and Gross; the same reasons justify the creation of a 3D digital application of any older city. The context in which these authors studied was Makkah, the first and most important city for Muslims all over the world, with a rich cultural, historical and religious heritage. Al Madinah is also located in Saudi Arabia, and it shares religious and historical importance with Makkah. Makkah and Al Madinah are both located in an area where large-scale demolition of historical places has happened in the name of modernisation and development. The paper by Koshak and Gross, which reports on 3D modelling of historic Makkah, discusses several issues that are relevant to the present project. Although the

paper focuses more on architecture, it does discuss a useful method for rebuilding the windows as 3D elements. Makkahs historical buildings have two notable types of windows, which are:

- Roshan: A wooden window that includes an extension, and
- Shubak: A flat window that is covered by woodwork. Figure 2.8

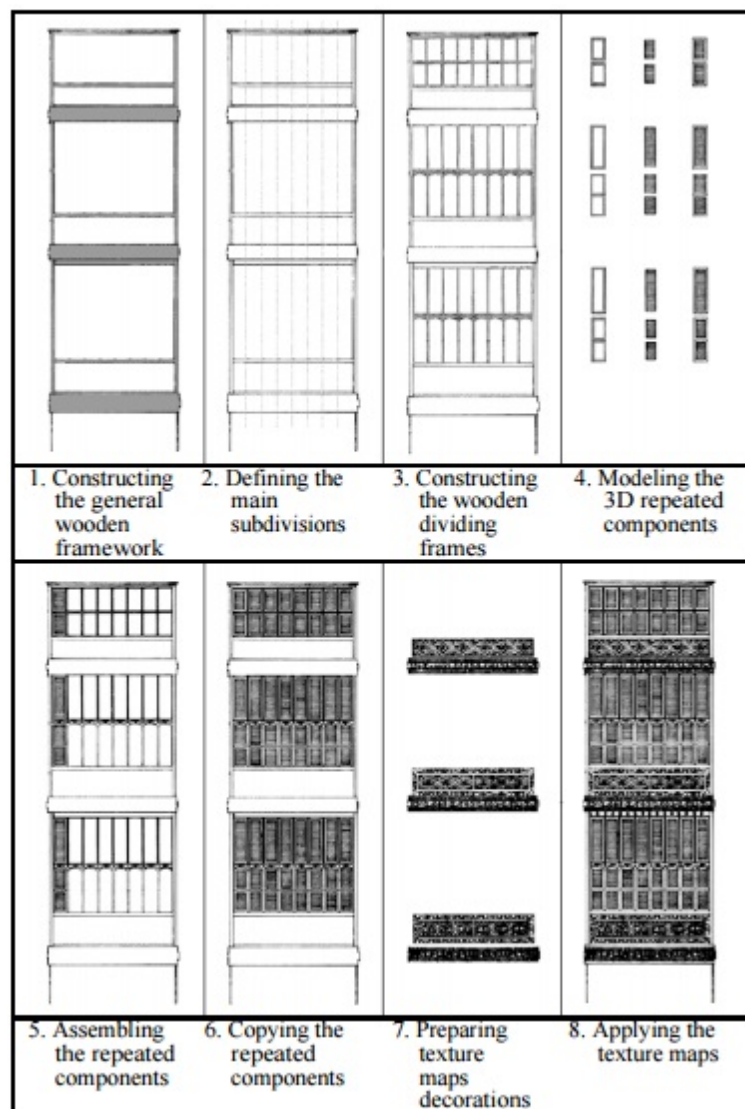


FIGURE 2.9: 3D Modelling process of Roshan by Koshak (Koshak and Gross, 1998)

In order to avoid distracting pedestrians, Roshans were never built on the ground floor; they were only used on the first floor and above. When developing their project, Koshak and Gross said their first stage involved deciding how to describe objects. Guided by their approach, and in order to understand the objects of the present research, the researcher personally visited several historical places in Al Madinah and collected old photographs. This was one of the methods also used by Koshak and Gross. The method they used for reconstructing the historical buildings in Makkah was to build the main walls before attaching the other elements to them. Using this method was helpful in reducing the time taken as the same elements could be reused. Figure 2.9 shows the process by which the Roshan windows were built.

The general idea from Koshak and Gross was adopted when building the historical Hijazi house for the MVH, but a different programme was used, called Autodesk Maya; this is mainly used by 3D artists, while CAD is mainly used by architects. Making use of the concept of reusing elements as discussed above, the Hosh system was built as virtual reality for MVH2.0.

The Hosh is an enclosed area surrounded by between seven and eighty houses, with an access gate that is closed at night. The neighbours living within the area are responsible for each other, and this unique system affects the social life and behaviour of the residents in the Hosh; they share happiness and sadness, and become very close to each other (Kaki, 2006). (see Figure 2.10)

One of the goals of a Virtual Heritage programme is to reconstruct a virtual reality version of the heritage cities or parts of them. Such virtual cities are also known as cyber cities or digital cities, and are visited by thousands of people on the World Wide Web for different purposes, depending on the services provided by the web site. There are different types of city sites on the Internet, and they

vary in their purpose, accuracy, hierarchy and style.



FIGURE 2.10: Map shows a Hosh system in Al Madinah with a focus on Al Magharba Hosh Kaki (2006)

One popular virtual heritage site, which uses a map and information text combined with interactive graphics, and can be accessed by clicking on a desired location, is exemplified by Virtual Bologna, Italy ([italyguides](#)). Here, users can navigate through the pictures, moving in different directions and using the zoom in and zoom out functions, but they cannot walk through. This type is based on photographs of the location captured from different angles, then stitched together using special software to produce a panoramic perspective (Figure 2.11). This is similar to what is done in Google maps, but in Google maps there is the option to explore a wider area by navigating through the location, while in this panoramic perspective the location is fixed, and the user can just explore within the specific location.

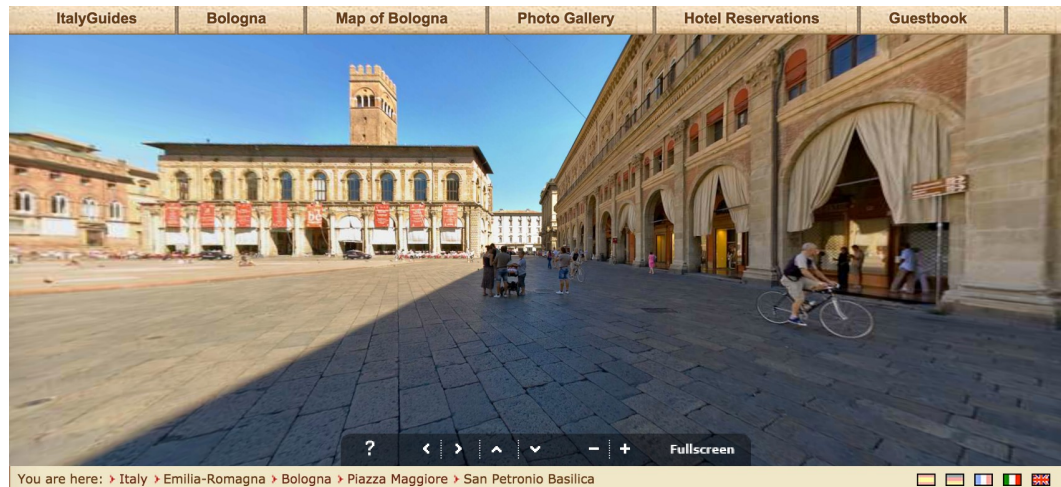


FIGURE 2.11: An example from the Virtual Bologna map

Another method to create virtual cities involves using Sketch-up software, which is the tool used to develop the fully textured high-resolution city model, NASA's Hangar, for Google Earth (2006). Virtual Cities 2007 is one of the Planet9 Studio projects, and this is a high resolution modelling of sixty-five cities located in the United States, which can be explored with mobile applications, web and GPS. Recently, the number increased so that there are now 120 city models that are compatible with smartphones, GPS and online applications. All these virtual cities have been developed in studios for commercial use. The next section focuses on the reconstruction of cities that have been done collaboratively by professionals from different backgrounds such as archaeology, architecture, geography and multimedia.

According to Borovsky (Borovsky et al., 2008), San Francisco was the first city to be created in virtual 3D. This was in 1991 when the era of virtual cities with a high degree of verisimilitude first began. Borovsky's article explains some of the recent developments in technology for creating virtual environments. The first phase was using panoramas; this was an easy way to produce a 360 view based on photographs. Nowadays, this method has become far easier with the

availability of a range of software applications that can build it with less effort and time, mainly for use in interactive maps such as Google Maps. The use of this method requires the existence of the target location, which was not the case in this project as the places to be recreated had been demolished, rendering this method ineffective for this project. In his second phase, Borovsky built 3D models using different techniques:

- Digital Terrain Models, where the data can be gathered from the municipality.
- Cadastral Data which depends on 2D images and on extruding them to achieve 3D objects.
- Photogrammetry outputs, which are based on the measurement of 2D and 3D photos or on motion graphs, and are then used to create real scenes.
- Geometric refining for reasons of accuracy,
- Texturing (the most important phase) to obtain the correct shape of the 3D model in order to make it look realistic.
- Modelling stand-alone structures (used as one of the stand-alone 3D multimedia objects of the Klarisky church in Borovskys project, called Historic Bratislava).
- Small objects forming part of a 3D model (also used in this project, mainly for textiles and utilities inside the virtual Hijazi house)([Borovsky et al., 2008](#)).

Finally, Borovskys visualisation of content to display Historic Bratislava was produced by using HTML and Adobe Flash software; this project was made

available on DVD. The development process took over 650 hours. This project shares some of the steps of Borovskys project: photographs were taken and used for the texturing process; 3D modelling was done using 3D software; and 2D and 3D elements were mixed to construct the 3D models. There were steps that were not used: For example, the Digital Terrain Data, Cadastral Data and some applications of photogrammetry, used to get accurate information about the geographical characteristics of the land, were not used in this project.

In this project, some of the steps described by Borovsky were used more frequently than others: For example, 2D images combined with 3D motion were used to extract measurements of locations or objects, thus employing some aspects of Photogrammetry. The 2D images were stitched together, based on the measurements, to create 3D models. A recent study that used Photogrammetry was carried out to protect the history of the buildings and the Standing Buddhas of the Bamiyan Valley in Afghanistan. The two large statues were sculpted out of the mountains 1700 years ago, and were destroyed in 2001 by the Taliban ([Gruen et al., 2003, 2004](#)). This loss is to some extent similar to the loss through demolition of the old and sacred historical places of Al Madinah. Photogrammetry proved useful in the case of the Standing Buddhas, as the demolition was relatively recent (in 2001), the place was well documented, and many photographs of high quality were available. The use of these photographs, in addition to image processing and location measurement, helped the researchers to reconstruct the 3D models in a very accurate way.

Another project that used photogrammetry was carried out by ([Drap et al., 2012](#)), an interdisciplinary team that included archaeologists and computer vision specialists who used photogrammetry, 3D projection, and 3D Geographical

Information System (3D GIS) to produce 3D models based on an archaeological database. Other studies reviewed in relation to a virtual environment also revealed aspects that are both similar to, and differ from, that developed for this research. In their paper, (Maver and Petric, 1999) describe the virtual city of Glasgow (VR Glasgow), which was funded by a research group from the University of Strathclyde in Glasgow, known as Architecture and Building Aids Computer Units Strathclyde (ABACUS). The initial concept was that the model would be the archives of the city, but it turned out to be much more than that. According to Maver, the city's residents and visitors are able to explore the city virtually, and the software allows visitors to obtain a great amount of knowledge about the city before actually arriving there. Moreover, the software has been used for educational purposes, giving young children the opportunity of exploring the city through VR Glasgow. This project is a good example of collaboration between architects, 3D artists and researchers. Such collaboration between specialists in different areas is the key to producing an effective and accurate model.



FIGURE 2.12: 3D View of Madinat al-Zahra ([Almagro, 2007](#))

In a study done by a team of researchers led by archaeologists to preserve the architectural heritage of Al Andalus, a database developed over 15 years by a research group at the school of Arabic Studies was used to reconstruct the historical buildings and gardens of Al Andalus. One of their projects was Madinat al-Zahra, shown in Figure 2.12, which was built as a 3D overview of the city. The project also focussed on the interior of the reception hall of Abd al-Rahman III, (Figure 2.13) ([Almagro, 2007](#)). In a similar manner, in this project an overview of Al Madinah city has been developed, and the interior of a Hijazi house has been reconstructed.



FIGURE 2.13: The Interior design of reception hall of Abd al-Rahman III (Almagro, 2007)

A project from the Malaysian culture used 3D to reconstruct a Malay heritage house called Rumah Tok Su (Ibrahim and Azmi, 2013). These authors explain the value of the traditional house and how it was built to adapt to environmental changes. This traditional house has been preserved and relocated, so that the process of reconstructing the 3D model was made much easier as there was an existing example of the house. Figure 2.14 shows the 3D modelling process employed in this research. The process of 3D modelling used is the same as that used in this project, but the buildings visited in Al Madinah were in very poor condition, having lost some of their features. Other locations created do not existed anymore, and so photographs were relied on as the main resource.



FIGURE 2.14: Rumah Tok Su Malay historical house, the original and the 3D (Ibrahim and Azmi, 2013)

Colin Johnson (Boland and Johnson, 1996), who reconstructed the Dudley Castle, used photographs as his main resource. He developed a virtual reality journey through the 16th Century Dudley Castle (see Figure 2.15) which was inaugurated

by HM the Queen Elizabeth in 1994. In addition to photographs, he used the ruins of the castle as a reference. Ruins give details on how to construct a site, especially in open areas to indicate where windows, doors and stairs need to be positioned.



FIGURE 2.15: Map of Dudley Castle, the original (left) and the 3D (right)

While some projects have more resources that make the reconstruction easy, others have very limited resources. Suzuki and Chikatsu ([Suzuki and Chikatsu](#)) reconstructed the historical city of Kawagoe in Japan from an antique map. The modelling of the city went through different phases, starting with the classification of the houses by their shape and size, and these varied according to the social class of their inhabitants. Six different houses were built using 3D software (3Ds max*), and the Kawagoe castle and the bell tower, both on the map, were

also modelled.

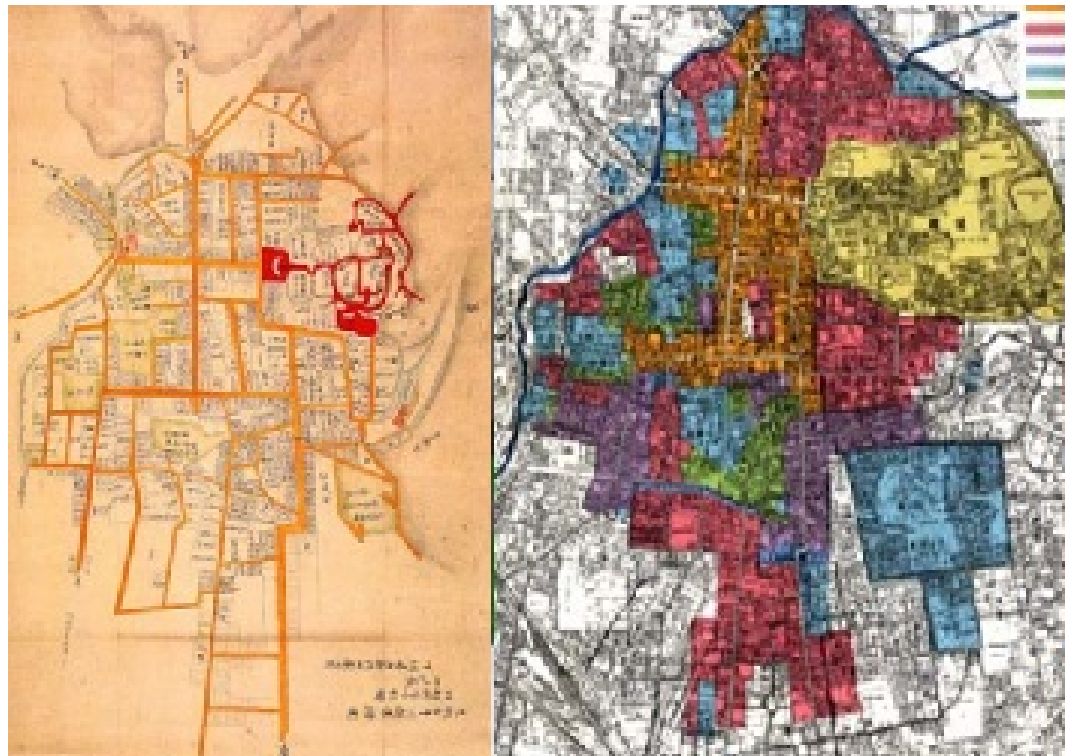


FIGURE 2.16: Antique map as a resource for 3D historical city of Kawagoe (left) modern map(right)(Suzuki and Chikatsu)



FIGURE 2.17: 3D models of historical houses built by Suzuki (Suzuki and Chikatsu)

Other objects, such as historical houses, were reconstructed using 3D objects. In the current project, several maps were used that reflect the historical period that MVH deals with. These provided the basis for the 3D map with interactive objects that was ultimately produced. In addition, 3D historical houses and

other key locations were built for the project.

Several cities across the globe have been virtually recreated, and the reason behind each recreation has been different. Some of them have reconstructed the past, which no longer exists, or else exists only in a deteriorated condition. 3D design helps viewers to visualise the original form. The other reason is to spread abroad information about the beauty of the historical building, as was done in the Malay project. What is common to all virtual cities is that they have an impact on the way learners understand specific historical contexts. In the following section, digital museums are discussed as a tool for preserving heritage.

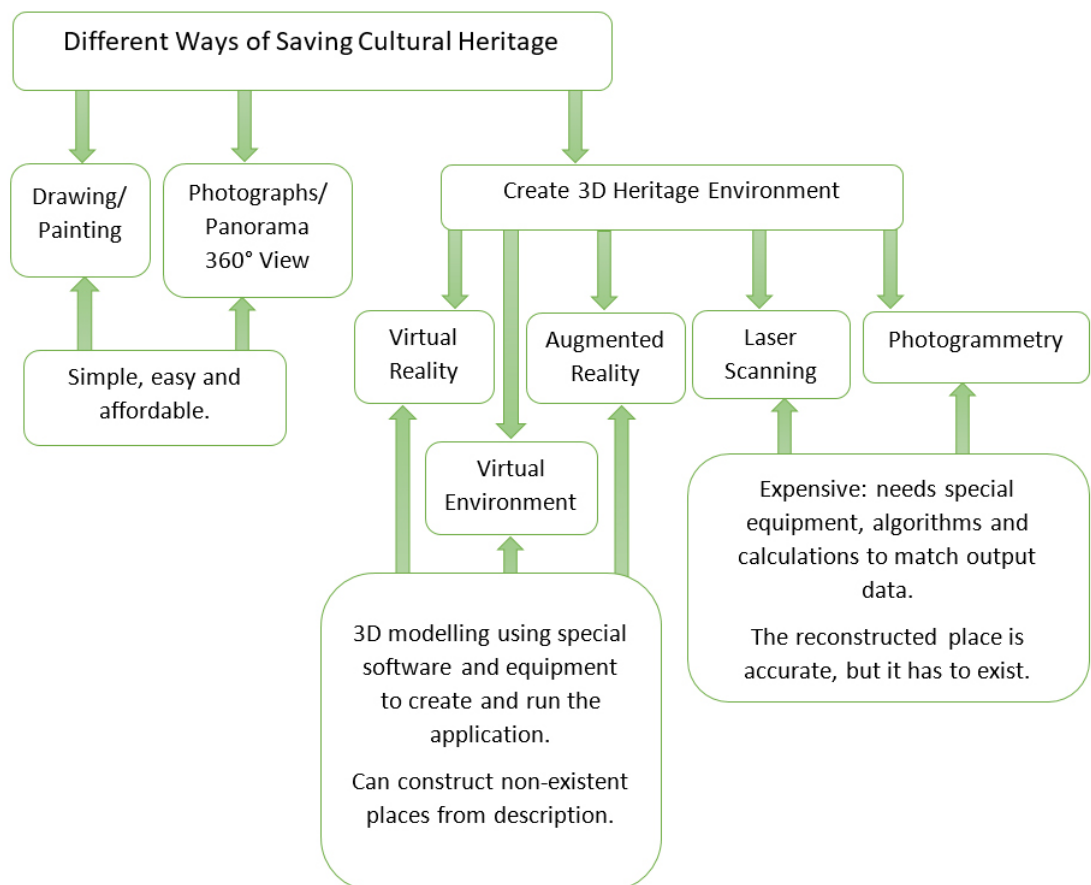


FIGURE 2.18: Different Ways of Saving Cultural Heritage

2.5 Conclusion

An increasingly large amount of research has been conducted into virtual heritage in order to preserve history in modern ways. Heritage includes objects, arts, craft and even whole cities. Virtual cities have been created to represent vanished cities. Virtual cities can be used not only to learn about cities of historical interest, but also for the purposes of tourism and discovery in modern cities. They can be presented in museums on a large scale, on the Internet, or on mobile devices. This kind of application makes historical knowledge accessible to people as it provides impact, while 3D applications can also be used in other ways to engage people in the learning process in medicine, science, history and other fields. The practical element of the research involved in creating a CG application will help an audience to learn interactively about the history of a city in a virtual reality environment. Oculus Rift was used for some parts of the current application, and the researcher anticipates that the final application will be incorporated into displays at local museums in Al Madinah. The next chapter focuses on the city of Al Madinah and its heritage. The study aimed to explore the heritage of Al Madinah and how it can be preserved by interviewing local people in Al Madinah who are concerned about the heritage of their city. In addition, two local museums in Al Madinah were visited to examine the display methods used there.

CHAPTER 3

Exploring the Potential of Al Madinahs Heritage within Local Museums

3.1 Introduction

The previous chapter discussed a number of studies focusing on the 3D digital environment, how to reconstruct historic buildings using 3D techniques and the various techniques that could be used for this. To understand the characteristics of the cultural heritage of Al Madinah, I carried out an exploratory study, during which I interviewed local citizens, museum owners and archaeologists about their views of this heritage and about their knowledge of the city's past culture. The interview questions were designed to gain an insight into Al Madinah's ethos and visualise the city from different perspectives in the period between 1850 and 1950. The interviews were semi-structured to allow the participants to give their responses within a flexible but focused framework.

In this chapter, I discuss the historical value of the period, with particular reference to two museums in Al Madinah and the media they use to display the citys heritage.

Al Madinah has a rich history, although many old buildings have been demolished since 1951 and a large part of the city walls and many gates have been removed. By 1993, most historic buildings had disappeared from the central area of the city, to be replaced by modern ones. Several factors have prompted these demolitions, including oil revenue, which led to huge spending on construction projects, and an increase in the population. Equally important was the lack of knowledge and care for heritage on the part of the government. Several attempts to save the heritage have been made over the years, but without success, and the demolition continues, even though few historic buildings now remain.

The traditional buildings in Al Madinah were characteristically built using mud instead of bricks and the height of such buildings in the central area of the city never exceeded the height of the Al Masjid Al Nabawi mosque (see Figure 3.1). These rules prevailed until the first expansion of Al Masjid Al Nabawi in 1950, when all the historic buildings within the area of expansion were demolished. The remaining buildings and parts of the city walls were removed between 1985 and 1993. Since that time, the central area of Al Madinah consists almost exclusively of modern buildings, most of which are hotels for pilgrims. The aims of this study were to:

1. Discover historical information about Al Madinahs heritage and identify the best time period to represent it.
2. Investigate the potential of local museums to present the heritage of Al Madinah.



FIGURE 3.1: Al Masjid Al Nabawi and the surrounding buildings now (above) and formerly (below)

3. Identify factors that restrict the availability of information about Al Madinahs heritage.
4. Investigate local initiatives to preserve this heritage.

3.2 Al Madinah from Travellers Eyes (Al Madinah During 1850 1910)

Before discussing research into the heritage of Al Madinah, it is useful to read the impressions of Al Madinah by visitors to the city during the period 1851 to 1878, as these descriptions still provide one of the major resources for discovering the heritage of Al Madinah. Those visitors did not come from one place; some of them were travellers from the East and others were travellers from the West. Some of the western adventurers pretended to be Muslims so that they could discover Makkah and Al Madinah, as it is prohibited for non-Muslims to visit the religious sites in both these cities. The restricted access to religious sites for non-Muslims is based on government policies, which have not been the same during all periods of history. Sir Richard F. Burton, a British explorer, went to Makkah and Al Madinah between 1851 and 1853; he pretended to be a Muslim from India, where he had spent a few years prior to this journey. In his narrative he describes his first view of Al Madinah:

On the left was a grim pile of rocks, the celebrated Mount Uhod, with a clump of verdure and a white dome or two nestling at its base. Rightwards, broad streaks of lilac-coloured mists, here thick with gathered dew, there pierced and thinned

by the morning rays, stretched over the date groves and the gardens of Kuba, which stood out in emerald green from the dull tawny surface of the plain.

Burton described the citys famous buildings very precisely, starting with a description of the Anbareya (Ambari) gate on the south east of the city through which he had entered Al Madinah. He adds his opinion about the buildings he describes, such as the Egyptian kitchen (Takiyah) and the army barracks:

It is flanked on the left by the domes and minarets of a pretty Turkish building, a Takiyah [...] on the right by a long low line of white-washed buildings garnished with ugly square windows, an imitation of civilised barracks(Burton, 1856)

Mohammed Sadig Baik made an exploratory journey to the Hijaz area, including Al Madinah, in 1861; he drew maps of the roads in Al Madinah. Baik went on another journey in 1880, when he described the pilgrimage in detail and described Makkah and Al Madinah geographically, with reference to the history of Syrian and Egyptian caravans. In addition, he was the first photographer to capture images of Makkah and Al Madinah (Albatnoni, 1910; Magdy, 2014; Alkhareef, 2008).



FIGURE 3.2: Al Madinah in 1888; photograph by M.Sadig Baik)

Traveller John Keane describes Al Madinah in his book *Six Months in the Hijaz Journeys to Makkah and Madinah 1887 1878*. He writes:

Medinah, when first sighted, may fairly be ranked with Constantinople from the sea of Marmora, or any one of the loveliest of the bountiful cities of the world. As seen from the distance, birds eye point of view to which it first presents itself to the pilgrims delighted gaze, its tall, snow-white, uninterrupted walls and numerous gilded minarets, with the morning sun gleaming over them, and the broad green belt of cultivated ground encircling it as seen, I say at such a time by the way-worn pilgrims from Meccah, it is a fresh bright jewel, bounded by a vast grim barrenness of desert, an opal and pearl mosaic set in a brilliant border of shining green enamel (Keane, 2007)

Keane continued his positive narrative about Al Madinah, adding:

Then Medina, I suppose that a more flourishing little city is not be found anywhere in the East. (Keane, 2007)

The images by which the travellers describe Al-Madinah are unfortunately not available to the citys people or to its visitors today. With limited access to resources about Al-Madinah in that earlier era, the young generation would struggle to imagine the Prophets mosque without the skyscrapers that surround it. Nowadays, the first thing pilgrims to Al-Madinah sees as they approach the central part of the city to visit the mosque, are the grand hotels and buildings.



FIGURE 3.3: Anbareya Gate; photograph by Ibrahim Pasha

In 1901, Ibrahim Rifat Pasha, who was an Egyptian major general, went on a pilgrimage to Makkah and Al Madinah; he describes the two cities precisely in his book *Merat Al Haramain (View of the Two Sanctuaries)*. (Meyerhof, 1927)

said about this book that it is remarkable in that it is the first detailed account of the holy places of Islam to be written by an educated and pious Muslim. This shows how poorly Al Madinah was documented in the earlier era. In addition to his excellent book giving a description of Al Madinah, Pasha performed the pilgrimage three times, in 1903, 1904 and 1908, and during these journeys, he managed to take many photographs. These photographs were a great addition to his descriptive text and the illustrations he had done earlier, and they remain an important resource for a researcher wishing to visualise Al Madinah in the early 20th Century.

These photographs were also used by Mohammed Al Batatoni to support his book about a journey to the Hijaz area in 1910 ([Albatnoni, 1910](#)). In the current project, in order to clarify the existing information about Al Madinah, local people were interviewed and asked to clarify aspects of the available photographs and drawings. Many of the answers revealed the stories behind these images. The next section is about Al Madinahs heritage from the perspective of its local inhabitants.

3.3 Selection of Time Period for Study

The first step of this study was to identify an appropriate time period that contained the features and elements most representative of the heritage of Al Madinah. According to Al Safadi, Al Madinah was architecturally particularly important between 1850 and 1950, because it had, by the beginning of that period, become a walled city with its own unique customs and practices([Alsafdi, 2007](#)).

The British traveller John Keane described the city in 1877 as:

Medinah, which should have been named The Fortunate. Walled habitations, green fields, running water, every blessing the Eastern mind could desire, was there.

Keane observed that the infrastructure of the city had been completely built by 1850. Apart from Keanes record, the traditional appearance of walled-in Al Madinah with its ancient buildings and palm groves was not properly documented, and the lifestyle of the twentieth century would soon replace it with a modern city. (Alsafdi, 2007), in collaboration with the Al Madinah Council, undertook a research project to document the late Ottomanearly Saudi era city by building a scale model of Al Madinah 1/180 the size of the actual city on a base of 8 x 5.5 m²; this was to represent all the key locations, including Al Masjid Al Nabawi, other important mosques, walls and gates, residential areas, markets and military and public buildings.

The project used some old photos but the majority of the work was based on descriptions from written accounts by Arab and Western travellers, and from interviews with old inhabitants of Al Madinah who still remembered various details of life in the city in the 1950s. The project, completed in 2007, later became a valuable resource used in local museums as a reference to build other scale models.

3.4 Selection of Museums

In this section, I describe and discuss the approach of a number of museums in Al Madinah to the citys cultural heritage. Two of the museums are particularly

concerned with the representations of Al Madinah and its heritage through history: Dar Al-Madinah Museum and Madina Media Museum. I visited these two museums to see what kind of information they have about Al Madinahs heritage and how they display it. Both museums are self-funded and use traditional display methods.

3.4.1 Dar Al-Madinah Museum

The Dar Al-Madinah Museum was established by A. Kaki between 1984 and 1993, after the demolition of traditional buildings in the central area next to Al Masjid Al Nabawi. He collected relics from ruined buildings, and when he had a sizeable collection, he started his own museum, adding to the collection every year. In 2012, the museum was moved from the busy and crowded Quba area to a newly developed area, where the museum now has more space for displays and provides easier access for visitors. On 3rd February 2015, Dr Kaki won the King Faisal International Prize for his efforts to save the heritage of Al Madinah, in particular through the encyclopaedia he compiled about the cultural heritage of the city.

3.4.2 Madina Media Museum

The Madina Media Museum is owned by K. Abul Khair, a media lecturer at Taiba University in the city. He established this museum with his own funds, with the aim of preserving the heritage of Al Madinah and educating local people and visitors about its history.

Exhibits at both museums include original old photographs reproduced in different sizes and styles. They also both include scale models, including the model of



FIGURE 3.4: Madina Media Museum and some of its exhibits

Al Madinah in the era in which I am interested. Details about the museums are presented in Section 3.9.1.

3.5 Selection of Participants

To select participants, I used snowball sampling, in which the participants refer the researcher to further participants (Streeton et al., 2004). The sample thus selected formed an informal group, whose members care about the heritage of Al Madinah. The initial interview was with local inhabitants who had lived there



FIGURE 3.5: Madina Media Museum and some of its exhibits

in the period in question or had memories from their own childhood or from their parents stories. I then interviewed the Madina Media Museums owner, an archaeologist, who possessed original documents about Al Madinah and had photographically documented most parts of the city before their demolition in the period leading up to 1993. This was followed by interviews with other museum owners and a researcher into Al Madinahs heritage.

3.6 Exploratory Study Method

The aim of this phase was to discover historical information related to Al Madinahs heritage and how it is displayed. I applied three research tools. The first was direct observation, which provided the exploratory framework for the research. For this, I was accompanied by an archaeologist on visits to surviving old buildings and other places of interest in order to determine their condition. Most of these buildings are located in out-of-the-way places and it was vital for me to see them and the materials used in their construction. The second tool was semi-structured interviews with local archaeologists and inhabitants, which were conducted to augment the inevitably incomplete data collected from the visits, specifically with information about Al Madinah in the 1950s and earlier. This included historical information as well as information from personal photographs, documents and memories about social life. Third, the analysis of documents played a critical role, as it helped me to better understand Al Madinahs heritage, especially with regard to the citys layout and how this affected the social lives of its inhabitants. The documents included textbooks, photographs in exhibitions, original documents such as personal photographs and maps from different sources.

3.6.1 Interview Structure

The interviews focused on four areas: the architecture of the buildings, social life, the difference between the past and present and the lost heritage and culture. Semi-structured interviews were used to explore peoples feelings, thoughts and memories by giving the participants the opportunity to talk openly about their

past and how life seemed at that time. They also allowed me to determine which parts of the interview were most important. At the same time, I was able to ask relevant questions at the right time, so that participants did not waste time by talking in too-broad terms or straying off into matters irrelevant to the purpose of the study. Semi-structured interviews thus provided a balance between the interviewees desire to share knowledge and the requirements of the research. Some of the principal interviewees were archaeologists, who typically had information that was not available in non-specialist books and that was most directly related to the research topic. The table in Appendix A gives details of the seven interviews conducted, including the specific purpose of each.

3.6.2 Building Surveys

Direct observations of surviving pre-1950s building in the city provided the opportunity to document activities, behaviour and the citys physical characteristics. These observations were conducted between 25th December, 2010 and 10th March, 2011. Some of the buildings that I documented were subsequently demolished. A DSLR camera was used to take high-resolution images for future reference.

3.6.3 Local Museums

My visits to museums in Al Madinah had two main purposes. The first was to collect information about the heritage of Al Madinah, based on the historical information and the physical objects that were available in the museums. Both of the museums permitted the taking of photographs. These photographs became a key reference for my visualisation of 3D objects such as furniture, domestic utilities and other equipment such as coal scuttles.

My second purpose was to explore the media used in the museums to display and preserve the cultural heritage of Al Madinah. The main media were photographs of various types and sizes and scale models, again of different sizes and made from a variety of materials, which recreated historical features, based on photographs or descriptions. Collections of old objects were also displayed, including household utensils and implements, especially those used in the kitchen. There were also some pieces of old furniture and relics from ruined buildings representing the patterns and decorations that distinguished pre-1950 buildings. All the museums I visited are self-funded by owners motivated by their love of the city to preserve its heritage and encourage people to visit and share knowledge, as well as to introduce the culture of the museum to their children, visitors and pilgrims.

3.7 Interview Results

Although the parameters of the interviews were the same, the information gained from the participants varied. Interviews 1 and 7 with local inhabitants included more memories and stories from the past and more emphasis on recently demolished features, focusing on the old city and how it had changed so rapidly. Interview 2, which was with an older local inhabitant who lived in the city during the period of interest and recognised all the historical places, included personal views and recollections, supplemented by personal photographs. Interview 3, with the Madina Media Museums owner, also a media lecturer, focused more on the museum itself; he explained the origins of the exhibits and was able to recommend books and experts. Interview 4, with an archaeologist, was visually rich, since it included the discussion of over 6,000 images and original maps and

documents. Interviews 5 and 6 were conducted in the museums. Interview 5, with the Dar Al-Madinah Museum owner, focused more on books and resources for understanding the heritage of Al Madinah and the museum itself. Interview 6, with Al Madinahs heritage reseracher, provided rich details about Al Madinah, notably its urban development and architecture. For analysing the data, I adopted theme mapping, as proposed by (Gary, 2009). After each interview, I came up with initial themes that I would explore further in the next interviews. Connected ideas were grouped together, and the most relevant to my research have been discussed in this thesis, with quotations, personal images and images of demolished buildings.

3.7.1 Al Madinah through Local Inhabitants Eyes

The inhabitants of Al Madinah are often very loyal to their city, many of them describing it as unique. In addition, some expressed a feeling that the current government neglected Al Madinah and wanted to remove from it any heritage related to previous regimes, especially the Ottoman, which had a significant impact on the infrastructure of the city. For example:

Ottoman, then Ashraf, ruled the Hijaz area. Al Madinah never surrendered. Ibn Saud could not enter Al Madinah with his army, because the walls protected the city. The wall was very thick: no bullet could penetrate it. The army laid siege to the city. The price of goods increased, so all members of families had to go out to work and earn more money to be able to survive. Then, negotiations started between the local people and Ibn Sauds army. The army agreed to the conditions demanded by the local people, because half the army suffered from Al

Madinah fever and subsequently died. That is why they didnt want Al Madinah to date (Interview 2)

The climate of the city was a theme in the interviews. This interviewee claimed that the winter in Al Madinah is unique, as the cold comes from the earth!

The very cold weather is caused by the rains, which continue for a month or two. The cold weather comes from the ground, quite the opposite of other cities, where the cold comes from the weather (Interview 2)

The cold comes from under the ground, not like other cities. Al Madinah and Taif are the two cities that have this feature (Interview 4)

When I asked for clarification, the interviewee replied, *We dont know; it is nature.* This interviewee had experience of living in other places (such as Makkah, Riyadh and some places abroad), and his explanation about the climate of the city was influenced by his other experiences. Nevertheless, his views about the climate and the fever are important expressions of the affection in which he holds the city. He added:

The concept of adapting to seasons has changed; in the past, one had to adapt to all seasons, feeling hot in the summer and cold in the winter. Now, during winter you want to feel warm and during the summer you want to feel cool! And this is contrary to the ways of nature; during the summer, people should tolerate the heat, but when it became possible to put up buildings very rapidly, people started to live faster, and now, from birth to death, they expect to live in a temperature of 25 degrees in summer and winter. This is possible because of the nature of modern buildings, with their industrial equipment and air conditioning (Interview 4)

3.7.2 The Lost Heritage of Al Madinah

It was inevitable that when the participants discussed the history of Al Madinah, the issue of demolishing its heritage would arise. Many historic sites were destroyed, having been barely documented for benefit of the next generations. Therefore, there was a sense of grievance among some participants as they referred to the expansion of the city. Moreover, the traditional buildings had held some meaning for the participants, especially those who had lived in them.

3.7.2.1 Feelings about the Demolition of Buildings

The recent demolition of buildings had caused ill-feeling, most strongly felt among older interviewees:

No one really cares about the heritage of Al Madinah, neither the government nor the people. Look around you. Everything is changed. You young generation dont know what life was like; yes, it may have been harder and tougher but it had more value. Everyone in the community lived as one family. We shared, we cared, we loved and we disciplined as well. (Interview1; local inhabitant)

However, younger interviewees¹ typically showed more sympathy towards the expansion and the ways in which it would benefit the city economically. The population increased every year, and massive numbers of pilgrims came to visit throughout the year; hence, this modernisation was necessary and the benefits would be reflected in peoples lives. On the other hand, younger people were keen to have some buildings preserved and wished to protect the few that remained

¹Views of younger participants are taken from later interviews, described in chapter 5, when testing MVH1.0.

as part of their heritage; they wanted Al Madinah to expand without its identity being destroyed by modernisation. They had heard a lot about the history of Al Madinah from their parents and grandparents, and felt it a shame that not many homes, schools and libraries had been preserved, where they could learn more about the old Madinah.

3.7.2.2 Social Life and Traditional Customs

The cultural heritage of Al Madinah has much significance for its people. It is recognized that the characteristics of buildings affect social life in most cities (Wu, 1995). Apart from their nostalgia for the old city, some of the participants referred to the social life and life styles of that time. The way in which people in Al Madinah used to celebrate Eid Alfitr and Eid Aladha was a common theme among the participants. One elderly inhabitant talked about the impact of the old city layout on creating a strong relationship among neighbours, bemoaning that fact that such relationships do not exist any more.

The neighbours were the family. When I got married and moved to my husbands house in another area, the neighbours became my new family.

Whenever I sought help, they provided it, even at night. If there was an emergency and there was no way to contact your own family, you would get a helping hand from your new family, your neighbours. (Interview 7)

Another traditional habit is one associated with Adhan [prayer call].

If any guests were staying at the time of the Dhauhr prayer call, they could not leave and must stay for lunch. And after the Esha prayer call, everyone should be back at home. (Interview 2)

In addition, as the city of Al Madinah is a religious destination, it constantly attracts pilgrims and visitors. Some of the houses used to provide rooms for them during the pilgrimage season. This meant that the family of the house would meet different people from all over the world at least once a year. The children of this period had a wider knowledge of languages than the children of today; a child would have known the everyday words and phrases used in the market in 10 languages.

3.7.2.3 Less Consideration from the Government

The demolition targeted not only the old city but also its environs, not even sparing the historic places directly linked to the Prophet (PBUH) and his family and companions. For instance,

On Zogag Al Towal there was a house in which the Prophets father was born; this house was destroyed in 1985.(Interview 2)

This was not an isolated instance. Houses, wells, libraries and historic buildings were razed to the ground as were structures such as wells and springs of water. Beer Alkhatem was one of the most important wells in the city and had been in existence for over 1,400 years, but it has now been filled in and the area made into a car park next to the Quba mosque.

In Quba there are many wells. The Ottoman rulers connected the water from Quba to Al Madinah, making a body of water 50 to 60 metres long and 20 to 30 metres deep, with stairs constructed to reach the water. The water was available 24 hours a day and there were no taps. Al Saggai was the person who served

water to the public. Ain Alzarqaa was also a very famous spring but it is also gone. (Interview 2)

3.7.2.4 Past versus Present

The interviewees drew many comparisons between the past and the present, including almost every aspect from social life to architecture. An archaeologist explained how the people used to enjoy their work:

In the past, work was a form of art; people were not working for commercial purposes. They worked as artists and in a relaxed way; they made something pretty, valuable and meaningful and gave it to someone who would treasure it.

That doesnt happen now. (Interview 4)

An elderly inhabitant similarly commented on changes in social customs:

In the past, the elderly were deeply respected, and their word obeyed. Now, no value, no word! In the past, women used to meet in the morning and took tea together, without sugar and served with dates. If the housewife had some work to do in the kit chen, all the guests would help her by chopping vegetables.

(Interview 2)

3.7.2.5 Al Madinahs Urban Development

Al Madinah has its own distinctive characteristics. One of the local archaeologists documents urban development in the city using photographs pinned to boards, in the same configuration as the original layout of the city, each board

representing a neighbourhood. As he showed them to me, he said: These neighbourhoods date from over 500 years ago. The boards were covered with plastic to keep them clean. Whenever he heard that a neighbourhood was about to be demolished, he would hire a photographer and together they would go there to document it. He now has an archive of more than 6,000 images, most of which are unavailable elsewhere.

This is the way I organised the photos when I started to forget where a particular house was located, and which area another one was in. So I started to put the photos next to each other based on location. (See Figure 3.6)

(Interview 5: researcher, architect, museum owner)

Although the transformation of the city started in 1952 when the walls and gates began to be demolished, Al Madinah kept its characteristic way of building, which involved leaving a green space between buildings. However, by 1985 the city had completely changed and all its traditional features had nearly vanished. A researcher in Al Madinah heritage whom I interviewed said:

The changes in the layout of Al Madinah started in 1951/1952 after the first expansion of the Prophets mosque [Al Masjid Al Nabawi] was begun by King Saud Ibn Abdul Aziz, who came into power in 1926. But the biggest change [due to] urban development was 30 years ago, specifically in 1405AH / 1985 AD. It was the start of the end of the planned city. So a researcher who is looking at this period has a difficult task. But luckily, there are some people who

documented this heritage. (Interview 6)



FIGURE 3.6: An attempt to preserve heritage: a board representing a neighbourhood with photographs of houses in their original locations before demolition

Undoubtedly, Al Madinah started its expansion like any other city, outwards from the centre, and then went on to expand randomly around the centre. This is the natural pattern of urban development (Kaki, 2001, 2006). At the centre of the city is Al Masjid Al Nabawi, established by the Prophet Mohammad (PBUH), who chose the location based on the history of the city, which was mainly agrarian at the time. The first planned building project was this mosque, followed by the houses around it and then by public buildings and markets. Thus, Al Madinah has had more than one planned development. During the first, Al Masjid Al Nabawi was the centre around which the expansion took place. All the radial roads led to this mosque, although the houses around it were built randomly. Later, the increase in population led to further expansion of the

city. The first wall was built for the protection of the city, followed by a second and a third. A development plan was formulated around this time, called the Hosh system, which was invented to afford protection for the city. As the first wall protected only the inner city and not the houses built outside it later, these houses needed protection. They were therefore built around a central quadrangle with gated access, creating a Hosh. This area was perhaps originally used for cultivation and later sold to families or divided among them as a residential area. Usually, the Hosh had one entrance from which the entrances to all the houses surrounding it branched out. Figure 3.7 an example of a Hosh development plan. The other elements also conform to the plan: the market has its specific place, as do mosques, public buildings, schools and hostels.



FIGURE 3.7: An example of the Hosh system in Al Madinah

The Hosh, or courtyard, formation is one of the unique features of traditional Al Madinah houses (Kaki, 2006, 2007). This development appears to have started in AD 1517, when the population increased suddenly and there was no room for new houses within the inner wall. People started to build houses outside the wall, but the fear of attack from enemies led them to adopt the courtyard formation. These quadrangles are large areas surrounded by houses and have a huge gate, which is closed at night. They are of different shapes and sizes and have different names. In AD 1163, at the request of the inhabitants who lived outside the inner wall, the Sultan built the outer wall, as well as buildings to form a Hosh. The wall has been renovated over the years. Even though the original idea of protection does not pertain any longer, the construction of the second wall formed an area outside the inner wall and inside the outer wall. The Hosh formation continues to influence the social life of the residents. The area in the centre can be used to hold events during times of celebration, which include the two Eids (Eid Alfitr, Eid Aladha) and the Ramadan period, and also occasions such as weddings. On ordinary days, these spaces act as childrens playgrounds. The gate of every courtyard is open from dawn to dusk, but no strangers are allowed to enter unless they are recognised by at least one of the residents.

3.7.2.6 Hosh System from Childrens Perspectives

One of the participants recalled his childhood memories about the Hosh:

It was really a good scheme and I wish it still existed. Every neighbourhood was independent. For example, I live in Al Mankhah. If I went to Al Tajoriyya, I would be beaten up. Why? Because Im a spy! If you wanted to visit a specific house, a mature person in the neighbourhood would ask me where I wanted to

go and who I am. And then he would take my hand and guide me to the house.

No one else could talk to me in this case. If anyone from a neighbourhood got beaten up, the whole of that neighbourhood would act against [the aggressors] for revenge. This process was really good. Why? Because there was discipline and children were under control, supervised. Every child played safely in his own neighbourhood with neighbours. Not like now: they go [away] and no one knows where they have been.(Interview 2: elderly local inhabitant)

3.7.2.7 Eco-Friendly Houses

The development of houses was based on the needs of their inhabitants.

The houses from that era were the most beautiful elements in the citys fabric, their privacy, their shape, their pattern! They were eco-friendly houses, which adapted to the weather, staying dry and warm. During the summer, the temperature went up to 45-49 °. This type of weather came around every 33 years, so the buildings were placed in the shade to block the suns rays, but at the same time there were pathways for ventilation. All these made it possible to live in them comfortably during the summer.(Interview 6: researcher, architect)

The external appearance of traditional houses was distinctive, with unique windows called Roshans and featuring different designs and patterns. Roshans were used in traditional buildings for ventilation and light, while also providing seclusion an essential requirement in Islamic culture. Roshans had wooden shutters, and every Roshan had a different style and design based on the location of the window in the house, as the windows on the ground floor were bay windows, while those on the other floors were bay windows. The size of the windows and

balconies depended on the wealth of the householder. The wood of these windows had ornate patterns on them, which were geometrical or depicted plants or combinations of these. In the top half of the wood there was a cross-hatched window for ventilation and light, which did not extend to the bottom half, for reasons of privacy.

Participant 5 (archaeologist) also talked about the Roshan:

It gave illumination and ventilation. At the same time, it provided privacy for residents who came in or went out. They made it at an angle. I dont know how they invented it. Stunning, absolutely stunning! I captured an image of it but it doesnt show its beauty. This is over 40 years ago, [when] cameras did not have the capabilities they have nowadays. Cameras were not readily available, [so] I used any opportunity to capture images with any camera I could find.

Although the Roshan topic was mentioned frequently by the interviewees, there were other elements inside the house that were also important to them, such as the hall (Al Qaah), Al Diwan and service units.

3.7.2.8 Personal Narrative about the Traditional Hijazi House

Our house on Al Manakhah has three Diwans [receptions rooms] on the ground floor [and] every Diwan has its own skylight for ventilation and lighting purposes, and at the end is the hall (Al Qaah), which is used for special occasions. When we sit in the hall, a breeze comes in and gives us the same feeling as a strong wind. There were four more rooms, two of them with a skylight. (Interview 2)

This quote provides an insight into the main elements in the traditional house, which may be divided into four main sections, according to Kaki (Kaki, 2007):

1. The Hall (Al Qaaa), located on the ground floor, contained two seating areas in front of each other, with no windows.
2. Al Diwan, which was similar to the hall, had one seating area with no door. It was also located on the ground floor, and was used for receiving guests and for the family in the daytime during summer. Usually, the Al Qaah was used during big occasions and festivals.
3. The vertical movement element, 1. which included the Al Jilaa (skylight), was an open area that provided the house with light and fresh air. There were between one and three skylights, depending on the size of the house. Traditionally, the skylights were covered by a fabric attached to a very long rope that enabled their opening and closing to be controlled; the skylight was covered by the fabric when it rained.
4. 1. There were other units for different purposes, including rooms based on the residents needs. For example, people usually slept on the roof, where it was cooler at night than the inside of the house. In winter, the family would usually use the first floor area for living and sleeping in, as that area would be warmer than the ground floor.

The wooden shutters of the Roshan window were of different styles and designs, according to the location of the window. The size of the windows and balconies depended on the wealth of the householder. The Roshans for Makkah houses were different from those of Al Madinah, which were ornamented in a unique style not seen anywhere else (Interview 4). Patterned and decorated wood covered the big empty space, looked attractive and did the job of giving complete privacy to the residents, so that they could sit there freely, while the pedestrians on the street could not see them but rather the beautiful art. This was the secondary purpose

of the Roshan. Some models indicated the financial status of the household (Interview 2).

This section has covered themes derived from the interviews I conducted with people from Al Madinah, from different walks of life. This was the initial phase of my study to understand the impact of urban development on Al Madinahs heritage and how different the city was in the past. The next section discusses traditional building styles in Al Madinah, with a focus on the traditional Hijazi house.

3.8 Traditional Building Types

This section offers an insight into traditional building types in Al Madinah, although resources and research in this area are limited, so I cover the main elements of such buildings in general and focus in particular on the traditional Hijazi house, which I chose to play a role in my project on the 3D environment. Details about the process of building the 3D environment can be found in Chapters 4 and 6.

The main constructed elements at Al Madinah are mosques, libraries, schools, hotels, Sabeels (natural springs of clean water), baths and traditional houses. Each of these has an impact on the lives of the people, and together they give Al Madinah its unique cultural fabric.

1. **Mosques:** There are many mosques in Al Madinah, dating from the early era of Islam, beginning around 662 AD. The first mosque built by the Prophet Mohammad was the Quba mosque. Until 1950, the Quba area

consisted of gardens and palm groves with the mosque in the centre; nowadays it is a very busy area occupied by blocks of flats and shopping malls. The explorer Richard Burton, in his book *Pilgrimage to Al-Madinah and Mecca*, described what he called the gardens of Kuba [Quba].

The area of Quba was farms; we used to pray Al Jumaa [Friday prayer] in the mosque; then we spent the afternoon in the farms every weekend.

Parents sat with a traditional tea with fresh mint, while children played some of the traditional games that used stones and marbles or that needed more space for running around and doing outdoor activities. (Burton,

1856)

The Prophets mosque, known as Al Masjid Al Nabawi, was built by the Prophet Mohammad (PBUH) after the Quba mosque and has always been treated with respect. It has undergone massive expansion and the Kingdom of Saudi Arabia has made it a priority to develop it. Some of the other mosques that stood in Al Madinah for hundreds of years have been demolished in the last twenty years. For example, Almsajed Alsabaa consisted of seven different mosques, of which six were demolished by the Saudi government, which then built one big mosque, named Al Fath after the largest one of the six. The surviving seventh mosque is called Al-Qibletain and has been refurbished recently. Some of the other sacred places have been ignored, having become prohibited areas because of their historical association with religious views that are now illegal in the country.

2. **Libraries:** Libraries have been an important part of Al Madinah society for centuries. According to a text dated AD 1886, there were more than 18 public libraries in the city at that time. The most famous were Aref

Hekmat, Amin bin Sheikh Al Haram, Al-Mahmoudia and Basheer Agha libraries. Aref Hekmat library, which was the largest and the best organised, was built in 1851 and demolished in 1990. All these libraries have now been destroyed. (Kaki, 2001) interviewed an elderly librarian named Sheikh Muhammed Al Farouki, who said,

Your future generations will be sorry for what your fathers did, but then being sorry will not do you any good.

This regret for the vanished landmarks of Al Madinah has affected the older generation who have roots in the city predating the oil revolution and the new layout of the modern city.

3. **Schools:** It is believed that the oldest school in Al Madinah was founded by Jewish settlers in about AD 500 for the teaching of their children (Badr, 1993). Later, Al Masjid Al Nabawi became the first Islamic school, after which Caliph Umar (AD 577644) established specific sites as schools and employed teachers. By 1901, there were 17 schools in Al Madinah and 13 Katateeb (singular: kutab). Kutab is an old name for a place of learning without a specific school building, where the children gathered and received education (Ibrahim, 1925).
4. **Hostels:** Hostels, known as Rebats, offered free accommodation to poor people (and to students if the Rebat also ran a school). Rebats were usually located near mosques and schools, and varied in size. In 1900, there were over 108 Rebats in Al Madinah (Ibrahim, 1925).
5. **Sabeels:** *Sabeels [were] built mainly to provide free drinking water in order to gain Allahs forgiveness and tolerance” (Interview 4)*
Sabeels were very popular and numerous in Al Madinah, especially in

crowded areas. Sabeels were of two main types: the first was the connected Sabeel, usually attached to the outer wall of a house, from which anyone could get water; the other type was the freestanding Sabeel, located in a public area and outside the city walls. The Sabeels were famous for their special design, with words from the Holy Quran engraved on their stone surfaces, encouraging people to support and be generous to one another. Unfortunately, all Sabeels have disappeared, although the idea of offering free drinking water still exists in the form of the electrically powered water coolers that have replaced them. These features of the city were familiar to the inhabitants and visitors of Al Madinah, as Burton observed: *[T]he remarkable features of the town thus presented themselves in succession. Outside, among the palm trees to the north of the city, were the picturesque ruins of a large old Sabil, or public fountain; and between this and the enceinte stood a conspicuous building, in the Turkish pavilion style the Governors palace. On the north-west angle of the town wall is a tall, whitewashed fort, partly built upon a large rock outcrop.* (Burton, 1856)

6. **Public baths:** The idea of a public bath was common in some Islamic regions such as Turkey and Syria (Kaki, 2001). After the establishment of the Hijaz railway, many traditions of these countries came to Al Madinah and became essential parts of it. Some families preferred privacy and used the public bath only on big occasions such as weddings or celebration days. There were two public baths in Al Madinah by 1918, but there are mentions of them in the accounts of travellers even before that time (Ibrahim, 1925).
7. **Forts (Atams) and citadels:** Forts existed in Al Madinah before AD 622. They were built of thick black stone and had high walls for protection. Citadels scattered all over Al Madinah within the city walls were

refurbished when work on the Al Hijaz railway started in 1901, finishing seven years later. Many citadels and towers were built during this time for military purposes, but most were demolished in 1951, along with their gates and walls.

8. **Shops::** At the time of the first expansion of Al Masjid Al Nabawi in 1952, there had already been a number of shops in that area for hundreds of years. The shops were named after the goods they sold. *Al Gammashah shop [selling textiles and fabrics] and Al Gaffash [hand-crafted cages] were situated next to Al Masri Gate [the Egyptian gate]. Later, Al Aineya street, built by the Ottoman rulers, became the main street for shops selling goods to both males and females.* (Interview 2) Another famous market was Al Manakhah market, which was planned by the Prophet Mohammad (PBUH) in AD 622. This area was reserved for traders and it became the citys main market. The shops here were more traditional; the last one to go, Al Anbareya, survived until 2006. Not only have the traditional shop buildings been demolished, but also the old trading customs have completely changed. The conversation below illustrates this.

Interviewee: *When Dhuhur Adhan [call for noon prayers, during which everyone is supposed to stop working and head to the mosque to pray] started, shops had no doors; they used a piece of fabric to cover the entrance to indicate that the shop was closed during prayer time. Who was allowed to approach the shop? No one! That was a matter of safety. The shop [extended] from here to there. There would have been a fabric from here to here to cover the entrance, but all the goods were inside on shelves, everything inside. No one came near it. Now we use locks and chains, and we ask God to keep us safe. This is the truth.*

Walaa: *Are there any incidents of theft?*

Interviewee: *Never. Who would dare to do something like that?*

Walaa: *Never, ever?*

Interviewee: *Could have happened during the [pilgrimage] season, and strangers came for that purpose from elsewhere, but on ordinary days no [such] incidents occurred.*

Another interviewee commented. *This is the secret. Al Madinah was one city: local people were well known to one another, and everyone trusted everyone.* (Interview 4)

9. **Traditional houses:** Traditional houses in Al Madinah share some features with houses found in the Hijaz area. (The Hijaz area is the western part of the Arabian Peninsula, and includes Makkah, Jeddah, Al Madinah and Taif). These features are visible in the interior design of the house. However, there are some unique features in the layout of the city which had been adapted to the inhabitants needs. The houses themselves are built in a way that adapts to different circumstances. Traditional houses in Al Madinah were built using clay and stone, with palm fronds forming the roof. The next section has details about the traditional Hijaz house and how it has been built to adopt with peoples needs.

3.9 Preserving the Heritage of Al Madinah

A new modern city of Al Madinah now stands where the old city once stood, and all the traditional buildings, libraries and schools next to Al Masjid Al Nabawi have been demolished. By 1993, all that was left of them were some photographs

and a few video recordings. There are several methods used to preserve the heritage of Al Madinah: creating museums, establishing an account on social media, producing a TV documentary or offering a package tour to places of historic interest. The following section explores the current initiatives for protecting the heritage of Al-Madinah, in physical as well as digital documentation. Although there are only a few museums with exhibits related to Al Madinahs heritage, several individuals have used social media to celebrate it and share it with others who do not have access to physical locations such as buildings.

3.9.1 Local Museums

I found many similarities in the medium of display used in Al Madinahs local museums. For example, both the main museums used traditional display methods, including old photographs, scale models and collections of old implements and other objects.

3.9.1.1 Scaled Model



FIGURE 3.8: Old photographs and scale models at Madina Media Museum show how mosques used to look

The scale model is a popular method of showing how Al Madinah looked in the past. Scale models come in different sizes and vary in quality and the material used. For example, Madina Media Museum uses small models to represent historic mosques. These models are made of foam and cardboard and their sizes range from 20 cm³ to 50 cm³. The other material used in the models is mud, representing the houses of the early days of Islam (7th century AD).

In the same museum, there are bigger models, which represent Al Masjid Al Nabawi; they are more accurate and look better than the previous models, as they are more detailed and images from the current interior design of the mosque are stuck to the model to help visitors visualise the first mosque and how it may

have shared similarities with the current one.



FIGURE 3.9: The quality of a scale model varies according to its religious value

Images are also superimposed on a current map of Al Madinah to represent historic battles. Figure 3.4 is an example; it represents the battle of Uhud (AD 625) by relating a map of the city as it is today to the historical locations of events. This idea is a useful way of giving a very vivid picture of the past, as most of the historical locations are now built over. This is in contrast to what I found during my visit to Battle Abbey in England, where King Harold was killed in the Battle of Hastings in AD 1066: here, the field of the battle is preserved for and open to visitors, with audio guidance provided.



FIGURE 3.10: Maps used to represent historical locations

The largest model and the one that best represents Al Madinah in earlier times is at the Dar Al-Madinah Museum. This model is the result of a study conducted in 2007 by a team of researchers to document Al Madinah from 1850 to 1950. The specific year mentioned on the model is 1926. The model depicts the entire city, including all historical sites, markets, neighbourhoods, hostels, forts, libraries and mosques. It was one of the primary resources on which I based my interactive map, as it helped me locate key landmarks accurately.



FIGURE 3.11: Scale model of Al Madinah in 1926 at the Dar Al-Madinah Museum



FIGURE 3.12: A scale model is a popular way for museums to depict the old city

3.9.1.2 Moving Images

Madina Media Museum shows films recorded in 1938 about the Egyptian caravans that came on a pilgrimage to Al Madinah at that time (Ibrahim, 1925). In addition, there is a series of old images of the city projected one after the other. Although the film is old and of poor quality, it is very rich in information about the locations recorded in it and highlights the enormous change that has happened in the city in a short period of time. A projector effectively displays information, while the use of a 3D constructed model improves the quality of the picture. Figure 3.14 shows an example of an old image and the 3D model I constructed based on the image. The 3D modelling makes filming possible, as a camera can shoot freely from any angle around a 3D object, which cannot be done with still photographs. With such photographs, sharpening and reprinting are often the limit of what can be done to improve the experience of people who wish to visualise the ancient city.



FIGURE 3.13: The 3D image (right) I designed from a still photograph (left)

3.9.1.3 Collection of Objects

Collections of objects are another important way of exhibiting heritage in museums. Objects include domestic tools and implements, such as the traditional utensils for cooking. Dar Al Madinah Museum has plenty of such objects on display in a section dedicated to household implements. All the objects are displayed behind glass, each with a label naming the object and outlining its purpose. Although there are many such implements there, the visitors cannot experiment with them. As such old objects are to be protected, the use of new technology could be the means by which the experience of using such objects can be simulated without causing any damage to the actual artefacts. This can be done by interactivity incorporated into the objects on a 3D digital tangible screen.

Also, there are sections in the museum that exhibit fragments of patterned windows and doors from demolished houses. These objects are also displayed behind glass. Dar Al-Madinah Museum displays the remains of an ancient door with a photograph next to it showing the traditional house in which the door was used. This link between the old photographs and the objects has the effect of enabling better visualisation. Similarly, remnants of the woodwork on a Roshan are presented next to the photographs of the house to which this Roshan once belonged.

3.9.1.4 Photographs

Although unfortunately few relics from the past have survived, comparatively many photographs have come down to us through history. Photographs are common in museums and are a primary resource enabling the researcher to get

an idea of what a city used to look like. Photographic images are displayed in various different ways in museums. They are sometimes classified on the basis of the buildings they represent and are usually complemented by other media such as scale models or physical objects. Old images are sharpened using specific software, and printed in different sizes.



FIGURE 3.15: Images are commonly used for display in local museums

3.9.1.5 Websites / Social Networks

Both museums I visited have increased their interactivity online. When I first visited these museums in early 2011, they had basic websites, with the museums name, address and contact number. Recently, both museums have developed better websites that include information about the museum and the galleries inside, and what the visitor can expect to see there. In addition, they are more involved with social media, particularly Facebook and Instagram, and have started to share their activities online. Although this step was essential for both museums

to advertise themselves and to encourage the public to visit, there is much more that needs to be done towards this end.

3.9.2 Saving the Heritage through Digital Media

Promoters of the history of Al Madinah are making the most of social media. The social media are a powerful communication tool, especially in Saudi Arabia, where there is a high level of interactivity online. There are several software programmes that certain organisations, groups or even individuals use to share their interest in the history of Al Madinah on the web. Some of these programmes are explored in the following sections. Facebook, Twitter and Instagram are widely used in Saudi Arabia, and several accounts have been set up to promote the heritage of Al Madinah or the Hijaz area in general. On Facebook, there are two main types of pages: those linked to formal companies or societies and those that feature personal timelines, postings and images. Most of the centres and museums concerned with Al Madinahs heritage have a Facebook page on which they share their events and encourage people to join them. The numbers of fans are small compared to those of other social media. The number of Likes on the formal pages varies from 565 (Museum, n.d.) to 3,617 (Museum, n.d.), whereas a personal page named The Hijazi Culture has 4,998 friends (Sokkar, n.d.). In this case, as the creator of the account has chosen to have a personal account, the number of friends is limited to 5,000. On Twitter, I looked for accounts that concentrate on Al Madinahs heritage. The accounts I found focused on Al Hijaz in general, not specifically on Al Madinah. Profile icons usually use old images of Roshans or, more commonly, an icon image of the Ghaban, a traditional head wrap for men. @aL7ijaaz is the first and largest account

related to the cultural heritage of the Hijaz area, with 177,000 followers and over 6,800 tweets (al7ijaaz, July 2012). Another account is @souraazzaljamel, which features old images about good times, related to but not limited to traditional clothes, old houses, antique items and traditional songs. This account has over 1,700 posts, which is fewer than the Hijaz-specific @aL7ijaaz account, but has 274,000 followers. On Instagram, there are fewer accounts, one being called The Quest and featuring the cultural heritage of Al Madinah. It started in 2013, exploring the old lesser-known places in Al Madinah, and currently contains over 1,135 images of Al Madinah, some being places of religious significance such as mosques. The large-scale demolition that is currently happening, in preparation for a further expansion of Al Masjid Al Nabawi, is also documented. The advantage of this account is its uniqueness; every picture uploaded has been taken by the account holder himself in recent times, whereas the previous accounts on FB and Twitter used photographs that are freely available online.

3.9.3 The Visual Perception

It would appear from my research that many social media accounts related to Al Madinah have images shared by other accounts at different times. The only difference is in the way the original images are edited and sharpened, with the account name inserted as a water mark! This underlines the fact that there is limited documentation on Al Madinah, and a small number of images has to be used again and again in different ways for different purposes. This is very common on social media, but it also occurs in museums. The same photographs were exhibited in both the main museums I visited, differing only in the manner of their reproduction and presentation.. Similarly, the scale models depict the

same specific locations or specific times in history, for example, the models of the Badr, Uhud and Al Khandag battles. Another example is the Al Masjid Al Nabawi and its expansion through the years. The relative paucity of the exhibits is not due to a dearth of material, as in my research I found a great many rare photographs, even from my personal contacts or in rare books. There are also some drawings and descriptions from both Oriental and Western travellers, albeit still hard to access. However, the use of the same popular images limits the unfolding of Al Madinahs heritage, of which large portions need to be documented and presented to the public. In my research, I focused on parts of this heritage in order to explore new ways of documentation that are not in use today. The focus on a specific subject (as illustrated by the banner with an icon depicting a traditional building with Roshan) causes a proliferation of redundant images, a phenomenon that also occurs in published textbooks, on YouTube videos and in museums. Although, as mentioned before, the heritage consists of several rich elements, most of these have been ignored, even by artists, who depict building exteriors, albeit from different perspectives and in different styles, but rarely represent the social life in Al Hijaz in their paintings. It may be worthwhile for those who wish to preserve the heritage of the city and the region to focus more on elements such as Sabeels, hostels and public baths and make them more widely known to the public.

3.10 Conclusion

This chapter discussed the history of Al Madinah and its lost heritage and showed the participants strong nostalgia for the past, accompanied by their sadness about the destruction of more and more of their city. It also reported the opinions and

responses of local people, attempts to save or retrieve the heritage, such as by local museum curators, and digital content. On my visits to the two local museums that cherish Al Madinahs heritage, I found redundancy in the images displayed and almost exclusive use of traditional display mediums. Similarly, digital content is poor and unorganised. The museums exhibits and means of display could be improved by the use of a wider range of photographs. In addition, it would be worthwhile to introduce more technology and digital media into these museums. To find out what type of technology is suitable for use in a museum context and how it can be applied, I conducted a study on the concept of heritage museums in the UK. The UK has many more heritage museums than Al Madinah, and they all receive state funding. My next question is: Can the display techniques used in UK museums be applied to Al Madinahs local museums?

CHAPTER 4

Investigation into the Best Practice of Using Digital Installations in UK Museums

The previous chapter combines qualitative interviews and surveys of buildings and museums with an overview of the main characteristics of the heritage of Al Madinah, the current situation of the city and the different ways it has been represented. This chapter extends the previous chapters themes by describing an explorative study that was conducted to determine the best practices in terms of using digital devices and 3D graphics in some UK museums. I visited ten museums in the UK to look for digital media and interactive devices that museums use to attain a better understanding of using technology in a museum context.

4.1 Selections of Museums in the UK

This selection was based on recommendations of local people and online research about popular museums in particular cities. Three of the museums are in Canterbury where I live and study; four museums are in London, while three are in Liverpool. In London, I targeted highly rated and popular museums and excluded art galleries that focused on collected objects, as I was looking for installations and digital media. In Liverpool, I received advice from local citizens and guidance from tourists about which museums to target. The museums I visited are described in the following sections, with the date that I visited them in brackets.

4.1.1 London Transport Museum (14 June 2013)

This museum is a very immersive and family friendly museum that tells the story of London and its transportation system and how it has been developed in the past 200 years. A few years ago, it also had major renovation work done, in which the question of using technology was carefully thought through. The museum contains nine galleries. The display media in the museum are varied, with old vehicle collections, rail maps and boards, and documentary clips widely used. Documentary films are available in the museum in two different types: the first type uses the kiosk touch screen, which provides text information along with images and short clips; the second type consists of films projected on the floor or against a wall. Information about London railways is displayed using real images for external view and 3D images to explain the internal infrastructure.

4.1.2 Museum of Liverpool (20 June 2013)

The Museum of Liverpool is a good example of how technology can be used for narrating the history of a city in an entertaining and educational way which is suitable for families, individuals and school groups. The history of Liverpool and its heritage are represented in different ways through documentary films and interactive games that are available on tangible screens of different sizes. Also, the content and design of the data has variety to cover all visitors tastes. The museum recounts the history and heritage of the city of Liverpool, its present-day situation, and predictions for the city in the future. In addition, the museum hosts different temporary exhibitions through the year. Overall, the museum has eleven main galleries. The display method in the museum is a combination of traditional exhibits, such as object collections, and more sophisticated media, such as an interactive installation. In addition, a theatre displays films that are related to the museum objects. Interactive digital installations are used widely and effectively. For example, Liverpool in the Past and the Future is an installation that gives information about Liverpool from 20,000 BC to the future. The information is displayed by using a large touchable table with an animated map, and the figure of a cartoon seagull works as a guide for users. Carters Challenge Game is an installation taking the form of an interactive game about Liverpool carters. The game itself is very basic and easy to play, and the idea is to present the old images with 2D graphics to explain the subject in a simple and interesting way. Welcome to Fernlea The Home of Douglas Crawford is a short animated film about the Douglas Crawford Chinese Art Collections. This animated film is displayed next to the physical objects that appear in the film.

4.1.3 Museum of London (14 June 2013)

The Museum of London has permanent galleries and several exhibitions. My focus was on the permanent gallery that tells the history of London, as I was exploring digital devices technology in general with my main focus on those that were related to the history of a city. This was one of the most interesting museums that I visited. It displays 3D in a different way. Touch screens of different sizes are used, some of them with the facility for simultaneous multi-person use. Computers are available in the case of some exhibitions to provide extra information, quizzes and virtual tours. The LBL London before London installation is an example of an exhibit with applications available on PC that include information, maps and virtual tours (a discussion about this exhibit is in Section 4.3.5). Another installation is Londinium and Beyond. This is a large interactive table with a Google Earth map which allows visitors to explore Roman sites in the London area. When a specific location is chosen, a number of objects from that era are displayed with information and 3D images. All maps and objects are touchable. More details about these items are in Section 4.3.6, which deals with interactive maps.

4.1.4 Natural History Museum (12 June 2014)

The museum has more than 80 million exhibit items relating to earth sciences. This museum has four different galleries: the red zone, green zone, blue zone and orange zone. The blue zone has a dinosaurs section which has some digital devices relevant to my research. For example, the living environment of dinosaurs is created by using 3D and displayed on two large screens, with information

about this environment written underneath. Projectors are also used to display 3D scenes, some of them for entertainment purposes and others for educational purposes. The digital devices used in the museum include interactive devices, tangible devices of different sizes, and a kiosk with a set of headphones. Using a smart card in the Natural History Museum is a good way to maintain a connection between visitors and the museums, as this card allows visitors to store their favourite media by swiping the card; users can then retrieve the stored data during a later visit to the museum website by inserting the unique code of the card.

4.1.5 Roman Museum (13 June 2013)

The Roman Museum in Canterbury is underground, at the level of the old Roman town. This is a small museum in comparison to the previously discussed ones, but it has a couple of digital devices. I classified the devices in the museum into three categories: static image devices, sequence image devices and interactive devices. The static image is an image which has been reconstructed in 3D form and displayed with no interactivity; the Roman Gate is an example of this. Static images include old black-and-white photo images of the original discovery mixed with 3D models that are imaginary conceptualisations of the original places. These images are displayed in sequence on a wall-mounted screen with no extra information, such as subtitle, audio or text. The interactive device in the museum is a kiosk which has a touch screen. For example, an imaginary view of the Canterbury Temple in its precinct is presented from plans made by the Canterbury Archaeological Trust. Although the Roman museum is a small museum compared to others in the city and is located in a small area, it succeeds

in effectively delivering the message about the location, the city of Canterbury, during the Roman era.

4.1.6 Science Museum (12 June 2013)

Technology is widely used in the science museum, and there are numerous digital devices in different sections. In addition, the IMAX cinema shows different 3D films. Although, the museum does not focus on the heritage of a particular city, the digital devices available in the museum are very good resources to examine a variety of exhibits and data that is represented. My focus, in particular, was on how the museum delivers complex information in an easy way with the help of technology.

4.1.7 The International Slavery Museum (19 June 2013)

This museum is rich with displays related to slavery stories in different media. Documentary films are shown using different methods. Some are projected on a kiosk screen, while others are shown in different sizes by using projectors. Interactive devices are also available to navigate through the information. Examples of these films are Plantation and The Voyage of the Essex.

4.1.8 World Museum (19 June 2013)

The World Museum in Liverpool has a wide choice of devices to investigate. The museum consists of four floors; each floor has a touchable screen with a 3D map of that floor and additional information about other facilities. Two interesting installations I found are the Catalogue of the Universe and the Earth

and Moon. These two devices have the same workflow, and the system has two main parts: a screen to show the selection and display the information and a control panel that contains three buttons to activate a selection. Other examples of relevant applications in the museum relate to Asia, the Americas and Oceania. These are different installations about continents, with each device focusing on one continent at a time. The installations have a variety of options to choose from and include games that can be played and different pieces of information available about the area. The temporary exhibition has a variety of visual methods of display, including interactive devices, a learning area, and objects and models. The use of different materials has enhanced the concept of the exhibition by offering different methods to cover visitors tastes and needs. These include handicraft items for young visitors, an open area for enacting plays and a documentary film with multiple language choices.

4.2 Explorative Study Method

The aim of this phase was to explore the current use of digital installations exhibited in UK museums in terms of what they display and, The aim of this phase was to explore the current use of digital installations exhibited in UK museums in terms of what they display and how it is displayed and developed. The result of the previous study about Al Madinahs heritage and how the local museums present it directed me to develop a framework to produce an installation on a limited budget that would be suitable for the budgets of local museums. Direct observations were utilised; this provided knowledge of the different installations and how popular they are in comparison to those of other museums; this knowledge was more relevant in relation to the traditional display method that has

been used in local museums in Al Madinah. I explored the digital installations and recorded relevant data through photographs and note taking. Photographs and note taking played a critical role in this phase, as they helped me to better understand the design and the navigation process of the installations.

4.3 Data Analysis

Observation, notes and photography were the tools I utilised to investigate the use of digital devices in a museum context. The categories that emerged are as follows: projector usage, location setup, links between digital and physical objects, cartoon illustrations and the number of design levels of the installations.

4.3.1 Using projector/s

Projectors are widely used in museums for different purposes; some of them are just for decoration, while others provide information as a main or secondary source combined with other types of media, such as video, sound track or textual information. There is also another kind of projector that seems to be less used in comparison with conventional ones: this is an interactive projector, which gives visitors the opportunity to interact with the device. The use of projectors for visual purposes is popular. There are two environments in which these are used: one is naturally lit spaces, such as in the Museum of London, and the other is dark areas, such as in the Natural History Museum in London. In my opinion, the dark area gave more prominence to what is shown and attracts more attention from visitors.

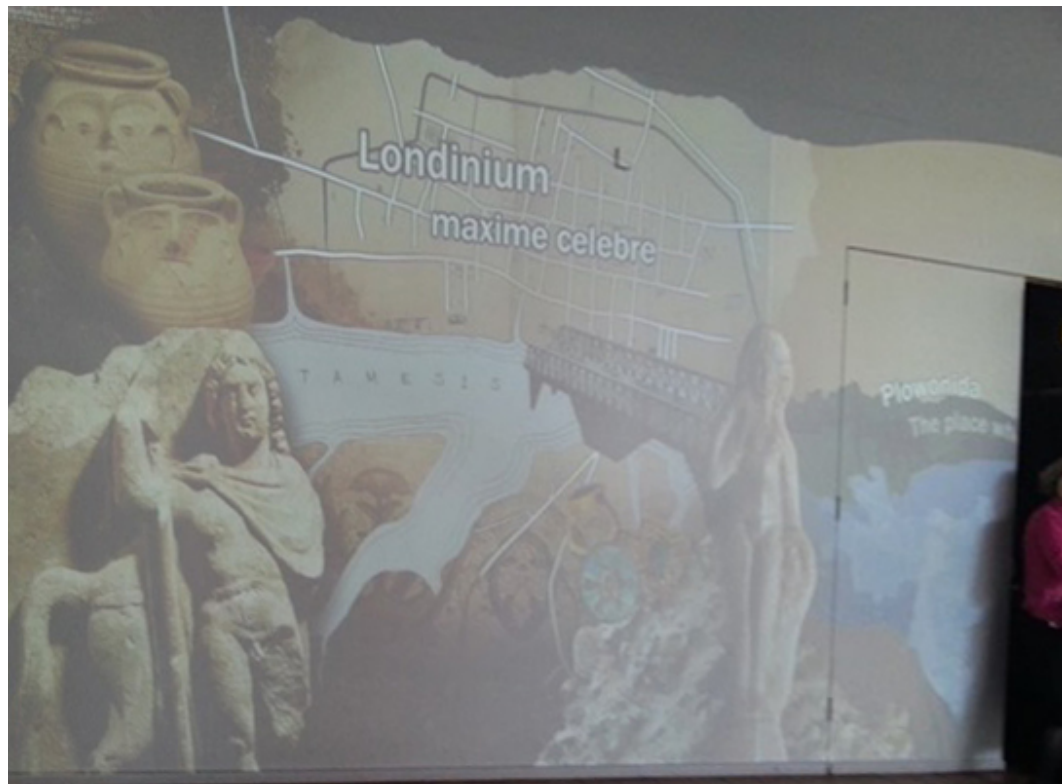


FIGURE 4.1: The use of projectors to cover white spaces

The use of projectors is thus not just for pure visual entertainment, as they also provide information. For example, the Museum of London uses reflected images to give the visitors an idea of what to expect inside the gallery, and in the Londinium gallery, the walls display a collage which represents objects from the same era and location (London of the Roman era). Figure 4.1 displays the map of Londinium, statues representing Roman places and jars from that time. These images cover the whole wall of the gallery. The reflected images are used also to fill the blank white gaps between different exhibitions. Another example is a projector used in the Natural History Museum to decorate the corridor with digital images of plants and flowers in the insect section. Figure 4.2 shows a projection of the natural habitats of the displayed insects.



FIGURE 4.2: Using projectors for decorative purposes

The World Museum in Liverpool also uses projectors for decorative purposes. In the Countries section, a calligraphy pattern is displayed on the floor. The calligraphy uses images of the current exhibition, which is also what the Transport Museum in London does with its display of the London Underground logo with different names and designs for decorative reasons (4.3).

Another reason for using projectors in museums is to provide different kinds of information, including text, images, documentary films, videos and short clips. This kind of use is the most popular and is seen in wide areas of different sizes and diverse setups. The Slavery Museum in Liverpool uses a curved display screen along with a flat one. The information on each screen display complements the other; one screen plays a documentary film, while the other provides more visual

details, such as extra images or animation. The curved screen provides an unusual display, as it has a wider view than the flat screen. Some of the display locations are a bit isolated and provide visitors with seats; these are mainly used for documentary films and medium-length shows which last between 15 and 30 minutes.



FIGURE 4.3: The variety of uses for projectors in a museum

The Museum of London uses two different projectors next to each other and provides pieces of information which are different in terms of the media used but complement each other to deliver the complete picture. For instance, the first projector displays images, and the second one, which is next to the first one, plays a narrative video with subtitles. Using two projectors at the same time is a creative idea to display content consisting of a variety of media but with a limited time for display; it is useful when there is a film showing at the same time that can support the ideas and photos being played on another screen. However, this kind of display should be designed very precisely, as inefficient production can confuse the audience. For example, if the information displayed on one screen has the same importance as that displayed on another, the same amount of concentration would be required, and audiences could find it difficult to decide which

one they should focus on more.

The Transport Museum uses a projector to provide information which is projected on a wall, and this is linked to what is projected on the floor; this is a creative way of displaying information, but it has some issues. For example, Figure 4.4 shows that the use of the projector is not accurate, as the displayed text information is cut and one part appears next to the edge. The use of the floor to display data is an inefficient method for displaying the information, as this part of the floor is not assigned as the projection area, and it is an open area where the visitors could walk through. People walking by could disturb the viewers who would like to read the text.



FIGURE 4.4: An example of the non-effective use of projectors in a museum

Interactive projections are available in the Natural History Museum where the audience can choose what to see. Some of the devices are linked to a computer where the display data is stored, and user selection determines what is displayed

at any given time. These projectors, controlled by the computers, provide a great opportunity for groups to share information: as a user selects the desired topic, the displayed information is available to more than one person; this is an advantage derived from the big space provided. In addition, some of the devices give users the opportunity to take a photo of themselves, choose the theme and the background for this photo, turn it into a card and e-mail the card to their family and friends, tagged with the name of the museum. Such projectors are controlled by a separate device, while other projectors have interactive features related to the displayed image.



FIGURE 4.5: An example of the effective use of projectors in a museum

This type of projector is the least popular due to its slow responsiveness, as the selection of image upon user command is not speedy. For example, Figure 4.6 shows an image projected by one of the interactive projectors after a user made a selection by touching the icon of a butterfly; the selection process was slow

and required several tries before it worked. This happened with other interactive projectors in the museum. This slow response of the projectors affected the popularity of the interactive projectors, even though the interactivity of other devices was enjoyable and attractive.



FIGURE 4.6: The interactive projectors used in The Natural History Museum, London

Projectors have various purposes in museums: for creating the ambience (for example, displaying design on the floor or walls) or for giving information by

displaying image, text and video. The majority of projectors used in a museum are non-interactive, while there are a few projectors which are interactive. Having introduced these devices in this section, the next section will explore how various technologies, including digital devices and a traditional one, work together.

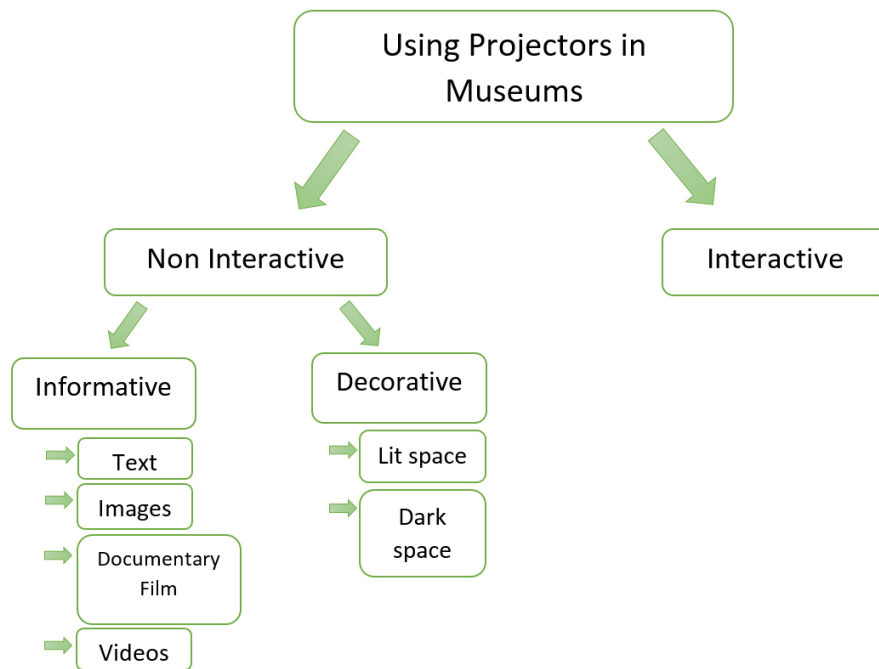


FIGURE 4.7: Using projectors in museums

4.3.2 Location Setup

The environment of the museum has indirect affects to the visitors The environ-
ment of the museum has indirect effects on the visitors satisfaction (Jeong and
Lee, 2006). Using a variety of display methods to deliver a certain theme is one
method that museums use. The Vauxhall pleasure garden in the Museum of Lon-
don is an example of this technique. This consisted of an area which contained
different mannequins, wearing different clothes from the 18th century. The decor
of the area was inspired by the same era, with different seats available to watch

a projected film. The film is run by two different projectors and projected from two different angles, each one displaying one part of the narrative film. From my observation, audiences were engaged by the dark environment, the dressed mannequins, props and decorations in the gallery, and the sounds and the video presented in creative way. For instance, the picture is split onto two screens separated by a space of non-projection in between. This space includes objects that emphasise the films atmosphere by using the objects seen in the film. This gallery is a very good example of how to make every single thing in a gallery work together to produce an effective environment which delivers one message through different kinds of media. The lady seen in the movie was also the same as the mannequin on display, so there was a synergy of media delivering one message. Another example is the World Museum, which has a gallery dedicated to the art of Indian storytelling. The whole section focuses on that idea, with various means of display. For example, there is an Indian temple with a seating area in the middle surrounded by three Indian female mannequins wearing traditional Indian clothes. In between the models, there are pictures from a projector, showing an Indian dancer with the audio of the music of the dance. The other facilities include a Rangoli installation. In Hindi, Rangoli means a pattern or design of colour. In the museum, Rangoli is an application that allows the user to choose the pattern and colour of different Indian designs, see Figure 4.8.



FIGURE 4.8: Exhibition of the art of Indian storytelling

Along with it, there is a documentary film in Hindi with English subtitles, and next to it is information in text form and images related to Indian stories, songs and scrolls. In addition, the gallery includes different documentary films with different Indian idols and figurines, such as one which depicts Lakshmi, the Hindu Goddess of Auspiciousness. In this section of the art of Indian storytelling, there are a variety of manually operated media to discuss a particular theme. The art of the Indian Storytelling exhibition is very effective, informative and enjoyable. It uses different media, both digital and traditional ones, to deliver the idea of

the exhibition with a variety of exploratory activities that are suitable for family members of all ages.

4.3.3 Using Physical Objects besides Digital Medium

Another way to demonstrate artefacts in a museum is to place 3D digital objects next to physical ones. The benefit of using the 3D artefacts is to let the visitor explore the objects from different angles and get more information about them. An example of using digital installation to support a physical object is found in the World Museum. There are two mummies, next to which there is a kiosk touch screen which allows the user to investigate the mummies bodies using two different methods: X-ray and CT scan. The X-ray method gives the user seven different mummies to choose from, but only two of them are available in the museum. Only these two mummies can be investigated with the CT scan. By the end of the investigation of one of the two available mummies, the phrase This mummy is beside you appears to remind the user to look again to view the real mummy. In addition, there is a map of the museum with a location indicator for other digital devices and physical mummies (see Figure 4.9).



FIGURE 4.9: Using digital installation to support a physical exhibit the mummy example

The use of the digital version of an object is very effective, as seen in the previous example. It helps users to visualise the mummy's face and get information about its life. This was not the case in the application of Welcome to Fernlea, the Home of Douglas Crawford in the Museum of Liverpool, which offers a

short animated film showing a living room and multiple 3D characters inspired by physical objects from Chinese art. The duration of the film is around four minutes. In the film, characters talk to each other and provide information about Douglas Crawford. The main characters are a dog and a horse, and real physical models of animals can be seen next to their animated counterparts. The animation film, though 3D, was not produced in a professional way. For instance, some objects have shadows, while others do not, even when they are next to each other.



FIGURE 4.10: Welcome to Fernlea, the Home of Douglas Crawford

The use of traditional artefacts in a 3D film has been done professionally and successfully in a Taiwan museum, in collaboration with a production studio (Lin and Din, 2008). The last example of using the combination of traditional and

digital methods is in the Roman Museum, which is based on the location of the Roman mosaic house excavation. The mosaics are still in place, protected by double-glazed glass. Next to them there are different pictures showing the different stages of the excavation. There is a screen displaying a sequence of images, starting with a black-and-white image from the time of the first discovery of the Roman house with mosaics. There are other images of recent excavations that were also constructed as 3D models. The use of photographs to document the excavation process shows the effort and time it took to establish the museum, and the use of the 3D construct helps visitors to imagine the structure of the ancient Roman house. However, the downside is that there is no index for the photographs in text or in audio format; this means that visitors have to look around for different photos before they can sit in the provided seats to look at this sequence of images to understand what they are about. When digital devices are used to support the physical objects, this support comes in different ways, such as aids in visualising non-existing objects (e.g., the use of 3D to create the mummy's face) or the use of traditional artefacts to tell a story about a historical subject or to document the historical process of a certain subject.



FIGURE 4.11: The Roman mosaic house excavation, Canterbury

4.3.4 Using Cartoon Illustration

Using cartoon illustrations is an effective tool to provide instruction for children (Mallia, 2007). Thus, some of museums used comics and cartoon illustrations to grab attention or simplify an idea. For example, the Museum of Liverpool uses a 2D cartoon Siegel character on a large touch screen to guide users through maps of Liverpool during the present day as well as in an imagined future. Another interactive device in the same museum uses a cartoon character to quiz users about the Scousers and give more information in the form of confirmation of a user-selected correct answer or a joke, with a hint about the correct answer if the wrong answer is picked.

4.3.5 Using Games and Tangible Kiosks

Using tangible kiosks is popular in museums. The contents of the installations vary from documentary films to interactive maps. My interest is in interactive media which gives the user the availability to navigate through the installation. This section gives an overview of different kiosks which used games in a museum context. The design of the installation and the level of simplicity differ from one installation to another. An example of a simple installation is an application called An Imaginative View of the Canterbury Temple in its precinct at the Roman Museum in Canterbury, which has a kiosk with an interactive application device that has a touch screen, and is based on a plan made by the Canterbury Archaeological Trust. A 3D model shows a typical classical temple, with two arrows in the bottom corner which give the options to go forward or backward; there are slides showing a 3D model of the centre of Roman Canterbury, a map

of Canterbury nowadays compared with that of Roman times, and a Roman street marked with different colours. While pressing the forward button, different pieces of information appear, complemented by an image or two. These 3D models are an effective way to reconstruct the heritage of the past, and this is the key role of this application, with some information text to support the 3D models. Figure 4.12 shows the 3D temple models used in the installation.



FIGURE 4.12: Using 3D to reconstruct Canterbury temple

In contrast with this simple installation about the Roman Temple in Canterbury, the Museum of London has several installations that represent the history of the London city during different periods. Some applications are more complicated than others, and give users more options to navigate and select the parts that interest them. London before London (LBL) is the first exhibition in the

museum. At the end of the tour of this particular section, there are three different desktop computers providing an application which gives more information about that section. The application includes gallery, tools and quizzes. The design of the application is very basic with text information (Figure 4.13).

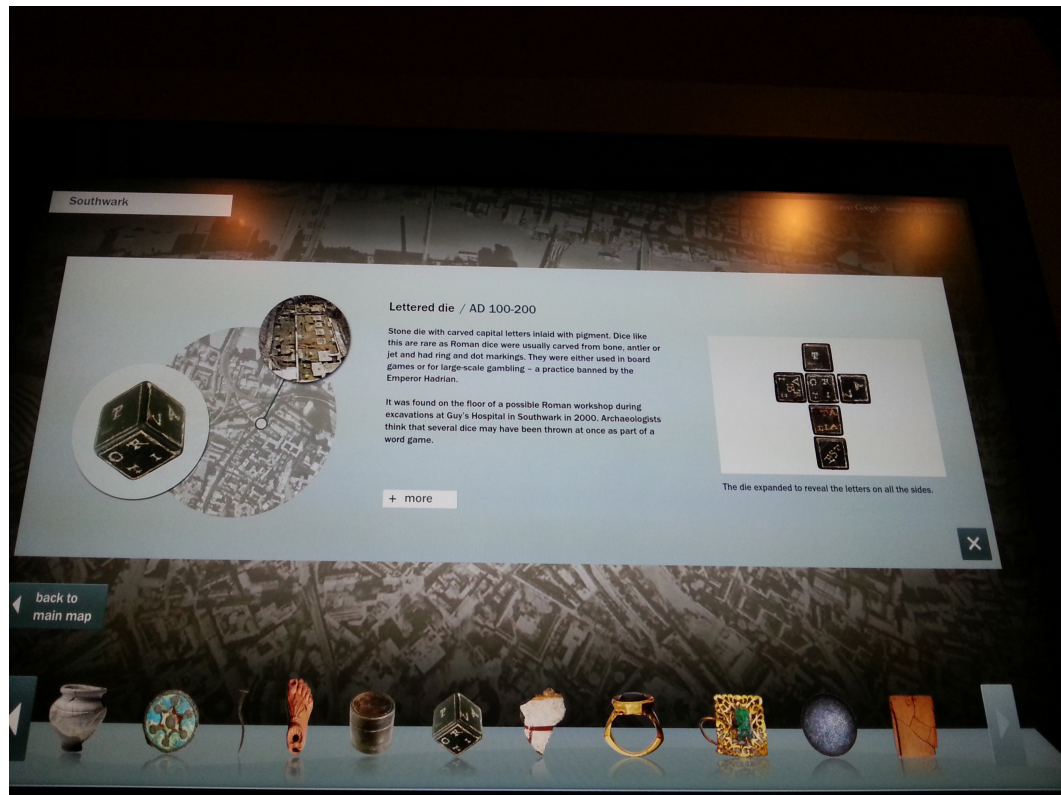


FIGURE 4.13: Tangible interactive table depicting Londinium

Another installation which uses a desktop computer is Medieval London; my observation is that such computers are not very popular. In my opinion, there could be different reasons for this, such as computer screens which are small and without a touch screen or the ambience being too much like that of a classroom. One has to sit while using the installation, and the application itself is somewhat complicated with many details to take in. Another issue that may make this section less popular is that the start screen of the application is very simple

and basic and does not reflect the exciting prospects of some latter parts of the application.

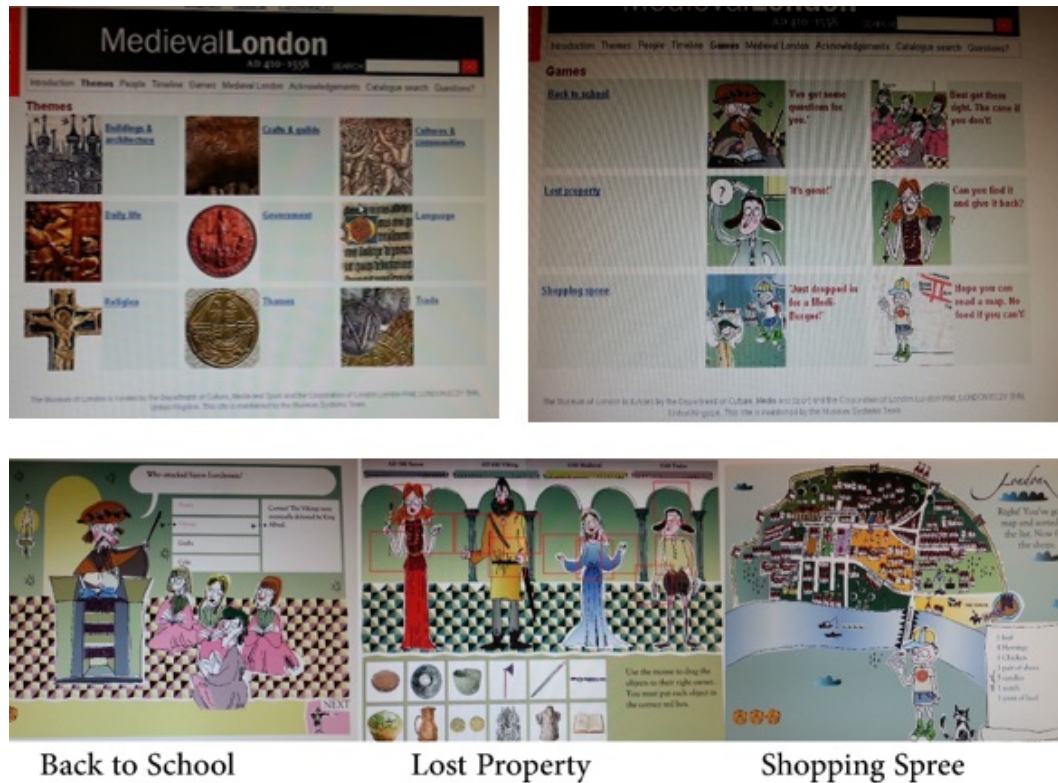


FIGURE 4.14: Installation depicting Medieval London

There is variety in the type of information at the Medieval London installation, including themes, people, timeline, games, Medieval London, acknowledgements, catalogue research and questions. The games section includes three different games: Back to School, Lost Property and Shopping Spree. All of the games are in the style of comic books and animations. The first game, Back to School, poses some questions to the players. If the answer is wrong, there is a pop-up that provides a hint to help them come up with the correct answer. When the players find the right answer, more information appears on the screen. The second game, Lost Property, has four different characters from four different eras and 12 different objects. Players have to assign the correct object for each character, and put

the objects in their correct places. There are hints to help players to complete the task successfully. The last game, Shopping Spree, offers a shopping list which includes different ingredients, and players have to try to find the correct shop on the map for buying these ingredients. This game helps players to understand the map of Medieval London and to recognise the street names. Even though the application is not popular, the information and activities are very informative. Three additional games provide the entertainment parts of the application by using cartoon figures representing Medieval London characters and their lives.

Another application which uses more modern equipment is Londinium and Beyond, which is displayed by using a large touch screen. This screen displays a 3D map with ten labelled areas, such as Hyde Park, Heathrow, Croydon, Londinium and Greenwich. A start button is in the bottom right hand corner. When the user selects a specific location, different objects are displayed in the bottom row; these objects include artefacts related to the selected area on the map. When users click on an artefact, the information about the particular object appears, combined with photos, details and a map location mark. The use of a large tangible screen is better than the use of a computer, as the user does not have to sit down and can simultaneously share explorative journeys with others. The graphics in Londinium and Beyond are high-quality images, and this helps to attract visitors who want to explore the content in an easy and effective way.

Another part of the installation allows users to focus on a specific subject, and different kinds of media are used to support the idea. For example, The Voyage of the Essex is a very informative application, which includes different kind of media (3D and 2D images, sound, animation and video clips). The application covers the voyages between 1501 and 1867. There are four different time periods to choose from.

In addition, there are different options to customise the user experience by having subtitles or no subtitles in videos, or no video at all. Even the video clips are separate so that the user has the choice to stop the journey or look for more information or continue the trip after watching one clip. The more options the application has, the more freedom the users have to customise their journey of learning. The variety of media used and the flexibility of the application are advantages, especially for a museum that targets people of different ages with different needs.

Most applications use mixed material to deliver one subject in the Museum of Liverpool. Installations relating to the First World War, Second World War, Late 20th Century Conflict, Empire Soldiers, and Medals and Photographs focus on one subject at a time and have a variety of choices to display the information. This information is in the form of short clips, photographs, illustrations and text.

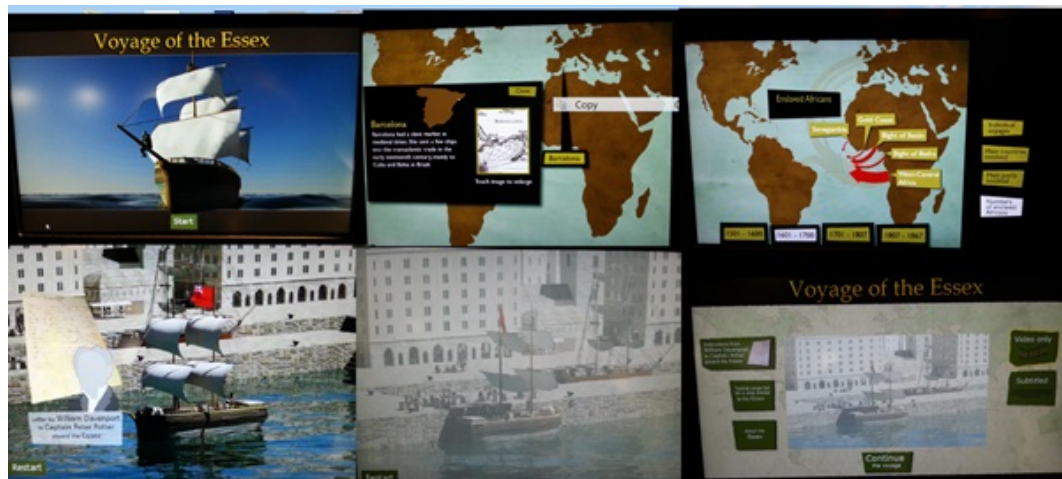


FIGURE 4.15: Voyage of the Essex, an installation that uses 2D and 3D animation

Another example is the application which provides information about the continents. The design of the activity is based on the characteristic of each continent.

The devices contain information about Asia, the Americas and Oceania in kiosks, but all the information is presented in one gallery, and the application provides two options for users: to play games or to discover more materials. When the preferred choice is selected, a list of options related to the main title appears. The information provided is supported with images, sounds and text. Different games are available, based on the selected area. Games include a trading game, a puzzle, matching cards, a quiz and a game involving hidden objects. The Trading Game, available on the Asia application, has the target of opening trade routes to India. After users choose to play game, a screen appears with a drawing of two travellers and a welcome message inviting the player (in the form of one of the travellers) to trade and make his or her fortune. To start the journey, the user has to pick six items out of ten. After the item is selected, the journey will start from the United Kingdom and end in Cape Town. In Cape Town, the user should rest and have food and water, so he or she has to sell selected items in the ships cargo. After the rest, the traveller continues the journey to reach Surat in India, where he or she finds that Portuguese traders have been there for over 100 years!

The second part is about learning interesting facts about Asian trade cities. The cities include Surat in India, Canton in China and Nagasaki in Japan. The information covers the reasons for trade and the people who are responsible for it, and links these with the role of Liverpool in the trade relations with Asia. When one of the cities is selected, more details are provided with images, and the user has an option to receive further details.

In the Oceania application, the same introduction screen appears. Games can be selected at this point, or more information can be asked for. If the player chooses games, more buttons for making selections appear; these buttons are

labelled with the names of countries in Oceania (Australia, Cook Island, Fiji, Hawaii, Kiribati, New Guinea, New Ireland, New Zealand, Samoa, Solomon Island, Tahiti and Tonga). Each one has an assigned game. This application also has more games, but all of them are very simple and short. For instance, a nine-piece jigsaw is available, or the player can choose the correct object to match with a displayed picture. Unlike the Asia application, which has one long game with multiple levels of play, this one has many games, which are shorter and playable only at one level.

The last type of application is based on a story game to deliver the information. The Carters Challenge is an application at the Museum of Liverpool. The game is a challenge to test whether the user would make a good carter. At the top of the kiosk device, there are pictures of carters. The introduction screen has a grey-scale image background of a stable, with a photo of a horse and a cartoon figure of a carter stuck on it. There are four main options to choose from: dodging kicks, travelling on a floating road, attending a May Day parade and loading your cart. Dodging kicks is a simple game which has the same elements as the introduction screen and a timing watch and a jump button to press to control the carter to avoid the horses kick. The second option focuses on Liverpools floating road, which has a revolutionary design that allows carts to access cargo boats, depending on the tide. The idea is very well explained with 2D animation. The other two options have simple instructions: one includes a photo of a horse with a flower attached to its head and a message indicating that the players horse is ready; the other is a cart full of goods, and the user has to empty the cart. In this application, there are different kinds of media used, such as a grey-scale photo, 2D images, 3D objects and 2D animation. The information is provided within the game, which is a positive point for a user who wishes to learn while

Technology	Situation
Projectors	Provides information, or decoration or both
	Multiple sizes
	Interactive and non interactive
Location Setup	Uses different medium, digital and physical to support a certain idea
Physical and Digital Objects	Physical objects and digital one are compatible with each other
	The digital objects gives a chance for exploring and interacting with objects
Cartoon Illustration	Uses cartoon illustration for instruction or inside applications
Games and Tangibles Kiosk	Is used widely for instruction and presenting data
	Applications has a variety in terms of simplicity/complexity
	Single users or multiple

TABLE 4.1: Main themes used in UK museums

having fun; the use of mixed material helps the player to imagine real life in a play mode. But the mixing of cartoon characters and real images could confuse the player, as real images are normally used for documentary and more serious applications, while cartoon images are used more in games and to simplify an idea. Overall, the use of mixed material is very popular in installations in a museum context, and this helps the visitor to receive a variety of information in different ways.

4.4 User Interaction with Technology in Museums

From my observations, the interaction with technologies in museums varies based on taste, age and the device itself. For example, I found that tangible (touchable) devices attract more attentions than others, especially with younger people, as they seem to avoid non-tangible devices. In tangible devices, a larger screen which is designed for multiple users attracts more people and provides more opportunities to socialize and share the experience. In contrast to the tangible devices, installations with a PC screen and mouse are not popular, even when the content is very rich and interesting. Although the tangible devices tend to draw

more attention, this is not the case with the interactive projectors, as they are not very accurate or as fast those with screens. The interactive devices require more time and patience. To deliver a certain idea, the use of different media seems very affective when traditional and digital display methods are available, including interactive devices. The use of task sheets or maps to track information enhances museum visits and encourages visitors to look carefully to complete a mission, and this is obvious with school pupils and families.

4.5 Conclusion

This chapter describes the installations used in UK museums that are relevant to Al Madinah museums in terms of heritage-related displays. The use of screens and projectors is widespread, and the same could be possible in Al Madinah. These devices could be incorporated in various ways, depending on the location and available budget. The design of the installation could cover very specific objects and time periods or could have a wider focus. The level of interactivity of the installations could also vary. Overall, this study has given me the knowledge and the confidence to design my own implementation. The process of my installation design and the ways in which I implemented the result of this study and that of the previous one are discussed in Chapter 5.

CHAPTER 5

Development of Al Madinah Virtual Heritage

5.1 Introduction

As discussed in the previous chapter, I learnt about using installations in a museum context, based on some of the UKs museums. The use of digital devices in museums is a very broad area. With all the technology and equipment available, the creative possibilities are endless. In my project, I looked for affordable ways to create an application that can be used in local museums in Al Madinah, which have low budgets because they are self-funded, as discussed in Chapter 3. Interactive installations are used widely in museums to present different content, and this is the option I chose for presenting the heritage of Al Madinah. In developing the installation, I had the opportunity to include the information gained from my study about the history of Al Madinahs wall and some of the citys key locations during the time period between 1850 to 1950, thus giving the user of the installation the freedom to choose what he or she wants to learn.

The idea of the installation was that it would act as an example of what could

be achieved to preserve the heritage of a city and how old photographs, maps and descriptions in books and from old inhabitants of the city could be used to produce such an installation.

In this chapter, the workflow of creating the installation I called Madinah Virtual Heritage (MVH) is presented. This chapter is about the first version tested: MVH 1.0. MVH 1.0 is a stand-alone installation built by using a combination of 2D and 3D software to present the heritage of Al Madinah. The focus of the content is based on two main themes.

1. The urban area of the old city was surrounded by walls, and based on the information available about the walls and gates, there are 22 gates and six key locations to discover on the map of the application.
2. The architectural theme: A 3D model of a Hijazi House is an example designed to be explored as a virtual environment.

Using the multiple levels allows me as a developer and designer to produce an informative installation with different elements, such as animation, an interactive map and a 3D virtual environment. The goal of this is to give the user the opportunity to experiment and choose how deep of a level of knowledge about the subject he or she wants to acquire. The development process included the use of preliminary data collected from Al Madinah in the first phase of the research. The material was used mainly as a reference to build a 3D object or an objects texture. Usability tests were applied to MVH 1.0 to get the feedback from the user.

5.2 Development of the Application (MVH 1.0)

MVH uses a mix of 2D and 3D software. The application provides historical information about Al Madinah between 1850 and 1950. The goal of MVH 1.0 is to introduce users to the heritage of Al Madinah in a contemporary way; as a researcher, my goal was also to understand users reactions and their behaviour while they use the application. As the main aim of producing this application was to introduce the neglected heritage of Al Madinah in a particular period of time in a modern way, the users feedback and any suggestions at this stage of the research were crucial and have been taken into account.

5.2.1 Description of MVH 1.0

MVH 1.0 is an EXE installation file, which can be run on any personal computer. The application starts with a short 3D animation video. This video shows five different scenes of Al Madinah during the target period. After the animation finishes, the main screen displays two options for users. The first choice leads the user to an interactive map of Al Madinah with 28 key locations and gates. The user has the option to explore all or some of them with additional optional information and images available about any specific location of interest. The second choice is to explore the Hijazi House by navigating through the virtual environment. Inside the house there is information about the furniture, textiles and tools that were used during that period. Moreover, there is a description of each room in terms of what it represents in the contemporary period and how this affected the social life of the people living there.

The 3D animation video is a 45-second video clip that appears when the applica-

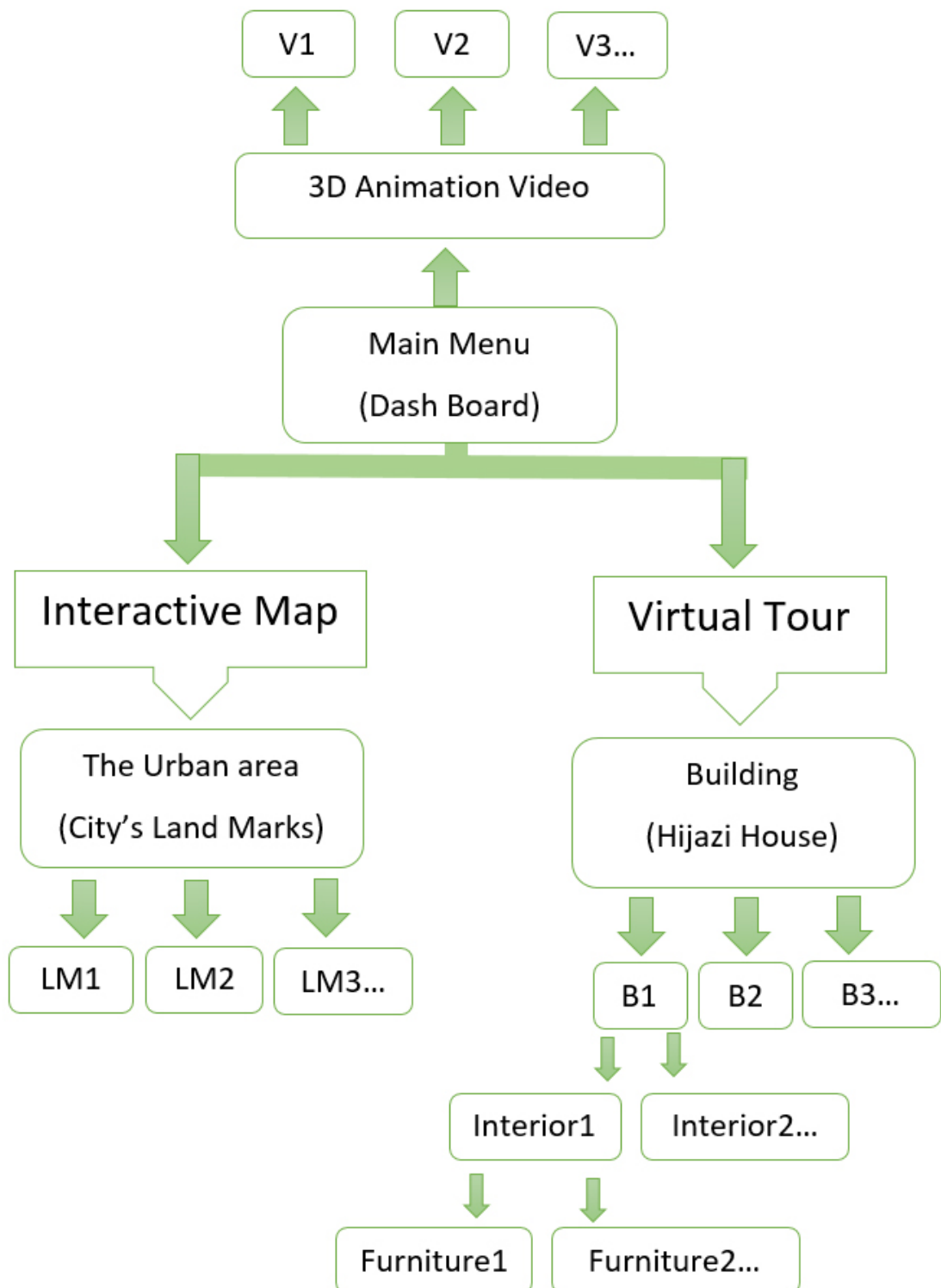


FIGURE 5.1: MVH1.0 prototype

tion is first run and shows five different places within Al Madinah. The first is a part of the Prophets Mosque and its green dome. This easily identifiable symbol of Al Madinah was chosen to show the relevance of the applications name and its purpose. The second shot is of Al Aiyneya Street, which was the main street of the city at the time and led to the Al-Salam gate, which is one of the gates of Al Masjid Al Nabawi. The following shot shows the Al-Salam gate and zooms in to show the old mosques carpet. The camera then zooms out to include in the frame the building next to the mosque; this reflects the reality of the target era, because a house next to this mosque clearly denotes a past before the 1950s as there have been no houses next to the mosque during the past 100 years. The fourth shot shows the Egyptian kitchen, which was built in 1816 and demolished in 1983. The last shot is of the Hosh system, which is the main characteristic of the citys layout during the period between 1850 and 1950. These five shots give an idea of what the user can expect from this heritage-related application.

The interactive map is the first option appearing on the main screen; it gives the user information about key locations during the target era. These are included in a 2D map of Al Madinah with different 3D models on it to represent the key locations. The map used in the application is a genuine map from 1926. The information included in the application was collected from different sources.

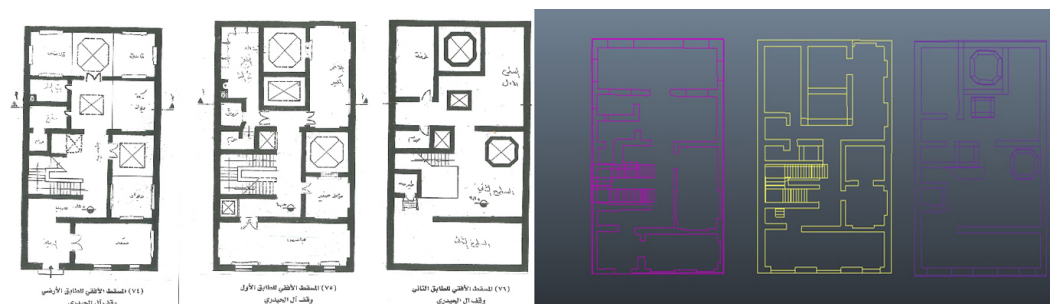


FIGURE 5.2: The plan of a traditional house from (Kaki, 2007)'s book (left) and the converted version to build the 3D model

This part of the system was mainly built by modelling the key location as 3D files to be used on Unity 3D. The models were then imported to the game engine software and named and located properly. As regards the interactive function, I used JavaScript for coding to detect the users selection and to provide more information about the selected target. The instructions and information used in the application are written in Arabic, as this is the native language of the target users. The Virtual Hijazi House is the part of the application that gives the user the opportunity to discover the Hejazi house. The virtual environment of the Hijazi House is based on a house plan drawn up by Kaki in his book (Kaki, 2007). I used this plan as a reference to model the house using Autodesk Maya. To capture the spirit of the past, I searched for more information about room furnishings and fabric textures traditionally used; as a result I have included descriptive text as well as old and recent images of antique furniture. The resources were found mostly on websites, in museums, in photographs, and through personal contact with families who have this kind of furniture.

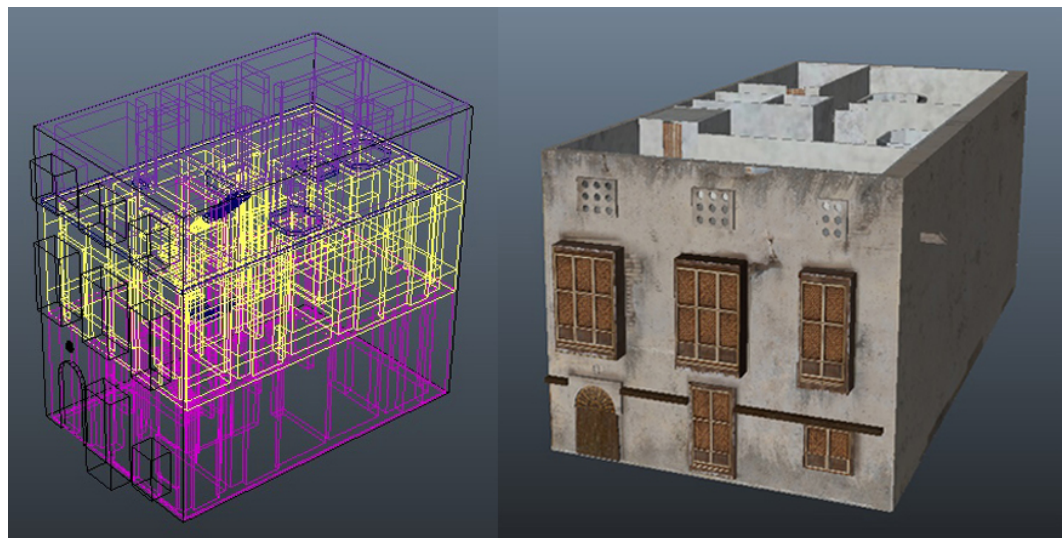


FIGURE 5.3: The 3D model of the traditional house derived from (Kaki, 2007)'s book

The modelling of the objects inside the house was done individually using Maya; they were textured using Maya, Adobe Photoshop and Mud Box. Most of the information is from genuine pieces of furniture of that time, and the process of extracting such information from photographs and using it in 3D models is explained later in this chapter.

5.2.2 General Implementation Production Pipeline

The process began with data collection and analysis, identifying the most relevant aspects to use. This was followed by the design and production of the software to be used. After each section was completed separately, all the sections were presented in the final stage as a unified system; the processes here were similar to each other in terms of the three types of JavaScript coding for detecting mouse action, the appearance of the information box for each option, and navigation to the user-selected objects.

The original plan was to create the whole menu using Unity3D, but as Arabic fonts are not used in Unity 3D, I chose to use images that were pre-designed and pre-developed with the necessary text saved as image files, which could be used as objects. This action solved the issues around using Arabic font, though it meant additional effort and time spent on more code-writing than originally planned. This necessitated a rethinking of the strategy for finishing the work successfully.

Most of the preparation was done using Adobe Photoshop. In the early stages this included conceptualisation; colour palette choice; and photo editing, including image cleaning, colour adjustment, resizing and cropping. Photoshop was also used for texturing, preparing and adjusting 3D objects and for buttons,

other handles and information boxes with text in Arabic font. The completed files were always saved as image extensions, based on type and purpose, as .jpg or, if alpha channel was required, as .targa.

All the 3D models for this project were made by using Autodesk Maya. The output from Maya was based on the purpose of the object. For example, the video objects were rendered inside Maya, and the output was a sequence of images in .targa format. The output of the interactive map was varied; some of the objects, such as the map itself, were rendered as .fbx files, while most others were converted to this format for importing into Unity3D. The objects for the virtual environment were exported as .fbx files.

Unity3D is a game engine mainly for 3D games, but in the recent version there is an added option which supports 2D games. I selected this software because it was the one most suitable for my purpose and because I have a programming background and can navigate confidently through a 3D world.

Software Name	Purpose of use	Example
Adobe AfterEffects	Create the animation video from 3D rendered images	Figure 5.4
Adobe Photoshop	Edit the images, create texture material for 3D models	Figure 5.5
Autodesk Maya	Create 3D models (land marks, buildings and furniture)	Figure 5.6
Unity3D Pro	Create the interactive map	Figure 5.7
	Create the virtual environment	Figure 5.8
	Produce the application MVH1.0	Figure 5.9

TABLE 5.1: Software used to produce MVH1.0



FIGURE 5.4: Using Adobe After Effects to produce animation video

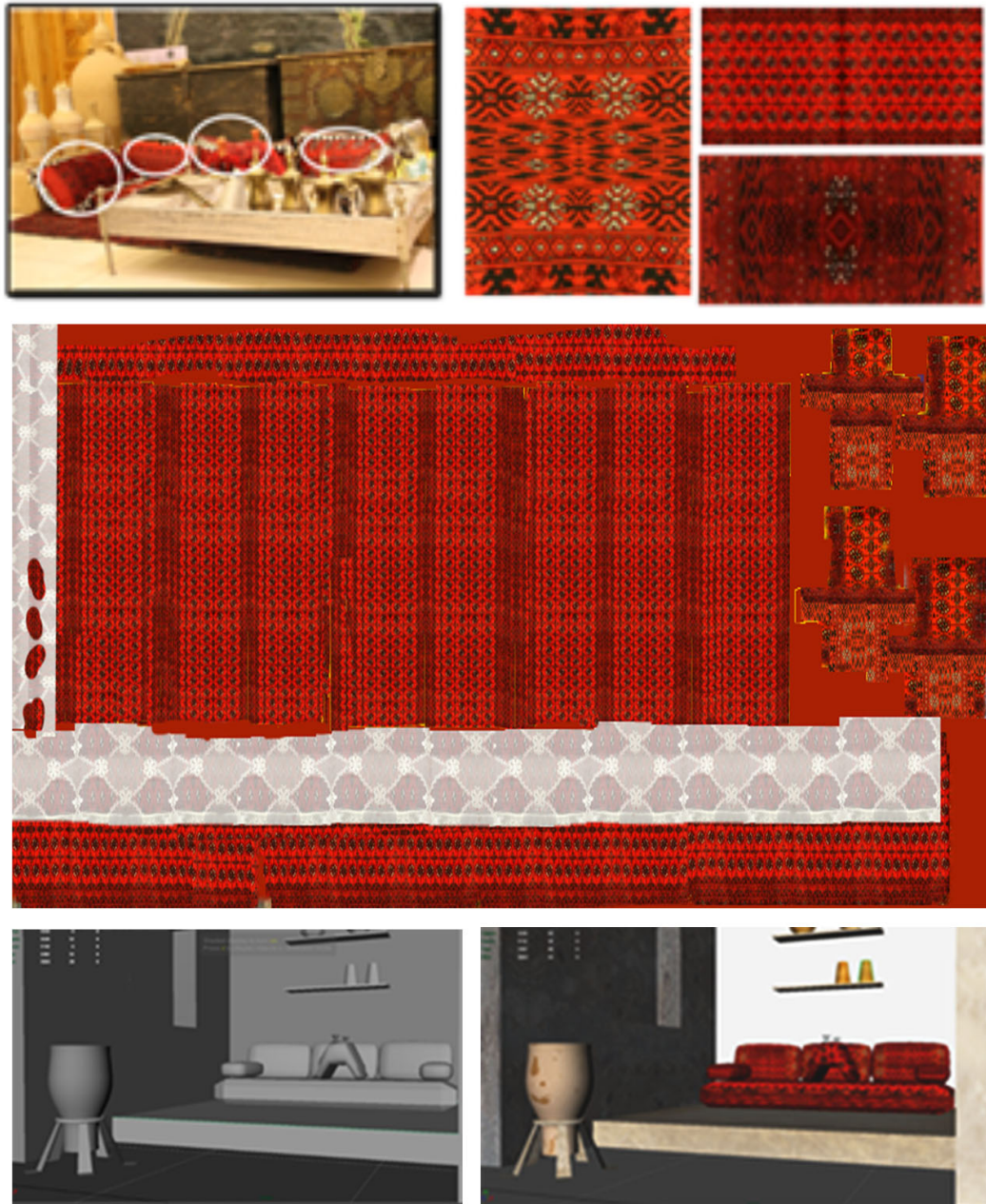


FIGURE 5.5: Using Adobe Photoshop to create material from images which applied to 3D objects

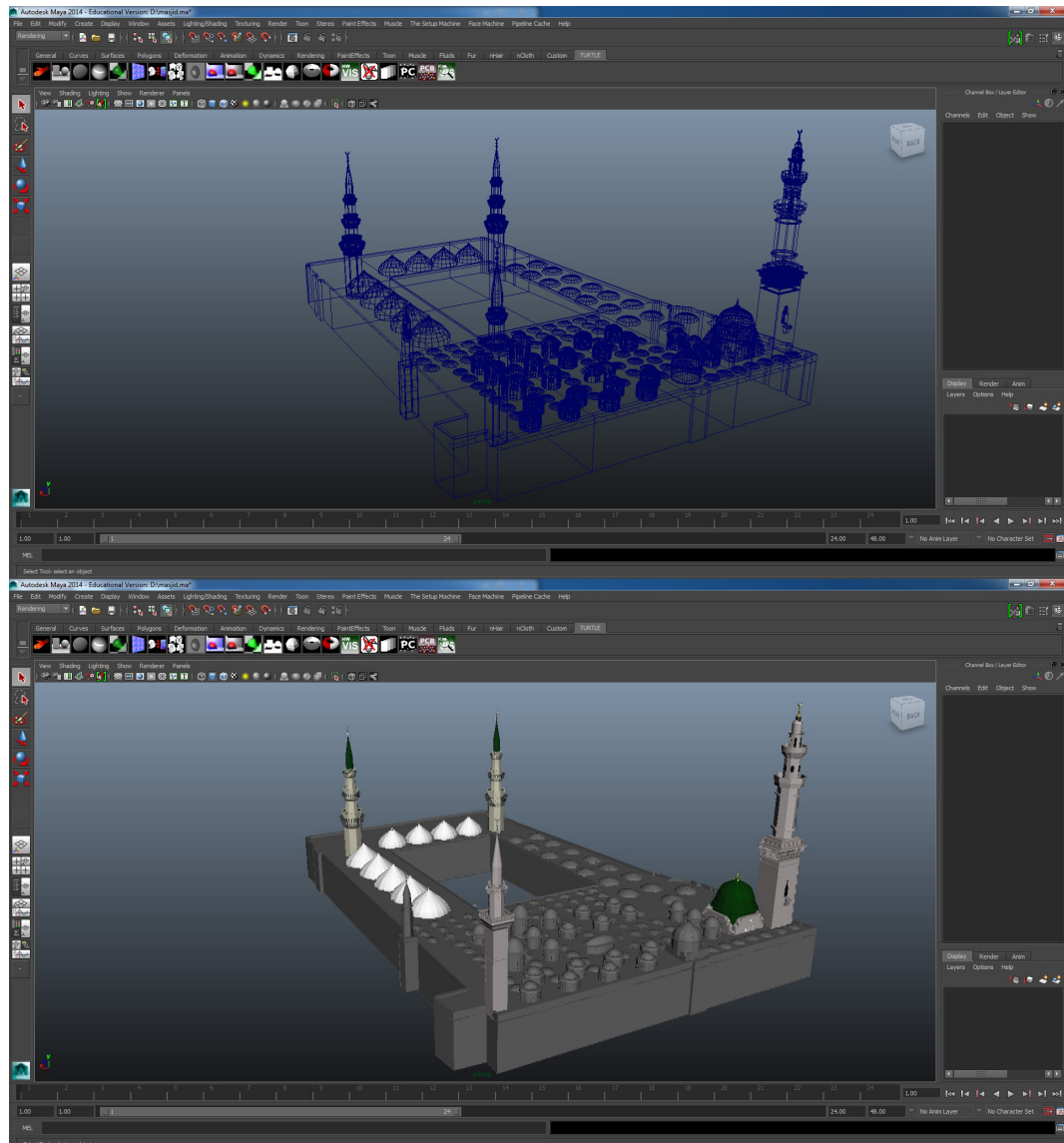


FIGURE 5.6: Using Autodesk Maya to create 3D models

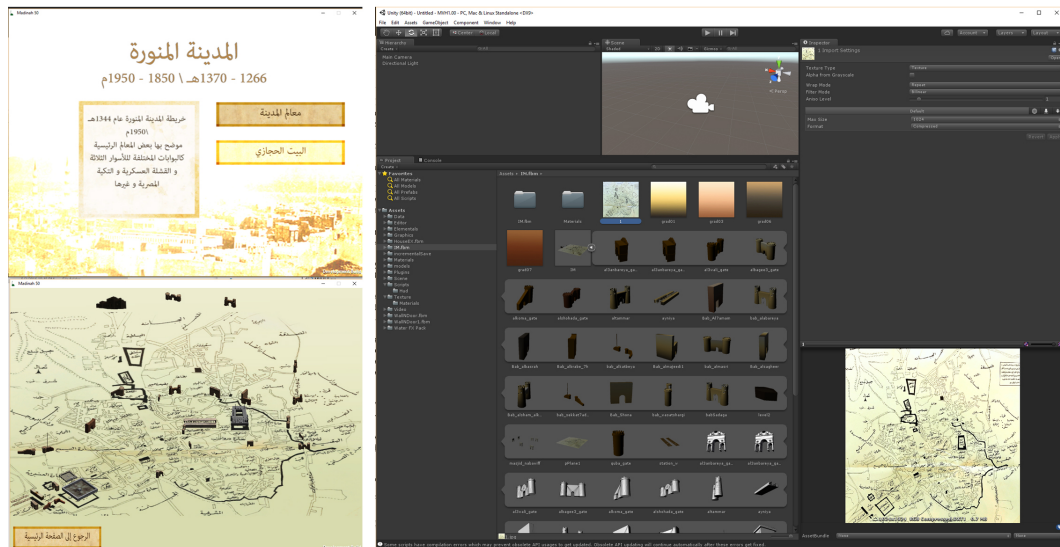


FIGURE 5.7: The layout of the interactive map from inside Unity3D software



FIGURE 5.8: Using Unity3D software to create virtual environment of internal building



FIGURE 5.9: Using Unity3D software to create MVH1.0 application

Unity3D linked all the parts together, and the JavaScript code provided the system with user interactivity. I prepared four different levels on Unity3D: Level 0 for the initial video, Level 1 for the main menu, Level 2 for the first option that has the interactive map and Level 3 for the second option to explore the virtual world.

Level 0 was prepared easily by assigning the rendered video to the video material in Unity3D, with a return button to go back to the main menu. In Level 1, most of my production work was done using Unity3D, except in the case of the images that had been exported from Photoshop. The JavaScript code had been added to every option beside the data panel. This level has two buttons, each button leading to other levels.

In Level 2, Unity3D was used extensively; all the objects had unique coding and therefore had to be clearly named. Interactivity was added to each object with options, and this part comprised the largest proportion of the Unity3D work, with the exception of Level 3.

Level 3 included the virtual environment, and the designing of such environments is a common function of Unity3D. The model was imported from Maya, and all the remaining work was completed using Unity3D. This work included programming, interactivity, first person controller, navigation plan and prompts which pop-up to help the user in navigation. In addition, the visual effects and sounds were all done using Unity3D. Finally, the implementation was also produced by Unity3D.

5.2.3 Image Processing

All the reference photos and maps were classified into two main sections. The first consisted of maps and photos used only as reference, and the second part consisted of those used in the system.

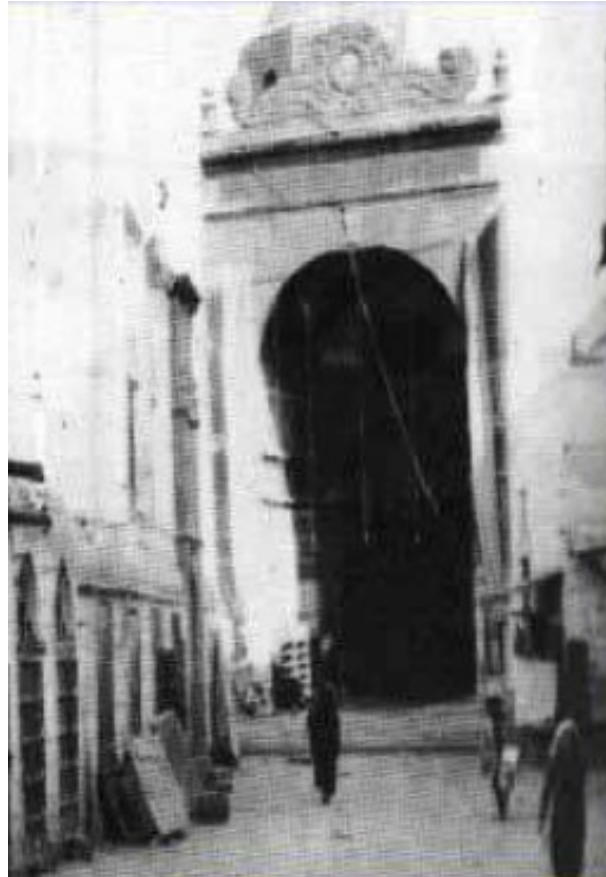


FIGURE 5.10: Old image of Bab Alsalam

The first section of reference images needed no extensive editing. The purpose of these images was to give an idea of the physical appearance of things. For example, Figure 5.10 shows an old image of Bab Alsalam Gate, which is one of the gates of the Al Madinah mosque, and the 3D model created of it is shown in Figure 5.10.



FIGURE 5.11: The 3D models of Bab Alsalam created by Autodesk Maya

The second type of images used in the application serves different purposes. Some of them needed only very light editing before use. A good example of this is a photograph of a sitting area. Since I only wanted to use the fabric, I used Photoshop to extract the relevant part and place it in a new document. This part was too small to be used for texturing an object, and the image was from a visual perspective, which would have been unsuitable for my purpose. Using Photoshop, I was able to manipulate the photo by duplicating it three times to get more space, by shuffling it with the offset filter in Photoshop and getting rid of unwanted edges by stamping or painting over with a transparency effect. The manipulated images were duplicated a few times to ensure there were no harsh lines.

5.2.4 Building 3D Models

As mentioned, all the 3D models were done using Autodesk Maya and can be categorised into four types. The first type included all the low poly triangulation models. These took the least time to model, given their basic geometry. This was done by sculpting the base shape, smoothing it, triangulating it and further reducing the number of faces of the object, applying the hard edge to the model, doing more smoothing and finally fitting it into the mesh in such a way as to give it a triangular look. These models are created in the initial video.



FIGURE 5.12: The low poly triangulation method

Even though the use of this method has become more popular in 3D games and has been used in a museum context, I felt that over-use of this type of modelling would affect the beauty of the building and reduce its quality, so I used a second type of modelling which consisted of scaled models. This type includes the walls,

gates, mosques, Egyptian Caravan, Aiyneya Street and more. The original idea was to build a model that represented the actual places. There were reference photos for some models, but in other cases I had only written descriptions to help me fashion them. The models that have been used in a video are of high quality as they have more polygons, in contrast to the models used in game engines which need to have fewer polygons. Having a smaller number of polygons is necessary in the case of game engines, as a higher number would compromise real-time rendering; thus, model quality is necessarily compromised for better real-time rendering in game engines. The solution for this is the use of normal mapping, as it gives the appropriate details for an optimal low poly model that would appear similar to a high poly one.

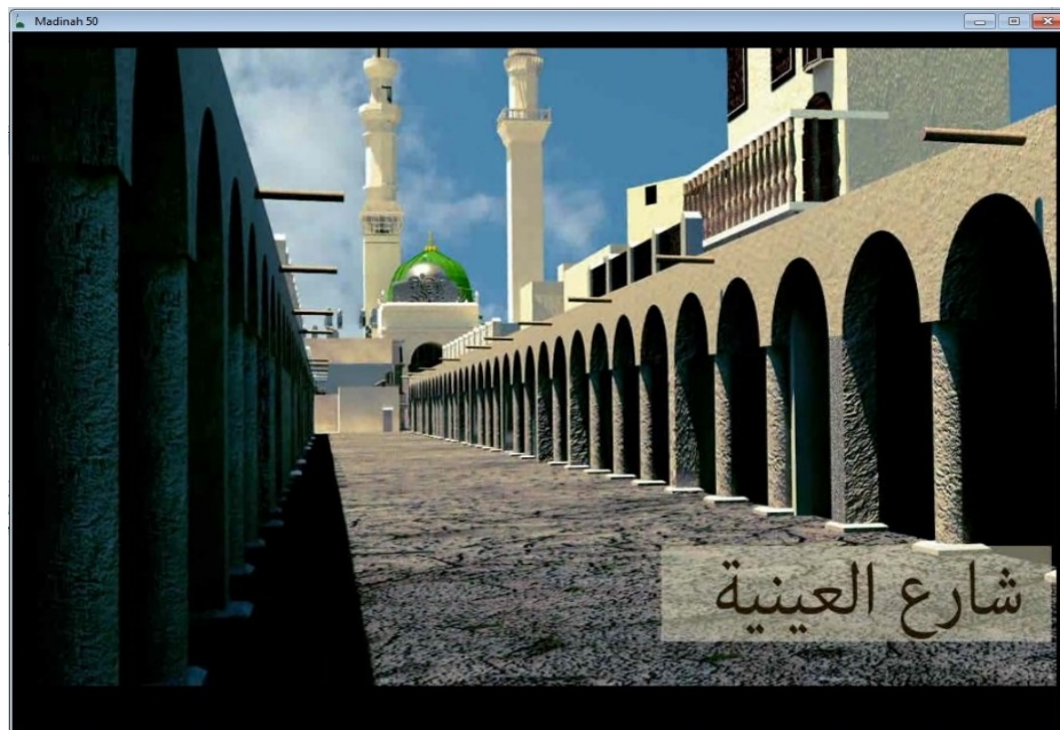


FIGURE 5.13: 3D modelling of Aiyneya street

The third type of modelling was required to create simple shapes which I mixed

with 3D objects and texture to build the city of Al Madinah in the interactive map section. This type of modelling involved creating more simple shapes; limitations with regard to time and equipment resulted in my not including minute details consistently in the design. I therefore have a detailed layout of the city but did not go into as much detail in building every single house. Using normal mapping/bump mapping allowed me to impart a sense of how Al Madinah was during the target period while not going into a level of detail the user is unlikely to notice or utilise, since the main purpose of the application is to search for key locations landmarked by an individual 3D object.

The last type of modelling was used in the virtual environment. This includes the Hijazi House, its furniture and other interior objects. The aim was to have a clean mesh, and compatible low poly, to enable effective engagement in the game. Each floor in the house was built separately and then grouped together. The furniture and other objects were also modelled in Maya.

5.2.5 Texturing and Colouring

The texturing process varied according to the objects textured. Some of the objects were easier to texture than others. For example, the exterior of the Hijazi House was textured using the photograph I took of the remains of an old Hijazi house in Al Madinah; this was then manipulated and assigned to the object by using a texture map. Also, the texture of the furniture of the house was based on another photograph I captured during my visit to the Dar Al Madinah museum. Figure 5.14 shows a photo captured in a local museum, with the desired area cropped, modified, extended and adjusted using Photoshop. The outcome was used in the UV outline for the 3D objects. As a result of this process, the grey

3D model is shaded by the colourful maps extracted from the original photo. This process was applied to the other objects in the application. The texturing process takes time and effort, as there is no ready material to be used to ease the process of shading.

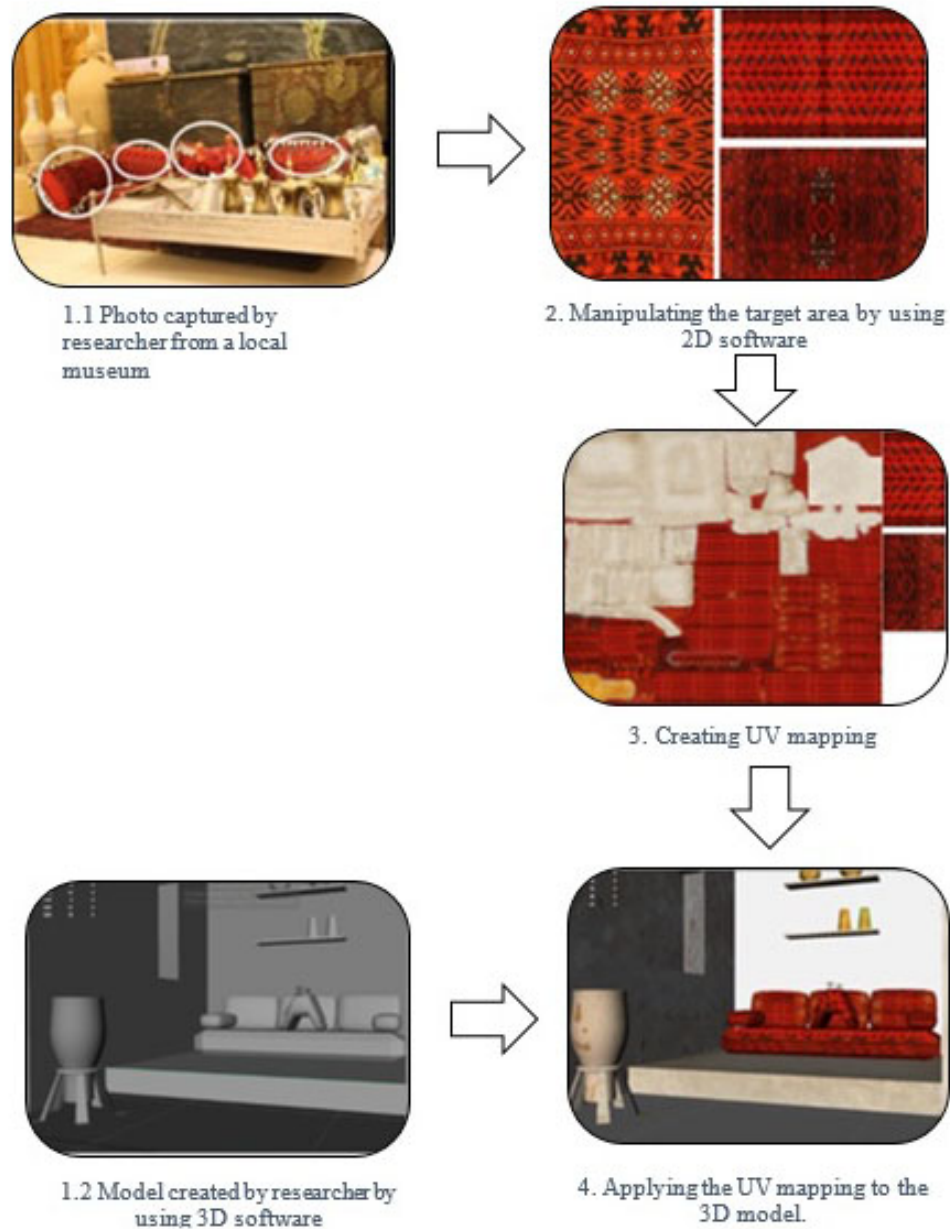


FIGURE 5.14: An example of how to extract texture material, manipulate it and apply it to 3D objects

5.2.6 Importing 3D Models to Game Engine Software

All 3D models were imported to the Unity3D game engine. The building of components was based on scenes. Each scene counted as a level. For example, the main page is a scene, and each part of it is a scene. The resources, materials and codes are shared between all levels, while each scene has its individual workflow based on its purpose. The first section of the application contains the animated video produced by the Autodesk Maya and Adobe After Effects software. Unity3D was used to link this part with the whole application. In the interactive map, Unity3D played a more crucial role in the coding part, while in the virtual environment it was the primary software used to help the user navigate through the 3D world. This is the last step before the construction of the application.

5.3 User Experience

5.3.1 Research Design

The study focused on the behaviour of users towards learning about the heritage of Al Madinah during a specific time period. The study focused on user feedback and the usability of the application as tested by using QUIS and SUS. Each participant had two tasks to complete to be sure that they had navigated through the application. The first task was to list the six most interesting key location models they found on the interactive map. The purpose of this task was to encourage the user to discover places and read the information about each place. The second task asked the user to check their knowledge about 11 traditional

terms used in the terminology related to the traditional rooms of the virtual environment and what they contained. The participant had three options for answers:

1. the terms and what they stood for were familiar to them before the test,
2. they recognised the terms but did not know what they stood for and
3. the terms were entirely new to them.

5.3.2 Participants

The participants for this study were selected randomly, but they all had to be able to read Arabic, since the target users would be native Arabic readers and speakers. In total, there were 18 adult participants, aged 18 to 45, from different educational backgrounds: Business (4), Education (3), Engineering (5), English Literature and Linguistics (2), Multimedia (2), Nutrition (1) and Psychology (1). All the participants are Muslims and have respect for Al Madinah and a desire to learn more about the city, due to its holy status in Islam. The majority of participants were from Saudi Arabia; 10 of them live in the Hiejaz area which includes Jeddah, Taif and Makkah, and two of them live in Al Madinah.

5.3.3 Procedure

The test was run individually for each participant by using the researchers own computer at a location previously agreed upon by the researcher and the participant. Each test took from 30 minutes up to an hour, including a semi-structured interview, the actual hands-on use of the application and the questionnaires. The

intention of the study was to collect qualitative data to explore the users opinions and feedback regarding the use of digital devices and their role in educating people about Al Madinah during a specific era; however, I did adopt some quantitative elements in order to measure the usability of the application. Therefore, semi-structured interviews and demographic questionnaires were developed for a pre-test. The interview objective was to explore the users previous knowledge about Al Madinah, particularly with respect to the period between 1850 and 1950; it was also useful in finding out which resources could be used to gain that knowledge and what the users opinion about the current documentation of Al Madinah was. During the test, observation and note-taking were used, in addition to Camtasia Studio 8.0 software for recording user behaviour while they navigated the application.

Post-test questionnaires were used with the aim of measuring the usability of the application and user satisfaction and to solicit suggestions and feedback. The two main questionnaires used were in keeping with the guidelines of the System Usability Scale (SUS) and the Questionnaires for User Interaction Satisfaction (QUIS). The SUS seeks users general impression about a system, while the QUIS is more precise and includes five different parts to test. This test based on five parts:

1. Screen: such as reading characters on the screen, the sequence of screens and the organisation of information
2. Terminology and system information: such as position of message on the screen, and terminology related to task and error messages
3. Learning: learning to operate the system, remembering commands and exploring new features

4. System capabilities : speed and reliability of the system, correcting mistakes, and the level design for user

At the end of the questionnaires, the participants were asked to write down the three most negative aspects and the three most positives aspects they encountered in the application.

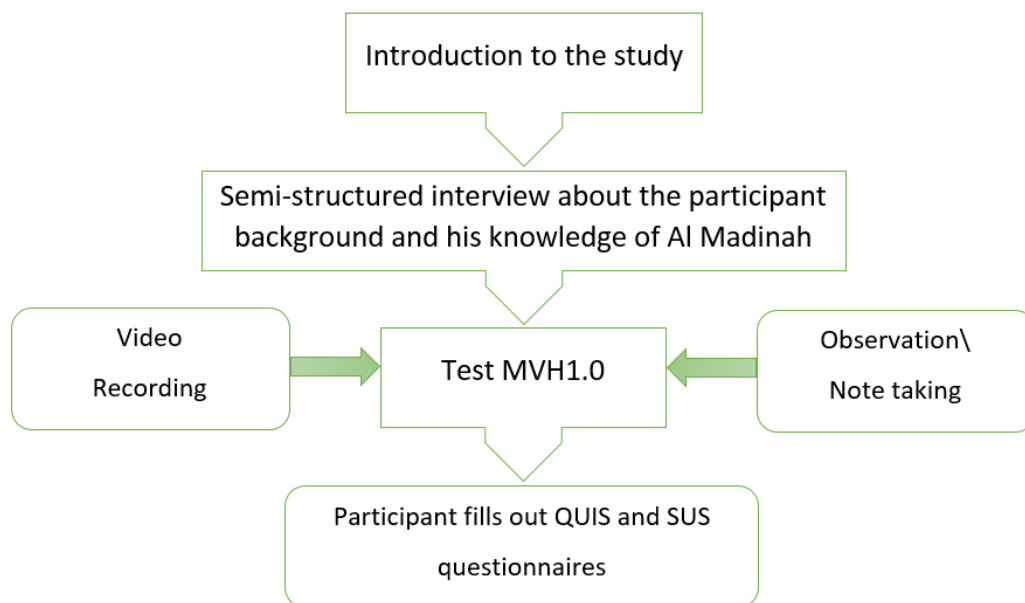


FIGURE 5.15: Procedure of the study

5.4 Data Analysis

5.4.1 Participants Knowledge about Al Madinah

During the pre-test, the researcher asked the participants how much knowledge they already had about Al Madinah between 1850 and 1950 and from where they acquired that knowledge. The response options were as follows: no information,

general information, old religious information and information at the current time.

When I asked P04 about her information about Al Madinah between 1850 and 1950, she replied I dont know anything about Al Madinah now, so it is obvious I dont know anything about its past as well, while P09 mentioned that she knows about the current Al Madinah but not of its past.

In contrast, P16 said that he has basic information about Al Madinah from a very long time ago (1400 years ago) and that all he knows about Al Ressalah is of the time when Prophet Mohammed lived there.

P05 mentioned that all she recognised about the heritage of Al Madinah was a mans dress, and that was from shows on national TV which targeted children. P18 had a different answer. As she is originally from Al Madinah, and her background is in history and education with a focus on Al Madinah, she said, I think [my knowledge] is very limited, and I always wanted to learn more about it [Al Madinah], but there is not enough information, and I have not been to any museums. They are not well recognised in the city, and most of them are [run by] individuals.

The situation of Al Madinahs local museums is discussed in Chapter 3. As regards documentation, all the participants agreed that there is not enough documentation about the city available for learners; this answer was predictable after the research I did on the heritage of Al Madinah in the first stage.

Although there are limited resources to obtain information about Al Madinahs heritage, there are a few which do provide rich information about its heritage. One of these resources is the historical tour which is provided in Al Madinah. The historical tours were mentioned by four of the participants (P01, P02, P06 and P08) as a resource for the previous knowledge they had about Al Madinah.

The historical tour covered some of the religious places such as mosques and places that are related to the early history of Islam, but most of the visited locations are ruins or have been replaced by modern buildings. P01 mentioned that ruins were all she and that the trip was verbally rich but not visually as there is nothing to see.

Another source the participants mentioned were memories and stories from parents, grandparents or old relatives. People of the older generation were sources of knowledge for participants P06, P07, P17 and P18. These memories and stories are sometimes accompanied by personal photographs or drawings which help the individual to visualise the environment. These sources are valuable, as every narrator has different experiences and different stories to tell. The issue is that if these stories remain untold, they will, with the passage of time, be lost to posterity if they are not documented. This is the perspective which informed the choice of resources for my data collection, and the subsequent production of a 3D installation to help visualise the past.

Old books were a resource mentioned by participants P01 and P18; P18 owned some books which specialised in the educational history of Al Madinah, but she stated, There are insufficient easily accessible sources about the history of Al Madinah, in particular sources that look at the social aspects and daily life.

Moving from old books to new media, P17 stated that the Internet, especially social media like Twitter, was a big source of her knowledge about Al Madinahs heritage; the information from this resource (as seen in Twitter and Facebook accounts) is discussed in Chapter 3.

5.4.2 Observation of the Participants During the Study

Observing participants as they used the application was one of the main tools for data collection in this project. The location of this use was previously agreed upon by the participants. The data discussed in this section were drawn from data gathered from both direct observation and the virtual observation through a Camtasia recorder. The themes are divided into two main sections based on the reactions to the interactive map and the virtual environment.

5.4.3 Exploring Key Locations on the Interactive Map

To persuade players to explore these locations, every player received a sheet with two simple tasks. The first one was related to the interactive map. The participants were asked to write down the six places they found most interesting out of the 27 locations. Twenty-three locations were mentioned by participants at least once, the most often named being Aiyneya Street (12 times). The Army Barracks came second (10 mentions). Table 5.2 shows the locations and how many times each was mentioned.

Key Locations	number of selection
Al Aineya Street	12
Army Barracks	10
Al Bagee' Gate	9
Wireless Station	8
Train Station	8
The Egyption Kitchen	7
Al Majeedi Gate	7
Al Kouma Gate	6
The Mosque	5
Al Shami Gate	5
Al Tammar Gate	4
Sekkat Alhadeed	4
Qubaa Gate	4
An Anbareya Gate1	3
Al Brabeekh	3
Al Abareyy	3
Al Shohadaa Gate	3
Al Awali Gate	3
Al Sadaga Gate	3
Al Basrah Gate	2
Al Hamam Gate	2
Al Anbareyya Gate2	2
Wasat Shami	1
Shona Gate	1
Al Masri Gate	0
Al Katebeyya Gate	0
Wasat Shargi Gate	0

TABLE 5.2: Key locations and the number of time selected

The four locations which were never mentioned as interesting are all gates, and three of them are located in a busy area next to one of the most selected interesting locations. This proximity could have affected the attention people gave them, because they would look at the interesting locations not at what was next to them. However, as my research was based on a genuine map, the location of each object was based on reality, and I could not change location of any gates. The average time taken to navigate in the interactive map was 7 minutes and 25 seconds. The longest spent time was by P15 (16 minutes); this above-average navigation time span was probably because the player explored all the locations (four of them twice) and sought further information on 20 locations, as detailed in his answer in the questionnaire. He mentioned that he found the application very good, with clear instructions and lots of details. In contrast, P12, who spent the shortest time (3 minutes and 4 seconds) exploring the interactive map, looked only at the locations names but did not click on any for more details. This participant who showed such low interest in exploring this section responded with a score of 6 (out of 10) to the scale question of *How likely are you to recommend this application to others?*

5.4.3.1 The Comfort Zone

The data shows that participants seem to concentrate their attention on certain parts of the interactive map rather than others. The tendency to focus on particular areas in an application is known as the comfort zone. The comfort zone is the area on which a player focuses more than on others, giving it more attention, spending more time exploring it and checking it more frequently. According to (Levillain et al., 2010) users get engaged in the game once they are comfortable with it and while still motivated by the task at hand. The importance of the

comfort zone emerged from the gathered data, as the results came from reviewing the video tracking of participant behaviour, showing how their attention was focused on specific parts of the map. For instance, for P02, the comfort zone was the Far East area where the train station and the Sekkat Alhadeed gate were located. This is possibly because of the participants previous experience, as she mentioned in her interview that she had visited Al Madinah many times and had recognised the name Sekkat Al Hadeed Gate from one particular historical trip she had been on to see the heritage of Al Madinah. It appears that P02 drew on her previous knowledge, and even though she had physically visited Sekkat Alhadeed, she was still motivated to explore the area surrounding it. P17s comfort zone was where this person recognised two gates of the city: Al Anbareyya Gate1 and Al Anbareyya Gate2. P17 pointed out that her father used to tell her many stories about his own childhood and youth and that these two places were frequently mentioned. P17, who is originally from Al Madinah, was not less motivated by her previous knowledge to explore the heritage of the city during that particular period. The participants relied on their personal experiences, and that was reflected in their behaviour while they were exploring the key locations on the interactive map.

The presence of specific knowledge about Al Madinah during this particular period had a clear impact on the behaviour of the participants as they explored MVH 1.0. The tracking video showed that when the participant recognises a specific place in the virtual environment, he/she is more likely to spend more time there. This is possibly to know more about that place or to retrieve memories related to it. All the places that individual participants recognised were then chosen by them as one of their three most interesting locations. For example, P17 said: *Oh, these gates Daddy told us about, theyre gorgeous, I like them .*

This is the most beautiful location, why it is not there anymore? such recognition keeps participants motivated to continue exploring.

5.4.3.2 Re-Exploring

While in the comfort zone, the user lingers for a while before exploring any new areas; during this re-exploring the user goes to the same location more than once, sometimes even without recognising it. This is caused by the large amount of information provided in the interactive map. Such re-exploring occurred five times during P12s test and three times during P13s; both of them explored some, though not all, of the locations they knew previously but did not recognise them during the interactive session. P15 re-explored four times but explored all 27 locations. This usually happens when there is no significant sign to tell users whether or not they have already visited a certain location. This tendency was not commented on by any of the users but was noticed from the researchers perspective; it will be essential to address this issue in the future development of MVH beyond this research. Finding a way to mark visited locations would help users to avoid revisiting locations (unless he/she chooses to) unnecessarily; in MVHs current setup, the user is likely to revisit locations by mistake as there are a large number of locations to visit and some are very close to each other, leading to some confusion about what has been and has not been visited.

5.4.3.3 Unique Architectural Design

Unique architectural design could be a factor that affects user behaviour in the choice of favourite places. Al Aineya Street was the most famous street in Al Madinah in the 1850-1950 period and has a very unique architectural design. As

the 3D model for each location was inspired by the actual location, this gates model possibly attracts the user due to the distinguishing features of its design, even though it is located in a busy area in the city centre next to two other gates. The Army Barracks and the Egyptian Kitchen also have unique design styles, and both are located in the far eastern part, opposite each other; both were chosen as interesting places by participants. The Army Barracks were chosen 10 times and the Egyptian Kitchen was chosen seven times. The Train Station and the Wireless Station also each have a unique style and building design, in addition to which they have the advantage over other locations of being extant. They are still used today but for different purposes than in the past and were both recently refurbished. The Train Station was turned into a museum in 1998; the first stage of refurbishment finished in 2011 and second is still underway. The Wireless Station is now an official site for pilgrimage research.

5.4.4 User Observation in the Virtual Environment

In the virtual environment, the user navigates through the interior of the Hijazi House, discovering in each room the furniture and material used during 1850-1950. A question mark is automatically displayed, and moving the mouse over this leads to detailed information about the specific room.

By default, the user starts from the roof. I made this decision because the roof is an open place, and there is a wide area to make it easier for users to familiarise themselves with the controls with minimum distraction. In addition, the user can soon locate the stairs to the first floor in this area, which helps make the first step of navigation trouble-free.

5.4.4.1 The Controls

The controls, as mentioned before, require the user to employ both hands to navigate through the virtual environment, one to direct the mouse and the other for walking or jumping using the arrow keys for direction (right, left, up and down). If the user does not have these keys available, the secondary keys (d, a, w and s) can be used instead.

Most of the users during the test became familiar with the controls in the first 30 seconds. P02 showed a very strong interest in using these controls, and she mentioned the similarity between this applications controls and those of the game Call of Duty. Due to this enthusiasm, she spent less than a minute exploring the roof, and moved straightaway down to the first floor. I found the controllers a bit tricky at the beginning, but when I started to use [them to navigate] throughout the house I felt more confident with them, as they reminded me of the controllers in the PC game Call of Duty, and eventually I started to enjoy it. The similarity between the two controllers was mainly [in] using the arrows on the keyboard to move from side to side and along the stairs as well as using the mouse to support the movement to manoeuvre around the house. (Quotation from P02)

In contrast, P06 struggled with the controllers, and she complained about using the mouse and the keypad at the same time, saying that it affected her navigation through the virtual world. She had been to the same room in the Virtual House three times in 4 minutes, leading to her taking the longest time (24 minutes and 27 seconds) among all participants to explore the house. This different attitude could be due to her age, as P06 was the eldest participant. She was not familiar with using the combination of arrow keys and mouse at the same time. She said that she mainly used a computer for typing and exploring the web.

5.4.4.2 Exploring Sequence

As for the order of exploring, the assumption was that the roof would be explored first and the first floor reached by using the stairs from there. After exploring this floor, the ground floor would be the next logical place to visit. This process was defined by the design, and the majority of users followed this process, with some variations in the order in which they explored the different rooms on each floor.

P03s and P04s behaviour in the virtual environment was predictable, as they explored the roof, then moved to the first floor to discover rooms and finally moved to the ground floor and visited the rooms there. P02 covered all the rooms in the house, while P04 missed one room on the ground floor, the hall (Algaah). P02 decided to go back to explore the roof again after one complete exploration of the house. P15 explored the roof first before he jumped through skylight (Al Jela) to reach the ground floor; he explored the ground floor and then went back to explore the first floor.

The assumption of the navigation design was as follows. The player/user would initially start on the roof, because it has a large empty space and fewer objects and walls. It is a suitable point to start the virtual house tour so that the user can get familiar with the controller in that space with fewer distractions. On the roof there are three sections with two rooms to be explored. The player is initially placed in the second section, which is the centre of the roof. The user can thus explore both sides, and directly in front are the stairs which lead to the first floor, with an arrow sign to clarify the direction.

In each section/room there is a sign with the name it would have been known by. The first floor is the second location (according to the assumption) to be

explored, and there are two directions to go here: the right-hand side which leads to the living room (Majles) and the left-hand side which has more rooms to be explored, including the childrens bedroom, bathroom and kitchen. The master bedroom is in front of the stairs which lead to the ground floor, the last section to be explored. The handout sheet included a map, which would help participants to find their current location at any time. Having discussed how the participants navigated through the environment, I shall now move on to summarise the various subjects that the environment inspired the participants to discuss.

5.4.4.3 Recalling Memories

The application also provoked one participant to discuss the different role of heritage in different countries. Specifically, P07 talked of how Canterbury is being preserved by maintaining the old buildings regularly, including the gates and the Cathedral, while Al Madinahs very rich history is being lost, as almost all the citys historical buildings and gates have been demolished over the past 70 years!

1

The testing also prompted enquiries from various participants. Some of these related to the content of the application and the historical information that it presented, while the others were about technical issues and about how I built the system. Other questions focused on the design of the house and the purposes of some of the objects. For example, P08 explored the house in detail and covered all areas during the test. She had questions about the modelling process and

¹Recently, the Al Masri gate has been reconstructed and located in one of the roundabouts in Al Madinah city. But this only partially compensates for the far more significant losses to the city that are still taking place

shading; her response to the experience was clearly influenced by her background as a student of Multimedia Technology and Design.

5.4.4.4 Extraordinary Behaviour

Extraordinary behaviour also occurred during the test. After looking at the assigned task, P02 realised that she had missed one room on the roof. So she went back to the roof to explore that specific room. After that she seemed excited and played around exploring the house, letting the player jump from the roof to the outside of the house, from where she could see the design of the house. She found it very interesting that she tried to go out through the main gate and could not, as it was designed as non-interactive. After reaching the ground floor from the outside she kept walking until she was out of the terrain (the playing surface) and she dropped into infinity!

P15 explored all the three sections on the roof. While he negotiated the roof, he decided to jump from the Al Jela, an open area along the house. He thus skipped the first floor and reached the ground floor without using the stairs. P14 explored the virtual environment twice, the first time as an ordinary player and the second time to give detailed feedback. The feedback from him was very useful and accurate, because as an engineering student he looked at very specific details and commented about design, objects, building and functions.

These behaviours are a result of the freedom for the player to navigate through the virtual environment. Some of the players are more curious to explore and discover new or hidden things, trying to connect better with the application. After navigating in the Virtual House, the players were given a questionnaire that included an assessment of their knowledge of the terms related to the 11 rooms and sections in the house, such as the traditional names shown on the

signs and in the information within the VR environment. The participant had three options to choose from.

1. I knew the term before and I could visualise the object.
2. I knew the term but I couldnt visualise the object.
3. I didnt know the term.

These terms for rooms and sections are given below:

- (a) Al Magaad : The guest room next to the main entrance
- (b) Al Diwan: Living room on the ground floor with no door, used in summer
- (c) Dakkat Al Diwan : An open area in the centre of the house and on the ground floor; it is built about 20 inches higher than the floor level, and used as a play area for children and for taking evening tea.
- (d) Al Moaakhar Al Kabeer : The childrens bedroom
- (e) Al Moaakhar Al Sager : The master bedroom
- (f) Al Tairama: The loft (storage area)
- (g) Al Morakkab: The kitchen
- (h) Beit Alma: The Bathroom
- (i) Beit Albeer: The area where the well to serve the water for the house is located
- (j) Al Gaaa: Guest hall for special occasions, normally seen only in big houses

- (k) Al Jela: A skylight to open and let air into the house; there could be more than one of these.

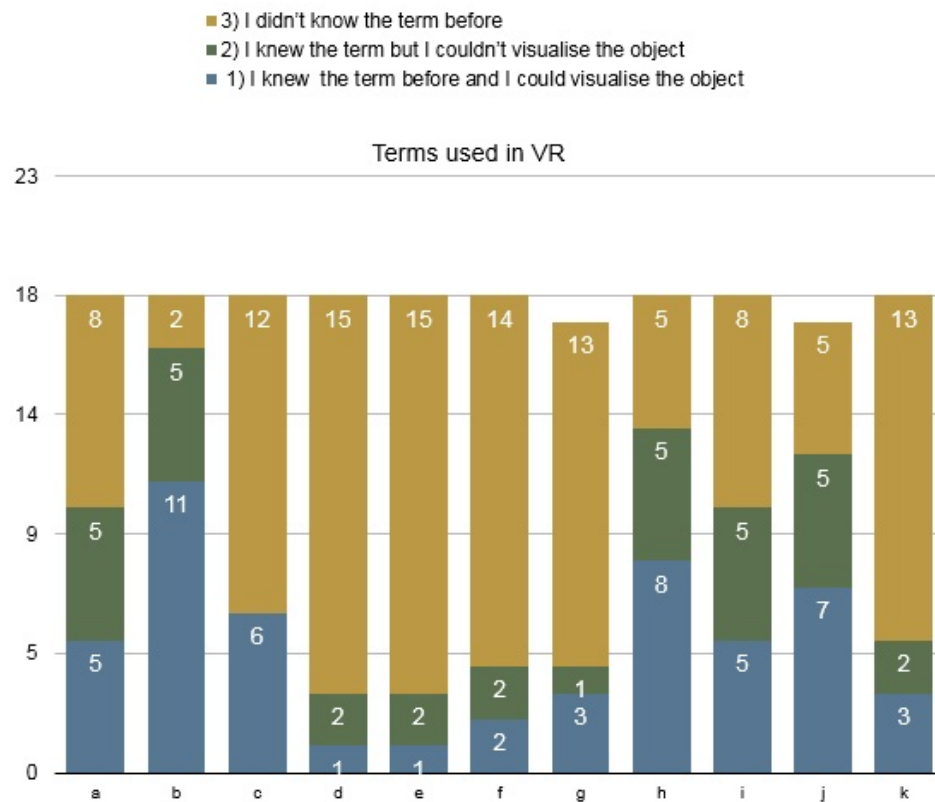


FIGURE 5.16: Participants responses to the traditional terms used in VE

All participants knew all the terms after the test. The graph below shows their previous knowledge of the terms. Every participant learnt at least two new terms, thus gaining knowledge about the old traditional terms for rooms inside the house. This helped them to sometimes visualise what the term stood for. For example, P08 had heard the term Al Moaakhar Al Sager, which means main bedroom, from her grandmother, but she could not imagine how it looked. When she navigated through the virtual environment, she recognised the place this term referred to. Her navigation through the room helped her visualise the room and remember it later. Other terms were recognised because they are still used in

some families by older family members or because the name itself indicates the purpose or location. Al Diwan was the most recognised room, due to the use of the same word nowadays, albeit with a change in emphasis (Al Diwaneya, the seat place, instead of Al Diwan, the seat). Beit Alma, which is the bathroom, was also well recognised, perhaps because of the combination of the two words (beit = house and alma = water, so the combination means waterhouse). Al Ga'aa is a currently used term for commercial halls which hold events. Though the purpose of the hall remains roughly the same (holding events), there is a commercial element associated with the word now, whereas in the olden days the events held in those big houses would have been with the objective of sharing or celebrating with neighbours.

The least recognisable terms were those used for the master bedroom and the childrens bedroom. These traditional terms were unfamiliar, as they referred to the location or size of the room and not its purpose. Al Moakhar, which means at the back, refers to bedrooms located at the back of the house, while the living room was at the front with a big Roshan and a view of other houses and neighbourhood activities. Al Moakhar Al Sager is the small rear room, and this room is the master bedroom for the parents, while the big one is for the family's children. If family members needed more rooms, they usually used the living room on the first floor during winter and the roof during summer to sleep. These two terms were difficult for the participants to understand, as they described aspects of the rooms that are not related to their current use in homes.

5.5 Suggestions and Feedback

In this section, I discuss the participants feedback and divide it into negative and positives aspects. Their final suggestions for updating the application and recommendations for future studies are also included and discussed.

Among the negative aspects, there were suggestions that the interactive map had too much information. P01 suggested dividing this map into three levels instead of two: the deeper the level, the more information it has. In this version of the application, users could choose how much information they want to receive. This suggestion is a practical one, as it gives the opportunity to the user to get more initial information. If he/she wants more information, this could be provided through text. P08 wanted a fixed place on the interactive map for the key locations names instead of them appearing next to the actual location in the map. While I considered the first point and found it very useful, I disagreed with the second one, as the locations and their names would be better matched in peoples minds if they appear next to each other. P12 commented that the actual map was not very clear, due to the use of a scanned photo of an actual map. This issue was resolved in MVH2.0; instead of using the scanned copy of the map, I built a simple 3D model of the city based on the map. On the other hand, most participants said that the interactive map was clear, simple and well designed. The detailed information and pictures were interesting to a number of participants. P04 asked for a copy of the application so that she could read the information at her own pace and keep it as a reference. This point is related to the future plan to establish (in collaboration with museums, researchers and developers) an online library that contains information about Al Madinahs heritage and to present information through a different media to the public. P14 and P15

mentioned that they like history and found the information on the application very interesting, but P15 asked for audio options to be available with text; this was also suggested by P13. Audio is an extra option that can be added to any application, although in a museum context, the use of audio would require a kiosk and a good design for headphones, because without these two things, there is the risk of too much noise.

P02 asked for more interactivity in the Virtual House, especially in the case of objects inside rooms. During her navigation, she tried to open objects such as the main gate and the cupboards and boxes located in the rooms. This option was considered, and, as a result, MVH2.0 has more interactive objects.

P01 asked for more furniture and detailing so that the Virtual House might look more like a lively home, P14 asked for more information on the roof section and P15 suggested a mini map on the screen along with the one provided as a handout. All these suggestions were valuable but required more time than was available to implement. Therefore, some of the suggestions were partly taken up to test the extent of their potential integration with the whole application.

P08 suggested having people inside the house, and P07 wanted a sound welcoming her every time she explored a room. I found these points useful in improving the experience of exploring the virtual house. P02 suggested that the information about each room should be optional instead of automatically displayed and wanted doors which open automatically instead of upon the mouse click of the user. These two points are covered in MVH2.0, as the doors now open automatically, and the information is displayed on the rooms walls for a player who wants to know more details about the specific room.

While there were many comments about adding more objects and interactivity in the house, P12 found the simplicity of the design a positive point, in that there

were no distractions and thus the player could get information easily. She also mentioned that she wished history teaching was like this, that is, using a virtual environment.

There were also comments regarding the technical building process. For example, P04, who is from a digital media and design background, spotted a mistake in one of the objects inside the kitchen, while P02, P03, P04, P07, P13, P17 and P18 were impressed with the shades and textures of objects, furniture and rugs and asked me about the resources I used for the images and the method I used to apply them to 3D models. Overall, the positives aspects are categorised into five sections: design and colours, ease of usage, usefulness and informativeness, positive impression and benefit to the new generation. The negative aspects are related to oversights in the design, the need for more activity and limited customisation of options.

5.6 Usability of the Application

Usability is the ease of using a system with human interaction and has different factors to look for as such as learnability, efficiency and satisfaction. I used two different tests: The System Usability Scale (SUS) and the Questionnaires for User Interaction Satisfaction (QUIS). The SUS seeks users general impression about the system, while the QUIS is more precise and includes five different parts to test. These parts include tests of reactions to the software, screen, terminology, system information and learning and system capabilities. These questionnaires were given to the users after the test. Sixteen of the participants answered the questions on the same computer, and these answers were recorded online, while two participants preferred paper-based questionnaires. The system usability scale

was developed by John Brook in 1986. The system is based on 10 questions with 5-point Likert scale answer options. The system is intended for an overall view of usability rather than to give indications about individual responses. As this application was a new concept to capture the heritage of Al Madinah, it was important for me to get an overall idea about the applications usability and to receive the impressions of the participants (Brooke, 1996; Bangor et al., 2008). If the average of the SUS score is above 70%, this indicates that the application is above average. Table 5.3 shows the results (Sauro, 2011; Brooke, 1996; Bangor et al., 2009).

Number of Participants	Score
1	75
2	77.5
3	97.5
4	97.5
5	85
6	82.5
7	85
8	85
9	100
10	87.5
11	77.5
12	100
13	75
14	87.5
15	95
16	97.5
17	77.5
18	82.5

TABLE 5.3: SUS score

An additional question about likelihood (rated from 1 to 10) of users recommending this application to others received good responses, the lowest value being 5 (from P10). Figure 5.17 below shows this information in the form of a bar graph.

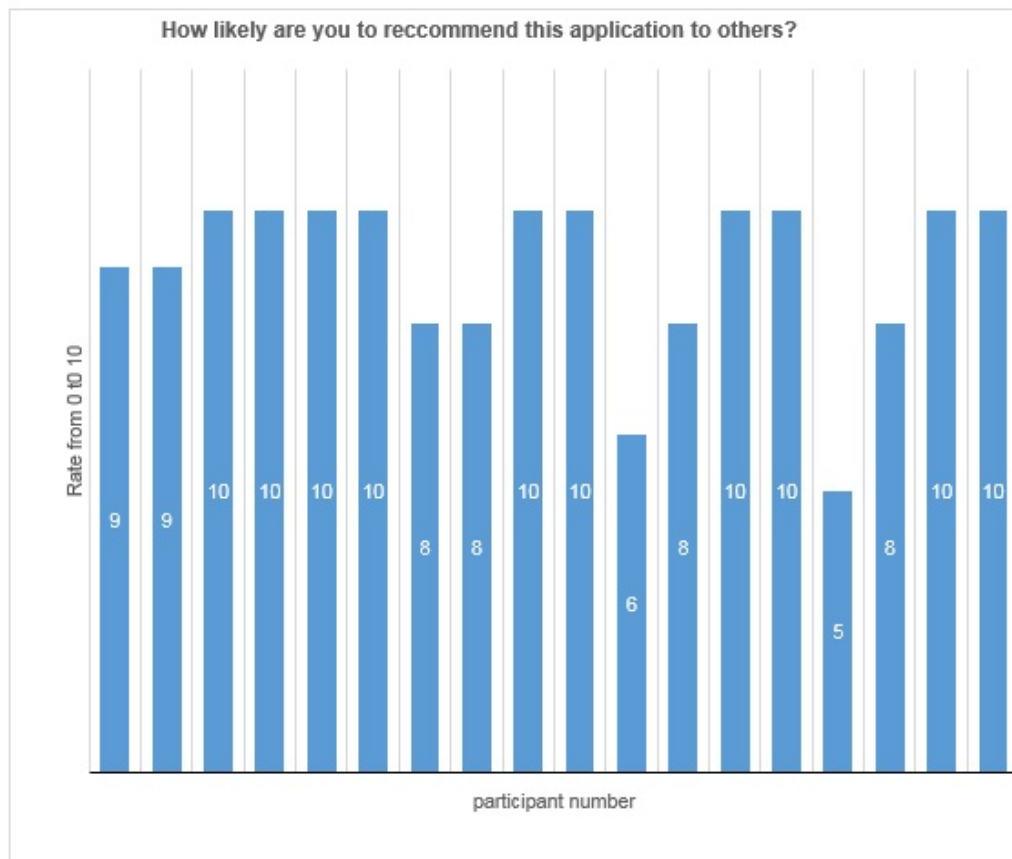


FIGURE 5.17: Likelihood of user recommendation MVH1.0, 10 most positive

5.6.1 QUIS

The Questionnaires for User Interaction Satisfaction (QUIS) were developed in 1987 by three doctors from psychology and computer science departments to measure human satisfaction with a human-computer interface. There are currently seven versions of it available as a software. In my study I used the early version, because it was shorter and covered the information I wanted from the participants (Chin et al., 1988; Sittig et al., 1999)

The QUIS has 27 questions divided to five sections: reactions to the software, screen, terminology and system information, learning and system capabilities.

The section called reaction to the software has six questions, with a Likert scale ranging from 1 to 10 where 1 is most negative and 10 is most positive. The questions are about ease of use, flexibility, satisfaction and simulation. The average value of the responses was 7.541 out of 10. The section regarding the screen covered the ability to read the characters on the screen, the sequence of screens, and how simplified the tasks were. The result was 8 out of 10, with a minimum value of 4 and a maximum of 9. The third section was about the terminology and system information, which included the terms used in the system and the assigned task in addition to the position of screen messages and input prompts. The feedback showed a value of 8.09. Learnability included the operation, recognisability of names and commands as well as system speed and system reliability. Overall, the score was 8.37. System capabilities includes the speed, reliability and the design for different users. The average result was 8.05.

5.7 Conclusion

In conclusion, the development process of the MVH 1.0 was based on the historical data about the heritage of Al Madinah that I collected in the early stages of the project. These data were used in different ways and contributed to ideas for envisaging the location and structure of 3D objects or for their texture process. Extracting texture material from photographs is a very important step in building up a material library which represented the Hijazi heritage in general and Al Madinah in particular. Building such a library and making it available for developers and designers will speed up the production process, as the designer can always use the ready-made material. In the same way, 3D models depicting the heritage of Al Madinah could become available online for reuse in different

projects. The collaboration of interested people is essential for building up a database about Al Madinahs heritage that contains several types of materials about Al Madinah and references for books and other resources which could help researchers to find what they are looking for. In this chapter I discussed the development of the MVH 1.0 and the feedback related to it. In the next, I will discuss the upgrading of MVH 1.0 to MVH 2.0 with the introduction of virtual reality, for which the head-mounted VR display was essential.

CHAPTER 6

The Development of a Head-Mounted VR Display for Exploring Al Madinah's Urban Heritage

6.1 Introduction

The previous chapter discussed the development and testing of MVH 1.0; this chapter discusses the second version, MVH 2.0, which includes interactive and virtual reality (VR) features using the Oculus Rift. The aims of this part of the project were to:

1. Develop MVH 2.0 based on participants' feedback on MVH 1.0;
2. Explore the potential of a head-mounted VR display using the Oculus Rift to express Al Madinah's cultural heritage;
3. Identify a framework to present Al Madinah's cultural heritage in a VR environment in a museum, on a low budget.

6.2 Development of the MVH 2.0 Application

6.2.1 The key elements of MVH 1.0 and their development in MVH 2.0

Although the feedback from the testing of MVH 1.0 was generally positive, there were a number of suggestions from participants. These included increasing the interactivity of the virtual environment, adding more details to the Hijazi House, correcting some shading, adding an urban layout view of the city, providing a clearer view of the interactive map, adding more levels to simplify the information provided to the user and adding an audio narrative.

All the feedback was considered, but due to the limitations of time and equipment, I adopted the most relevant of these suggestions and added more features. These included the suggestions to provide a clearer map with more interactivity in the virtual environment and an external view of the city landscape. The suggestions from most participants seemed viable from my perspective as a designer and were adopted. Subjective suggestions and those that were contradicted by other participants were disregarded.

The main feature changes I made were:

1. Simplification of the design theme;
2. Conversion of the 2D interactive map into a 3D interactive map;
3. Addition of external landscape views of the city's urban development;
4. Adjustments to the internal view of the Hijazi house, adding more details and fixing errors;

5. Addition of more VR elements using Oculus Rift to allow greater immersion.

	MVH 1.0	MVH 2.0
Themes and Design	Designed for PC	Designed for multiple platforms
	Figure5.9	Figure6.2
Interactive Map	2D	3D
	Figure6.3	
Urban Scenes of the City	Not available	Available
		Figure 6.1
Virtual Environment	Normal	Using head-mounted VR display
Texture and Shading	some errors	Fix errors and add details
Audio	No Audio	Audio to make more engaging

TABLE 6.1: The differences between MVH 1.0 and MVH 2.0



FIGURE 6.1: Urban scenes of the city in MVH 2.0

The application design was done with an upgraded version of the game engine software Unity3D 4.6, which has a new graphical user interface (GUI) feature. This feature helped to reduce pages of code to a single command, in addition to making the application compatible with other platforms, such as Xbox, web games, Apple and Android, with no additional work.

The main menu has options, and when a user clicks on one option, a window appears with details of what the user could expect to see and how it could be used. In the interactive map, there is a brief description of the key locations and how the user can navigate through the map using keyboard keys.

In the Virtual Reality section, the user receives instructions about how to wear the Oculus Rift and how to navigate through the VR environment by using the controller and the head-mounted device. The 2D map was transformed into a whole new 3D city layout that has two types of objects: coloured 3D objects that represent key locations in the city and grey objects that represent generic buildings and neighbourhoods. I used the grey objects to emphasise the overall mass of buildings in the city and to indicate that these objects are not interactive. In the future, I aim to develop more interactivity and more details and photos that compare the current look of the city to that of the last century.

MVH 1.0 gave users the chance to explore the model of the Hijazi House from the inside. MVH 2.0 also offers this option, with the added ability to explore the surrounding urban environment, which was possible because of the Oculus Rift.

6.2.2 An Evaluation of the Software Tools for Developing MVH 2.0

The main software for developing MVH 2.0 was Unity3D 4.6, with Autodesk Maya for the 3D objects and the surrounding buildings. Adobe Photoshop was used for the interface design with typefaces in Arabic. The Oculus Configuration Utility was used to activate the Oculus Rift. The prototype design was inspired by a Roshan design, because the Roshan has become symbolic of the historical Hijazi House, I simplified the shape of a traditional Roshan to create a design to use in the application. This design reflected the value of the heritage architecture with an image of Al Madinah in 1888, which was used as the background for the design. The title screen included the name of the city and the period as well as four options: Interactive Map, Virtual Reality, Information about the Application and Exit (Figure 6.2).



FIGURE 6.2: The prototype design inspired by the traditional Roshan and an early photograph of Al Madinah from 1888

6.2.2.1 Interactive Map

The interactive map was based on an original map, which MVH 1.0 had used as a background with key locations superimposed. From the participants' comments, it was clear that the quality of this map was not very good, so I worked on its presentation for MVH 2.0. I used the original map as a reference and inserted more 3D models. In doing this, the key locations, which were easy-to-locate 3D objects in the first application, became less visible. To distinguish the active locations, I shaded the whole city in grayscale and used colour only for the interactive locations. These locations have signs on top of them; the information given in these signs includes the location names. Figure 6.3 shows the three

iterations of the interactive map: the original, the one in MVH 1.0 and the one in MVH 2.0.



FIGURE 6.3: The development of the interactive map in MVH 1.0 (top right) and MVH 2.0 (bottom) based on original map (top left)

6.2.2.2 Virtual Reality

Virtual reality (VR) is the most important additional feature in MVH 2.0. The use of the Oculus Rift provides users with a more immersive experience of being in Al Madinah between 1850 and 1950 than was available in MVH 1.0. The feedback about the virtual Hijazi House in MVH 1.0 was positive, and users said they enjoyed the experience. However, some asked for an external view of the house so that they would be able to see the city from the outside. In response, I added a VR environment of several blocks of the city as they looked at that time. The texture of the buildings was extracted from real images of Al Madinah collected during phase one, all of which provided details of the buildings between 1850 and 1930. The process of developing the models and their texture is shown in Figure 6.4.

The first two images were captured during my building survey to collect historical material in the first study. I edited these photographs and extracted material to use in a texture map, which was then applied to the 3D model. There are two types of maps: the diffuse map with which to apply the material to the 3D model and the normal map (the picture shaded in blue), which provides building details.

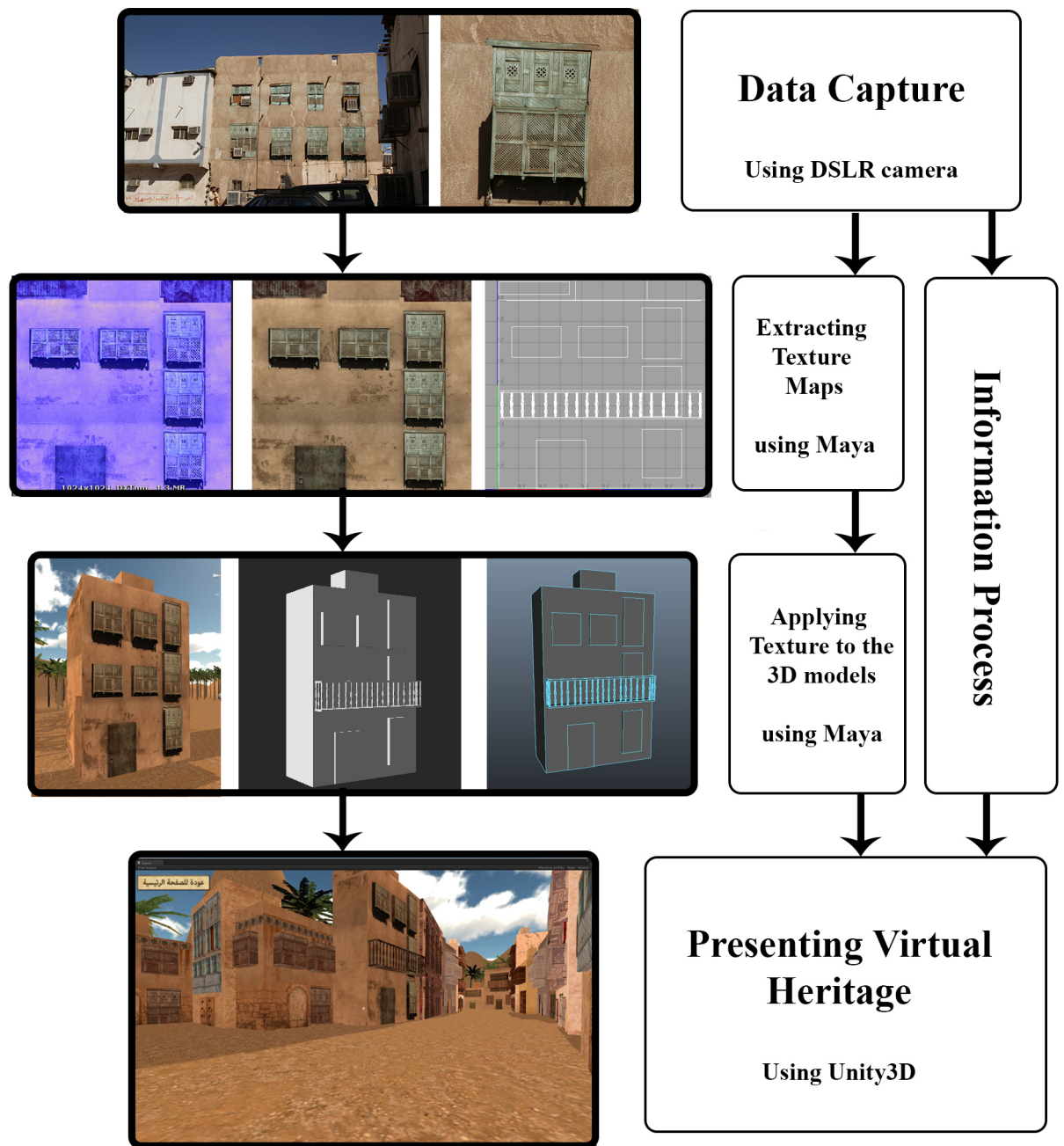


FIGURE 6.4: An example of modelling the Hijazi House based on a photograph

6.2.3 Hardware Configuration

Because the Oculus Rift is a developer kit that includes specific hardware and software, the use of it affects the flexibility of the application, so that unlike MVH 1.0, MVH 2.0 has to be run on specific machines. The use of Pro Unity3D, with a high-quality graphics card to run the game, was essential to get the VR feel. In addition, the setup and adjustment of the Oculus Rift required effort, research and experimentation. The Oculus Rift development kit had some issues during its run with Unity3D. The use of screen capture to save the experiment was not possible, as it clashed with the use of the Oculus Rift. The reason for the problem is unclear but is possibly related to the use of the graphics card. Filming participants while they were trying MVH 2.0 was essential, as my later analysis was based on this data. So, to address these difficulties, I used my research computer to run the application for all the participants; I also used two video cameras to record the procedure. This included tracking the physical behaviour of the users and their movements while exploring the VR environment.

6.3 The User Experience

The participants were asked to sign a consent form before testing the application; no further explanation was given about the aim of the study, which was to check whether the instructions were clear enough. There were a total of 18 participants, eight of whom had tried MVH 1.0 and 10 of whom had not. The task for the participants was to try the MVH 2.0 application and then give feedback. The participants who had tried MVH 1.0 were asked to compare the two applications and comment on the development process.

6.3.1 The Study Design

The study explored users' behaviour using VR when learning about the heritage of Al Madinah during the period in question (1850 to 1950). The study tracked users' behaviour and sought their feedback for future adjustments. The process of using the application was as follows: When the user starts the application, the screen has four options: Interactive Map, Virtual Reality, Application Information and Exit. The first two are primary options, each giving the user instructions about how to navigate through the application and information about what can be expected at that particular stage. The application was run in play mode inside Unity3D, which creates a mix of the normal mode and VR. The use of Pro Unity3D was essential when using the Oculus Rift, because there is an inherent device restriction associated with this application.

6.3.2 Participants and Materials

The participants were selected almost randomly, with the criterion that they be able to read Arabic, as that will be the common characteristic of the target users for the final version. In total, there were 18 adult participants, seven men and 11 women aged 18 to 38, eight of whom had already tried MVH 1.0. The majority of participants were from Saudi Arabia. Of the 14 Saudi participants, 10 were from the Hijaz area and one was from Al Madinah. The four non-Saudi participants were from Kuwait, Sudan, Jordan and Oman. The participants came from a range of educational backgrounds across the sciences and humanities. All the participants were Muslim and expressed a respect for, and a desire to learn more

about, Al Madinah due to its status as a Muslim holy place. Each participant took between 15 and 20 minutes to complete the process.

6.4 Data Analysis

The participants reacted differently when experiencing the virtual tour of historical Al Madinah. This difference in views may have been partly because they were encouraged to express their thoughts and give immediate feedback.

6.4.1 The 2D vs. 3D Interactive Maps

While some participants were impressed with the development of the application from its previous iteration, others preferred certain aspects of the previous version. For instance, P01 preferred the 2D interactive map in MVH 1.0 rather than the 3D map in MVH 2.0. S1 was the only one who preferred the previous version of the interactive map, while the other seven participants who had tried both versions preferred the 3D map, the latest version. One of the comments P01 had was about the zooming. I had applied a border to restrict the navigation area for users, because the applications would have come up with a fatal error message if I had not done so. The limited zoom zone was applied on the interactive maps of the applications, just as I have seen done in different museums. This is also the case with interactive maps available online, such as Google Maps.

6.4.2 The Virtual Reality Controllers

As they familiarised themselves with the application, the participants became more immersed in the history of that period. On several occasions during her VR exploration of the city, P02 expressed her amazement at the experience. P02 also indicated that the use of the VR controller was not easy in the beginning, especially when she wore the head-mounted VR display and needed to use the keyboard keys to move forwards, backwards and sideways. P04 suggested that the application should move the player automatically along a pre-assigned path, with the user being able to choose the direction. This method is often used in games where the player has to focus on other tasks that that need to be achieved; this idea would have been valuable had the main aim of the application been entertainment instead of education by using an automatic method such as the one described, the user might miss out on the more informative parts where stopping and taking in the information is required. After the discussion about this suggestion, P04 further suggested road signs for the navigation path that would guide users through the VR. This idea could be an optional add-on in the future development of the application.

Another discussion was related to the hardware, specifically, the lead of the head-mounted VR display device, which in some cases, constrained users' movement.

"In the beginning, it was a bit difficult. I couldn't synchronise the movement between the hand controller and the head tracker. It is interesting, but in the beginning, it was difficult to get used to it; even when I rotated, I felt the [Oculus Rift] lead hold me back." P02

6.4.3 Hardware Limitations

This hardware limitation was mentioned by several users. Although they enjoyed the experiment, they wished for more freedom to act and move around. P01 suggested a separate room just for this application, so that the users have the freedom to navigate without a wire. P02, P05, P07 and P011 wished they could use a joystick, while other participants suggested a game pad.

Even though P02 struggled in the beginning, it did not prevent her from carrying on. Once she got used to the way the hand controller and head tracker moved, she enjoyed the application immensely, with comments such as:

Wow, amazing, amazing, amazing! Using this in a museum very, very interesting. P02

P07's experience was quite different from that of others. Even though she expressed her admiration for the experience, the use of the multimedia seemed to be too much for her. She remarked:

Amazing! But I felt quite dizzy. How did you do it?

Coming from Al Madinah's neighbouring city of Makkah, P07 was engrossed in the details of the city and asked more questions about the geography of Al Madinah in that period.

6.4.4 Previous Knowledge and Resources on Al Madinah

P08 was from Makkah and was familiar with Al Madinah because of his annual visits to the latter; he shared his sadness about the demolition in both cities and the undocumented lost heritage. He enquired about familiar places in Al Madinah, such as the Qubaa mosque, and wondered why it was not on the map. The answer is that it was outside the wall and therefore not inside the old city, while nowadays, it is in the heart of the city, which is an indication of how much the city has expanded.

The participants' backgrounds and knowledge about Al Madinah impacted how they communicated with me. For instance, P04 showed sufficient knowledge about present-day Al-Madinah and his questions were specific. When he was giving his feedback, he discussed several issues:

P04: Oh, OK, I see what do you mean. What about other mosques?

As I mentioned before, although the Qubaa mosque is a very important location, I did not include it because it is outside the city's walls; the other mosques inside the city were not included in this iteration because I focused on the walls, gates and other landmarks. My plan for the future is to include mosques, libraries, schools and the names of neighbourhoods.

P04: Have you got an old map of Al Madinah?

P04: Oh, OK, I see what do you mean. What about other mosques?

In response, I said that there are different versions, as most of them were based on travellers' descriptions.

P04 was not the only participant who questioned me about my sources and references. In doing so, the participants were showing their own awareness about the research topic and research methods. For example, P08 asked:

When is this map [from]? At what time? Where is the Qubaa Mosque?

Having to wear the head tracker seemed to encourage the participants to express their opinions and to ask questions for which they did not expect immediate answers. This could have been because their senses were fully engaged by the application, leaving them no opportunity for eye contact (Figure 6.5).



FIGURE 6.5: Participants interacting with MVH 2.0 using the head-mounted VR display

Participants' questions were not only related to the sources of information; often, they requested more precise information with regard to the layout of the

application, the furniture in the Hijazi House and the colour of buildings. Referring to the kitchen implements inside the Hijazi House, P04 said:

The objects are quite big, these implements are for giants.

I explained that the use of the Oculus Rift head tracker should be adapted to the user to avoid this feeling.

Other examples of such engagement were about how users' felt when experiencing the environment. When trying to enter through the gates in the virtual environment, P08 said:

I am walking inside Al Madinah, the old Al Madinah.

Similarly,

Yes, it's very clear, even for people who do not know Al Madinah, it gives a good idea about what Al Madinah looked P03

In contrast, the use of grey shading in the interactive environment to represent houses seemed a bit confusing to some users. Indicating the non-interactive houses on the interactive map, P10 asked:

Were their houses grey like that?

I explained that I had coloured them grey to show their current non-activated status and that they would look different in the next iteration, when they are activated. So, this greyness may need to be explained in the user instructions.

6.5 Conclusion

Using the head-mounted VR display engaged the players with the environment, achieving a mix between the informative and entertainment aspects of the application, which enhanced their experience. During this testing phase, suggestions from participants focused on the application's VR aspects. The main points of these suggestions were:

1. Create a separate room for free movement without the hindrance of the Oculus Rift lead;
2. Provide a game pad or a joystick instead of a keyboard;
3. Offer a wireless head tracker.

These points are mainly related to the device that I used, which was the development kit of the Oculus Rift. This provided an affordable VR experience to suit the low budgets of local museums. Even though by December 2014, Oculus had launched GearVR, which addresses the three suggestions mentioned above (it is wire-free, has a game pad and more freedom of movement), I could not use it because it has to be used exclusively with a Samsung GalaxyS6 smartphone. The application I had was designed to work with an Oculus Rift device that is run using a personal computer. Moreover, the new feature called UI in the Unity3D software that was launched later in 2014 allows the developer to produce different versions of the software, quickly producing a version that can be used on an Android platform.

Suggestions related to the modelling of the environment were to: include high quality texture, adjust object sizes according to the player and include more

customised options. Adding people to the scene was also suggested, as the city looked deserted. The use of people or characters (the latter would also require a plot) would have a different purpose than the one for which this application was developed but could be an idea to consider in future development. For example, characters such as player avatars used in social games could add a dimension to the existing application, as users could then interact with each other. A character could also be a guide for solo users.

Another issue raised by participants was the target period. They wanted to know why I chose this period rather than the time of the Prophet's life around 620 AD. I explained that the period between 1850 and 1950 was supported by pictorial evidence to show the speed of the demolition process and that I wanted to document this period of Al Madinah's history before it is lost. My explanation also touched on the fact that the earlier period has less ambiguity around it, which is in direct contrast to the period I chose, because it has received limited attention. The application focuses on 1926, because that is when the source map was made, which is also the date of the most recent buildings that I included in the application.

The two participants from a digital art background also raised questions and started conversations about the process of constructing the environment, including details on the modelling, texturing and rendering processes. This conversation was rich in terms of the practical details of the work, such as the different methods used for 3D modelling and the types of restrictions developers face. These issues were topical and related to the 3D modelling software, game engine and hardware, including the processors and graphics cards, which have all improved since the time of the test.

CHAPTER 7

Conclusion

7.1 Discussion

This chapter presents the results from a series of studies performed to add to existing knowledge by applying the concept of digital heritage through a virtual reality installation that presents the heritage of Al Madinah. This chapter summarises and discusses the finding from these studies. More importantly, a set of guidelines is derived from the findings to show how virtual heritage can be designed and produced to preserve the history of Al Madinah and disseminate it to younger generations using new technology. Finally, recommendations are given concerning how to apply this technology in local museums in Al Madinah at an affordable price without losing the educational and entertainment aspects of digital devices.

7.1.1 The Heritage of Al Madinah and Its Resources

The heritage of Al Madinah is extremely rich, but the limited documentation and resources available affected the research process. In the earlier chapters of this thesis, I discuss how I based my project on data collected first-hand by interviewing local inhabitants of Al Madinah to explore its heritage. The interviewees included archaeologists and researchers who specialised in Al Madinahs civic history. I also performed building surveys to explore the remaining historical buildings (most of which are in ruins). These surveys examined the characteristics of the traditional Hijazi house, such as the traditional Roshan and other elements, which are discussed in Chapter 3.

In addition, I conducted an exploratory study of local museums that focus on the history of Al Madinah. The two museums I visited were Dar Al Madinah and Madina Media Museum. Both primarily used traditional display methods, including scaled models, physical objects and photographs. Scaled models were commonly used to represent the historical mosques at a smaller size. A large model (1:80) which represented the city as it was in 1926 was based on the first and only research to document Al Madinah between 1850 and 1950. This 1926 model of Al Madinah was adapted by both museums to create their own models of the city.

The use of photographs was also very common in the museums, and limited collections of photographs have been printed and displayed. Some photographs from these collections are also available online and have been circulated in social media. Although there are numerous photographs in existence, many have not gained wide popularity. The limited collections of photographs in the museums could be expanded by digitising old, rare books which include other photographs.

In addition, people could be encouraged to share their personal photographs of historical places and events through a database that includes information about Al Madinahs heritage. Engaging local inhabitants is an important factor in preserving the heritage of a city. These efforts should not be confined to collecting photographs but should be extended to exploring the perspectives of older people through narratives of their memories and stories which provide deep insights into the social life and environment of past years.

Although there is rich information about the heritage of Al Madinah, it is not easy to access and requires further research. The earlier suggestion to establish a database to collect information about Al Madinah from sources including photographs, videos, memories and stories is relevant in this context. This project would require the collaborative efforts of a team of experts in various fields related to Al Madinahs heritage to validate the data before making it publicly available online.

The second part of the thesis deals with the use of digital devices in museums and discusses ten museums in the UK. The use of technology in the museum context has increased ([Wakkary et al., 2008](#)). Using projectors is very common in UK museums for different purposes, such as providing information from documentary film footage or presenting photographs and information. The images are projected onto a screen or against a wall or the floor. In Al Madinah museums, projectors are used but in more traditional ways, such as showing sequences of black-and-white photographs. This method could be improved by displaying interesting, colourful images or videos that present the past in a modern way. The other popular technique in the UK is using tangible kiosks which display a variety of subjects.

7.1.2 Digital Installations in Museums

Design, content and level of simplicity differ from one digital installation to another. A digital installation has the advantage of being able to contain huge amounts of information, allowing users to decide how much information they want. In addition, various media can be used in a single application. The flexibility of a digital installation makes it the most suitable medium to present the rich heritage of Al Madinah as it presents a wealth of information and mixed materials to support the subject. The use of technology has increased in the museum context, as discussed in Chapter 4. Developing digital museums in Al Madinah will positively affect the preservation of the city's heritage. As (Tang, 2005) states, this not only preserves the heritage of a place but also shows and shares it. Members of the public can access the rapidly increasing number of digital museums in recent years via the Internet (Schweibenz, 1998).

As a first step, the Dar Al Madinah Museum in Al Madinah has become more active on social media. This step can be taken further by developing a digital museum. In practice, several museums from throughout the world have put their collections into a shared database to collaborate, which has helped them organise their exhibits (Marty et al., 2008). Such a database on Al Madinah's heritage will be a great resource for research materials and would be more accessible than conventional resources.

An example of the creative use of projectors for decorative or informative purposes is discussed in Chapter 4. In Al Madinah, museums use projectors in traditional ways and generally show sequences of black-and-white images. This method could be improved by displaying interesting, colourful images or videos that present the past in a modern way. Another potentially popular method

is the use of tangible kiosks which display information on a variety of subjects. Photographs were used as a main resource by Colin Johnson, who constructed a virtual reality journey through 16th-century Dudley Castle (Boland and Johnson, 1996) which was inaugurated by Queen Elizabeth II in 1994. In addition to photographs, Johnson used the ruins of the castle as a reference. Ruins give details on how to construct a site, especially in the case of open areas, such as windows, doors and stairs.

7.1.3 Using Virtual Reality to Represent Al Madinahs Heritage

Building a virtual environment based on historical data has been done in different projects using different methods for various purposes. The primary question is how much material is available to support the development of a heritage virtual environment. Although I focused on recent history in my study on Al Madinah, the documentation available was insufficient, and the use of first-hand material was essential to collect information and build a base for constructing a virtual environment to disseminate Al Madinahs heritage. A secondary challenge was that this type of work is usually done by groups which include experts, such as archaeologists, architects and digital artists, who produce a high-quality virtual heritage installation. My interview with archaeologists and architects helped me better understand the context, but their influence was limited to the knowledge I acquired from my interviews of them. Using a game engine to present the historical city of Al Madinah is a new way to preserve the citys heritage and engage younger generations in learning more about their history. Using such media to exhibit the heritage of cities is thought to be suitable in museums and

educational institutions and on the Internet. The educational dimensions of the present research are in line with what (Mei, 2004) argues: a digital museum is not limited to archiving existing materials. It provides the opportunity to make connections between exhibit items and their history and location in a learning process. In addition, a digital museum overcomes the lack of feedback available in conventional museums by enabling more complex functions which allow educators, researchers and visitors to interact with the digital devices and give feedback. As explained in chapters 4 and 6, participants obtained information about Al Madinahs heritage and were exposed to the citys architectural style and environment by using the application. As far as I am aware, this application is the first one which looks closely and solely at Al Madinah. Fifteen years ago, the use of virtual reality in a museum context would have cost up to US\$150,000 for just the hardware, as in the case of TODC project (Cremer et al.). Today, this amount has decreased significantly to less than US\$350, giving museums the opportunity to innovate within their own environments and make interactive exhibitions.

The development process of the Madinah Virtual Heritage (MVH) installation was done completely by me. It included researching the raw materials, investigating the use of digital devices in UK museums and developing the installation. Due to the limited time and resources available for the project, the installation covered only 22 key locations in the city. The installation includes the facility to explore urban development from an external perspective and the Hijazi house from both external and internal perspectives, using Oculus Rift to provide virtual reality. Oculus Rift stands as a major achievement in the virtual reality world as it has become affordable for developers to purchase at a relatively low cost and, in this case, to produce a virtual reality environment which can be used in local

museums of Al Madinah.

7.1.4 Virtual Reality and the Future

Although the use of virtual reality to preserve heritage digitally has become more popular today and been applied in numerous researches conducted around the world, digital data need to be aligned with other ways of preserving heritage in the future. For example, a series of printed books, with copies saved in local libraries, is essential to preserve data, in addition to the use of new technology, such as 3D printing, to produce models of traditional houses and buildings.

7.2 Research questions addressed

Overall, this thesis addressed three research questions:

1. How was the history of Al Madinah documented between 1850 and 1950, and which of these resources are available?

This question is addressed in Chapter 3 through the discussion of the exploratory interviews, building surveys and visits to two local museums in Al Madinah. The results of the research show that there are significant gaps in the documentation of Al Madinah not only during the period of interest to this study but during other periods as well. The two local museums in Al Madinah are self-funded institutions which preserve the city's heritage. Both use traditional display methods to present information. In addition, there are redundancies in the displays of historical photographs in both museums, although the photographs are printed in different ways to match the theme of each museum.

2. What types of digital devices are used in museums?

This question was addressed by investigating the use of digital devices in UK museums. The research covered ten museums in London, Liverpool and Canterbury, as discussed in Chapter 4. The results show that the use of digital devices is popular in the museum context in the UK and that the information available digitally covers different subjects. Also, the level of interactivity of digital installations depends on their content and objectives. Digital installations have the advantage of giving users the freedom to choose their learning path.

3. How can an effective installation be developed to present the heritage of Al Madinah in a museum context?

This question was addressed in chapters 5 and 6 by testing the two versions of the MVH installation, which I developed based on the findings presented in chapters 3 and 4. The first phase consisted of a usability test based on MVH1.0, which received positive feedback. The second cycle tested MVH2.0, which introduced virtual reality to navigate the old city of Al Madinah. The feedback related to this offering was positive, with a number of suggestions for further development.

7.3 Contribution

7.3.1 Representing the Heritage of Al Madinah Based on the Collected Data

The key contribution of this research is the production of an effective application using new virtual reality and 3D technology that displays the history and heritage of Al Madinah and can be used by museums in the city. The use of 3D modelling to produce historical information, especially for the purpose of re-creating lost heritage, is new in the context of Saudi Arabia, especially Al Madinah, which is the second holiest city to Muslims.

7.3.2 Using Virtual Reality to Preserve Heritage on a Limited Budget

In another contribution of this research, the successful development of this practical application offers museum management in Al Madinah and interested researchers and developers a working example of how an installation which is based on historical material and provides information in an entertaining way can be developed. This is the first installation produced that uses a virtual environment to preserve the heritage of Al Madinah. It is grounded on research I conducted to collect preliminary data, the results of which revealed a major gap in the documentation of lost heritage. The content of the installation was designed after examining more than 30 installations in UK museums.

Using a game engine to provide interactivity in a virtual historical city is a new

way to preserve the heritage of Al Madinah and to encourage younger generations to learn more about their history. The use of virtual reality to explore virtual heritage has been done, but most such projects have required high budgets. Using a head-mounted virtual reality display in this case, Oculus Rift to provide a virtual reality environment on a low budget makes a new contribution that could be invaluable for museums which use traditional display methods.

7.3.3 Application of the Method in Other Domains

The work-flow of developing the virtual environment could be applied in other domains, such as education, medicine, tourism, training and entertainment. In education, the use of virtual reality technology could benefit the learning process and give students the opportunity to interact virtually with objects. For example, instead of hearing stories about the past, history students could live in the past in a virtual building environment of the target period studied. As well, in science, virtual reality could simplify complex subjects, such as anatomy, and allow students to interact freely with objects and explore hidden areas. In medicine and health care, the use of virtual reality could improve the communication process between doctors and patients by providing clear, simple images of patients. Virtual reality is not limited to education but can also be used in tourism, entertainment and other domains. The use of virtual reality can be applied in many areas, but the most important factor in producing an effective application is the collaboration between the domain specialists and the 3D team.

7.4 Future work

The aim of this thesis was to provide an effective way to preserve the heritage of Al Madinah, which has so far been mainly based on photographs, books, memories and stories. A digital installation based on a map of Al Madinah in 1926 and some of its key locations was developed. The plan for future research is to further develop this map and add details of other key locations, including the names of roads and neighbourhoods. This work will require more research to document the city and could involve collaboration with local museums. Another feature which I would like to develop involves more work in the field of virtual reality: an informative, engaging game based on the urban layout of Al Madinah and the Hijazi house. This research can be adapted and used commercially and in local museums as a new medium and technology to live the old life in Al Madinah and learn about its heritage. As new virtual reality devices rapidly come out in the market, the use of virtual reality has become accessible to a wide range of users. All they need is a head-mounted virtual reality display, the application itself and a device to run it, such as a computer or smartphone. This is the beginning of using virtual reality technology and points to a wide area to be explored in the near future.

Appendix A

Exploring the potential of Al Madinah heritage within local museums

Participants demography in study one about the heritage of Al Madinah, in addition to the interviews questions.

Interview Questions

Participants demographics in Study One in relation to the heritage of Al Madinah as well as interview questions.

The original interviews were conducted in Arabic, which is the native language of the participants.

1. The architecture of buildings

- (a) What are the main characteristics of the Hijazi building in general and its location in Al Madinah in particular?

2. Social Life

- (a) How do the architectural characteristics of the building affect peoples social life?
- (b) Describe the way in which people lived in the past.

3. Difference between the past and present

- (a) In your opinion, what are the main differences between the past and the present?

4. Lost heritage

- (a) What do you think about the current situation in relation to Al Madinahs heritage?
- (b) How can we preserve the lost heritage of Al Madinah?
- (c) What resources are needed to gain knowledge about Al Madinahs heritage?
- (d) What is the role of local museums in terms of the lost heritage of Al Madinah?

Interview Number	Interview Date	Interview Location	Interviewee Background	Purpose of Interview
1	2011 26/12/2010	3 months 1 hour, 30 minutes	Online Participant's house	Local inhabitant of Al Madinah Old local inhabitant of Al Madinah
2	25/12/2010	5 hours	Madinah Media Museum	Senior lecturer in Media/ and museum's owner
3	01/01/2011	3 hours, 30 minutes	Archeologist's office	Archeologist and expert of Al Madinah heritage
4	02/01/2011	3 hours, 50 minutes	Dar Al Madinah Museum	Researcher, Architect and museum's owner
5	02/01/2011	2 hours	Dar Al Madinah Museum	Architect/ Researcher who has researched Al Madinah's heritage
6	04/01/2011	3 months	Online	Local inhabitant of Al Madinah

Participants demography

To obtain information about the heritage of Al Madinah
 To obtain information about the heritage of Al Madinah, specifically the social life in 1950s and earlier
 To obtain information about the heritage of Al Madinah, and recommendations about research resources
 To obtain information about the heritage of Al Madinah, and gets old images and information about heritage building and locations of the surviving building
 To obtain information about the heritage of Al Madinah, and recommendations about research resources
 To obtain information about the heritage of Al Madinah, and recommendations about research resources
 To obtain information about the heritage of Al Madinah

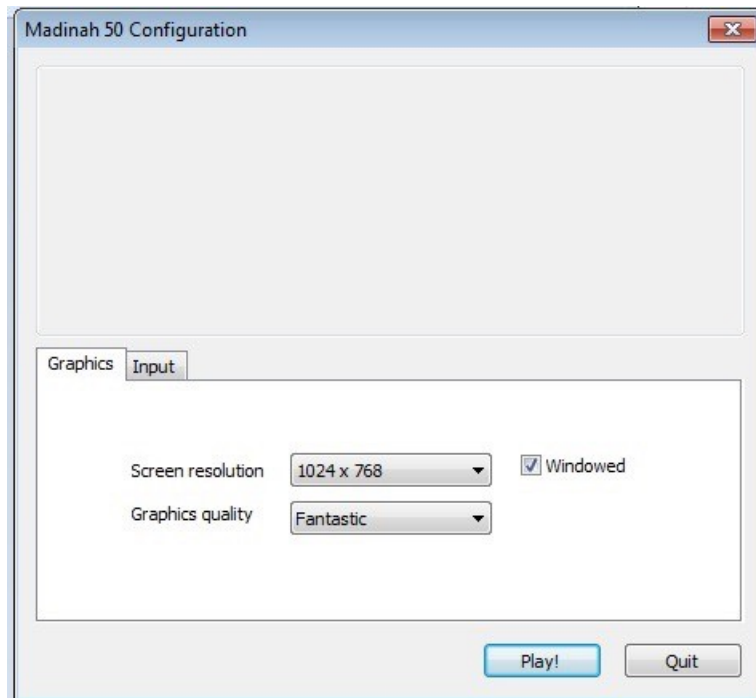
Appendix B

Developing and testing MVH1.0

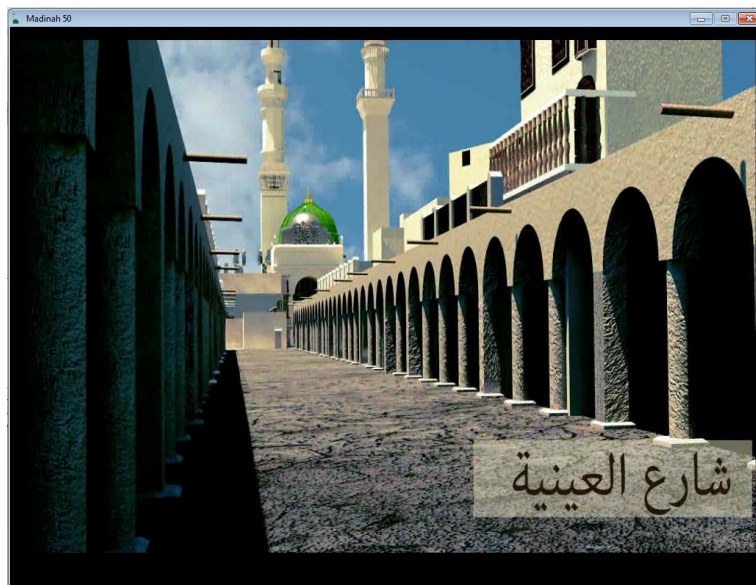
Screen shots of MVH1.0:



Installation Icon



Setup screen



Screen shot from video



Main menu



Main menu: interactive map



Interactive map



Interactive map



Main menu: virtual environment



Virtual environment



Virtual environment

Usability test

System Usability Scale

*Required

Participants Number: *

1. I think I would like to use this application frequently.

1 2 3 4 5

Disagree Agree

2. I found the application unnecessarily complex.

1 2 3 4 5

Disagree Agree

3. I thought the tool was easy to use.

1 2 3 4 5

Disagree Agree

4. I found that I need the support of a technical person to be able to use this system

1 2 3 4 5

Disagree Agree

5. I found the various functions in this system were well integrated.

1 2 3 4 5

Disagree Agree

6. I thought there was too much inconsistency in this application.

1 2 3 4 5

Disagree Agree

7. I would imagine that most people would learn to use this application very quickly.

1 2 3 4 5

Disagree Agree

8. I found the application very cumbersome to use.

1 2 3 4 5

Disagree Agree

9. I felt very confident using the application.

1 2 3 4 5

Disagree Agree

10. I needed to learn a lot of things before I could get going with this application.

1 2 3 4 5

Disagree Agree

How likely are you to recommend this application to others? *

0 1 2 3 4 5 6 7 8 9 10

Not at all likely Extremely likely

Comments:

Submit

Never submit passwords through Google Forms.

100%: You n

18 responses

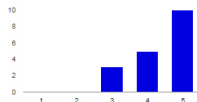
[View all responses](#) [Publish analytics](#)

Summary

Participants Number:

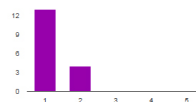


1. I think I would like to use this application frequently.



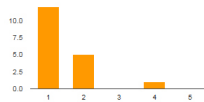
Disagree: 1 0 0%
 2 0 0%
 3 3 16.7%
 4 5 27.8%
 Agree: 5 10 55.6%

6. I thought there was too much inconsistency in this application.



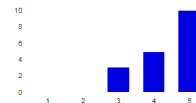
Disagree: 1 13 76.5%
 2 4 23.5%
 3 0 0%
 4 0 0%
 Agree: 5 0 0%

2. I found the application unnecessarily complex.



Disagree: 1 12 66.7%
 2 5 27.8%
 3 0 0%
 4 1 5.6%
 Agree: 5 0 0%

7. I would imagine that most people would learn to use this application very quickly.



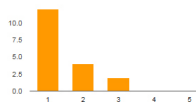
Disagree: 1 0 0%
 2 0 0%
 3 3 16.7%
 4 5 27.8%
 Agree: 5 10 55.6%

3. I thought the tool was easy to use.



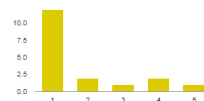
Disagree: 1 0 0%
 2 0 0%
 3 2 11.1%
 4 4 22.2%
 Agree: 5 12 66.7%

8. I found the application very cumbersome to use.



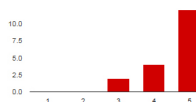
Disagree: 1 12 66.7%
 2 4 22.2%
 3 2 11.1%
 4 0 0%
 Agree: 5 0 0%

4. I found that I need the support of a technical person to be able to use this system



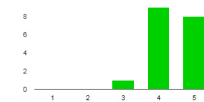
Disagree: 1 12 66.7%
 2 2 11.1%
 3 1 5.6%
 4 2 11.1%
 Agree: 5 1 5.6%

9. I felt very confident using the application.



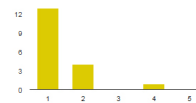
Disagree: 1 0 0%
 2 0 0%
 3 2 11.1%
 4 4 22.2%
 Agree: 5 12 66.7%

5. I found the various functions in this system were well integrated.



Disagree: 1 0 0%
 2 0 0%
 3 1 5.6%
 4 9 50%
 Agree: 5 8 44.4%

10. I needed to learn a lot of things before I could get going with this application.



Disagree: 1 13 72.2%
 2 4 22.2%
 3 0 0%
 4 1 5.6%
 Agree: 5 0 0%

The Questionnaires for User Interaction Satisfaction

*Required

Participants Number: *

Reaction to the software

0 1 2 3 4 5 6 7 8 9

Terrible Wonderful

0 1 2 3 4 5 6 7 8 9

Difficult Easy

0 1 2 3 4 5 6 7 8 9

Frustrating Satisfying

0 1 2 3 4 5 6 7 8 9

Inadequate Power Adequate Power

0 1 2 3 4 5 6 7 8 9

Dull Stimulating

0 1 2 3 4 5 6 7 8 9

Rigid Flexible

Comments:

Continue »

Page 2 of 2

Screen

Reading characters on screen

0 1 2 3 4 5 6 7 8 9

Hard Easy

Highlighting simplifies task

0 1 2 3 4 5 6 7 8 9

Not at all Very much

Organization of information

0 1 2 3 4 5 6 7 8 9

Confusing Very clear

Sequence of screens

0 1 2 3 4 5 6 7 8 9

Confusing Very clear

Comments:

Termonology and system information

Use of terms throughout

0 1 2 3 4 5 6 7 8 9

Inconsistent Consistent

Termonology related to task

0 1 2 3 4 5 6 7 8 9

Never Always

Position of messages on screen

0 1 2 3 4 5 6 7 8 9

Inconsistent Consistent

Prompts for input

0 1 2 3 4 5 6 7 8 9

Confusing Clear

Computer informs about its progress

0 1 2 3 4 5 6 7 8 9

Never Always

Error messages

0 1 2 3 4 5 6 7 8 9

Unhelpful Helpful

Comments:

Learning

Learning to operate the system

0 1 2 3 4 5 6 7 8 9

Difficult Easy

Exploring new features by trial and error

0 1 2 3 4 5 6 7 8 9

Difficult Easy

Remembering names and use of commands

0 1 2 3 4 5 6 7 8 9

Difficult Easy

Performing task is straightforward

0 1 2 3 4 5 6 7 8 9

Never Always

Help messages on the screen

0 1 2 3 4 5 6 7 8 9

Unhelpful Helpful

Supplemental reference materials

0 1 2 3 4 5 6 7 8 9

Confusing Clear

Comments:

System Capabilities

System speed

0 1 2 3 4 5 6 7 8 9

Too slow Fast Enough

System Reliability

0 1 2 3 4 5 6 7 8 9

Unreliable Reliable

System tends to be

0 1 2 3 4 5 6 7 8 9

Noisey Quiet

Correcting your mistakes

0 1 2 3 4 5 6 7 8 9

Difficult Easy

Designed for all levels of users

0 1 2 3 4 5 6 7 8 9

Never Always

Comments:

QUIS

List the most negative aspect(s):

1.

2.

3.

List the most positive aspect(s):

1.

2.

3.

Suggestions and feedback:

AppendixC

Developing application MVH2.0



Main menu



Interactive map- Land mark



Interactive map- Land mark



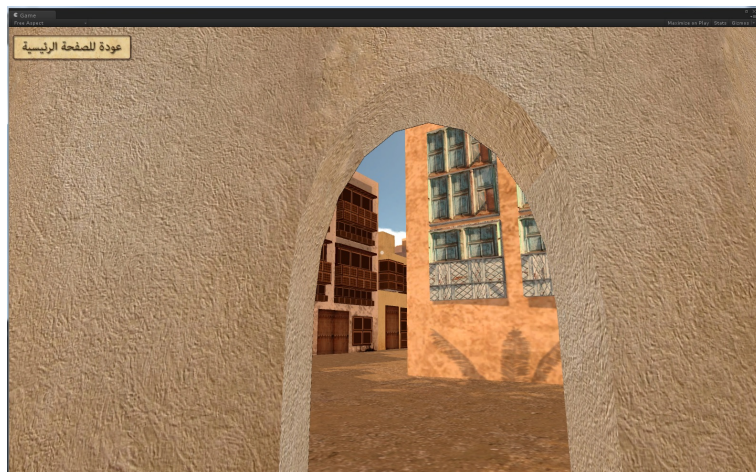
Interactive map- Land mark



Interactive map- Land mark



Interactive map- Land mark



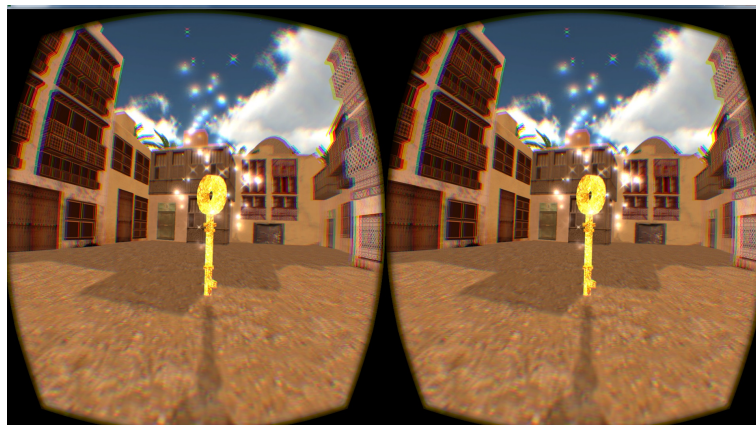
Virtual reality- The Urban



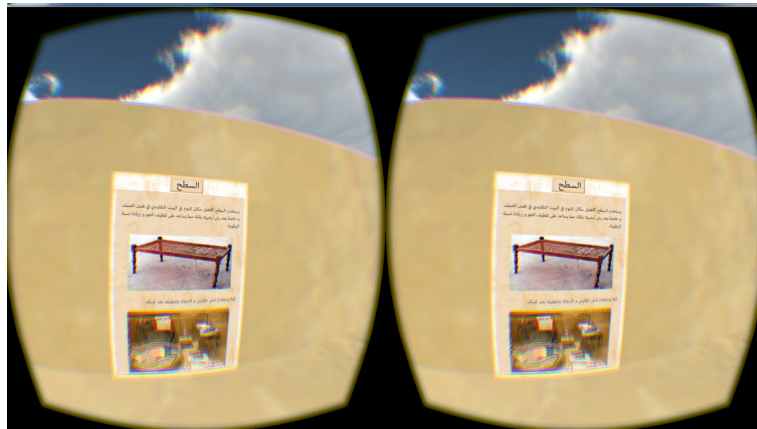
Virtual reality- The Urban



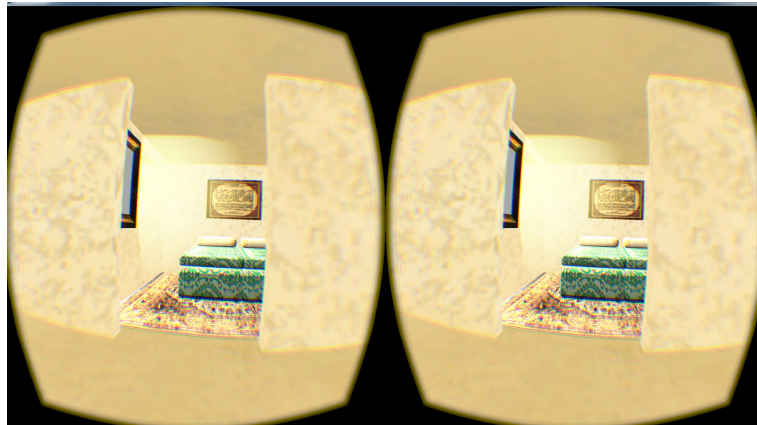
Virtual reality- The Urban



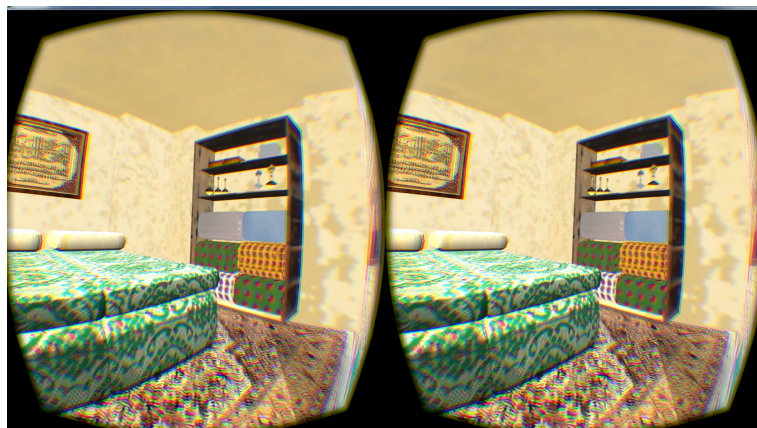
Virtual reality- The Urban



Virtual reality- The Urban



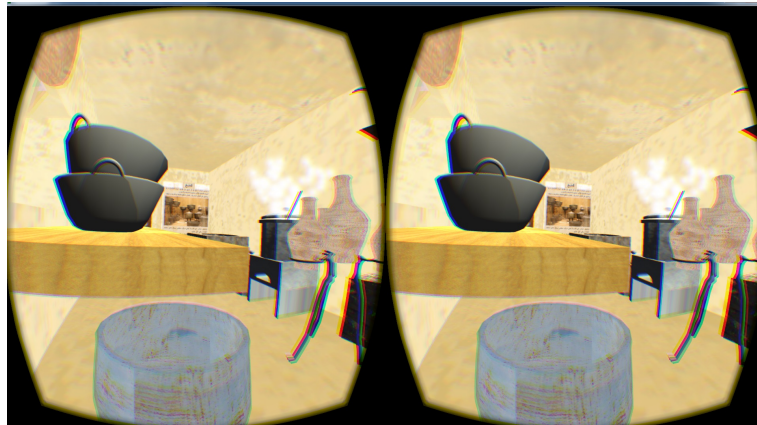
Virtual reality- Building



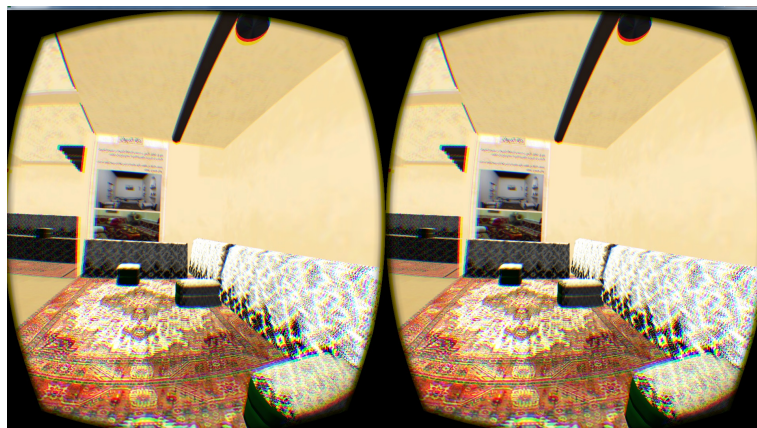
Virtual reality- Building



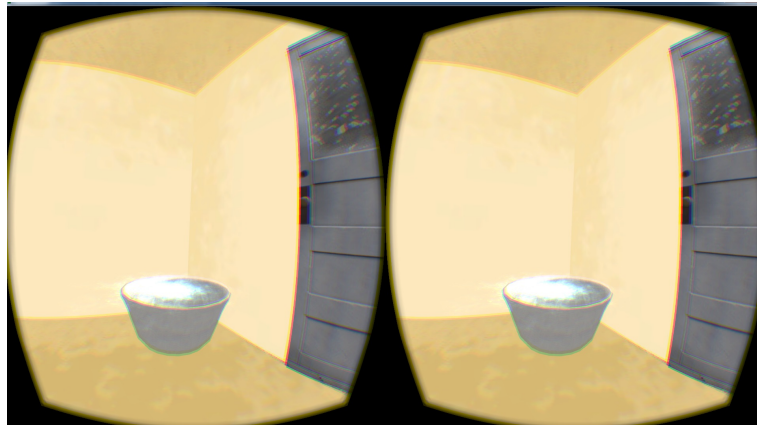
Virtual reality- Building



Virtual reality- Building



Virtual reality- Building



Virtual reality- Building

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