THE DEVELOPMENT OF AN INTERACTIVE VIRTUAL ENVIRONMENT FOR HISHAM PALACE IN JERICHO, PALESTINE

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Abstract
This study aims to introduce Virtual Reality (VR) techniques as a tool to develop an interactive environment for cultural heritage sites in Palestine; these sites have their own specific problems and challenges, which have significantly affected most of the existing sites and cause their continuous deterioration. The virtual replicas of these sites and landscapes can act as a medium for their preservation, documentation, interpretation and intervention, assisting in education, tourism and an increase in public awareness regarding their significant value. For this purpose, Hisham Palace in Jericho was chosen as a case study. The historical layers of Hisham Palace were studied and visualized using advanced 3D visualization techniques by applying a five-step approach to analyze and model different elements of the palace to assemble them at a later stage. This approach was implemented due to the critical condition of the physical remains and the insufficient literature on the history of the palace. As a result, an initial 3D virtual reality model was obtained, presented and discussed in a 3D immersive environment at the Virtual Reality Lab (VR Lab) at Birzeit University.

Keywords: immersive media; virtual reality; interactive environment; 3D modeling; Hisham Palace; Palestine.

INTRODUCTION

Palestine, located in the heart of the Middle East, has always been one of the major cultural and religious centers for mankind. Over 6000 archaeological localities have been identified in the West Bank and Gaza Strip, and more than 190 major sites have been excavated (Greenberg and Keinan, 2009). These localities have diverse values, contributing to the cultural history of the region from prehistoric times until today. A review of the development of conservation strategies for cultural and natural heritage sites during the British, Jordanian and Israeli periods shows that these authorities did not show any significant consideration for heritage sites and that most or even all of the planning activities ignored the existence of historic as well as distinct and valuable natural resources (Abdelhamid and Amad, 2005). This oversight caused incalculable losses of important material through illegal trade and direct destruction

Hassan and Salem (2008) stated five main challenges facing the historical sites in Palestine: 1) The destruction of the sites through deterioration, erosion, heavy vegetation, architectural collapse, as well as damage due to animals and human plundering; 2) Illicit excavations of archaeological sites as a source of income; 3) Urban expansion and building activities that gradually threaten the major sites; 4) The impact of the on-going construction of the separation wall between Palestinian Territories and Israel, bypass roads and new settlements on the historical landscapes and historical sites; and 5) The absence of strategies for the preservation, conservation and protection of historical sites. A recent study by Daoud (2012) added two more challenges: 1) The age of the existing laws, which are very old, primarily depend on the British Mandate legislations and do not protect the entire set of cultural heritage components (this factor also includes the inability of the executive authorities to implement the existing laws regarding the cultural heritage); and 2) The lack of financial resources, of appropriate capacity building, community awareness and of a comprehensive database for all cultural heritage components all over Palestine.

Since 1994, Virtual Reality (VR) has made it possible for anyone with a personal computer to access images of heritage sites that are displayed on the Internet. Recently, technologies such as 3D television, interactive computer games without physical controllers, 3D movies and cinemas and web-based virtual tours have become more available and accessible to the public. VR is no longer viewed as a field for specialists; rather, it has become a mainstream medium and a part of global pop culture. The major applications of this technology are in archaeology, cultural heritage sites, the military, visualization entertainment, manufacturing, augmented reality, education, tourism, employee training and medicine. However, the most familiar applications of virtual reality are in the spatial and architectural fields; in these fields, it is used as a tool for a ‘virtual visit’ of historical sites and for creating a walkthrough environment in architectural projects, i.e., to allow the user to explore a 3D scene in real-time. This improvement provides new tools for heritage site interpretation and presentation and for sustainable tourism (Lettelier, 1999).

In this regard, this study represents the first attempt to introduce VR as a tool for studying cultural heritage sites in Palestine. The primary objective was to conduct a pilot project in the field of cultural heritage, using Hisham Palace in Jericho as a case study. The purpose was to create an interactive 3D digital model for Hisham Palace that could be shown in an immersive environment using the established technical capabilities at the VR Lab at Birzeit University. This palace is a complex that was built in Khirbat al-Mafjar in Jericho under the Islamic Umayyad regime. The coherent unity of the palace site and the scarcity of studies have made it a suitable case study; these aspects will help in interpreting, verifying and presenting its various aspects. Another objective of this case study is to provoke public awareness of cultural heritage and further discussions about the future of the ancient sites and the need to further develop dynamic VR models of such sites. In the case of Hisham Palace, the data available from the site and written resources, despite their scarcity, could form a suitable basis for a general image that can be the subject of further studies and might be used for a comparative analysis with other architectural complexes built during the same time frame and in the same region during the Umayyad period.

A five-phase modeling approach was proposed (Figure 1). The datasets required for the modeling work were obtained through site visits, photos, performing necessary measurements and making use of the available written literature about the palace, with special emphasis on the interpretation work of Hamilton published in his book “Khirbat al-Mafjar: An Arabian Mansion in the Jordan Valley” published in 1959, to build the interactive 3D digital model. This modeling approach was proposed to manage the technical capabilities of the VR Lab in Birzeit University and the scarce sources of information available to the research team.

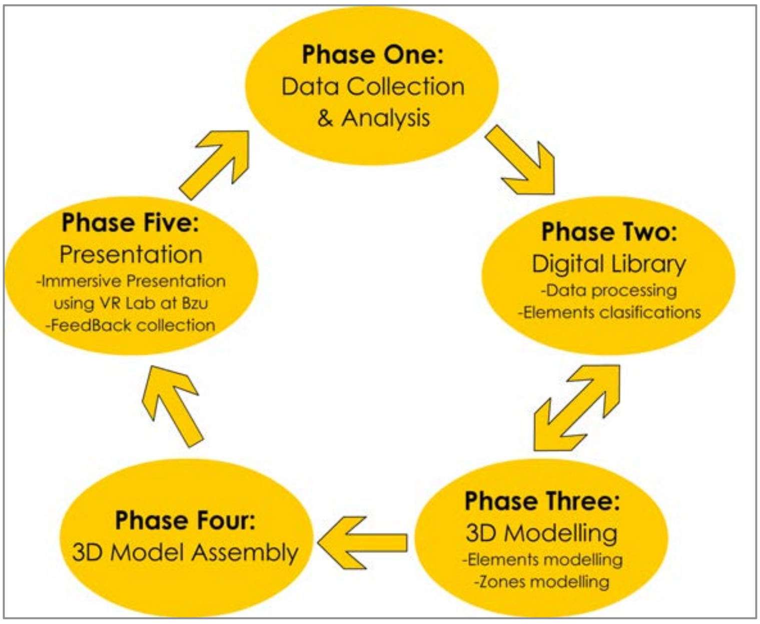


Figure 1: Illustration showing the proposed Five-phases modeling approach (Source: Researchers, 2010).

THE VIRTUAL REALITY LABORATORY AT BIRZEIT UNIVERSITY

VR technology is of great importance for Palestine, a country with rich cultural heritage sites and diverse landscapes that demonstrate the accumulation of historical civilizations and a diversity of geographical structure. Virtual replicas of such sites and landscapes can act as a medium for preservation, documentation, interpretation and intervention, allowing for education, tourism and an increase in public awareness regarding the significant value of the local heritage. As Jokilehto (1996) described, cultural heritage issues should be discussed as “a question of education and training, of multidisciplinary collaboration and of communication between the population and the decision making bodies”. For that reason, VR courses have been conducted at the Department of Architectural Engineering at Birzeit University since 2006. The main objective of these courses was to enable the architecture and engineering students to recreate engineering and cultural heritage virtual environments. For the further development of the VR culture, a VR Lab was established at Birzeit University in early 2010. It is the first of its type in the territories and was created as part of cooperation project between Birzeit University and the Norwegian University of Life Sciences; it was funded by the World Bank. In addition to the educational and training activities that take place at the lab, the lab has allowed several pilot projects to be conducted in various fields, including the cultural heritage field.

The VR Lab at Birzeit University was designed as a three walled U-shaped theatre with a capacity of 28 people. The display system is composed of three high-gain displays with a total display area of 10.68 m x 2.63 m (Figure 2a & b). The display structure represents an open cube with three equal projection walls: a central display and two side displays, installed with an angular shift of 135^{o} with respect to the central display. The displays form a fully immersive exocentric virtual environment for the complete set of VR theatre users. The environment represents an egocentric environment with full immersion for the leader, who controls the special interaction equipment from the central seat or from any point in the tracked space of the virtual environment. The image is projected using a front-projection passive stereoscopic configuration, which uses a set of two projectors; one for each eye (Figure 2c). Static polarization filters are used to polarize the left and right eye images from the projectors, and users wear polarized glasses to direct the left/right images into the correct eye (Belleman et al., 2001).

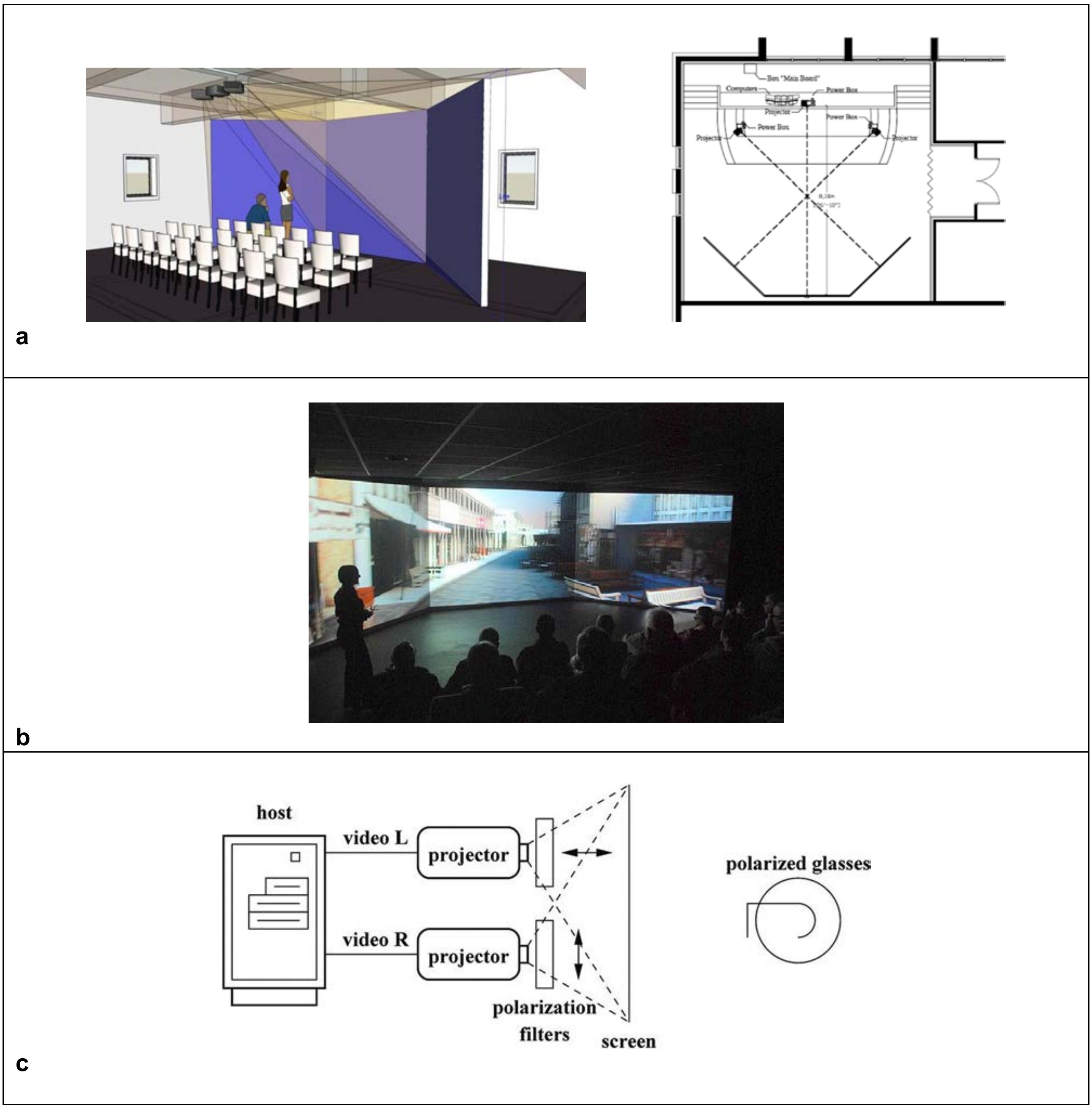


Figure 2: a) The Virtual Reality Lab at Birzeit University- Palestine: b) VR-Lab Environment and b) VR-Lab plan layout (Source: www.birzeit.edu), and c) Passive Stereo System (Source: Belleman et al., 2005).

Six DLP projectors are used to project the stereoscopic image on the left, central and right displays from three different positions. The sense of presence in the virtual environment is increased by the use of a high-quality 3D sound system composed of an audio control unit, a subwoofer unit and five speakers. The interaction with the virtual environment is an important attribute that defines the level of immersion, and it is implemented at the VR Lab using an optical tracking system of cameras. The position tracking of the lead user is performed by the installed cameras, which track a pair of stereoscopic glasses on which five optical sensors are installed. The manipulation of the virtual environment is accomplished using a tracked programmable X-Box controller and a wireless mouse. The position tracking system uses 15 black-and-white cameras to cover the predefined motion space. These cameras are installed on a circular section in the ceiling of the hall.

The Lab uses Eon Reality and VR4Max technology as its operating systems, and they run on a cluster of three workstations. The use of two operating systems provides more flexibility for handling various types of models and interactions. The primary workstation runs the processes that control the central visualisation display system, the tracking system and the control devices. The left and right slave workstations control the left and right visualisation systems, respectively. The workstations and all of the necessary control devices (keyboards, mice, screens and others) are installed in a special control area behind the theatre that is devoted to the system operator, who operates and maintains the system equipment and programs.

The VR Lab has a set of software packages for the development of VR applications. This software includes different format converters that allow 3D models generated by more than 15 3D design tools to be imported into the VR development environment. Examples of these tools are Maya, Solid-Works and 3D-Max. The software packages also include a library with over one hundred VR applications and their source programs. This library is used as a demo application for learning VR application development. An SDK package is also supplied to develop new VR entities that use programming languages such as JAVA, C^{++}, Visual Basic and others.

VR TECHNIQUES FOR THE PRESERVATION OF CULTURAL HERITAGE SITES

Cultural heritage sites are sensitive spatial fabrics that are constantly in inevitable physical flux and their documentation not only describes the context in which the materials were found but also acts to monitor the remains of past human activities. Haddad and Akasheh (2005) argued that the documentation process, which may be undertaken as an aid in various activities, such as the protection, identification, monitoring, interpretation and registration of stolen historical objects, can benefit tremendously from the various modern techniques that are currently available, especially from virtual reality technologies. Hassan (2002) explains that conventional methods of documentation such as photographs, physical models, text materials and drawings, among others, create an incomplete image of the settings of cultural heritage sites and that 3D-digitalised models provide a virtual copy of the actual settings. These copies make it easier for users to fully observe and understand these settings interactively and dynamically and provide a comprehensive presentation for the historical debates of archaeologists, and these copies are usually presented in a written media and technical illustrations.

The use of VR technologies as part of the process of presenting and documenting cultural heritage sites has become a very successful technique worldwide. These technologies enable cultural heritage sites, which, if they still exist, are often inaccessible to the public, to be recreated extremely accurately so that the recreations can be published in various media. Thus, this visualisation makes it possible to visit a historical place virtually, anytime and from anywhere with freedom of choice in movement and observation. VR provides a full walkthrough experience that shows the complete state of the site and provides a workspace for presenting future development projects in historical places. Additionally, VR provides a testing environment for the study of a wide range of historical and future concepts about that space.

Significant studies have emphasised the added value of using 3D and VR models for communication and learning. One of the earliest studies on this subject was conducted by Pimentel and Teixeria (1995). This study aimed at evaluating the potential of VR for education and emotional satisfaction in a simulation of the real world at the Computer Museum in Boston. Their observations showed that people spontaneously prefer to learn through an interactive experience rather than reading text.

In addition, web-based virtual tour applications constructed by 360º panoramic images have started being used extensively all over the world, including for cultural heritage sites. The effectiveness and usability of these tours were discussed by Bastanlar (2007) and Villaneuva et al. (2004). Example studies of the 3D reconstruction of cultural heritage sites were performed by merging image data with the output of a 3D laser scanner (Guarnieria et al., 2004; Kadobayashi et al., 2004; Conforti & Pinto, 2004), where a 3D-scanner technology was developed to scan the environment and add colour information to generate the 3D model. However, the necessary equipment is still very expensive, and capturing the 3D data and post-processing is very time-consuming.

In a study at the Ename Archaeological Museum in Belgium, Pujol and Economou (2007) indicated that VR offers the possibility of reconstructing and manipulating elements and historical processes that can no longer be seen. The study further concluded that VR is attractive, motivational and useful for describing content such as objects and processes. A later study by the same authors, Pujol and Economou (2009), undertaken for the Museology Laboratory of the University of the Aegean at the Foundation for the Hellenic World in Athens (Comsos), investigates whether VR is suitable for learning about historical sites and historical cultural heritage settings. This study included a qualitative and quantitative analysis of the gathered data, which confirmed that VR allows for a different type of learning and communication. A recent comparative study using interactive and VR systems in museums for cultural heritage sites by Michael et al. (2010) shows that interactive exhibits, including VR exhibits, have been rated higher than traditional learning methods for communication and learning about cultural heritage sites.

Zara (2004) presents various issues addressing the presentation of cultural heritage objects in a virtual space, arguing that attention is being paid to the visualisation approaches for a wide audience, i.e., techniques targeted to the web. He discussed examples and practical experience from the design and implementation of the EU project Virtual Heart of Central Europe to show that the web-based presentation of three-dimensional scenes requires specific user interfaces.

Virtual environments for cultural heritage sites have been created regionally and internationally for documentation and presentation purposes. Examples of such projects are a real-time simulation model of the Herodian Temple Mount (Figure 3a) and the Rome Reborn project (Figure 3b). The real-time simulation model of the Herodian Temple Mount was developed jointly in 2001 by the Urban Simulation Team at the University of California-Los Angeles (UCLA) and the Israel Antiquities Authority (2012). Although this model consumed two years of hard work, a non-realistic model was created because there are no remains of the temple, leading the model to be built on predictions and historical theories. Rome Reborn was completed by a group of students and professionals under the supervision of University of California- Berkley in the USA and represents the high end of virtual modelling for a walkthrough experience. Although this product has produced fully detailed virtual spaces, the outcome is still non-realistic. However, a more realistic experience was achieved by montage, which converted the walkthrough experience into a movie (Frischer, 2008).

a b

Figure 3: Illustrations showing the applications of VR modeling in the field of cultural heritage: a) VR model for Herodian temple mount (Source: ust.ucla.edu) and b) VR model for Rome Reborn, (Source: http://www.romereborn.virginia.edu/).

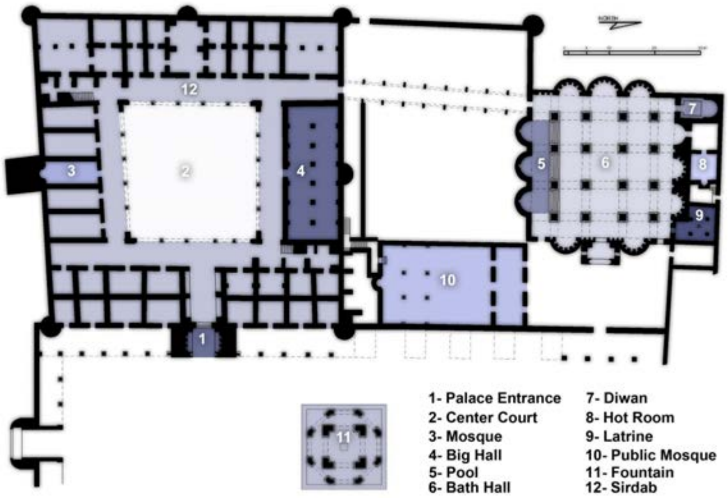
Zara and Slavic (2003) discussed three different approaches to cultural heritage modelling and presentation in the Czech Republic. The first example, Celtic oppidum Závist, represents a simple but efficient utilisation of virtual reality for archaeology. The next project, Virtual Old Prague, is a complex web-based application allowing for dynamic walks through virtual cities. Lastly, the EU project, the Virtual Heart of Central Europe, is an example of several cultural heritage sites that are thematically interconnected into a common virtual environment.

THE CASE OF HISHAM PALACE

The archaeological excavations carried out by Hamilton in the 1930s and 1940s identified the ruins at *Khirbat Al-Mafjar* as a palatial complex built during the Umayyad period in the first half of the eight century A.D. The site served as a quarry of cut stones for the people of Jericho before its identification. According to the Palestinian Ministry of Tourism and Antiquities (PMTA, 2008), the complex was attributed to the Caliph Hisham and is thus known as Hisham Palace. Hisham Palace is the most important monument from the Islamic period in the Jericho region (Figure 4).

Figure 4: Location of Hisham Palace and City of Jericho in the Palestinian Territories, Source: http://maps.google.com/

The palace was a countryside residence built either by the Umayyad caliph *Hisham Ibn Abd Al Malik* or by his nephew *Al Walid Ibn Yazid*. The palace is a complex of buildings and colonnaded courts constructed in a south-north direction within a perimeter wall that was never completed. The complex consists of a palace, a monumental fountain, a mosque and a thermal bath complex. Partial excavations in the area to the north of the complex revealed a series of rooms that were thought to be the living quarters of families in the landowner's service or a caravanserai. The luxury, complexity and lavishness of the palace are amply demonstrated by the recovery of fragments of poly-chromed frescoes, mosaic floors, marble, stucco walls, reliefs and sculptures that decorated the components of the palatial complex. The palace's mosaics and stucco ornaments are fine examples of early Islamic art and architecture, but the palace was destroyed by an earthquake before it was completed in 746 (Figure 5). The accumulated sand and debris resulting from this event helped to preserve the palace's sophisticated mosaic floors in the great bath hall, assumed to be one of the most important mosaics from that period, as is the case with the Tree of Life (also called the Tree of Human Cruelty), which is found in the guest room. Many of the carved stuccos and statues from the palace are displayed at the Rockefeller Archaeological Museum in Jerusalem.



a

b

Figure 5: Hisham Palace Complex in Jericho, Palestine: a) The Palace complex plan prepared by Hamilton in 1959 (Source: ArchNet- www.archnet.com) and b) The ruins of Hisham palace in Jericho city, (Source: Researchers).

The current situation of the palace is very critical in terms of spatiality, historicity and physical condition. The only existing elements are several walls of the ground floor and several columns in the palace and the bath hall; there is nearly nothing left from the monumental fountain. Most of the frescoes, reliefs and sculptures are no longer present. The mosaic floor in the bath hall is still covered with sand for preservation purposes. The famous star in the palace courtyard, which was a window in the pediment of the eastern wall of the upper floor, was rebuilt and placed in the centre of the space after the excavations. The reinforced concrete columns and the truss roofing on the guest room at the bath complex were added by the Jordanian Department of Antiquities prior to 1967. All of these factors create an evoked and incomplete understanding of the spatial configuration of the palace and distort the historical and architectural characteristics of the most important Umayyad monument in the region. The book "*Khirbat al-Mafjar*: An Arabian Mansion in the Jordan Valley" written by Hamilton in 1959 presents the original situation of Hisham Palace using written material, detailed illustrations for the artistic features, two-dimensional architectural drawings, photographs, perspectives and isometrics, as envisioned by the writer. In four chapters, the book discusses in detail the spatial configuration of each part of the palace, including the palace, the bath, the forecourt, the pool and pavilion and the mosque. The book has another four chapters that discuss the works of art in the palace, including the carved stone works, the carved plasters, the paintings and the mosaic floor of the bath. While the book is considered to be the most important work written about the palatial complex, its style is very complicated, and it fails to provide a comprehensive appreciation of the spatiality and historicity of the palace.

Many development projects for the palace have been proposed by local and international architects; in particular, projects have been proposed for the bath hall roofing system to reveal the mosaic floors. However, there is a condition of uncertainty regarding the visual impact that these projects may have on the sensitive fabric of the palace. Therefore, VR techniques can be used for the documentation, presentation and experimental investigation of the different historical layers of Hisham Palace.

THE DEVELOPMENT OF A VR-MODEL FOR HISHAM PALACE

The 3D digital model to present the original layout of Hisham Palace was created by adopting the proposed five step approach: data collection and analysis, the use of the digital library, 3D modelling, model assembly and presentation using virtual reality and feedback (Refer to Figure 1).

Data Collection and Analysis

The data collection and analysis step was necessary for implementing the different phases of the model, which uses both primary and secondary data. The primary data were obtained from site visits by taking high-resolution photos and measurements of the different elements and spaces available at the site such as uncovered architectural details and the mosaic floors. The secondary data were obtained from archived sources, mainly the recent digital CAD survey map for the palace site, which is available at the Palestinian Ministry of Tourism and Antiquities; the digital copy of the plan prepared by Robert Hamilton, which is available at the ArchNet website (Islamic Architecture Community; www.ArchNet.org); and the drawings and illustrations available in Hamilton's book, which were scanned and digitised to be used in the later phases. The individual primary and secondary data required specific methods of processing and analysis.

There were two site visits held on February 15th and May 23rd, 2010, in which 685 high-resolution photos were taken to document every element of the site. The second site visit coincided with the periodical maintenance process for the hidden mosaic floor in the bath hall, which makes them visible and thereby enabled the research team to photograph these authentic elements. All of the photos, including these of the mosaic and of different elements such as column capitals, stone works and motifs were processed using photo rectification or perspective rectification with Adobe Photoshop software to convert high-resolution images of the perspective scenes into 2D texture materials, which could then be used for texturing different elements of the VR model in the later phases. Another digitised function used by the research team to process the photos was the photo-patching process, which stitches photos together for the purpose of obtaining a complete wide view of the structures of the palace, similar to creating a panoramic view using digital processes. The photos taken during the site visits were also used as a reference to determine the dimensions of different elements of the palace, as it was impossible to measure every part of it. Additionally, these photos were used to characterise the internal and external elevations of the different structures at the palatial complex.

The measurements of different elements of the palace were used to check the correctness of the measurements provided by the survey map and the digital plan. These measurements were important in the modelling phase because they were converted into 2D digitised drawings using Autodesk AutoCAD software to provide precise geometrical references and to define proportions and characteristics in the modelling phase.

However, the lack of many details at the site due to the misuse and relocation of several elements of the palace, vandalism throughout history, which drastically changed the authentic character of the palace, and the limited tools available locally for high-quality site scanning made it very difficult for the research team to depend on the current conditions of the site to provide a model for the original layout of Hisham Palace. Therefore, the illustrated materials created by Hamilton were fully studied and analysed for use as a primary source, in addition to the photos processed earlier, for the subsequent phases.

The illustrated materials in Hamilton's books can be divided into three types: black and white images taken when the palace was discovered, architectural drawings and fully-detailed illustrations of several elements of the palace. Each of these types of material was processed using a different approach. The images were compared with those taken through the site visits to allocate any changes since the complex's discovery. The architectural drawings were scanned and digitised using tracing techniques with Autodesk AutoCAD software to be used in the modelling phase, which converts these 2D materials into 3D objects. The fully detailed illustrations of several elements of the Palace were scanned at high resolution and processed using Adobe Photoshop for use as textures in the model (Figure 6).

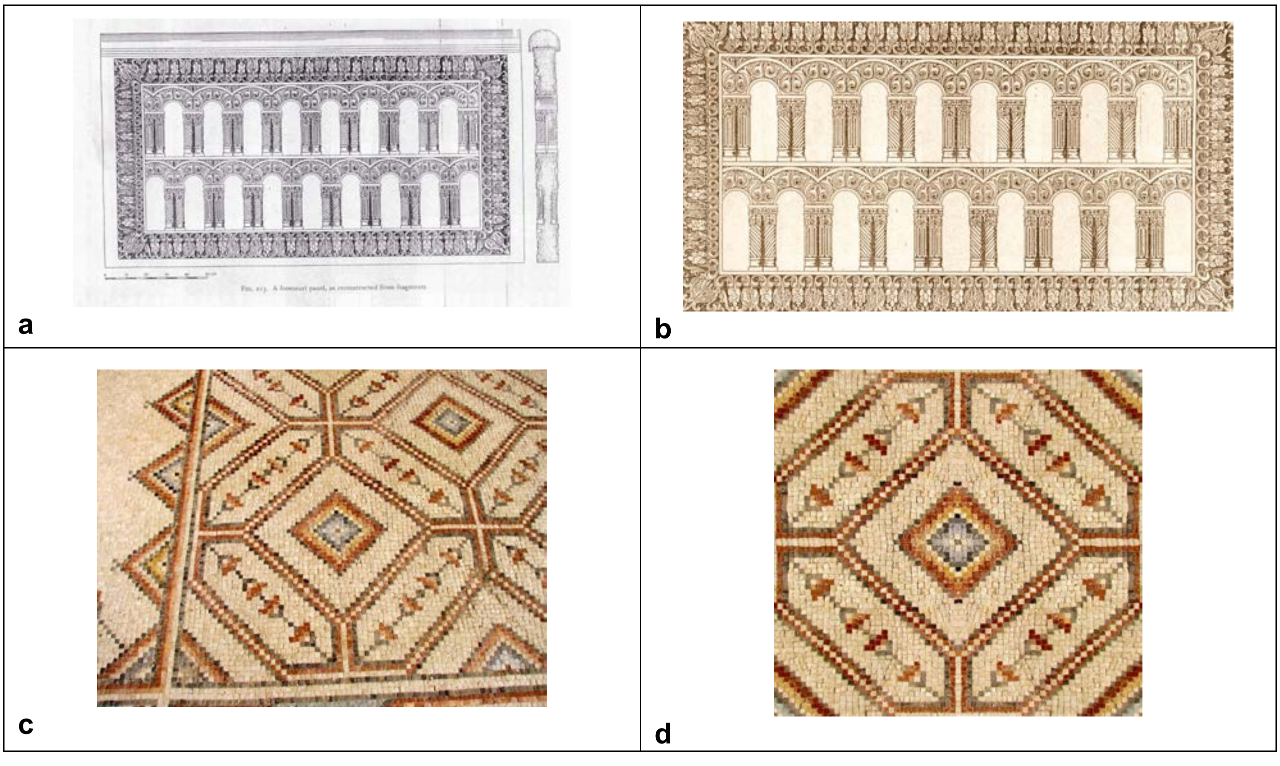


Figure 6: Sample of illustration conversion into photo-texture of some details: a) Original illustration by Hamilton of the palace parapet (Source: Hamilton, 1959), b) Processed illustration to be used in 3d modelling (Source: Researchers, August 2011), c) The photo image of the ceramic floor before rectification, d) The photo image after rectification (Source: Researchers, August 2011).

The Digital Library

The analysed primary and secondary data were overlapping and complement each other. The existing conditions provided a basic understanding of the spatial configuration of the palace, while

Hamilton's book completed this understanding and provided an integrated conception of the spatiality of the palace through its illustrations. These two primary references allowed the research team to adopt an assembly approach, dividing the entire palatial complex into zones, which needed to be defined and organised within a digital library.

Figure 7: Samples of the 3D elements available in the Digital Library, (Source: Researchers, 2011).

For this purpose, the research team decided to unify the repeated elements such as the columns, column capitals, arcades, watchtowers, domes, niches, windows, vaults, mosaic panels, carved plasters, stone works and statues to obtain a reasonable file size that would be easily navigated at the VR Lab at Birzeit University. These repeated elements of the palace were modelled and textured using Google Sketch-Up software using processed data from either the site or Hamilton's book; these were then saved in the digital library to be used in the later phases (Figure 7). All of the details were coloured sandstone to match the palace and maintain consistency with the model. The library was of great importance to the research team because it was dynamic and allowed for continuous updating throughout all of the phases of the VR model.

The 3D Modelling

These 3D dynamic components of the digital library were used to assemble the different zones of the complex: the palace, the forecourt and the fountain, the bath hall and the mosque with the enclosed garden, in a manner similar to the assembly of Lego construction toys (Figure 8). The library also contained the raw material of each component that was obtained either from the site or Hamilton's book to be used for any additional required editing throughout the project. The Google Sketch-Up software was used throughout the project, because it is a dynamic and efficient application. Many historical sites have been modelled using this software worldwide and the results have been efficient and realistic. Google Sketch-Up has also been taught at the virtual reality courses at Birzeit University for use in simulating the old town of Birzeit and the Nablus historic centre.

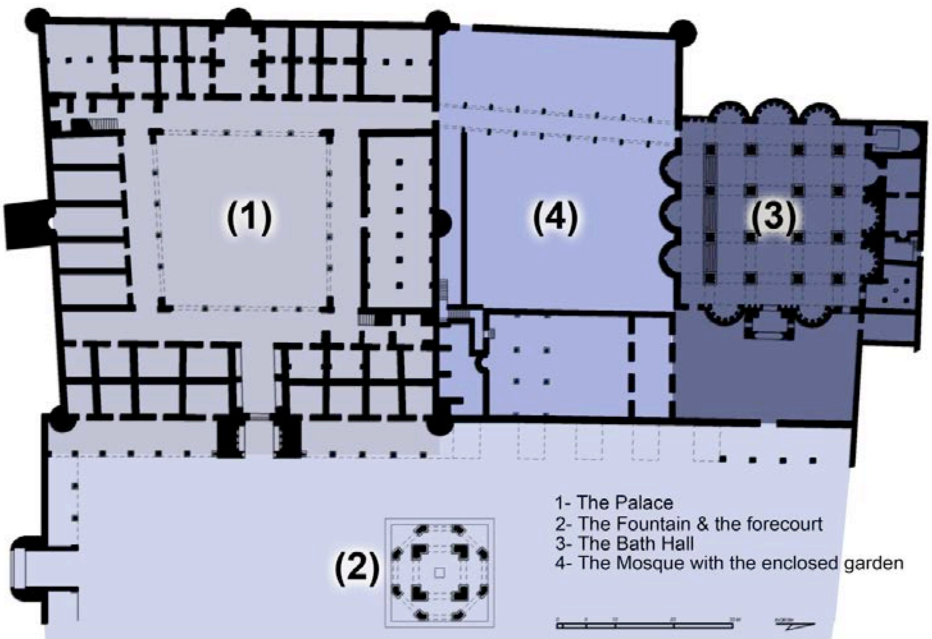


Figure 8: Digital Plan of Hisham Palace Complex, showing the four zones that will be used in the VR model. (**Source:** Researchers, based on Hamilton plan available at ArchNet- Islamic Architecture community- www.archnet.org).

The research team began with the internal court of the palace, as there were two complete facades provided by Hamilton for this component. The other two facades were reconstructed repetitively. The modelling process at this point extended from the inside of the palace to the outside, where a study the Umayyad architectural style in the Levant region led to the modelling of parts that were not discussed in Hamilton's book and that have been destroyed, such as the watchtowers, the main gateway, the wall of the forecourt and the colonnaded path that connected the palace with the bath.

The research team faced many dilemmas during this phase, as there are no data available for some parts of the Palace, for instance, the back garden of the mosque and the Vault (*Sirdab*), which was the private bath of the caliph in the basement of the palace. These sections were both modelled only from the outside for two reasons: there were no data for their interior and the research team was not allowed to enter the *Sirdab* by the guards of the palace. However, there were some parts that were fully modelled due to the comprehensive data provided by Hamilton, such as the Bath Hall and its gateway and the monumental fountain at the forecourt. These parts have detailed architectural drawings such as plans, sections, elevations and isometric views provided in Hamilton's book. Moreover, the research team was careful to produce reasonable file sizes throughout the modelling phase using geometry reduction techniques. In this phase, each zone of the palatial complex was modelled, textured and saved in the digital library to be assembled using Hamilton's architectural drawings to obtain the VR environment of Hisham Palace in its authentic original situation (Figure 9).

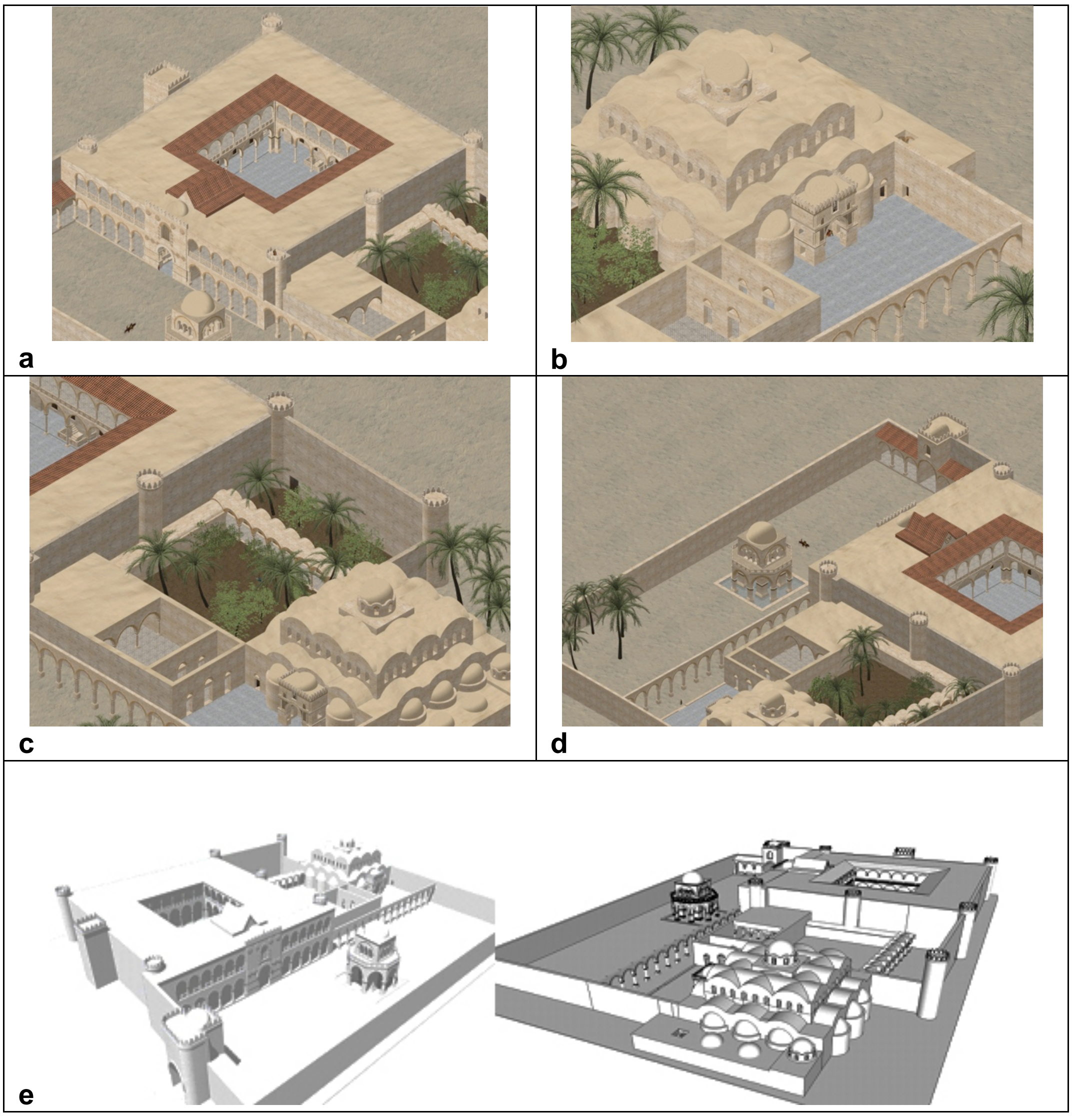


Figure 9: The VR Models of the Four Zones in Hisham Palace: a) The Palace, b) The Bath Hall, c) The Mosque & the enclosed garden, d) The Fountain & the Forecourt and e) 3D initial views for the entire complex, (Source: Researchers, 2012).

The Modeling Assembly

During the model assembly phase, the modelled zones of the palatial complex from the digital library were put together using Google Sketch-Up software guided by the digital copy of the plan prepared by Hamilton. The file however, was very large, and it was very difficult for the research team to navigate within it. To obtain control over the final appearance of the objects, each object from the digital library was separately optimised and the polygons were reduced. The count of the polygons became 50% of the original (1.8 million polygons rather than 3.6 million). Figure 10 shows an example of a pillar capital with the polygons and faces count before and after the optimisation process. Additionally, at this phase, the textures were converted from JPG and TIFF formats into DDS format for better system-memory performance at the VR Lab. The result of this phase was a virtual environment for the original spatial settings of Hisham Palace as conceived by Hamilton.

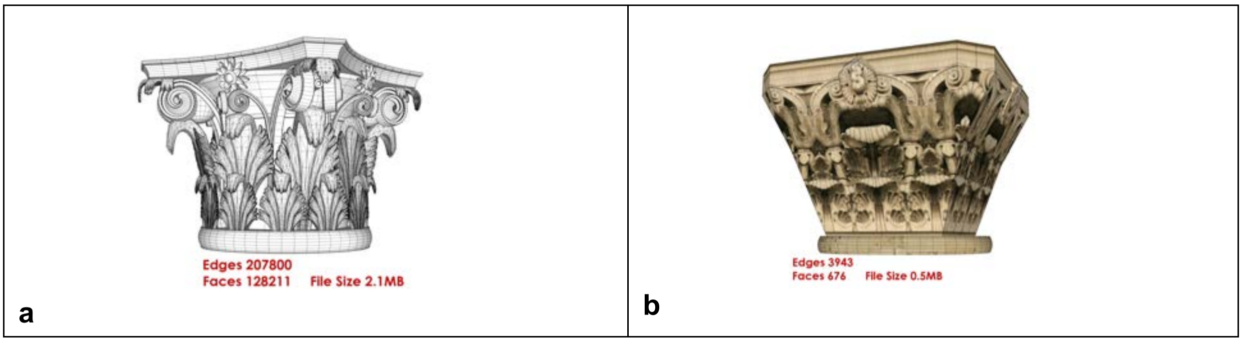


Figure 10: Representation of polygon reduction in modelling the different elements in the palace the case of a column capital: a) fully modelled capital and b) reduced model of the capital, (Source: Researchers, August 2011).

To present the VR model of the Palace, Autodesk 3D-Max and VR-4Max software were used to run simulations in real-time and immersive media, as they are supported by the VR Lab at Birzeit University. The model was exported to Autodesk 3D-Max software, where other further optimisations and geometry reductions were conducted. The geometry reduction attributes at this phase depended on the position of elements by eye, as distant parts and elements were rendered using the fewest number of possible polygons. The VR model was then initially tested for presentation using the VR-4Max plug-in; this test was of great importance for locating errors and modelling mistakes while running the simulation. Later, final editing and tuning were performed to obtain a more immersive experience. The user-camera settings, lighting properties, environmental elements and optimisation attributes were optimised at this point for better simulation quality (Figure 11).

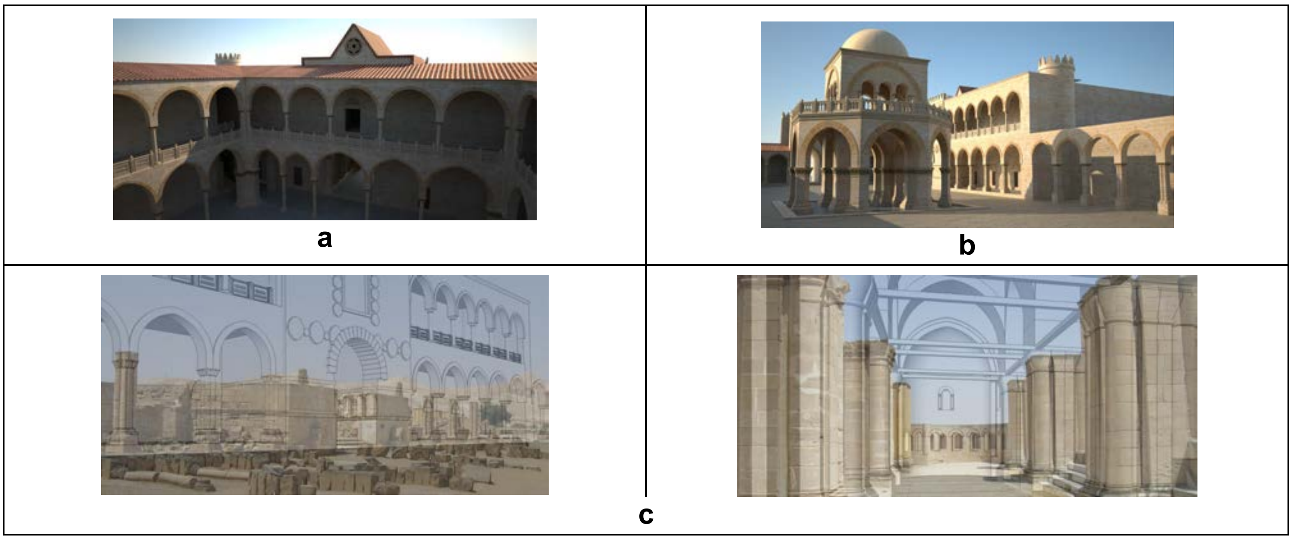


Figure 11: Hisham Palace: Rendered shots of the interior court and the forecourt according to Hamilton assumption: a) The interior court of the Palace, b) The fountain and the forecourt and c) Interior shots for the main palace door, (Source: Researchers, August 2012).

The Model Presentation

The VR model of the original spatial settings of Hisham Palace was presented using two movement modes: the fly mode and the walkthrough mode. These two modes enable the end-users to approach the different parts of the palatial complex and roam freely around and above them. Several presentations were conducted with participants from the universities, the public sector and the governmental sector. These presentations provoked discussions connected to the correct interpretation and demonstrated that the method has the potential to be used as a collaborative visual tool for communication among various disciplines: scholars, architects, archaeologists and historians. Starting with the first presentation, feedback was collected from the end users, who discussed some incorrect assumptions in Hamilton's vision, such as the alignment of palace's columns and the roof tiling in the interior court of the palace. This feedback also pointed out that the forecourt and the fountain area still need to be studied for a proper configuration of its context; primarily, the access to the servant block assumed to be located at the eastern part of the complex as well as to the main garden of the palace located at the eastern part of the complex. Additionally, some scholars have pointed out that Hamilton's vision adopted an Orientalist perspective, as he had conceived of Hisham Palace as an Andalusian Umayyad structure, which is very different from the Umayyad structures built in the Levant deserts (Figure 12), such as the Great Umayyad Mosque in Damascus or the Al-Aqsa mosque in Jerusalem, including the use of pitched roofs, their tiling and the form of the pediment in the interior court of the palace.

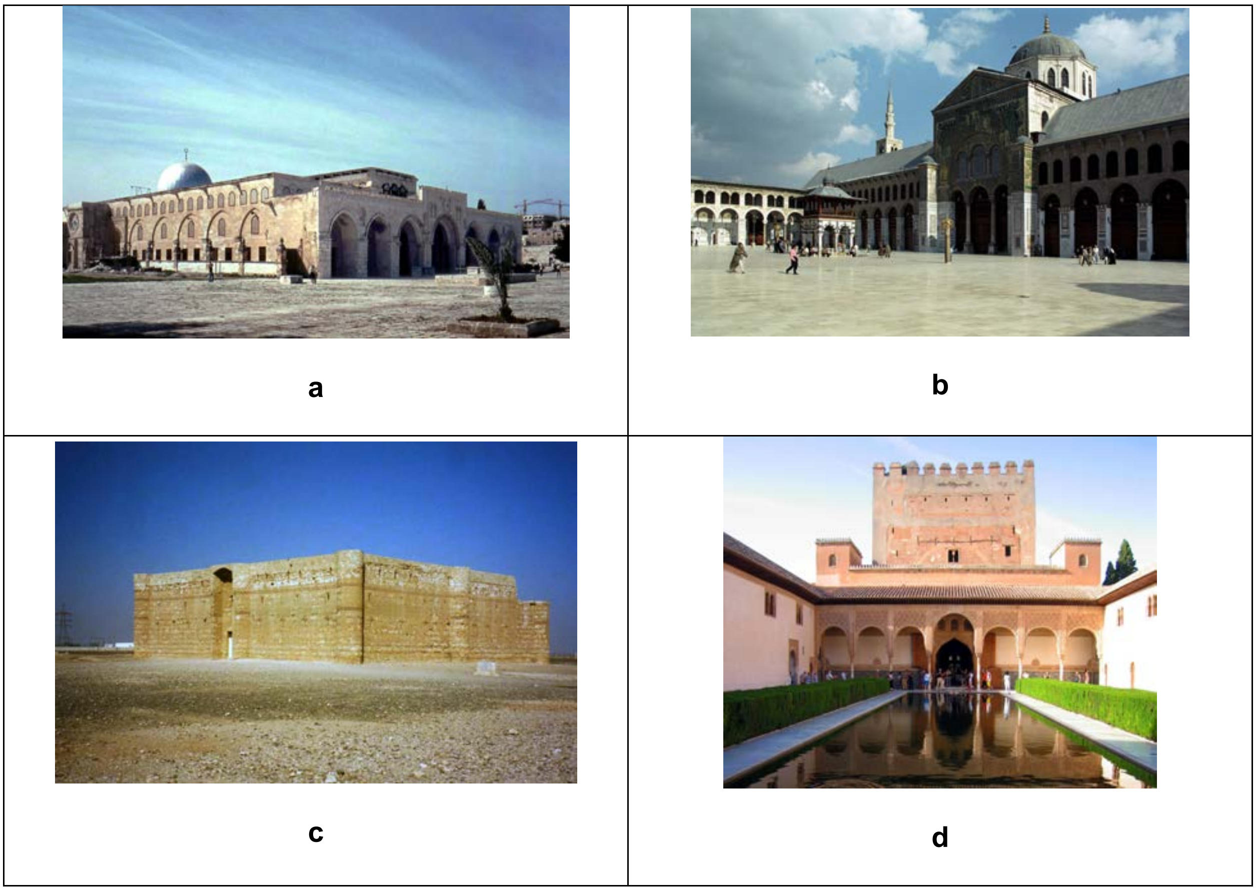


Figure 12: Umayyad architecture built in the Levant region and Andalusia: a) Al- Aqsa Mosque- Jerusalem (http://en.wikipedia.org/wiki/Al-Aqsa_Mosque), b) The Umayyad Mosque- Damascus (http://en.wikipedia.org/wiki/Umayyad_Mosque), c) Qasr Al-Harraneh – Jordan (http://www.starstourdirect.com/tours/Hammat%20Ma'in/qasr_al_kharaneh_dvh.jpg) and d) Alhambra Palace – Granada (http://en.wikipedia.org/wiki/Alhambra)

Furthermore, the discussions were very useful for defining the future steps for the development of the VR model for Hisham Palace. One example is the consideration of further development of a dynamic model that could include different scenarios based on various interpretations among archaeologists and historians. In this regard, the model achieved the primary objectives of this study: the construction of an interactive virtual environment that generates public awareness and provokes serious discussion among different groups.

One final note, while the other examples reported in this study (Herodian Temple Mount and Rome Reborn) focused on the visualization of a final 3D model based on a scenario showing a specific historical layer, our approach was directed towards an investigative process and learning through the development of the immersive, interactive and dynamic VR modeling of the historical data. The presentation of the VR model in a large-screen immersive environment provided the possibility of a live experience of the site and it brings historical details closer to the subject's minds. The interactive approach provided the ability to navigate anywhere and anytime while presenting the model. In addition, the discussions created among the planners, historians and archaeologists were used as a point of departure for the further development of the dynamic VR model of the palace. The dynamic features means that different scenarios could be elaborated and shown based on various interpretations, primarily among archaeologists and historians.

CONCLUSIONS

Virtual Reality technology was used in this study as experimental tool to investigate the processes and potential to study, document and communicate information on historically important sites in Palestine. In the absence of strategies and resources addressing historical sites in Palestine, virtual replicas of cultural heritage sites and landscapes could become a medium for preservation, documentation, interpretation and intervention, education, tourism and raising the public awareness regarding the significant value of the local heritage. In this context, this experiment represents a pioneering case in Palestine, and the outcome of this project will hopefully inspire other possible uses of VR for presenting models reflecting the dominant ideologies and cultural heritage.

Despite the amount of available data, it was possible to provide a general vision of Hisham Palace. The work and the methodology used for the creation of an interactive virtual reality environment for the palace proved to be within the technical capabilities of the VR Lab in Birzeit University. Because the VR model of the palace represents only a visual experience of the spatial configuration of the site, the results prove that there is still a need for a team of archaeologists, historians, architects, urban designers and 3D artists to execute the work professionally and efficiently to provide a thorough rendering of the different historical dimensions of this palace and to provide the entire community with a comprehensive understanding of the spatial configuration of the palatial complex. Until these studies are conducted, the palace will be modelled through a prototyping approach, using the elements available in the 3D library. Indeed, the virtual environment presents a potential tool for the further creation of an experimental environment to demonstrate the on-going or future rehabilitation and conservation projects at the palace proposed by local and international institutions, architects and designers.

Lastly, in contested regions, such as Palestine, this method may include a political dimension. The study of the history of these areas should take precedence by means of focusing on studying specific historical layers and reconsidering other layers. However, further research studies are needed to investigate and measure the local community acceptance in terms of using this type of technology and to determine whether this technique could really make a difference in elevating public awareness. This empirical study is planned for the next phase of this project work.

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