

Using Metaverse to Rebuild Non-reachable or Ruined Heritage Buildings

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Abstract: Virtual 3D models are seen to be of great use in 3D Documentation of historical buildings as well as in teaching Islamic architecture history courses in Architecture Schools. Heritage Buildings which urgently need architectural documentation may be generally classified into two categories, Non-reachable and Ruined buildings. This paper presents a scientific and practical methodology to create fully immersive interactive 3D Virtual Reality models in *Metaverse* of either cases based on new fully immersive virtual reality technologies supported by Photo-modelling techniques. The research aims to apply the proposed method to generate virtual 3D models of two case studies; the first, the Non-reachable Al-Aqsa Mosque, in Jerusalem, Palestine, and the second is the Ruined Badr El-Din Mosque in Al-Sayeda Aisha area, in Cairo, Egypt. In Documenting Non-reachable Heritage Buildings, The research produces a complete virtual copy of “*Al Aqsa Al Sharif Mosque Compound*”, with all its Islamic and Christian monuments and gates. In Documenting Ruined Heritage Buildings, The research produces a complete virtual copy of “*Badr Edeen Elwanaey Mosque*”, created in details depending on researcher proposed designs, then the walls, ceilings and floors of this model were covered with texture driven from the Architectural Designs made by the researcher, which depends on elements of the comparative analysis study for the Four Mosques in the same era as the ruler and by the same architect.

Keywords: Metaverse, Archaeological Documentation, Non-reachable and Ruined Buildings, Close Range Photogrammetry, Information Technology, Virtual Reality

1. Introduction

After the COVID-19 pandemic, and the impact of it on Education generally, [30] and on Architecture Education specially [6, 9, 11, 15, 26, 27, 30] people are looking for a virtual world in which to escape from the horrors of reality, an idea that has re-emerged strongly with the world of "Metaverse."

The term "Metaverse" appeared from few months, it consists of the prefix "meta" (meaning beyond) and "verse" (from "universe"); the term is usually used to describe the concept of a future iteration of the internet, consisting of a continuous, shared, 3D virtual spaces that are connected in a perceived virtual universe. Elements of the metaverse include video conferencing, gaming, email, virtual reality, augmented reality, social media, and live streaming. The metaverse system considers user-centric elements including Avatar, Content Creation, Virtual Economy, Social Acceptance,

Security and Privacy. Metaverse does not have practical applications till now but it is directed mainly towards Games & Entertainment. [12, 21, 31-34]

The Palestinian land in general, and the city of JERUSALEM (Al-Quds) and its Islamic heritage in particular, have suffered from the violations of the Israeli occupation, which obliterated the Arab-Islamic identity of the city. Moreover, the occupation is trying to demolish Al-Aqsa Mosque by digging under the Grand Mosque. All this aims to distort the historical facts and erase the Palestinian cultural heritage. Therefore, obstacles were always put in place to stop any restoration efforts. We did not have access to JERUSALEM (Al-Quds) to scientifically take Photos to generate a 3D Virtual model (Non-reachable), in this case study the research uses Photo-modelling techniques [5], 17, 19, 35, 36] to create models covered with textures suitable for use in Metaverse fully immersive virtual 3D models based on the images available in the existing references. And

we use also some techniques to control accuracy in large Heritage sites, these techniques are as follow:

- 1) Differential Global Positioning System [4] & Global Navigation Satellite System [10, 13]
- 2) Digital Image Processing
- 3) Change Detection Study [7, 13]

The second case study is the Ruined Badr El-Din Mosque in the Al-Sayeda Aisha area in Cairo, as this mosque was completely destroyed as a result of the 1992 earthquake leaving only the minaret and the walls of two facades. In view of the condition of the mosque, the researcher resorted to the Islamic Antiquities Registration Center to obtain drawings, studies, and photographs of a number of mosques that were erected during the same period as the mosque was built, in the same era as the ruler, and designed by the same architect. A comparative analytical study was conducted to reach a 3D Virtual model to be useful in presenting an interactive Environment in Metaverse to be used by the Permanent Committee of Islamic and Coptic Antiquities to take the right restoration decision.

2. Methodology

2.1. Theoretical Approach

Investigating the idea of METAVERSE, and the possibility to use it in Rebuilding Non-reachable or Ruined Heritage Buildings. Also a detailed study of fully immersive virtual reality technologies; using "Photo-modelling techniques" is conducted, in addition to investigating the historical background and the architecture of the two case studies.

2.2. Practical Approach

The practical approach comprised the following actions; using the already available photographs via photogrammetry and videogrammetry techniques, photo-modelling software (Photomodeller) to complete the missing parts of heritage buildings, image processing, 3d modeling using SketchUp or 3dmax software, then Exporting to *Unity Gaming Engine*, to create fully immersive interactive virtual reality models (to Scale 1:1) of these buildings. The research ends up with Conclusions & recommendations, and also points out to new horizons along the same research interests.

3. Results

In Documenting Non-reachable Heritage Buildings, a complete virtual copy of "*Al Aqsa Al Sharif Mosque Compound*", with all its Islamic and Christian monuments and gates, was built using the proposed method. A digital, 3D model was created for the architectural content of the site in details, then the walls, ceilings and floors of this model were covered with texture, drawings and writings on the walls, ceilings and floors of the real heritage. And in case of any real missing parts we use the old photos available in references, supported by photomodeler software to complete the missing model and cover it by available textures.

In Documenting Ruined Heritage Buildings, a complete virtual copy of "*Badr Edeen Elwanaey Mosque*", was made using the proposed method. Therefore, a digital, 3D model was created for the architectural content of the Mosque in details depending on researcher proposed designs, then the walls, ceilings and floors of this model were covered with texture driven from the Architectural Designs made by the researcher, which depends on elements of the comparative analysis study for the Four Mosques in the same era as the ruler and by the same architect.

4. Discussion

4.1. Virtual Reality and Its Applications in the Field of Archaeology

In the early 1960s, virtual reality sciences began to emerge as the development of modelling science. In the mid-1960s, the clearest idea of virtual reality was produced by Ivan Sutherland, when he wrote "The ultimate display" [18, 20]. In the mid-1980s, this science was developed and introduced directly into architectural applications by Brooks' Group of Researchers. [24].

At first, virtual reality applications in the field of archaeology start in entertainment and games fields; when some American companies begin to make inaccurate virtual models of some Pharaonic monuments in order to add them in some electronic games or websites for entertainment purposes [13]. When the idea succeeded in attracting huge followers to those games, the games greatly developed by using 3D modelling. Nowadays, the most important games which depend on virtual environments are;

1. Need For Speed (Underground 2),
2. GTA Vice City Program,
3. Delta force,
4. Medal of Honor,
5. Doom,
6. Grand theft auto V 2013
7. Assassins creed odyssey "Greece" 2018
8. Assassins creed origins "Egypt" 2017
9. Assassins creed unity "France" 2014
10. Mafia 3 2016
11. Watch dogs 1 2014
12. Watch dogs 2 2016

Afterward, the virtual reality applications were used by some entities interested in archaeology to introduce the original form of collapsed or demolished monuments in order to support and help the restoration or rebuilding operations (Example: *Notre Dame Cathedral in Paris Case _ Assassins creed unity "france" 2014*). Later, the applications were devolved to create virtual copies of the monuments that can be referenced in 3D documentation [13]. A project was prepared in which a realistic modelling of Nefertari's tomb in Luxor was made on computer by program which is displayed in stereoscopic form on curved Screen with 180-degree view angle, which makes the viewer walk inside the tomb in a way that is similar to the magnificent, accurate and realistic

walking inside the tomb. 3D modelling techniques are used to create an engineering model for the architectural structure of the tomb and all its details, then covers this structure by photos, drawings, and marks of the tombs' Ceiling, walls, and floors which makes the tomb building saved on the computer become in real way, so you can walk and approach form any part to see it more closely and accurately. The computers create sequential 3D images on screen and move it quickly which makes the images look like scenes and move so naturally. The documentation of Nefertari's tomb was made by huge work team of foreign experts from the Getty Institute of Archaeology (Italy) during the restoration project. The documentation was made on super computers contain 8 processors working simultaneously, when the price of this computer exceeded USD 1,000,000. Also, they use complicated programs which were available only to specialists and the work on this version take several years to be done [14, 29].

Furthermore, there were two projects were executed by Egyptian work team and with regular equipment available to any engineer; one of them was 3D documentation of Pashdo 3rd tomb in Luxor [12] while the other was 3D documentation of Banhasi tomb in Al-Matareya [13], but those projects were too small and consist of one or several rooms. So, it was necessary to try those programs on the big and complicated projects which consist of a large public archaeological site that includes many archaeological and architectural monuments with different shapes and sizes, to know how far we can execute the documentation with the human, and technical capabilities in Egypt [23, 28].

4.2. Jerusalem Case

Jerusalem is considered as one of the holiest and most famous cities which sacred by the followers of the three religions; Judaism, Christianity and Islam. Al Aqsa Mosque is the first of the two Qiblas and the third of the two holy Sanctuaries under Islamic Law. Moreover, the Dome of the Rock is the site that mentioned in Isra and Mi'raj journey and Church of the Holy Sepulcher is sacred by Christians. Many historical conflicts have occurred in attempts to control Jerusalem that led to the Crusaders occupation to Jerusalem and its liberation by the Arabic leader/ Salah al-Din al-Ayyubi, 583 H. For Israel, it wants to make Jerusalem a capital that only Jews can inhabit and the Israeli government is deporting Palestinians, and forfeiting their identity cards, lands, and properties and the Islamic and Christian sanctities. Also, the Israeli government demolishes the Arab neighborhoods and buildings, and expends in Jewish neighborhoods, settlements and buildings to create new demographic reality dominates by Jewish identity and destroys the Arabic and Islamic identity of Holy Jerusalem [1].

In the past, the entire "*Al Haram Al Sharif (Jerusalem House)*", including its facilities as the most important of which is the Dome of the Rock and Al Aqsa Mosque itself was called Al Aqsa Mosque. In addition, Al Haram Al Sharif has four closed gates and seven gates that are still in use.

These gates are: Damascus Gate - Dung Gate - Golden Gate (Sometimes it is called Gate of Mercy) - Jaffa Gate - Lions' Gate - Gate of the Prophet David - New Gate. [1]. The Mosque Compound is a large, high land surrounded by walls. Its length is estimated at 492 m from the west and 462 m from the east. As for its width, it is 310 m from the north and 281 m from the south. Its walls were surrounded from the inside by corridors, gardens and squares interspersed with various facilities, such as schools, fountains, domes and corners, some of them referred to the Umayyad era, and some were built in later eras. [3]. Among the most important heritage in Al Haram Al Sharif are the following: [16].

4.2.1. Al Aqsa Mosque

Al Aqsa Mosque is considered one of the most important facilities that established by Al Walid ibn Abdul Malik. This Mosque is located on the axis of the Dome of the Rock towards the south and adjacent to the southern wall of the Mosque Compound, however, the current building does not belong to the era of Al Walid. The origin of this building is ancient and Omar ibn Al Khattab built his first Mosque on it, then Abd Al Malik removed it and establishes Al Aqsa Mosque, which was completed by his son Al Walid. The Mosque was completely destroyed in 18th C as a result of a violent earthquake, then it was restored during the Abbasid Caliphate, then the Fatimids built the dome at the beginning of 11th C, after that the King Jesus son of the king Al Adel Al Ayyubi (1236 AD) re-established it, following that the Mamluks restored what the Crusaders had destroyed. It was recently restored during 20th C [2, 25].

The Length of the Al Aqsa Mosque from the inside is 80 m and its width is 55 m. The Mosque has seven corridors, including a central corridor surrounded by three corridors on the east and three corridors on the west. These corridors were established on 53 marble columns and 49 stone columns and at the top of the Mosque is a dome. The Mosque has eleven gates, seven of which are in the north, one in the east, two in the west, and one in the south. [1]. During the ruling of Salah Al Din, a marble prayer niche was constructed which is the large prayer niche that still exists, it is established on 583 AH / 1173 AD. In addition, the famous wooden pulpit that was made during the ruling of Sultan Nur Al Din Mahmoud ibn Zanki in Aleppo and Salah Al Din ordered to bring it to Jerusalem, and it is considered one of the best pulpits of Islamic architecture. It was burned when the Jewish settlers set fire to the Mosque on August 21st, 1979. [3].

4.2.2. Dome of the Rock

The Dome of the Rock is a polygonal construction, topped by a dome. It is a rare artistic masterpiece has the following characteristics:

- First: It is one of the oldest Umayyad shrines. It is the most ancient Islamic construction, which still keep its original contours, despite the additions and reforms made due to the earthquakes, notably the earthquake of 1016 AD.
- Second: It is the only Mosque characterized by its

octagonal shape and blueprint. It is a unique Islamic construction.

This dome was built on a sacred rock, with a length of seventeen meters and seventy centimeters, a width of thirteen meters and fifty centimeters and height of two meters. It is of a hard and not trimmed stone. It is barren and dark in color. This rock has its sacredness that goes

Third: back to two events. Firstly, Abraham intended to slaughter his son, as an offering to God. However, God redeemed him with a ram. That happened on this rock and in that location. The second event is the Mi'raj¹. Prophet Muhammad (peace be upon him) ascend to the heaven by Buraq², taking-off from this rock. [2]

The Dome of the Rock comprises an octagonal base. The length of every side of the octagon is 20.95 meters. This polygon surrounds an internal polygon, whose sides are 14.45 meters in length. Such internal polygon, in turn, surrounds columns raise the dome. The dome has a diameter of 20.44 meters and a height of 31.50 meters. It is composed of two wooden layers. The upper one is covered with lead sheets. 10200 sheets of gilded copper are glued to it. A layer of felt is placed in a wide vacuum between both layers, in order to reduce the intense heat of the summer. The Dome of the Rock has four main gates. They are double gates that made of wood covered with lead sheets. These gates are as follow:

1. Eastern Gate: positioned next to in the direction of the Dome of The Chain. It is also known as "Zion Gate".
2. Western Gate: positioned in front of Al-Qatanin Gate.
3. Northern Gate: known as Gate of Heaven.
4. Southern Gate: positioned in front of Al-Aqsa Mosque [2].

For the outer heights, they range from twelve meters, in the outer wall, to thirty-five meters at the top of the dome, except the crescent, whose height exceeds by four meters. The architecture and architectural elements are not only the source of the artistic beauty and admiration of the Dome of the Rock, but also the decorative cladding of marble and mosaics, which add to the beauty and glory of constructions [3, 8].

There are several other elements, including Western Wall, Al-Buraq Mosque, Al-Silsila Fountain, Fountain of Al-'Atem Gate (or Fountain of Sharaf Al-'Anbiaa Gate), Brakah El-Soltan Fountain, Shaalan Fountain, Tariq El-Wady Fountain, Qasem Pasha Fountain, Qaitbay Fountain, Wall of Jerusalem, Dome of Arwah, Dome of Al-Khadr and Dome of the Chain. The Dome of the Chain that located in the Al Aqsa Compound, is one of the oldest monuments in Temple Mount. It is belonging to the age of Abd al-Malik Ibn Marwan, who built the Dome of the Rock. [2] Furthermore,

there are the Dome of the Ascension, Dome of the Prophet, Dome of Soliman, Dome of Moses, Dome of Youssef, Castel, Mihrab Dawud, Gate of Patriarchs, New Gate, Iron Gate, Jaffa Gate, Golden Gate, Herod's Gate, Al-Silsila Gate, Damascus Gate, Al-Gawanmeh Gate, Triangular Gate, Modarej Gate, Gate of Purifieds, Al-Buraq Gate, Al-Nnazir Gate, Zion Gate, the One Gate, Huta gate, Sharaf Al-'Anbiaa Gate, Tal'et El-Manzel Gate and Al-Luqluq Tower.

As the above presentation of the elements of Al Aqsa Compound demonstrates the magnitude of "3D documentation of this area" project. In addition, covering every inch of such area with a real and recently- captured photos is impossible, due to the difficult political conditions in it. Thus, the researcher decided to use some of the surveying techniques of photogrammetry, for which programs have been designed to assist in 3D documenting such huge number of architectural elements located in sprawling Jerusalem.

4.3. Photogrammetry

It is defined as a science of measuring using photos. It had appeared firstly to determine the third dimension of the aerial photographic mapping. Then, it was used in other fields, other than the topographic maps. The International Society for Photogrammetry (ISP) convened a conference entitled "Photogrammetry Applications". This started with a branch that later named "Close Range Photogrammetry". In 1971, the American Society for Photogrammetry (ASP) convened a conference on such branch, in which the several applied usages of such science was discussed. The Single Metric Cameras and Stereo metric Cameras can be used to photograph the 3D matters, in order to measure them by photos. Thereafter, the architectural applications to "Close-Range Photogrammetry" began to emerge. It should be noted the first measures using the photogrammetry were taken to the monuments in the mid-nineteenth century. There is also another important reality that: term "Photogrammetry" was coined by the architect Albrecht Meydenbauer, who introduced the first study of photogrammetry in 1867. The close-range photogrammetry is the most precious and fastest method to determine the dimensions of monuments [22].

How to Create Fully Immersive Virtual Reality for Major Projects and Compound Projects

The following are the theoretically steps of creating a virtual reality for major projects:

1. Idea
2. Make a scenario on the 3D interactive display of the archaeological site.
3. Take a documentary scientific photographs of the walls, floors and ceilings of all elements placed in the archaeological site.
4. Make a computer 3D model for all the details of the elements placed in the archaeological site (Modeling).
5. Prepare and Process photos for being integrated in their places on the electronic 3D model (Textures).
6. Prepare the scientific material and audio commentary that come with the model.

1 Mi'raj is defines as the ascension of Prophet Muhammad to Heaven, typically paired with his night journey (Isra') to Jerusalem.

2 Buraq defines as a legendary beast, that is a winged horse with the face of a woman and the tail of a peacock, on which Muhammad ascended to heaven.

7. Prepare the soundtracks and the special effects that the project needs.

8. Develop the interactive movements program in the 3D model (Programming).

9. Stereoscopic Display [12] & to make it fully Immersive Virtual Reality interactive Documentation (to Scale 1:1) we must add the following steps to view it on Oculus Quest 2 Device:

10. Importing 3d model in Unity game engine

11. Assigning model textures to its corresponding UVmap

12. Adjust lighting for outdoors and indoors to add a sense of realism

13. Add movement logic and restrictions inside the environment

14. Import VR related libraries and program the user movement to respond to HMD and controllers movements and commands.

15. Convert assets to mobile usage using Android studio and publish it to be able to use it in the headset itself. (Oculus Quilt 2) [12]

We observe that all the previous elements can be practically achieved, except Items (3), (4) and (5) related to the scientific photography of archaeological sites that contain a large number of elements, creation of three-dimensional models for all of these and processing such photos. The bases of scientific photography that produced photos to be used in the virtual reality techniques diverse from those of normal photography, especially in case of large and compound archaeological sites that have a large number of archaeological elements. Firstly, photos of every wall of every element in the archaeological site should be taken separately in a certain number, taking into account all the conditions required in such type of photography. [12]

There are many virtual environments software, which are useful in case of major projects, including:

1. World Up Modeler & World Tool Kit

2. 3D-Max

3. Light Wave

4. MultiGen

5. Performer

6. Vizard

7. Trucan

8. Maya

9. Unity Game Engine 2020.

10. Unreal Game Engine 2020.

11. CryEngine Game Engine 2020.

12. Amazon Lumberyard Game Engine 2020.

Most of such softwares handel the models at number of phases, among them three main stages, as follow:

1. Wire Frame Model 2. Material Model 3. Texture Model

4.4. Virtual Reality System

This research chooses to use the “Unity Gaming Engine” & the display mainly on standalone “Oculus Quest 2” with internal storage 256 Mb).

Due to the magnitude of "3D documentation of this area"

project and the impossibility of covering every single inch in such area with real and recently- captured photos, the researcher attempted to adopt some of the techniques used in the sciences of modeling, photography, image processing and architectural representation by using computers to make a prototype for each material in the site separately. In case that there is no real picture of the material in its place, this prototype can work in repetitions, so that the result obtained is as close as possible to the practical reality of the monument located in this area. The accuracy of the 3D documentation of the monument is in proportion to the relevance of the monument. The popular and important monuments; such as the Al-Aqsa Mosque and the Dome of the Rock, about 90% to 95% of the real photos of each part inside and out were obtained. However, this percentage was decreased, in case of the less important monuments, and so forth.

Regarding the 3D architectural model, it was created with complete accuracy. All the dimensions of monuments, Mosques, gates and main domes in the site are found in a large number of sources and references. The intervention was made restrictively in the (Texture).

There are several problems that have emerged as a result from the project magnitude. These problems are likely to be common in all major projects of multiple buildings and sites. They are as follow:

1) We have no photos of some places.

2) The accurate scientific photograph of some archaeological elements is not possible.

3) The large number of polygons in the model; due to the magnitude of the project.

4) The object and its texture burden the device, during presentation.

5) There are photos of the external finishing materials of models and other photos of internal finishing materials of some Spaces.

6) There are no complete drawings for some elements, which makes the creation of 3D model (Model) is difficult.

The following are the details of every problem and the solution reached:

1) Absence of Photos of Some Places and Backgrounds:

This was the main problem, especially the background surrounding the hills around the Temple Mount. Therefore, the correct parts, of which we have photos, were placed in their proper places. For the missing parts, a dummy background was temporarily placed instead of them, until their realistic photos were found in the references or were photographed at another time. In order to solve this problem; regarding the finishing materials used for the floors of compound or the facades of the elements, of which there are no photos, computer programs were used to create a prototype for each material on the site separately by Adobe Photoshop and 3D-Max programs. In case that there is no real picture of the material in its place, this prototype can work in repetitions, so that the result obtained is as close as possible to the real monument located in this area. For example, more than one form of stone that placed at the

facades and floors were made in. More than one shape also was made for the remaining other missing materials to replace them in a dummy way, until they could be photographed or replaced with such prototype.

2) Inability of accurate Scientific Photographing of Some Archaeological Elements:

In order to solve this problem, the already available photos in our references were processed. There are many popular programs designed for this purpose, notably Adobe Photoshop program. It is a best-known photos processing program. It processes the photos that are taken from certain angles to appear as if they were taken from a level parallel to the level of the photo. Thus, any distortions or distorts in the photo due to the angles can be cured. This can be as simple as in the case of photographing a very high building; such as a skyscraper, where the width of the building from the top appears less than the width of the building from the bottom, due to the Vanishing lines of the perspective. This can be treated by processing the outcome photo through stretching the boundaries of photo in specific ways for equating the photo width from the top with its width from the bottom. Thus, the distortion disappears from the perspective. Adobe Photoshop 2021 (version 22.4. Sep 2, 2021) is the latest version currently available in the market. It is a very accurate version and has a large number of commands help to fully control the settings or adjustments of any photo in any format. It also supports a large number of formats for different programs that handle and produce photos.

3) The Model Consists of Large Number of Polygons regarding vast scale of the Project:

Large number of polygons causes slow movement and loss of memory available on the computer. To solve this problem, more than one model was executed for each element such as; simplified models for remote vision and accurate models in case of focusing on the element (Such as columns and its Crowns), as curved, cylindrical and spherical shapes result in a large number of polygons, which leads to enormous consumption of computer memory.

4) The Model and the Texture use enormous memory During Presentation:

To solve this problem, more than one copy of the texture has been made for each element according to the "Level of Details method", so that the regular texture are of medium size used in the normal views of the site and texture are made in high resolution to be used in the case of approaching of the walls or ceilings of the heritage from inside or outside, to identify closely of certain details or to read certain texts that may be verses. [12]

5) Presence of material Textures of External Finishing simultaneously with material Textures of internal Finishing overloads the memory as well:

This also leads to a large memory consumption and to solve this problem, the model was programmed so that the texture of the internal finishing materials are not rendered when the viewer's camera is outside, but when the viewer's camera collides with the entrance door to the internal space (Collision Detection), the situation is reversed and the

memory will be free from the texture of external finishing materials, and texture of internal finishing materials is displayed and rendered, vice versa, when the viewer's camera collides with the exit door from the internal space to the outer yard, the memory will be free from the texture of the interior finishing materials and the texture of the external finishing materials are displayed and rendered. In addition, the memory of computer is checked and the scenes behind the camera are deleted a first-hand basis, so that the finishing materials are not shown except to the areas within the scope of the viewer's cone of vision. Before making any of these solutions, the camera was moving slowly and we could only run the model smoothly on multi-processor devices.

6) Lack of complete drawings for some elements, which hinder creating its 3D Model:

To solve this problem, the Photo Modeler program was used, which is a program based on the idea of "Close Range Photogrammetry". This program can convert texture taken of some models into a real model covered with this texture through some data that the user enters in order to define the horizontal and vertical lines and polygons on the texture. It is also characterized by the accuracy of handling with curved, cylindrical and spherical levels, as its old versions were accurate in dealing with flat surfaces only. The currently available version of this program is (Photo Modeler Premium 2020), which is a much updated version, easy to use to a large extent, and provided with tutorials for the program, video and multimedia, by which the required model can be obtained with several levels of display as follows:

- 1) Points Model
- 2) Line Model
- 3) Curve Model
- 4) Wire Frame Model
- 5) Material Model
- 6) Texture Model
- 7) Quality Texture Model

Programming for the Interactive Movement of Al Aqsa Mosque Compound Project:

The movement has been programmed in this project in four stages as follows:

First: It is the stage of approaching the general site of Al Aqsa Mosque Compound, in which the places surrounding the compound and the background appear, and it is in a compulsory path that reviews everything surrounding the site before reaching the gates and after entering them. In addition, Fly Navigation method is used to control the height of the viewer's camera, in order to be able to see the general site with a bird's eye view.

Second: It is the start of searching and taking a quick trip around the site, accompanied by a general explanation about the history of the Al-Aqsa Mosque, the Dome of the Rock, and some other elements of the site.

Third: The stage of the optional interactive path, in which the viewer walks around freely by using the navigation tools inside the model so that he can focus on what he is interested in or fast pass as desired. In addition, the method of Physical Collision Tray is used in which the height of the viewer's

camera is determined automatically from the height of a human eye view to interact automatically with climbing stairs and ramps without user intervention or difficulty in movement.

Forth: It is the stage of knowledge keys, and these knowledge keys are flash spots located around the model that the viewer faces while free navigation. During navigation, marble panels appear on which the name of the heritage is written, emitting a colored flash to indicate that it is possible to obtain more information about this area or this element. At this moment, the viewer can click the mouse on this aforementioned marble panel, and a special voiceover begins, which explains the history and components of this heritage, with a detailed explanation of some things. Furthermore, after the end of this audio explanation, the navigation may be completed for the remaining of site.

5. Conclusion

5.1. Case Study No. 1: Non-reachable Heritage Buildings

Creating fully immersive VR models of JERUSALEM Islamic Architecture Heritage Using Photo-Modelling Techniques:

A complete virtual copy of “*Al Aqsa Al Sharif Mosque Compound*”, with all its Islamic and Christian monuments and gates, was built using the method proposed by the researcher. A digital, 3D model was created for the architectural content of the site in details, then the walls, ceilings and floors of this model were covered with texture, drawings and writings on the walls, ceilings and floors of the real heritage, whereas the site and its details are registered on the computer in a 3D manner in order to enable anyone to see and focus on any part of it to view its details, inscriptions and writings in reality and easier than reality, especially in the case of making studies that require access to high places to study certain details in the inscriptions. In fact, for example, we find that to closely review the inscriptions in the middle of the dome, there should be scaffolding to reach the top of the dome that exceeds 30 m, but on the virtual model it is possible to move and fly in all directions; up or down, left or right, forward or backward, and it is also possible to turn around the horizontal or vertical axis in the space and focus on any inscriptions for any distance allowed by the accuracy of the textures that make up the model. This project was executed with 3D-Max and Light Wave programs were also used to create some models, while Photo Modeler program was used to convert some images into 3D models, and the images were processed using Adobe PhotoShop. The work team consisted of the researcher as a supervisor of the project and responsible for providing all references, images and engineering drawings of heritages, maps, data and review, in addition to, three persons for designing 3D models on different programs, image processing, and programming the movement within the interactive model. The Model contains about 1413 textures and 326 3D

Models. Furthermore, figures from 1 to 6 show some virtual images of some of the external architectural elements of the Dome of the Rock and Al Aqsa Mosque. However, figures from 7 to 12 show some virtual images of some of the internal architectural elements of the Dome of the Rock such as arches, columns, crowns, cornice decorations, ceilings, inscriptions and dome windows.



Figure 1. A virtual image showing Al Aqsa Mosque Exterior.



Figure 2. A virtual image showing Al Aqsa Mosque Exterior.



Figure 3. A virtual image showing Arcades & Some Elements.



Figure 4. A virtual image showing Arcades & Some Elements.



Figure 5. A virtual image showing the Dome of the Rock Exterior.



Figure 6. A virtual image showing the Dome of the Rock Exterior.



Figure 7. A closer virtual image showing the crowns of the columns.



Figure 8. A closer virtual image showing columns and cornice decorations.



Figure 9. A virtual image showing corridors surrounding the Dome.



Figure 10. A virtual image showing corridors surrounding the Dome.



Figure 11. A virtual image to the entrance to the down stairs to the Rock.



Figure 12. A virtual image to the entrance to the down stairs to the Rock.

5.2. Case Study No. 2: Ruined Heritage Buildings

A complete virtual copy of “Badr Edeen Elwanaey” Mosque, was made using the method proposed by the researcher. Therefore, a digital, 3D model was created for the architectural content of the Mosque in details, then the walls, ceilings and floors of this model were covered with texture, drawings and writings on the walls, ceilings and floors of the real remaining parts of the Mosque, whereas the site and its details are registered on the computer in a 3D manner in order to enable anyone to see and focus on any part of it to view its details, inscriptions and writings. This project was executed with *SketchUp* software and “*Unity Game Engine*”, and the images were processed using Adobe PhotoShop. Figures from 20 to 27 show some virtual images of some of the external architectural elements of the “Badr Edeen Elwanaey” Mosque and some virtual images of some of the internal architectural elements such as arches, columns, crowns, and windows.

This Mosque was completely destroyed as a result of the 1992 earthquake and as a result of its long-term abandonment, and there is currently nothing of it except the minaret and the walls of two facades. As for the rest of the

Mosque, it is just ruined ruins, where the arcades fell and the columns, crowns and bases disappeared, as there is no minbar and there is no wooden ceiling for the entire monument. (Figures 13, 14, & 15) In view of the condition of the Mosque, the researcher resorted to the Islamic Antiquities Registration Center to obtain drawings, studies and pictures of a number of Mosques that were erected during the same period of construction of this Mosque and in the same era as the ruler and by the same architect. Four Mosques* that meet these conditions have been reached, and they have been studied in a comparative analytical study of the forms of arcades, columns, crowns, bases and wooden ceilings to reach the optimal method for the restoration and rebuilding of this Mosque with the same archaeological assets followed during this period. (Figures 16, 17, 18, 19).

*AL-Ashraf_Qaitbay-Sahara_99, AL-Kadi-Yehia Zain-EL-Din_204, Lagen-AL-Sayfi_217, and AL-Ashraf Qaitbay-EL-Roda_519.



Figure 13. Ruined ruins of Badr Edeen Elwanaey Mosque.



Figure 14. Ruined ruins of Badr Edeen Elwanaey Mosque.



Figure 15. Ruined ruins of Badr Edeen Elwanaey Mosque.



Figure 16. 1st mosque of the Four Mosques in the same era as the ruler and by the same architect. (AL-Ashraf_Qaitbay-Sahara)



Figure 17. 2nd mosque of the Four Mosques in the same era as the ruler and by the same architect. (AL-Kadi-Yehia Zain-EL-Din)



Figure 18. 3rd mosque of the Four Mosques in the same era as the ruler and by the same architect. (Lagen-AL-Sayfi)



Figure 19. 4th mosque of the Four Mosques in the same era as the ruler and by the same architect. (AL-Ashraf Qaitbay-EL-Roda)

The project had to be presented to the Permanent Committee of Islamic and Coptic Antiquities to obtain their approval for this comparative study. The proposed method provides an easy visual alternative for a quick comparison of the shape of the Mosque in the case of using the different possibilities of the forms of arches, columns, crowns and bases. A comparative analytical study was conducted to reach a 3D Virtual model to be useful in presenting an interactive Environment in *Metaverse* to be used by the Permanent Committee of Islamic and Coptic Antiquities to take the right restoration decision. (Figures 20, 21, 22, 23, 24, 25, 26, 27)



Figure 20. A virtual Model showing Badr Edeen Elwanaey Mosque Exterior.



Figure 21. A virtual Model showing Badr Edeen Elwanaey Mosque Exterior.



Figure 22. A virtual Model showing Arcades & columns.



Figure 23. A virtual Model showing Arcades & columns.



Figure 24. A virtual Model showing Windows from interior.

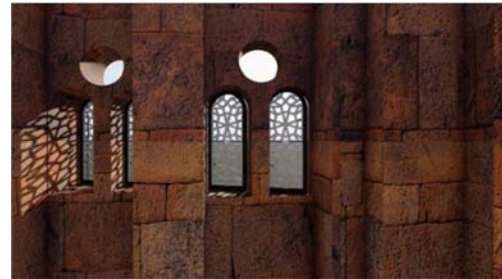


Figure 25. A virtual Model showing Windows from interior.



Figure 26. A virtual Model showing Windows from Exterior.



Figure 27. A virtual Model showing Windows from Exterior.

6. Recommendations

1. Building 3D Virtual copies of all important monuments should be considered.
2. Virtual light copies (VRML) can be executed and placed on online architectural or Heritage sites.
3. Universities should consider establishing VR labs with Panoramic Screens and light virtual copies of heritage buildings suitable for work on regular devices for use in teaching history of architecture, heritage and art courses.
4. VR techniques can be applied in architectural and interior design courses, as the immersive or interactive 3D virtual environments help to visualize more

accurately.

5. Cooperating with the UNESCO in developing appropriate legislation to preserve the characteristics of historical places all over the world.
6. A copy of this work could be given to the Islamic University of Gaza to encourage such works to prove the Arab Islamic heritage rights in the remaining of Palestine.

It is seen that future work in this domain should consider using *Metaverse* to register cities and villages having historical buildings using drones and GIS adopting the methodology proposed in this paper, which is seen to be an international Endeavor in favor of fulfilling the sustainable goals of the UNESCO.

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