Metaverse In Architectural Heritage Documentation & Education

"Use of Fully Immersive Virtual Reality Techniques to Generate Scale 1: 1 Interactive Models of Pharaonic Tombs"

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Abstract: At the beginning of 2019, the problem of Covid-19 began to appear and develop in a rapid and dramatic manner. The pandemic has hit architectural education institutions around the world. Traditional architectural education has been questioned, lost forever in universities which have been urged to abandon all face-to-face teaching methods & begin to use distance-learning methods. This forced these schools to become adaptive systems, they must include change, flexibility, and adaptation as part of the curriculum structure, studio design practices, and teaching and learning processes.

The Researcher suggests to use the Metaverse Virtual Environment in Architecture Education to make an interactive relation between architecture students & their professors & instructors without Physical existence to avoid Covid-19 problems. This Paper examines how to teach History of Architecture courses via Metaverse by presenting a scientific and practical framework, in a realistic attempt based on the current actual capabilities available in Egypt, which may produce a fully immersive virtual copy of any heritage building that may be subjected to interactive 3D documentation. The practical part of this paper presents a fully immersive scale 1:1 interactive virtual reality model of a Pharaonic tomb to examine the possibility of the paper's suggestion, and ends with a conclusion & recommendations that help any school of architecture to build a fully immersive VR models of any architectural building to use in teaching. The paper also suggests the main components required to build a fully immersive VR laboratory capable of producing interactive VR models.

Key words: Metaverse - Archaeological Documentation - Architectural Education - Information Technology - Virtual Reality.

1. Research Goal:

The research goal is to develop a practical framework by specific steps, which may produce a fully immersive virtual copy of any Building that may be subjected to interactive 3D documentation. This research aims to produce a fully immersive scale 1:1 interactive virtual reality model of a Pharaonic tomb (Pashdou III tomb which located at the West Bank of the Nile in LUXOR) to use it in teaching *"History of Architecture"*

courses, as well as providing the full opportunity to students (or tourists) to enjoy walking inside this virtual version. By Building other 3d VR interactive models of the Valley of the Kings in **Metaverse**, the *"History of Architecture"* course will be exiting & lovable to the staff & the students. It is like they go to Luxor & Enjoy walking together (staff & students) via the King's Valley & can walk together inside the tombs themselves.

2. Methodology:

Theoretical approach:

Investigating the idea of METAVERSE, and the possibility to use it in Architecture Education. Then through a detailed study of fully immersive virtual reality techniques the paper presents a practical framework, to produce virtual models of buildings or Heritage buildings.

Practical approach:

The practical approach comprised the following actions: photographing from the site, image processing, 3d modeling, preparing the required narration, choosing suitable background music, using **Unity Gaming Engine** 4 , to create a fully immersive scale 1:1 interactive virtual reality model of a Pharaonic tomb.

The research ends up with Conclusions & recommendations, and also points out to new horizons along the same research interests.

3. Discussion

Introduction:

With the huge progress in computer sciences and its abilities, with emergence of the super computers that work with more than one processor at the same time, and the development of virtual reality and visual and audio display devices, the virtual reality software imitate the reality, create and show great number of sequential 3D images on screen and move it so quickly which makes the images look like scenes and move so naturally, which can be done by creating 3D model on computer for anything you want to make virtual model for which. Then the user can walk interactively inside the virtual model by special control tool similar to which uses in video games. The user may move the drawings which embody the model forward, backward, up and down to give a real impression that the user really exists in this model [Ghaitas, 1998]. The use of Standalone HD Head mounts (without cable) with internal RAM & Storage (Oculus Quest 1, & Oculus Quest 2) raise the immersive perception so that the user feel that he is in the actual space not a virtual one. [Lee, 2021]

METAVERSE:

At the beginning of 2019, the problem of Covid-19 began to appear and develop in a rapid and dramatic manner. (Robin 2021). This constituted a defining moment in the history of architectural education. Overcoming the challenges may eventually change traditional architectural education. There are many opportunities to reshape the future of architectural education. (Salama 2020). (Evelyn 2021)

One of the advantages of this period is the training and encouragement of students to participate in online competitions and workshops that enriched students' skills and allowed them to follow and join international events and webinars instead of the traditional project Exhibition view. (Elrawy 2021)

After the pandemic, 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."*

What is metaverse?

Imagine a digital world where you can live a parallel life without leaving home, "Facebook" and other internet and video game giants see Metaverse as the next big leap in the evolution of the web. From dancing in the nightclub with friends in the form of an "avatar" to climbing Mount Everest through a virtual reality helmet to holding meetings with colleagues in digitally reclaimed offices. Metaverse opens up avenues that push the boundaries of the physical world, bringing the real and virtual worlds closer together.

The concept was developed in 1992 by Neil Stephenson in the science fiction novel "Snow Crush", a reference book for entrepreneurs in Silicon Valley, the term "Metaverse" has become in recent months one of the most popular words in the world of technology and video games. Even the largest companies in the sector are investing millions of dollars in its development. The latest to join this field is "Facebook", which announced the creation of a team dedicated to "Metaverse". This is going to be a very big part of the next chapter for the tech industry, network president Mark Zuckerberg told The Verge, noting that "Metaverse is the heir to the mobile Internet". (Al Ain News 2021) He wants to know the "Facebook" as the Metaverse Company, not Social Media Company. (Conversation Newsletter 2021)

METAVERSE in Architecture Education:

The Researcher suggests to use the Metaverse Virtual Environment in Architecture Education to make an interactive relation between architecture students & their professors & instructors without Physical existence to avoid Covid-19 problems. The researcher wants to examine how to teach *History of Architecture courses* (as an Example) via Metaverse. The practical part of this paper is to create a fully immersive scale 1:1 interactive virtual reality model of a Pharaonic tomb to examine the possibility to do such suggestion. The researcher end

with conclusion & recommendations that help any school of architecture to build a fully immersive VR laboratory capable of producing interactive VR models of what they teach in History of Architecture courses.

Virtual Reality system:

This research uses the Virtual reality system **"*Unity Gaming Engine 4"*** & the display mainly on standalone **"*Oculus Quest 2"*** with internal storage 256 Mb)

The main factors of virtual reality system include;

1- 3D and Standard Input / Output Devices.

2- Head-Mounted Displays which achieve a high level of immersive.

3- Wide-Angle Displays which didn't achieve non-immersive.

4- Head and Body Trackers.

5- BOOMs and Binocular Omni-Orientation Monitors which are Stereo Scopic Viewing Devices.

6- Control Devices such as Data Glove and Sensors Bodysuit which later developed to Tactile Feedback Facilities that enable the user to feel the temperature, pressure, or texture and interact with it.

7- Navigation Devices.

[LARIJANI, 1994], [WODASKI, 1995] and [KALAWSKY, 1993].

Use Virtual Reality Techniques in Documenting Pharaonic Tombs

The technical condition of Egyptian monuments and the inscriptions and drawings on their walls were impacted by many factors, notably the various weather conditions. Such impact can be shown clearly on the wall of the Pharaonic tombs that located in West Bank in Luxor. The most serious of these factors is the condensation of water vapor on the surface of the paintings and inscriptions, resulting in the saturation of the stone's top layer with water vapor. When this vapor dries up, the salts in the stone turn into crystals, afterwards crystals size enlarge which pushes the surfaces of the stone apart. Ultimately, the outer layer, which filled with paintings and inscriptions, falls down. As an Example Tomb of Queen Nefertari study recommendations to maintain the tomb was:

1- Injection the rocky layer above the tomb ceiling to fill its cracks for preventing the rainwater leakage.

2- **Closure and suspension of visiting** in order to keep the relative humidity in the tomb atmosphere stable.

3- Support and tie up the ramshackle inscriptions to the tomb walls to preserve them, until the beginning of the tomb salvage operations. [Shahin, 1994]

During its restoration project, a virtual model of Nefertari's tomb was created by a large team of foreign experts from Getti Conservation Institute GCI. The work was done by super computers, whose prices exceed a million dollars, and complex software that available only to specialists. The work in this model took several years.

Thus, the researcher attempts to use modern technologies, especially fully immersive virtual reality technology, to solve this problem by creating 3d VR models of Pharaonic tombs to be used in visitor centers in areas where these tombs located. A complete virtual model of the relevant tomb is displayed on the latest 3D visual and audio display devices.

Such display has relevant archaeological commentaries that allow the tourist to "walk through" the virtual tomb and observe all its details. Only a quick visit is to be offered to the physical tomb in a limited time that would not affect the condition of the tomb. We also use these VR models in teaching the "History of Architecture" courses in Architecture Schools.

However it was necessary to create a fully immersive virtual model of a Pharaonic tomb with our local capabilities in Egypt as a case study. This should be achieved by a small team (5 or 6 people) and with standard personal computers available anywhere. In addition, it was also important to choose the software that can perform the task on these devices. Therefore, a search for a small and beautiful tomb, which was not geometrical complex, was made. At the same time, it should have an archaeological importance, due to its beauty and uniqueness. By the search, and in coordination with the Egyptian Antiquities Registration Center of Supreme Council of Antiquities, Tomb of Pashedu (No. 3) that located in the Necropolis of Deir al-Madina east of the Queens Valley in the West Bank of Luxor, was chosen. It serves our purpose and matches our research goal. Because of the importance of this tomb, it was restored and developed in 1994 for being protected from damage. Glass protection panels, wooden walkways and adequate lighting were placed. [Nour El-Din, 1994]

Necropolis of Deir al-Madina

It is located in the West Bank of Luxor, at the Southern edge between Queens Valley at the west and Ramesseum at the East, in particular. It is laid at the foot of Theban Hills to the west of the Workmen's village. In Egyptian texts, the Deir el-Madina was known as "The Place of Truth" or "Set Maat". The workmen of this village were called "Servants in the Place of Truth". For the current name, it is likely named for a monastery built by Copts during their persecution by Romans. The workers' tombs in Deir al-Madina are distinctly different from the royal tombs or tombs of the nobles. This graveyard dedicated for artists, sculptors, engineers,

and workers of the ancient capital (Ouaset, Thebes, Luxor), and those who built temples and tombs of kings, queens and nobles in the West Bank in the era of both nineteenth and twentieth dynasties. They therefore preferred to lay their tombs near their domiciles [Taha, 2000]. So they carved their tombs, which characterized by beautiful colors and scenes, in that area. Every worker mastered in his tomb, with the assistance of his colleagues from the elite artists and sculptors of this era.

Tomb of Pashedu (No. 3)

It is located in the necropolis of Deir al-Madina. Pashedu was the supervisor of the work of House of Amun in Karnak. He was also as a servant in Dar al-Haq in West of Thebes. These positions indicate to the high position he attained, during the reign of the Ramesside. He built this tomb for him, his wife, his children and some of his relatives. Pashedu intensively took care of this tomb, as he carved on it colorful inscriptions and symbols portraying him and his family accompanied by various gods.

He was called "Pashedu" after "Shad" (The Savior) [Taha, 2000], who helps the people in hard times. We view him as a young man has a lot of the attributes of the "Horus". [Cherny, 1987] Upon visiting this tomb, we can go down some stairs to the corridor leading to the burial chamber. On the corridor walls, we can view a scene of Anubis. It is depicted as a jackal sitting on a pedestal. The burial chamber (which has a ceiling shaped like a cellar, is filled with beautiful scenes of bright colors. Over the entrance wall, we find a scene of "Ptah-Sokar" in the form of a winged falcon in a boat. In front of it, there is the son of Pashedu worshiping behind the boat. There is another son praying to a group of deities depicted on the other wall. Below this scene, on the right of the enterer, there is a scene of Pashedu kneeling under a fruitful palm tree and drinking from the lake. On the left the enterer, on the same wall, there are three rows of Pashedu's relatives. On directing to the Southern wall (on the left of the enterer), we view Pashedu and his family worshiping Horus in the form of a falcon. On the Northern wall (on the right of the enterer), there is a scene of Pashedu and his daughter standing and worshiping. We view a scene of the holy journey to Abydos, where Pashedu, his wife and a daughter are setting in a boat, in front of offering table. On the wall facing the enterer, there is a scene of Osiris sitting on his throne in front of a mountain. Behind Osiris, we view Horus in the form of a falcon. In front of Horus, there is an Udjat-eye holding a double-burning brazier. Below, there is Pashedu worshiping and kneeling before Osiris and holding also the same brazier. Scenes below such view are indiscernible. On the Southern half of the ceiling, we view paintings of some deities. On the Northern half, there is also another group of them. [Taha, 2000]

How to make a virtual reality model for a pharaonic tomb

Virtual reality techniques depend on many technologies and computer programs assisting in the fields of 3D modeling, image processing programs, phonics programs and motion programming within models. The steps for an interactive 3D documentation of a Pharaonic tomb are divided into the following steps:

1- Idea.

2- Making a scenario for the interactive 3D display of the tomb.

3- Scientific documentary photography of the walls, floors and ceilings of the tomb.

4- 3D modeling on the computer for all details of the tomb.

5- Processing and preparing textures for the possibility of integrating them in right place on the electronic 3D model.

6- Preparing the scientific material and the voiceover of the model.

7- Preparing the soundtracks and special effects of the project.

8- Programming the interactive movement within the 3D model.

9- Stereoscopic display.

& to make it fully Immersive Virtual Reality interactive Documentation (Scale 1:1) we must add the following steps to view it on Oculus Quest 2 Device * : *(Will discussed hereafter)

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 Quist 2)

The following is a detailed explanation of some steps in order:

1- The idea:

This step includes determining a specific idea in order to focus on the monument to be documented, according to its importance and the state of the monument.

2- Scenario Display:

This scenario includes a complete plan for what will be displayed and how it is, and the total time for the visual display should be taken into account, in addition to, the fast and general compulsory paths of the tomb should be determined and the locations of hot points that need additional explanation.

3- Scientific photography of the tomb:

The rules for scientific photography of textures to be used in virtual reality techniques differ from the rules of regular photography. First, each wall should be photographed separately with a certain number of textures, and the following should be taken into account:

A- The wall should be divided into a number of textures consistent with the level of resolution required in the 3D model.

B- Overlap should be existed in all textures from all sides to facilitate the installation of textures on each other at the phase of image processing.

C- The imaging level and the angle of inclination of the lens are adjusted to be parallel to the surface to be photographed (using the water balance tool). Special scaffolds can be used for this purpose in heights.

D- The camera's lens is set at the center of the required scene.

E- A consistent and homogeneous neutral lighting is used on the entire wall, and it is recommended to use day light lamps for lighting.

F- The exposure Meter is used to control the light.

G- The stand is used for the camera and the remote capture feature is used to prevent the texture from flickering.

H- It is prohibited to use flash or any type of filter, except the polarizing filter in the event that there are glass surfaces in front of the drawings to be photographed.

I- In the case of outer photography in open places (entrances of tombs and approaching ways), an Ultra Violet Filter or Sky Light Filter is used.

J- It is recommended to use Full Frame digital cameras with a sensor ranging from 12 to 45 Mp to obtain an accurate and clear texture. (Camera Nikon D6 – Nikon D850)

4- 3D modeling on the computer:

There are many programs that enable the user to make a 3D model for any architectural or spatial shape, including AutoCAD 3D, 3D max, and Sketchup, …..etc.

The model should fulfill the actual dimensions of the tomb, which are derived from the Plans, Sections and the original facades of the tomb.

5- Textures Processing:

After completing the photography, there are two ways to place the textures on the 3D model after processing:

First:

The wall of the model is divided into the number of textures that have been taken for a number of faces for the same wall and puts each texture in its place on the 3D model.

Second:

Making the whole wall as a single texture by montaging all the textures of the wall that have been taken by image processing programs and taking into account the adjustment by (the aforementioned) overlap to be one big texture for each wall (for each separate face). This method used for only small tombs.

More than one copy of the textures can be made according to the level of details method, so that the regular textures are of a medium size and are used in the normal views of the tomb. High Resolution textures are made to be used in the event of close proximity to the walls or ceilings of the tomb in order to focus on specific details or read certain hieroglyphic texts.

6- Preparing the scientific material and commenting:

The scientific material concerning the certain tomb is prepared from the references, books and data of the Pharaonic Antiquities Registration Center at the Supreme Council of Antiquities. An audio commentary related to the display scenario is made and based on the previously prepared scientific material, taking into account the conformity of the audio and descriptive commentary with the programmed movement path according to the proposed scenario.

7- Preparing soundtracks and effects:

An appropriate soundtrack is chosen or a specialized composer is assigned to make the music under condition of being appropriate and compatible with the age of the tomb. In addition, the special effects are integrated in proportion to the movement within the model according to the proposed display scenario. The soundtrack and effects are divided into two parts:

Part (1): It is special and linked to the compulsory movement path, which takes a short time at the beginning of the display, in which a quick walk throughout the entire tomb is executed with a short and simplified explanation of the whole topic.

Part (2): After finishing the compulsory path, regular and repetitive music and effects are set following the user throughout his optional interactive walk around the virtual tomb.

8- Programming the interactive movement:

Usually, the movement is programmed in such projects in four phases:

Phase (1):

It is the phase of getting close to the entrances of the tomb, in which the surrounding places appear, such as the entrance of the tomb, and it is in a compulsory path that reviews everything surrounding the tomb before reaching its gate.

Phase (2):

It is the beginning of navigating and taking a quick look around the tomb, with a general explanation according to the proposed display scenario. The compulsory path should stop at the starting point after completing the quick navigation in the tomb.

Phase (3):

It is the phase of the optional interactive path, in which the student (or tourist) navigates as if he/she wants by using the navigation tools within the model so that he/she can focus on what he/she is interested in or fast pass as desired.

Phase (4):

It is the phase of knowledge keys. These knowledge keys are hotspots located around the model that the tourist faces during his free navigation. During navigation, a sign appears indicating that it is possible to obtain more information about this area and at this moment the student (or tourist) can click a certain button and stop the interactive display, and an outline of the hotspot contents begins to display, which may be an audio and video explanation of more information and details about some of the drawings and shapes on certain walls, reading and translating hieroglyphic texts or a detailed explanation of some items. After completing this tutorial, the display will return to the optional interactive path. These hotspots can contain an integrated historical and archaeological explanation of all the contents of the tomb so that the tourist can use for more information about the tomb.

9- Display:

The types of 3D show *for groups* of people are divided into a number of types, including:

1. Flat rectangular screens

2. Curved screens

3. Multiple screens

4. The virtual cave

5. Display on the dome

But the types of *3D fully immersive* show devices *for individuals*, including:

6. Modern Head mounts with cable (HTC Vive, Oculus Rift, & Oculus Rift S)

7. Modern Head mounts with Movement platform (The Virtuix Omni)

8. Standalone HD Head mounts (without cable) with internal RAM & Storage (Oculus Quest, Oculus Quest 1, & Oculus Quest 2)

The disadvantage of flat screens is that it does not reflect the stereoscopic feeling that curved screens reflect. As for the display in the panorama hall via the curved panoramic screen, on which the stereoscopic image is installed through the interlaced display by 3D Projector it gives a 3D model sense that is better than the flat screen display. Therefore, the researcher suggests that the display in the VR panorama halls in Architecture schools (or visitor centers) should be in this way. In addition, (Figure 1) shows the curved screen and the positions of the interfering projectors. It is noted that the audio display should be in the surround system (5 speakers) -or the Dolby Atmos system-, which contains three front speakers; each one gives a different audio dimension, in addition to, two speakers in the back, on the left and on the right, given the effects, besides the subwoofer as an amplifier for tones. The VR panorama halls in Architecture schools (or visitor centers) should be air-conditioned and have comfortable seats, and the number for each display ranges from 20 to 30 tourists. While choosing the places of the visitor centers, it is taken into account that they are close to the sites of the largest number of targeted tombs.
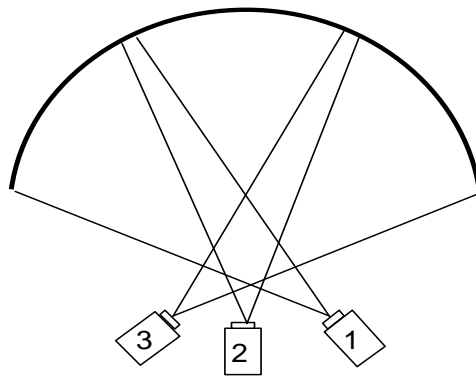
(Figure 1) Curved Screen and Interlacing Projectors. Source: The Researcher

But the Ideal way to feel *fully immersive environment* is to display by wearing a *Head Mount*, in case of one person, as the show in this way increases the sense of indulgence. Hereafter some Head mounts that provide the possibility to feel like you are in the actual Space not a digital one.

HTC Vive:

The HTC Vive is a virtual reality headset developed by HTC and Valve. The headset uses "room scale" tracking technology, which allows the user to move in 3D space and use motion-sensing controller to interact with the environment. This system consists of: Vive Headset, Vive Controllers, Vive Base Stations, and Vive Tracker. The Vive headset has a refresh rate of 90 Hz and a 110 degree field of view. The device uses two

OLED panels, one for each eye, and each with a screen resolution of 1080×1200 (2160×1200 pixels combined). Safety features include a front camera that allows users to observe their surroundings without removing the headset. (Figure 2)

(Figure 2) HTC Vive: Source : https://www.vive.com/eu/

Oculus Rift S:

The oculus Rift S is a virtual reality headset co-developed by Lenovo Technologies and Oculus; a trademark of Facebook Technologies. Announced in March 2019 and released in May, it has noted changes including a new "inside-out" position tracking system with built in two cameras inside the headset unit. Rift S uses a single fast-switch LCD panel with a resolution of 2560×1440 and an 80 Hz refresh rate, the Rift S uses one screen instead of two. (Figure 3)

(Figure 3) Oculus Rift S: Source: https://www.oculus.com/experiences/rift/

The Virtuix Omni:

Virtuix Omni is an omnidirectional treadmill simulator for virtual reality games and other applications. It uses a platform to simulate locomotion i.e. the movement of walking, which requires special shoes or shoe covers and friction-reducing surface. It works in tandem with the HTC Vive, and allows a vive user to walk within a few number of games. It uses inertial sensors to track a person's position, their stride length, and the speed at which they are moving. The information is then sent to a computer which translates the data into the game moves. (Figure 4, 5)

(Figure 4) The Virtuix Omni: Source: https://www.virtuix.com/

(Figure 5) The Virtuix Omni: Source: https://www.virtuix.com/

<u>**Oculus Quest 1:**</u>

Oculus Quest is a virtual reality (VR) headset developed by Oculus, a division of Facebook, released on May 21, 2019, is a standalone device that can capable of running games and software wirelessly with an Android-based operating system. It supports position tracking with six degrees of freedom, using a built-in sensors and a series of cameras on the front of the headset instead of external sensors. The cameras are also used as part of the "Passthrough" safety feature, which shows the view from the cameras when the user exits a defined area. Subsequent software updates added "Oculus Link", a feature that allows Quest to connect to a computer via USB, enabling use with Oculus Rift-compatible software and games. It runs an Android-based operating system, with changes to improve performance in VR applications. A diamond-shaped Pentile OLED display is used for each eye, with an individual resolution of 1440 × 1600 and a refresh rate of 72 Hz. and features physical interpupillary distance (IPD) adjustment. (Figure 6)
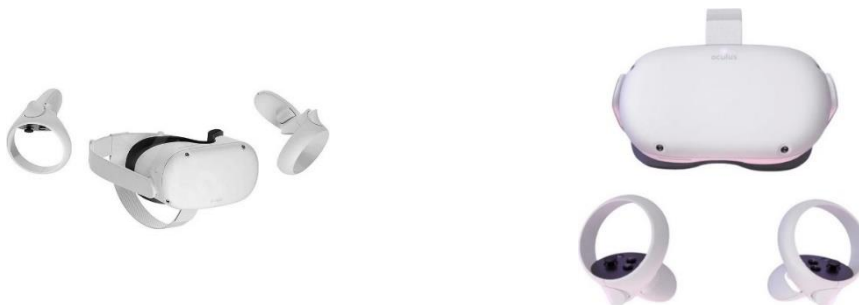
(Figure 6) Oculus Quest 1: Source: https://www.oculus.com/experiences/quest/?locale=en_US

Oculus Quest 2:

Oculus Quest 2 is a (VR) headset made by Oculus, a Facebook brand. It can function as either a standalone headset with an internal operating system based on Android, or with Oculus-compatible VR software running on a computer when connected via USB or Wi-Fi. It's like the original Oculus Quest with a similar design, but with a lighter weight, updated internal specs, a display with a higher refresh rate and per-eye resolution, and an updated Oculus Touch controllers. The display is a unique fast-switch LCD panel with a resolution of 1832×1920 per eye, which can operate at a refresh rate of up to 120 Hz. The headset includes physical interpupillary distance (IPD) adjustments. This is also combined with software customization. (Figure 7, 8)

(Figure 7) Oculus Quest 2: Sourse: https://www.oculus.com/experiences/quest/?locale=en_US

(Figure 8) Oculus Quest 2: Sourse: https://www.oculus.com/experiences/quest/?locale=en_US

Case Study:

   The Pashedu Tomb is considered one of the most beautiful Pharaonic tombs on the western bank of the river Nile at Luxor. The steps proposed by the researcher have been implemented on this tomb, so a 3D virtual copy of the tomb was produced. This practical experience resulted in some observations that should be taken into account to obtain an accurate virtual copy of the tomb.

1- All assembly points and corners of the tomb faces should be carefully reviewed.

2- The assembly points of all rotating faces (vaulted or domed) should be carefully reviewed.

3- The methods of focusing by lighting or focusing by frames should be used in order to clarify the part of the drawing on which the audio commentary is made, and this requires making more than one copy of the models and images according to the number of drawings that are explained in the audio commentary. In addition, (Figure 9) shows the focus on lighting, and (Figure 10) shows the focus on the frame.

4- The *Unity Game Engine* was chosen to be used because it work on any platform (Supplies) "Hardware Independent", which means that it can work on devices starting from personal computers equipped with "Graphics Accelerators" , even "SGI" Silicon Graphics Workstations, and the cutting edge standalone head mounts (Oculus Quest 2 – 256 GB).

(Figure 9) How to focus on drawings with lighting. Source: The Researcher


(Figure 10) How to focus on drawings with a frame. Source: The Researcher

4. Conclusion

A complete fully immersive scale 1:1 virtual copy of the Pashedu III Tomb on the western bank of the river Nile at Luxor was made by using the method proposed by the researcher. Thus, a 3D digital model of the architectural content of the tomb was executed in details, and then the walls, ceilings and floors of this model were covered with textures, drawings and writings on the walls, ceilings and floors of the real tomb, so that the tomb building in all its details became registered on the computer in a 3D manner, so that anyone could navigate in it and focus on any part of it to view its details, inscriptions and writings. The viewer via the head mount *Oculus Quest 2* feels that he/she is in the original tomb not a digital copy.

For Multiple users it could be also displayed in stereoscopic form on a large panoramic screen for groups in schools of architecture (or in any visitor center). Such displays can be used for tourism promotion by placing them in Egyptian embassies and tourist offices abroad and in visitor centers in the tourist areas. It is also considered scientifically as a 3D and interactive documentation of the monuments and for its very fine details. Furthermore, it is considered a technological and good alternative for tourists who cannot visit the tomb because of the lack of time, the remoteness of the place or for any other financial reasons. Instead of physically visiting the real building, they may visit it using this virtual model, which provides information that they may not have during actually visiting the tomb. It is also possible to provide the Faculties of Architecture, Arts and Archeology in various universities with the suggested system (hardware & Software) to be used in *teaching history of architecture*, *archeology* and arts. (Figure 11) shows a snapshot of the original tomb and (Figure 12) shows a screenshot of the virtual copy.
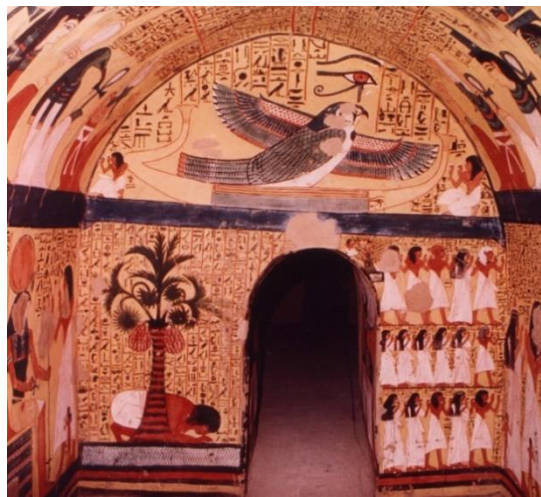
(Figure 11) A photograph inside the original cemetery. Source: The Researcher
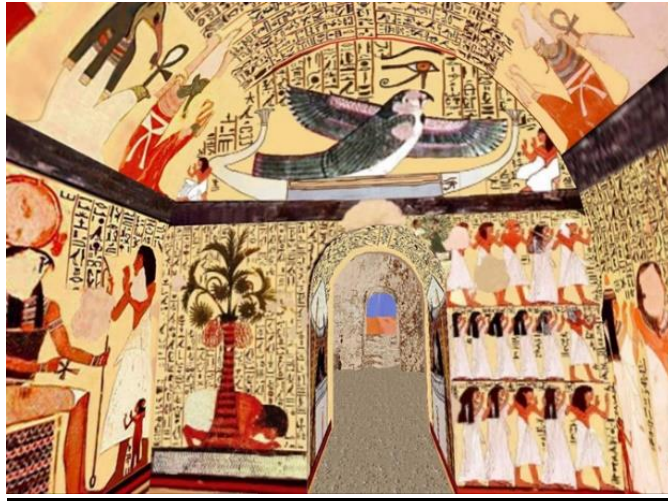
(Figure 12) A screenshot of the virtual version. Source: The Researcher

Recommendations

1- It is recommended that Schools of Architecture and Archeology start building their own virtual reality labs, according to their own needs and plans, and use such systems as the one suggested in this paper to teach the history of architecture, antiquities and arts courses.

2- Fully Immersive Virtual Reality techniques can be applied in architectural design and interior design courses for students of architecture and decoration departments, as the immersive or interactive 3D virtual environment helps to visualize in a more accurate way.

3- Fully Immersive Virtual copies of the destroyed buildings (such as the old Opera Building, the Alexandria Lighthouse, and the Great Library of Alexandria) can be made for the purposes of scientific or historical research, even for entertainment.

4- Architecture schools in Egypt can cooperate collectively in making virtual copies of all Egyptian antiquities in coordination with each other, providing a copy for each university and exchanging copies among them based on a scientific plan in a specific time schedule.

5- The idea of visitor centers equipped with Panoramic Screens should be generalized to all archaeological sites, especially Pharaonic tombs.

6- Virtual copies of Pharaonic antiquities should be expanded, especially the important and famous ones.

7- Virtual copies on CDs may be available to tourists for marketing purposes.

8- Every Egyptian embassy, consulate, cultural or tourist center in foreign countries may install a virtual reality Panoramic Screen that displays Pharaonic, Islamic, Coptic and Roman tombs and monuments to attract the tourists.

9- Based on the researcher's experience in this field, the following components could help any school of architecture to build a fully immersive VR laboratory capable of producing interactive VR models as a guide:

<u>**System Requirements (Suggested)**</u>

Description	QTY
PC-Powered VR Gaming Headset , Oculus Quest2 (256 GB) with PC cable	5
Laptop Dell G3	5
Software Package: 1. Unity pro (License to 6 PCs for 3 Years) 2. Unity reflect (License to 6 PCs for 3 Years) Or any similar 3D modeling software optimized for VR, and Interactive Real Time Simulation (Creator)	1
Full HD 3D Projector	1
3D Glasses (active) with charger – Multiuse	25
Northstar™ is 3DP's turn-key simulation display solution, Or any similar Projection System, Full 3D with Curve Screen about 9.5 x3 m	1
DELL OPTIPLEX 7070 I7-9700/16GB RAM/512 SSD/GTX 1650 4G/Wifi/BT+KB+Mouse with GUI	25
Monitor DELL 21.5" Vga-HDM	25

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