Revitalising Heritage Sites Through 3D Modelling: An Analysis of the (iHeritage) Project's Outcomes ICT Solutions.

مقال
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الملخص:

يتناول هذا البحث التقنيات التكنولوجية المتطورة المستخدمة قيد التنفيذ للمشروع التطبيقي المنفذ من خلال الباحث والممول من مؤسسة اليونسكو و الذي يحمل عنوان "iheritage" في مصر لاحياء التراث الاثري المصري من خلال إعادة بناء المواقع الأثرية المحطمة باستخدام التكنولوجيا الحديثة، اختار الباحث مدينة العمال في الأهرامات، وسفينة خوفو الشمسية، لدراسة مفصلة لآليات استعادة تلك المواقع الاثرية مرة اخرى في البحث ، حيث يهدف البحث الي وضع آلية لاستعادة المواقع الاثرية وذلك من خلال وضع اسس إنشاء نموذج ثلاثي الأبعاد دقيق للمواقع الأثرية وإنشاء تمثيلات واقعية افتراضية ومعززة باستخدام منصات الأجهزة الناشئة للصور ثلاثية الأبعاد والتفاعل المتجسد لزيارات الموقع الاصلي من خلال الدراسة الأثرية المعتمدة التي أجريت في المشروع لانشاء محاكاة طبق الاصل ,إذ إنَّ تم إنشاء نموذج ثلاثي الأبعاد دقيق لمدينة العمال وأجزاء من مركب الشمس من خلال عدة مراحل تتبع خطوات نظرية وتطبيقية لاسترجاع التراث الأثري المصري ، وقد استخدم الباحث الأساليب النوعية والكمية لتحديد فوائد وتحديات استخدام التكنولوجيا لتحسين تجربة المستخدم في منطقة الاهرامات، حيث توصل الباحث الي اهمية التعاون المشترك بين كل من (مصمم الجرافيك +الاثري) لعمل مجموعة عمل مشتركة للوصول لآلية ناتج فعال الي جانب توضيح دور مصمم الجرافيك في وضع اليات واضحة تطبيقية لتحفيز الابتكار و استعادتها مرة اخرى في مصر باستخدام التكنولوجيا الجرافيكية المتطورة من خلال النمذجة ثلاثية الأبعاد لتطوير المناطق الاثرية المحطمة بفعل الواقع الزمني واستعادتها مرة أخرى لتطوير المواقع الاثرية والحفاظ عليها.

الكلمات المفتاحية: التراث الاثري ، الاستعادة التكنولوجية ، النمذجة القائمة على الواقع ثلاثي الأبعاد. .

INTRODUCTION

A digital "object" can take various forms such as a text message, 2D/3D images, movies, or sound. It can be a reproduction of a physical artifact or natively digital. If it is limited to reproducing a real object, the digital replica becomes a transmitter of information that allows for the preservation of the object's knowledge. Rapid prototyping techniques can be used to print physical copies of digital replicas, which can be touched or relocated in their original context to restore a fragmented or lost cultural object.

However, the digital "content" should not be limited to reproducing an object. It should be a communicative and cognitive unity with form and meaning. The primary goal of virtual heritage is to create a dynamic space of relations and interactions (Pasikowski, S. 2007), rather than just digitally recording an object or model in an objective manner. Therefore, the process of creating virtual heritage is critical, as it stimulates critical thinking, understanding, and attribution of meaning. The virtual process aims to increase perceptual and cognitive levels, reactivate spatial-temporal relationships and meanings of the cultural object, and facilitate the mental process of imagination. In order to effectively create a virtual heritage, it is necessary to establish connections between all available information about an artefact and its context. This information should be organized according to relational maps and made accessible through experiential spaces. Typically, this is a three-dimensional space that allows for greater interaction, exploration, and analysis (Antinucci, F. 2014).

1-1 The cognitive activity in virtual space affects the user on two levels:

1- Perceptual-motor level: This level refers to the sensory perception of form and affordances that are stimulated by the cognitive activity itself. It involves the user's physical interaction with the virtual environment, such as exploring, moving, and changing the point of view.

2- Symbolic reconstruction of meaning level: This level refers to the association of deeper levels of understanding with the visible appearance of the virtual object. It involves the user's exploration of the virtual environment to understand the context, relationships, and meanings of the cultural object. This level allows for the integration of the artifact, such as virtual restoration, virtual reconstruction, relationship with the environment, or values and meanings attributed to the artifact by various societies.

Certainly! Heritage sites around the world are increasingly threatened by natural and human-made disasters, as well as the effects of climate change, pollution, and urbanization. To address these challenges, researchers and heritage conservationists have turned to new technologies such as 3D modelling and virtual reality as a way to preserve and revitalize these sites. The iHeritage project, funded by UNESCO in Egypt, is one such initiative that aims to use these technologies to restore and promote the country's rich cultural heritage.

This research paper explores the outcomes of the iHeritage project, with a specific focus on the ICT solutions used in the project to create 3D reality-based modeling, immersive visualization, and virtual reality experiences. The paper provides a comprehensive literature review of the existing research on the topic of using technology to revitalize heritage sites. The literature review examines the various applications of 3D modeling and virtual reality technologies in heritage conservation, their benefits, and challenges, as well as the impact of these technologies on the preservation of cultural heritage.

The restoration of virtual identity is a collaborative process that involves using high media technology to create a virtual site on the internet or an accurate location. This process involves a joint effort between graphic designers, archaeologists, and surveyors to create an inventory of several holdings of a common nature (Elkheshen, G 2022). One example of this restoration process is the City of Workers in the Pyramids (Hitet Elghorab), which has been digitally reconstructed using 3D virtual reality technology. Users can navigate through the site using a mouse pointer or 3D glasses to explore and interact with the site virtually.

The principles of restoration through virtual reality are based on a historical-critical approach and our reference in this project is the archaeologist professor (Shamaa, E) and requires a fusion of historical and technical-scientific expertise. These principles have been developed over time and are now considered international fundamentals for any restoration activity through technology (Pietroni, E. 2021).

1-3 They can be summarized into five key issues:

1. The first issue is the respect for the aesthetic and historical value of the cultural asset, ensuring that the meaning, history, and authenticity of the artwork are preserved.
2. The second issue is compatibility, which involves identifying the material of which the cultural assets are made and using compatible materials for the intervention.
3. The third issue is the recognition of intervention, ensuring that the original parts of the artwork are legible and that any integrations are recognizable.
4. The fourth issue is reversibility, requiring that any material used in restoration is removable to allow the artwork to be returned to its original conditions for future restoration.
5. Finally, the fifth issue is minimal intervention, which emphasizes the importance of repairing or conserving original parts rather than replacing materials to maintain the historical value of the artwork. These five principles concerning the material consistency of artwork have become established as international fundamentals for any restoration activity.

1-4 Restoring Virtual Identity: Key Features:

Virtual restoration is a methodology that combines technique and purpose to intervene in damaged heritage in a virtual way. The term was first used by Professor (Fiaccadori, G) in 1994 (Pietroni, E. 2021), and it has gained more attention in recent years. The Principles of Seville (Jose Cela, J. 2013), which focus on computer-based visualization in archaeological heritage, define virtual restoration as the process of using a virtual model to visually recreate something that existed in the past. As part of this process, the available material remains are rearranged, potentially including the use of virtual anastylosis to reconstruct fragmented parts within a virtual model. The aim of virtual restoration is to provide a way to restore heritage that has been damaged or lost, allowing people to experience and appreciate it in a way that would not be possible otherwise. By using digital

technology to recreate historical sites, virtual restoration can help to preserve the legacy of these sites and ensure that they are accessible for future generations to explore and learn from.

1-5 physical restoration in iheritage project:

Digital technologies are increasingly being used to plan and assist physical restoration projects. This approach allows for the prefiguration of the restoration result by simulating all separate phases of intervention. For example, in the restoration of (City of workers, Hiet Elghorab) (Fig 1) a city that had been damaged by natural reflections or earthquakes, 3D digital technologies were used to assist in the real restoration of the worker's life and city. Before operating on the fragmented City, researchers simulated their recombination in a virtual environment using digitized 3D models of the city fragments. This reduced the manipulation of the fragments, prevented damages, and increased the capabilities to evaluate different reassembly options. A rapid prototyping device was utilized to design and manufacture a physical supporting structure, using digital 3D models as a reference.

(Fig 1) The City of Workers – Hiet Elghorab
Source:https://www.nbcnews.com/science/science-news/ruins-barracks-port-unearthed-egypts-giza-pyramids-flna2d12018117

(Fig 2) Khufu Solar Boat
Source:https://www.egypttoday.com/Article/4/106718/Khufu-s-Solar-Ships-The-

Another example is the virtual reconstruction of the Solar boat (Fig 2), which was discovered in 1954. The virtual reconstruction aimed to create a digital model of the boat by the Nile River to support the physical preservation and restoration works on site. This allowed for the exploration of possibilities for a future anastylosis starting from the remaining fragments of the boat.

In the field of digital restoration, specific digital image processing techniques have been developed to analyze damaged areas, such as cracks or gaps, and to solve difficulties related to pictorial reintegration. These techniques have been refined over the years to improve their accuracy and effectiveness in preserving and restoring cultural artifacts.

2- Research problem:

One of the research problems in the field of Graphic digital restoration is the restoration of cultural artifacts that have been lost or damaged over time. The City of Workers in Pyramids Giza is an example of a project that employed a process of analyzing and creating correspondences among fragment profiles to achieve a partial physical relocation of most of the fragments. Another example is the Iheritage project in Egypt, where 3D modelling technologies were used to digitally rebuild damaged monuments, allowing for their preservation and accessibility through virtual reality applications.

In fields like archaeology, virtual restoration represents the only possible technique of effective restoration that can preserve these cultural visual assets and their historical value, regardless of their material support. Digital interventions can also reconstruct an artefact in its integrity, following the principles of "stylistic restoration", which aims to reconstruct the unity of style corresponding to the hypothetical original aspect. This approach, also called "virtual iconographic restoration", is especially useful for paintings.

Nevertheless, the primary concern when it comes to stylistic virtual restoration pertains to the issue of authenticity, To address this, a rigorous philological method has been developed over the years, ensuring that the interpretation and restoration of the missing parts are not invented but based on the concepts of style and analogy are employed to ensure the credibility and dependability of the work, the added value of this approach is that it integrates physical methodologies, allowing for an undisturbed reading of restored artifacts and improving their legibility for interpretation and museum communication projects.

3- Research objectives:

The objective of this paper is to use a descriptive method to analyze the content of the models presented in a practical experiment, specifically the iheritage project, which involves the restoration of the City of Workers and Solar Boats. The analysis will be objective and experimental in nature, aiming to evaluate the effectiveness of the restoration methods used.

The paper will focus on three main research objectives:

- **First,** evaluate the effectiveness of 3D modelling in revitalising heritage sites, specifically through the iHeritage project's use of ICT solutions.
- **Second,** analyze the outcomes of the iHeritage project and its impact on the preservation and promotion of cultural heritage.
- **Finally,** provide recommendations for the future implementation of 3D modelling and ICT solutions in the revitalization of heritage sites.

By achieving these objectives, the paper aims to contribute to digital graphic restoration by providing insights into effective restoration techniques and methodologies.

4- LITERATURE REVIEW:

According to the study (Forte, M. About Virtual Archaeology: Disorders, Cognitive Interactions and Virtuality; BAR International Series 843; BAR: Oxford, UK, 2000.) Virtual restoration and

virtual reconstruction are two concepts that often coexist in virtual archaeology projects. When presenting a building in its past appearance and function, many existing parts are digitally restored, such as paving mosaics and fragmented columns, and integrated into a wider virtual reconstruction, which aims to provide a general idea of the cultural context. As a result, many "local" interventions of digital restoration are typically included in a virtual reconstruction, with differing levels of reliability that must be carefully documented.

One of the factors that affect the operational methodology of virtual restoration is the different disciplinary backgrounds between archaeology and restoration as a study of Various studies has been conducted by archaeologists and other experts in the field of archaeological and historical science (Limoncelli, M. 2019, Virtual Hıerapolıs. Virtual Archaeology and Restoration Project (2007–2015); Hierapolis di Frigia 13; Ege Yayinlari: Istanbul, Turkey.), Although these two disciplines often work together in the same contexts, they have distinct theories and methodologies. Virtual restoration is a natural evolution of physical restoration, sharing the same aims of image restitution and legibility. However, in the field of archaeology, the term "reconstruction" is more appropriate as it emphasizes the deficient state in which monuments are typically found and the need for a more extensive interpretation. This highlights the importance of understanding the context and background of both archaeology and restoration in the process of virtual restoration and reconstruction.

The use of the term "reconstruction" In virtual archaeology projects, the concepts of virtual restoration and virtual reconstruction often coexist (Forte, M., Ed. 2010); Archeopress: Oxford, UK; pp. (63–73). When a building is virtually presented in its past appearance and function, existing parts are digitally restored and integrated into a wider virtual reconstruction to provide a general idea of the cultural context. This means that many "local" interventions of digital restoration are typically included in a virtual reconstruction, with varying levels of reliability that must be carefully documented.

In another study of (Mortara, M.; Catalano, C.E.; Bellotti, F.; Fiucci, G.; Houry-Panchetti, M.; Petridis, P. Learning cultural heritage by serious games. J. Cult. Herit. 2014, 15, 318–325.) Over the last two decades, rapid technological and cultural development has enabled the proliferation of various digital applications, such as virtual reality, augmented reality, mixed reality, and serious games, all of which are oriented towards communicating the past using 3D content. Today, 3D technology and virtual reality make digital interventions possible that were previously inconceivable in the mid-nineties. Consequently, virtual restoration has been applied not only to two-dimensional features such as wall paintings, canvas or wood paintings, mosaics, documents, and library materials, but also to other forms like 3D restitution of artefacts like sculptures, movable artefacts, and, above all, architecture.

Criticism has been directed towards the high graphic quality of virtual reconstructions. As the idiom goes, "seeing is believing" in the research of (Bentkowska-Kafel, A.; Denard, H.; Baker, D. Paradata and Transparency in Virtual Heritage; Routledge: London, UK, 2012.), and the realism achieved by modern visualization systems may lead users to perceive the virtual model as "truth" instead of as an interpretation. As a result, it is crucial for every virtual reconstruction to adhere to appropriate procedures that declare its level of authenticity, enabling differentiation between what is genuine and what is interpreted.

In this research has complained that most virtual reconstructions lack such procedures This can be challenging because it is often difficult to make all the sources that contributed to the creation of a hypothetical reconstruction transparent, particularly in cases involving intricate contexts or contradictory information, These criticisms were generated in part by the fact that the first applications of The use of virtual reality for 3D visualization of archaeological data had certain shortcomings. Initially, there was a dearth of cohesive virtual archaeological projects that aimed to use digital technologies to obtain accurate answers. Numerous projects were primarily focused on the technological aspects of exhibition and dissemination, rather than on scientific inquiry. The initial models lacked transparency with regard to their sources, and the reconstructions were presented in a dogmatic manner, without providing alternative hypotheses search, which is the research will focus on here adding a method.

5- METHODS

The technique of "stylistic restoration" is typically used for small gaps or areas where the missing pieces can be replaced based on tangible evidence of the same project area, such as in the case of the City of Workers and Solar Boat. In some instances, missing pieces can be deduced through the conjunction or continuation of lines or situations to integrate a clearly identified figure of the site, as seen in the map of the City of Workers. This approach was followed in the virtual reconstruction of the city, where missing details, such as anatomical parts of the city where people used to live, were reconstructed using analogous elements present in the representation itself.

However, when the gaps were too large or there was insufficient information from archaeologists, operational approaches were borrowed from physical restoration techniques based on the description of the city. This allowed for a more accurate and reliable reconstruction of the city in its former state.

5-1 The process of establishing a virtual reality of the restoration of virtual identity involves six stages (Elkheshen, G. 2022). These stages are as follows:

Developing a virtual heritage project that involves digital restoration or reconstruction of an ancient artefact, architecture, or landscape for research and cultural dissemination is a challenging and complex workflow. the process employs both bottom-up and top-down strategies, Bottom-up strategies are related to still-existing material and measurable evidence, while top-down strategies refer to information from interpretative studies based on This involves utilizing a range of sources such as literary and iconographic materials, cultural patterns, proportion rules, and comparisons.

The entire work is carried out by different professionals, including computer scientists, graphic designers, archaeologists, architects, and art historians. by comparing, integrating, and verifying their respective activities, it becomes possible to establish a robust and dependable scientific pipeline to develop

interpretations and virtual reconstructions. The workflow is organized as follows:

- **Surveying:** The process of geometrically and graphically capturing a cultural heritage site in its current state of preservation is crucial for creating a digital replica of the site. This step is essential for gaining a formal understanding and studying the object itself. Different image-based and range-based technologies with different characteristics are available today.
- **Documentation:** The second form of data utilised to help the philological reconstruction is the bibliography, which includes textual and iconographic sources linked to the item under research, as well as any previously organised and structured data, where accessible. Virtual reconstruction, like rebuilding damaged texts, needs a philological method to assure that the visual output is not solely a product of imagination.
- **Data processing and interpretation:** All data collected and processed are then analyzed and discussed among professionals in different domains to formulate a reconstructive proposal that is as accurate as possible according to the available resources. The following contents are taken into consideration and combined in the interpretative process: elements still visible on site, elements that were documented but are no longer visible today, style and theory of proportions, figurative deductions, and typological comparisons and cultural patterns. After analysing the data and resolving significant concerns, the first possible reconstruction is created, which restores an object's formal and ornamental wholeness.
- **The creation of the 2D or 3D reconstructive**: hypothesis is a complex phase that occurs simultaneously with the previous phases. It can be particularly challenging depending on the type of artefact to be reconstructed and its state of preservation. Ancient architecture, for instance, is a complex area of reconstruction due to the often-ruinous state in which the structures are preserved, as well as the fact that buildings usually include other categories of cultural heritage, each with a different degree of conservation. As a result, each reconstructive model has varying degrees of dependability, which must be expressed graphically to allow the interpretative intervention to be recognised.

5-2 The Importance and Mechanisms of Virtual Reality in Cultural Heritage Preservation and Presentation: Revolutionising Archaeological Sites

The use of virtual reality (VR) has transformed the protection and display of cultural assets. It provides guests with a totally immersive experience that transports them to ancient realms and brings historical events to life. We intend to investigate the significance of employing VR at ancient sites and the mechanics behind its functionality, but before we do so, we must complete a crucial process: the site's moulding (3D Modelling, Landscape, Shapes).

VR works by simulating a real-world environment on a computer and allowing users to interact with it via a headset or other VR device. VR can reproduce old architecture, buildings, and landscapes with astonishing precision by employing 3D models and high-resolution photos. Visitors may explore the site from various perspectives, walk about the area, and even interact with the simulation's objects and people.

The principles behind virtual reality are complicated, but the fundamental method (Part 6) in research is generating a 3D model of the place using photogrammetry or laser scanning technologies.

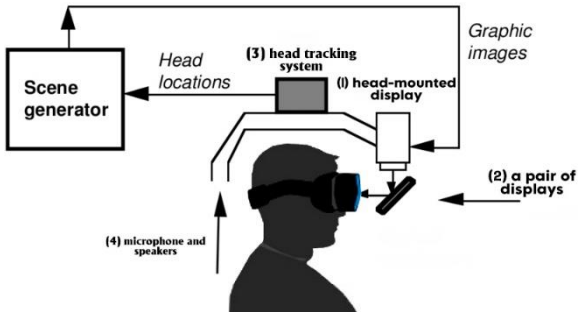
This model is then imported into a VR platform and examined using a headset or other VR device the application of virtual reality in ancient sites is critical for cultural heritage protection, It provides a one-of-a-kind opportunity to engage guests and give an immersive experience that may bring history to life, and this's what we offer through our project.

5-3 Virtual Reality Head-Mounted Displays (HMDs):

by the end of our work, we will add the outcome of our project to a Virtual reality (VR) is a simulated experience that can be similar to or completely different from the real world, by head-mounted displays (HMDs).

HMDs are a type of VR device that fits over the user's head and displays images in front of their eyes. HMDs typically have a pair of displays, one for each eye, that provide the user with a stereoscopic view of the virtual world. The displays are often made of high-resolution OLED or LCD panels, and they can be used to create immersive virtual reality experiences that feel like the user is actually inside the virtual world, HMDs also typically have a number of other features, such as built-in sensors to track the user's head and eye movements, and a built-in microphone and speakers to allow the user to interact with the virtual world.

(Figure 3) shows a diagram of a typical HMD. The HMD consists of a head-mounted display (1), a pair of displays (2), a head-tracking system (3), and a microphone and speakers (4) all gathering in a scene generator, The head-mounted display fits over the user's head and displays images (Graphic image) in front of their eyes. The displays are typically made of high-resolution OLED or LCD panels, and they can be used to create immersive virtual reality experiences that feel like the user is actually inside the virtual world. The head tracking system tracks the user's head and eye movements, and it sends this information to the virtual reality software. The virtual reality software then updates the images on the displays to match the user's head and eye movements. The microphone and speakers allow the user to interact with the virtual world, The images can be created in a variety of different formats, such as 3D models, 2D images, or video. Once the images are projected, they can be viewed by the user through the HMD, we are using the 3d models and render them through Blender and Maya then Cinema 4D.



(Fig 3) The VR (HMD)
Source: Author

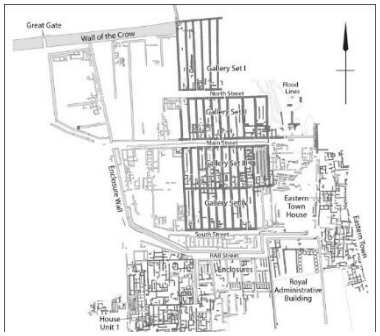
6- Fundamental of the project Methods (iheritage):

Plans and maps

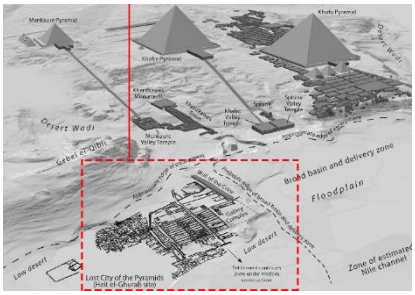
The site we chosen in our research is known as Heit el-Ghurab in Arabic, but in popular texts, it has been referred to as the "Lost City of the Pyramid Builders." It is believed that the people who built the pyramids, likely including the pyramids of Khafre and Menkaure, lived here. The site includes various features that one would find in a city, such as bakeries, housing for both the working class and elite, and administrative buildings. The city is surrounded by walls on its western, southern, and northern borders. Evidence has been found for administrative areas within the town, including houses for administrators and the royal administration building. Large amounts of meat and fish processing evidence have been found, indicating the feeding of a significant number of workers. This site provides valuable insight into the daily life of an Egyptian during the 4th dynasty.

The city of workers (Heit el-Ghurab site) is situated at the low southeastern base of the Giza Plateau, as a definition of the AERA team map (Fig.4) the main archeologists in the Plateau. Approximately 400 meters south of the Great Sphinx. This site was one of several settlement patches that stretched out north-south along the eastern base of the plateau, as revealed by drill cores and trenches conducted in the late 1980s during the Greater Cairo Waste Water Project. These settlements likely flanked the western side of a Nile channel located about 200 to 300 meters east of the Giza site.

During the 2015 excavation season, the team at Heit el-Ghurab gained additional knowledge about the site as a whole, whishes is the accurate plan we start work on it.



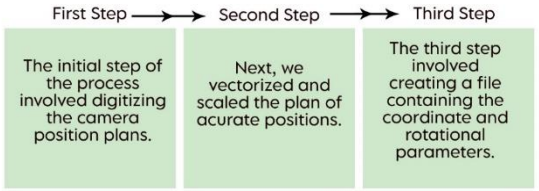
(Fig 4) Part of the cartographic reference made by the AERA team in 2022. Source: https://aeraweb.org/about/



(Fig 5) The main spot of the city and the accurate distance between the pyramids after the map study. Source: author

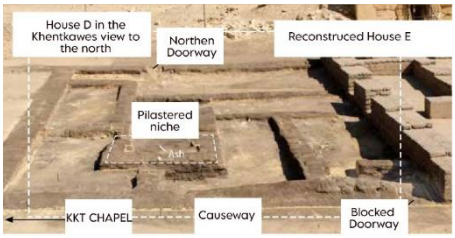
Digitization process:

There are various methods used to capture the three-dimensional geometry of a site, including laser scanning, photogrammetry, and structured light scanning. In the case of the City of Workers, laser scanning may be used to capture the site's three-dimensional geometry accurately. This technology involves using a laser scanner to capture millions of points on the site's surface. These points are then used to create a 3D model of the site through a main three steps of the process involved digitizing the position plans, followed by vectorizing and scaling the plan. Finally, we created a file containing the coordinate and rotational parameters (fig 6).

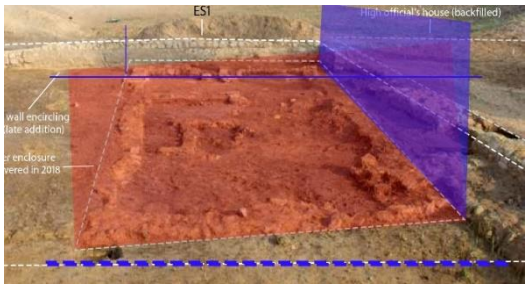


(Fig 6) depicts the process of creating the file containing the coordinate and rotational parameters. Source: Author

Photogrammetry is another popular digitization method. It involves capturing a series of overlapping photographs of the site from different angles. These photographs are then processed using specialized software to create a 3D model of the site this's what we used in our project as a base of Mark Lehner, 2018 studies (fig 8).

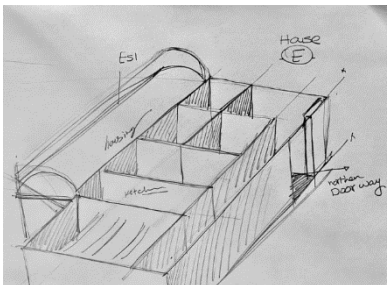


(Fig 7) Photogrammetry of the (House E) The elements that were modelled by hand, such as the floors, the Door of the house, a portion of the terrain, and the handrail, were aligned with the photogrammetric surfaces Source: https://www.aeraweb.org/wp-content

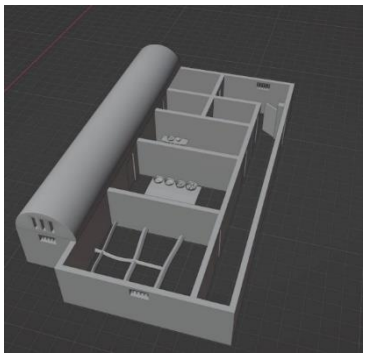


(Fig 8) Photogrammetry of the (House E) The elements that were modelled by hand, such as the floors, the Door of the house, a portion of the terrain, and the handrail, were aligned with the photogrammetric surfaces Source: https://www.aeraweb.org/wp-content

Once the 3D model of the City of Workers is created, the data can be exported in various file formats, depending on the further processing program and method and before this step we draw accurate plan from the photometry data and after the archology's revision of houses an example House E (fig 9). For instance, the data can be exported in a format that can be used to create a virtual reality model of the site. This virtual reality model can be used to visualize the site's layout and features accurately. Additionally, it can be used to simulate different scenarios and test the impact of various restoration methods on the site.



(Fig 9) The sketching process for each part of the city (house of workers) House E 1 Source: Author



(Fig 10) digitization of the sketch in 3dmax and vectorization process of house E Source: Author

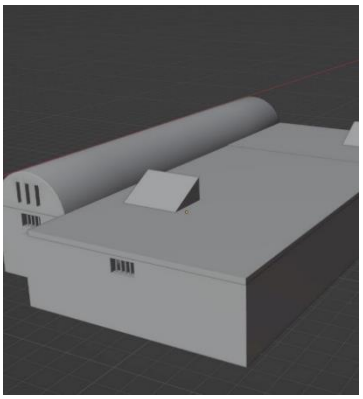
The digital documentation created during the digitization process can also be used to aid in the restoration of the City of Workers. For instance, the 3D model can be used to create a physical replica of the site as example house E that show how we built the house through 3dmax (fig 10). This replica can be used to test different restoration methods and materials before being implemented on the actual site. Additionally, the digital archive of the site can be used for education and research purposes.

6-2 3D RECONSTRUCTION FROM HISTORICAL MATERIALS

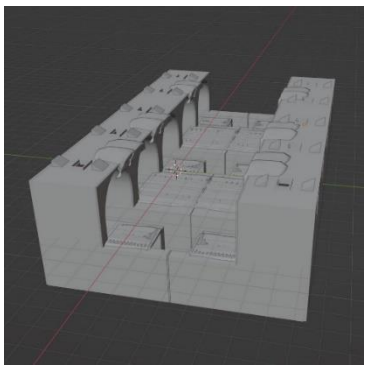
The majority of current techniques for creating 3D models rely on the vector version of architectural plans. As previously mentioned, these plans can be in either raster or vector format and may be created either digitally or on paper. In the case of paper plans, they must first be digitized using a high-resolution scanner by a graphic designer under the supervision of an archaeologist. This collaborative process is crucial to ensure accuracy. When converting the plan to an output file, using the TIFF format is recommended because other file formats can result in more speckles and unnecessary distortion of the plan during the conversion process.

In our project, Iheritage, which involved documenting the city of workers, we utilized several 3D modelling techniques that relied on accurate architectural plans and graphic design work. Specifically, we employed methods such as:

1. floor generation and wall extrusion from vector data.
2. as well as modelling from floor plans and elevation plans using vectorized 2D data in software such as 3Dmax (fig11).
3. we utilized techniques for modelling from floor plans and elevation plans using raster data (fig 12).

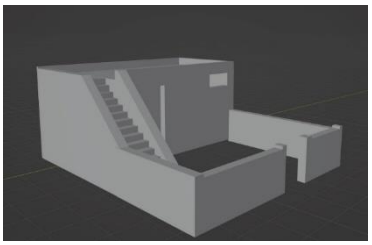


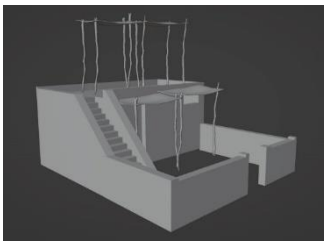
(Fig 11) vectorization the data into 3D house E Source: Author



(Fig 12) We employed techniques that allowed us to create models using raster data sourced from floor plans and elevation plans. Source: Author

In this particular step, which is the fourth stage of the 3D max process, we took all of the plans of the city of workers through a rigorous process to construct the various types of houses that exist within the city. The diversity in the design of the houses comes from the differences in the layout of the accurate plans of the city, as depicted in (fig13).





(Fig 13) Another Exist house in the city the layout of the house plan was different from the other 2 houses we have been mentioned Source: Author

6-3 Rendering of restoration 3d file:

how technology can aid in this process through 3D rendering, as demonstrated in the outcome of our work in the city of workers. Our virtual restoration and reconstruction efforts not only preserved the physical characteristics of the city's cultural artefacts but also allowed for a deeper understanding of their historical and symbolic significance through using accurate rendering of the buildings and landscape (fig 14), also the interior setup (fig 15) shows the realistic interior of one the houses.

(Fig 14) the view of the city after rendering (1)
Source: Author

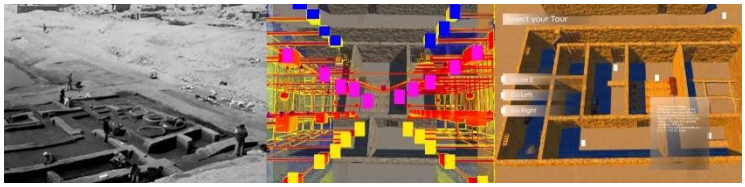
(Fig 15) one of the interior setups inside one of the houses
Source: Author

6-4 Methods of Applying 3D in Virtual Reality for the Iheritage Project:

This stepped approach is a collaboration between (technical IT for the cyber map and Graphic designers) the solutions to the challenge of virtual heritage. Rather than simply digitizing or creating a replica of cultural heritage objects, virtual heritage aims in iheritage projects in the city of workers to enhance their value beyond their physical form by providing information associated with them. In the absence of materiality, the interaction processes, feedback, and semantic values that can be attributed to the virtual model are crucial. This connection results in the development of the cognitive process, to make this process of interaction possible, there are two basic conditions.

Firstly: the virtual reconstruction should be part of a virtual ecosystem that is not limited to pure visualization as we did in the previous part informative network should be established to connect the 3D elements with the knowledge available for each of them.

Secondly: the principle of "data transparency" should be followed by declaring interpretative sources and processes and making them explicit in virtual reconstructions as the main archaeology supervised like in (fig 16) the integration makes sensors of some parts for the VR to add the user experience visit in the one of the houses also the information the audience like to know through audio and visual experience.



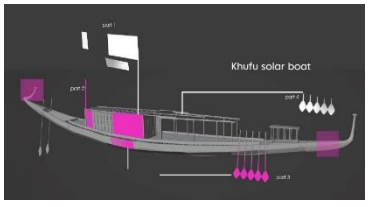
(Fig 16) The City of Workers on the left project utilized outcome, virtual reality technology to create an immersive experience for visitors. The virtual reality application included a 3D reproduction of the iconographic space, in the middle the cyber map that represented each scene with a box and thematic layers, and on the right a main menu that allowed visitors to activate different thematic layers in the VR look.
Source: Author

By meeting these two conditions, the virtual environment can trigger a process of learning through experience, combining perception, movements, behaviors, and symbolic-reconstructive mental faculties. This approach has been adopted by the multidiscipline of the technology company Applied to the Cultural Heritage in our project for the VR.

The successful virtual restoration and reconstruction of historical places require a scientific approach that involves a multidisciplinary team. In line with this approach, our project included the virtual restoration of the (Khufu Solar Boat), following the same methods used for the City of Workers project. In recent years, various projects and documents have aimed to establish guidelines and best practices for scientific visualization of the past to ensure efficient and accurate virtual reconstruction.

For reconstruct the Khufu Solar Boat, we utilized a three-dimensional survey of the archaeological remains and fragments that had been relocated to the Grand Egyptian Museum. Through a process of virtual anastylosis, we were able to restore the over 13 missing parts of the boat in a virtual view as shown in the (fig 17).

To complete these missing parts, we referred to numerous iconographic testimonies, historical-archaeological documents, and stylistic comparisons of small mockup boats. After the archaeologist's review, we simulated the restoration process using 3D Max and then converted it into a VR experience (fig 18).



(Fig 17) vectorization of the solar boat and showing through the 3d missing parts Source: Author

(Fig 18) the restoration of the Khufu boat with all fixing missing parts Source: Author

When creating virtual restorations and reconstructions of cultural heritage, there are two possible communicative approaches: one aimed at experts and the other at a wider audience. The target audience greatly influences the design of

the experience, with specialized audiences requiring a more analytical approach and non-expert audiences benefiting from a more mediated, narrative, or playful approach that introduces the cultural context and its historical background.

The medium used for communication also greatly influences the type of experience that can be created. A movie, for example, consists of a predefined sequence that connects perspectives and contents according to a given logical process, making it useful for recording and documenting different phases of a process. However, passive viewers have no possibility of performing an active role in the knowledge process, making movies less suitable for interactive learning that's why we add the user experience to our conditions when we approach this call of iheritage and how we develop an ancient historical site through technology.

In contrast, an interactive environment allows users to play an active role in shaping their personal knowledge process through an alternation of actions and reactions. Decisions regarding rendering techniques, contents and metadata, visualization technologies, and investigation tools change according to the different audiences, even if they always follow methodological awareness and scientific criteria.

In our research, we applied these concepts to two main experiences: the City of Workers project and the virtual restoration of the Khufu Solar Boat. These projects utilized a scientific approach and followed established criteria for virtual restoration and reconstruction, while also considering the needs and expectations of different audiences.

7- Conclusions:

The iHeritage project has shown that 3D modelling and virtual reality are powerful tools in revitalizing heritage sites. The project's methodology, which involves the exchange of information between digital and physical components, has created an immersive experience that enables scholars and the public to interact with cultural heritage in a meaningful way. This methodology, which prioritizes recognizability, transparency, and reliability, has allowed the iHeritage project to translate the city of workers and other items into a wider cultural transmission, enhancing cultural awareness and sensitivity.

The iHeritage project's outcomes have demonstrated the positive impact of ICT solutions in preserving and promoting cultural heritage. By following a methodology that considers the needs of the audience, virtual tools have the potential to enhance understanding and appreciation of cultural heritage. These tools facilitate a deeper comprehension and contact with the past culture, fostering new processes of interaction and critical thinking.

Furthermore, the iHeritage project's success in revitalizing heritage sites through the use of virtual tools paves the way for future implementations. The potential for digital multiplications of cultural heritage to enhance the value of cultural heritage has been illustrated, debunking the notion that virtual restoration and reconstruction trivialize its value. Instead, the iHeritage project demonstrates that the real and virtual should not be considered as opposed, but as a "continuum" that brings value to the cultural and human experience, with the observer becoming an active participant with a leading role.

In conclusion, the iHeritage project's implementation of 3D modelling and virtual reality has demonstrated the potential of ICT solutions in revitalizing heritage sites. By following a methodology that prioritizes recognizability, transparency, and reliability and considering the needs of the audience, virtual tools can enhance understanding and appreciation of cultural heritage, fostering new processes of interaction and critical thinking that benefit both scholars and the public. The iHeritage project's outcomes illustrate the positive impact of ICT solutions in preserving and promoting cultural heritage, paving the way for future implementations in the revitalization of heritage site

As a main point of conclusion:

- The iHeritage project's use of 3D modelling and virtual reality has demonstrated its potential in revitalizing heritage sites.
- The methodology used in the iHeritage project prioritizes recognizability, transparency, and reliability, which has allowed for the translation of cultural heritage into a wider cultural transmission, enhancing cultural awareness and sensitivity.
- The positive outcomes of the iHeritage project illustrate the potential of ICT solutions in preserving and promoting cultural heritage, paving the way for future implementations in the revitalization of heritage sites.

8- RECOMMENDATIONS

- Develop virtual archaeological sites to preserve and showcase cultural heritage in Egypt, especially for sites that are difficult to access or at risk of damage or destruction.
- Utilize virtual reality to restore monuments that are difficult to fully reconstruct, providing immersive experiences that showcase their original beauty in other Egyptian sites.
- Implement artificial intelligence programs to enhance restoration and preservation efforts in Egyptian museums with collaborations with art universities, using virtual websites to aid in their implementation.
- Establish a virtual reality design unit in collaboration with the Ministries of Antiquities and Culture to construct Egyptian museums and archaeological sites.
- Promote multidisciplinary studies between graphic designers and archaeologists through a multidisciplinary program at art universities.
- Organize conferences to foster multidisciplinary study among surveyors, archaeologists, and graphic designers and aid in the restoration of devastated ancient sites.
- Involve local communities in heritage preservation techniques and the restoration process to promote a sense of ownership and pride in their cultural heritage, and provide training programs to facilitate this involvement.

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