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Virtual reconstruction of Heritage Sites in Luxor through Augmented Reality Technology

La reconstrucción virtual de sitios patrimoniales en Luxor mediante la tecnología de la realidad aumentada

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Abstract

The research aims to investigate the virtual reconstruction of historical sites in Luxor through augmented reality technology. To achieve that, this research employed a method of descriptive analytical methodology by using a questionnaire tool. Where a questionnaire was prepared and distributed to a random sample of 436 visitors to Luxor, whether foreigners or Egyptians. The results of the tools were analyzed using descriptive statistics, reliability analysis, coefficient analysis, and Pearson correlation analysis with the support of SPSS 25.0. The research results show a very strong positive correlation between the use of augmented reality at historical sites and the future of augmented reality at historical sites. The research recommended that the Ministry of Tourism and Antiquities pay more attention to the studies and research that concern the usage of new technologies in cultural heritage sites.

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Keywords: Historical sites, Augmented Reality, reconstruction, temple of Amenhotep III, Luxor.

Resumen

Este trabajo ha tenido como objetivo investigar la reconstrucción virtual de yacimientos arqueológicos en Luxor a través de tecnología de realidad aumentada. Para lograrlo, esta investigación empleó un sistema de metodología analítica descriptiva mediante el uso de un cuestionario que se elaboró y distribuyó a una muestra aleatoria de 436 visitantes de Luxor, ya fueran extranjeros o egipcios. Los resultados de este cuestionario se analizaron mediante estadística descriptiva, análisis de fiabilidad, análisis de coeficientes y análisis de correlación de Pearson con el apoyo de SPSS 25.0. Los resultados de la investigación muestran una correlación positiva muy fuerte entre el uso de la realidad aumentada y el futuro de la misma en yacimientos arqueológicos. Esta investigación recomendó que el Ministerio de Turismo y Antigüedades egipcio preste más atención a los estudios e investigaciones que se refieren al uso de nuevas tecnologías en los lugares Patrimonio de la Humanidad.

Palabras claves: Sitios históricos, Realidad Aumentada, reconstrucción virtual, templo de Amenhotep III, Luxor.

1. Introduction:

One of the most recent and cutting-edge fields of technology is augmented reality (AR) (Boboc et al., 2022). In addition, Flavián et al. (2019) noted that augmented reality (AR) is a visualisation technology characterised by digital multimedia information superimposed on the user's actual surroundings; AR apps offer a mediated perception of the real-world environment by seamlessly integrating real-world images with computer-generated content. Han et al. (2019) concluded as a result that AR have significant potential for the preservation of distinctive and charismatic cultural resources. On the other hand, Farid and Abdelhamed (2018) noted that numerous structures have suffered substantial harm and alterations due to inadequate management of heritage sites or as a result of the negative effects of excessive tourism (Capocchi et al., 2019). There are many different types of virtual reconstruction, including the state of complete physical loss of heritage sites, the re-creation of a vanished human environment, the fusion of the virtual world created and reality through enhanced reality technology, or in the case of historical changes to historical sites and their monitoring over time. The virtual reconstruction of monuments to heritage sites has attracted significant attention around the world in the past decade (Farid, & Abdelhamed ,2018). In the present tourism discourse, the potential of AR for historical tourism is getting substantial traction (Cisternino et al., 2021; Hincapie et al., 2021). Cultural heritage is divided into two distinct categories, tangible and intangible heritage, such as customs and information that may be used to have a better understanding of the past and civilizations, according to Kim et al. (2019).

AR has been used in a variety of industries, including healthcare, tourism, the automobile industry, education, and medicine (Arena et al., 2022). It has been shown to be particularly helpful for managing and preserving cultural heritage (CH). The following are the primary uses of AR in CH: enhancing the exploration, reconstruction, and visiting experience (Okanovic et al., 2022), AR has been applied in various fields, from medicine to education, automotive industry, healthcare, or tourism (Arena et al., 2022). In particular, it was proven to be useful for the management and preservation of cultural heritage (CH). There are some main purposes for which AR is used in CH: improving visitor experience, reconstruction, and exploration (Okanovic et al., 2022), Additionally, it is used for conservation and preservation (Merchán et al., 2021) and for bringing historical events to life (Boboc et al., 2019). Digitization is the technique that is most frequently used in each of these scenarios. It is utilised as an additional technique to protect CH assets and to improve conventional conservation techniques (Salleh, & Bushroa, 2022).

Research Problem:

Despite Luxor owns a large treasure of historical sites and monuments. However, the heritage sites in Luxor suffer from multiple problems represented in the poor handling of the heritage site and the lack of protection for those sites. Which lead to the deterioration of some sites, and with the technological advances that the world is witnessing today in all spheres of life, Augmented Reality Technology is emerging as one of the solutions that can be used in heritage sites in Luxor. That is one of the latest and most innovative technologies for the virtual environment, working on the reconstruction of historical sites as they were at the beginning of their construction.

Research questions

The study examines three research questions:

1. What is the importance of using augmented reality technology in historical sites in Luxor?
2. What extent of user acceptance of augmented reality technology?
3. What is the future of augmented reality technology in heritage sites in Luxor?

Research Aim

The main aim of the research is to investigate the virtual reconstruction of historical sites in Luxor through augmented reality technology.

Research importance:

The importance of this research is to shed light on using of augmented reality technology in restoration of archeological sites in Luxor. A virtual reconstruction of the temple of Amenhotep III in the west bank guarded by the statues of Memnon was chosen to conduct the research as a model of augmented reality technology.

2. Literature Review

2.1 The Difference between Augmented Reality and Virtual Reality

Despite the similarities between AR and VR (Ong et al., 2008), table (1) demonstrates how AR varies from VR. Virtual Reality (VR) was a well-known, widely used technology that allowed users to access information in an interactive setting until recently (Kounavis et al., 2012). In addition, Fritz et al. (2005) said that Virtual Reality (VR) is a well-known technology that aims to change how people interact with information and communication technology by giving data a creative outlet. Additionally, Khalil (2014) pointed out that the phrase "Virtual Reality" refers to 3D computer-generated settings that let users explore and interact with a different reality. Some people define virtual reality (VR) as anything that shifts a person's perspective temporarily and places them in a different reality. Occasionally, this alternative world is referred to as a virtual environment (VE), "Where the user is completely immersed to the point that any way they look or turn, they are still immersed" (Podgorny, 20104). Augmented reality (AR) is "a visualisation technique that superimposes computer-generated data, such as texts, videos, graphics, GPS data, and other multimedia formats, on top of the real-world view, as captured from the camera of a computer, a mobile phone, or other devices," according to Kounavis et al. (2012, p.1). While Farid & Abdelhamed (2018) noted that one of the most important differences between AR and VR is that while AR allows users to see the real world with two-dimensional (2D) or three-dimensional (3D) images overlaid upon the real-world images or videos, VR completely immerses users inside a Virtual Environment (VE) so that they are unable to see the real world around them.

Table1. Augmented reality (AR) vs. virtual reality (VR)

TECHNOLOGIES	VIRTUAL REALITY	AUGMENTED REALITY
LOCATION	Off-site	On-site
VISITATION	Before and after actual visit	During the visit
PLATFORM	Website	IOS or Android
DEVICES	PC, HMDs, etc.	3G Mobile Devices

CONTENT	Large information (text, animation, video, audio, virtual tour featuring 360-degree panoramic images)	Bite site information (text, animation, video, audio, images of early years, suggestions on where to go next, what to do next)
NATURE	Informative, interactive, Immersive	Informative, interactive, immersive
FUNCTIONS	Marketing tool to attract tourists, tour planning prior to visit, informative and educational, virtual visits, post-visit updates	Marketing tool to attract tourists, informative and educational, interactive actual visits, virtual tour guide

Source: Adapted from Ab. Aziz and Siang (2014) p/334.

Virtual Reality (VR) technologies were one of the most well-known technologies up until recently (Fritz et al., 2005). The basic goal of virtual reality (VR) is to completely immerse users in a computer-generated 3D environment known as a virtual environment (VE) without allowing them to see the surrounding real world (Guttentag, 2010; Aziz & Siang, 2014). Thus, despite the widespread use of VR applications, their primary drawback is the lack of a connection between the user and the real world (Fritz et al., 2005). Because augmented reality technologies enhance the real world rather than replace it and enable users to experience the real world enhanced with two-dimensional (2D) or three-dimensional (3D) graphics overlapped to his field of view, they are consequently growing in popularity (Fritz et al., 2005; Rivera, 2013; Rivera,2015).

According to the Milgram's reality-vitality continuum (Figure 1), AR lies among the virtual environment and the real environment (Milgram et al., 1994).

Fig (1) Milgram's Reality-Virtuality Continuum

Source: Milgram et al., 1994 p/ 288

2.2 Augmented Reality in Culture Heritage (CH)

Over the past ten years, AR has been introduced to the Culture Heritage sector, mostly as a helpful tool for guiding visitors through historical buildings or museums (Pedersen, 2017). By getting over limitations in time, location, and language, it enables visitors to investigate and enjoy the artefacts on display (Chung et al., 2018); Damala (2016); And Bostanci et al. (2015) both agreed that using improved user engagement techniques enhances the learning experience in culture heritage. As an illustration, in (Deliyiannis & Papaioannou, 2014), the data is arranged in finite triplets (visual representation, context, and related audiovisual content) in order to be displayed in a customised, interactive way on users' individual mobile devices. Additionally, AR technologies have shown their significance in the virtual reconstruction of historical landmarks, holding the promise of offering a fresh perspective on the past by simulating in-person historical encounters (Chung et al., 2015). Many items, monuments, or historical locations were recreated in digital formats over the past ten years due to its significance. The importance of reconstruction also lies in its ability to bring historical components to life (Kysela & Torková, 2015; Boboc, 2017) and to conserve, safeguard, and interpret culture and history (Creed, 2013). The digital heritage is predicted to rise tenfold between 2013 and 2020, with a size increase of a factor of two every two years, according to Tan, Lim, & 2017a. While virtual heritage (VH) involves the synthesis, conservation, reproduction, representation, digital reprocessing, and display of monuments, artefacts, buildings, and culture in order to be more accessible to audiences around the world, digital heritage (CH) is primarily concerned with the preservation of CH (Noh et al., 2009). However, Hincapie et al. (2016) noted that it is still difficult to design applications that aim to reactivate CH. Therefore, according to Gao et al. (2013), it is crucial to consider the process of evaluating digital cultural resources. According to Gao et al. (2013), digital resources are a collection of cultural resources that have been produced using computer and multimedia technologies. They may be accessed and used digitally.

2.3 Challenges of adopting AR

Despite the many advantages that AR has brought to visitors and cultural heritage sites, its use is still not widespread and effective, and its uptake has been slower than anticipated (Chung et al., 2015). Additionally, Cranmer et al. (2016) noted that due to several difficulties, only a small number of cultural heritage sites are now utilising AR to its full potential. Abboud (2014) categorised the difficulties associated with AR into three categories: technical difficulties, human problems, and budgetary constraints.

The tracking system is the main focus in terms of technical difficulties (Mohd et al., 2015). Since augmented reality (AR) is fusing computer-generated data with the physical environment (Abboud, 2014), it necessitates efficient tracking technologies like the Global Positioning System (GPS) to precisely pinpoint the user's location. According to Azuma et al. (1997), Höllerer & Feiner (2004), Rabbi et al. (2013), and Mohd et al. (2015), such

technological systems are essential for registering the elements of the real world and supplementing them with digital data. Additionally, using the AR system in the tourism industry typically necessitates having access to the internet, which is easily accomplished through Wi-Fi or 3G (Kounavis et al., 2012). However, not all tourist destinations or cities have Wi-Fi networks that provide 3G and free internet access. In addition, many travelers still pay high data roaming fees, particularly those who are younger (Kounavis et al., 2012). Resistance to change is regarded as a significant hindrance in regards to human issues (Abboud, 2014). Since many tourists still place a high value on conventional knowledge sources like books, the acceptance and dependency on such foreign technology would initially encounter opposition (Pang et al., 2006; Han et al., 2014). Another hurdle is thought to be a lack of understanding on how to use and adopt such new technologies (Cranmer et al., 2016). Finally, many tourist locations face difficulties with budgetary constraints and a lack of funding opportunities (Fritz et al., 2005). To equip the sites for the implementation of the AR system, additional costs will be required (Abboud, 2014). Despite the difficulties in the past, augmented reality (AR) will soon play a significant role in the tourism business thanks to its practical usefulness and ability to be used both indoors and outdoors (Fritz et al., 2005). To stay competitive and appealing, many tourist sites should make ongoing investments in these new technologies (Fritz et al., 2005).

2.4 Case Study:

Farid, and Abdelhamed (2018) state that there is a need to introduce and use the application of virtual heritage in the provision of Egyptian cultural heritage for visitors, as this helps to improve their knowledge of Egyptian heritage and aids in the arrival of visitors to a high level of indulgence and integration by giving them the opportunity to experience enhanced simulation and view the reconstruction of heritage sites as they existed in the past.

The following are the most crucial reasons why the temple of Amenhotep III was selected as a case study: - - One of the biggest temples Egypt had ever seen was the temple of Amenhotep III. In 1998, Armenian archaeologist Hourig Sourouzian persuaded the World Monuments Fund to list the Mortuary Temple of Amenhotep III as one of the world's "100 Most Endangered Sites." There have been numerous initiatives to save and repair the temple. Sourouzian set out on the expedition to save the interior statuary and the long-forgotten place. The Colossi of Memnon were the only two items still present at the temple. Researchers from France, Switzerland, Spain, Japan, and Germany were requested to assist with the difficult task of raising the Amenhotep III temple. Over 400 local labourers and the researchers were put to work by Sourouzian. This project was witnessed as “One of the most ambitious initiatives Egypt has seen in decades"

2.5 Amenhotep III Temple

On the western bank of the Nile River, across from the contemporary city of Luxor, is where you'll find the Amenhotep III burial temple (Fig. 2). Ancient Thebes, which is now

known as Luxor, was the capital city of Egypt for many centuries and is one of the most well-known archaeological sites in the entire world (Karakhanyan et al., 2010). The Valley of Kings, Theban necropolis, and Valley of Queens, as well as a number of temples constructed by pharaohs of the Middle and New Kingdoms, can all be found in a short region of 10–12 km2 on the western bank of the Nile (Fig. 2).

When it was finished, the Amenhotep III memorial temple had a magnificent array of pylons, great halls, chambers, stelae, and statues that covered an area of more than 385,000 m2 (Weeks, 2005). It was one of the biggest temples ever constructed in Egypt. The main axis of the temple extends roughly 700 metres from its first pylon in the west to its back wall. With its dependencies and processional routes, it extended from the Ramesseum and the temple of Medinet Habu to Malqata, the enormous palace of Amenhotep III, with an estimated width of 500 m (Karakhanyan et al., 2010). Along with the temple, the enormous temple complex formerly had two 18-m-tall colossal statues of Amenhotep III, also known as the Colossi of Memnon(Karakhanyan et al., 2010).

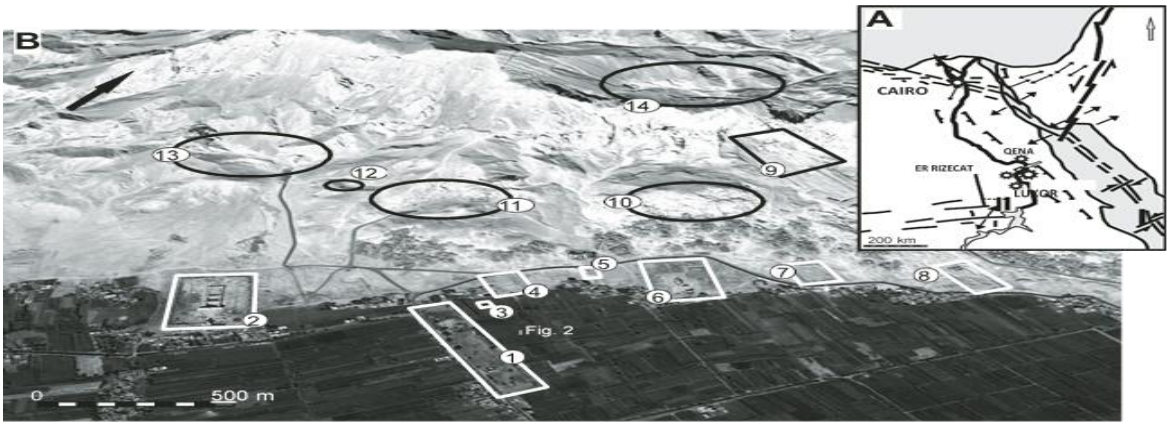

Figure 2. (A) General tectonic settings of Egypt according to Youssef (2003); The arrow indicates the site of works in Luxor. (B) West bank of the Nile opposite to Luxor: 1—the temple of Amenhotep III, 2—temple of Ramses III (Medinet Habu), 3—location of fragments of a colossal statue of Amenhotep III, 4—temple of Merenptah, 5—tomb of Khonsuiri-dis, 6—temple of Ramses II (the Ramesseum), 7—temple of Tuthmosis III near the Ramesseum, 8—XX Dynasty temple, 9—temple of Tuthmosis III in Deir al-Bahari, 10—Sheikh Abd el-Qurna hill with the Theban necropolis, 11—the village of ancient Kings Valley's builders in Deir Al-Medina, 12—sanctuary dedicated to the goddess Meretseger and to the god Ptah, 13—the Valley of Queens, 14—the Kings Valley . **Source**: *Karakhanyan et al..2010 p/200*

This research attempt to reconstruct one of the most significant cultural sites as one of the most significant historical monuments of pharaonic civilization by relying on virtual heritage technology and augmented reality technology. Visitors will be able to view the entire history and lore of the location because it will be completely reconstructed in augmented reality.

Gathering information, documents, sketches, and speculations is the first step in creating augmented reality for this website. To generate an architectural documentation of the site, all data is processed and analysed. Views are adjusted to the site's historical age, and augmented reality is supported with historical tales and facts on the archaeological site. Visitors can exhibit augmented reality anyway they choose. She has provided a number of augmented reality display techniques in her research that can be used with smartphones, tablets, or smart glasses. Figures (a) show the Amenhotep III temple as it is right now, and (b) show the temple enhanced with a rendered version on a mobile device.

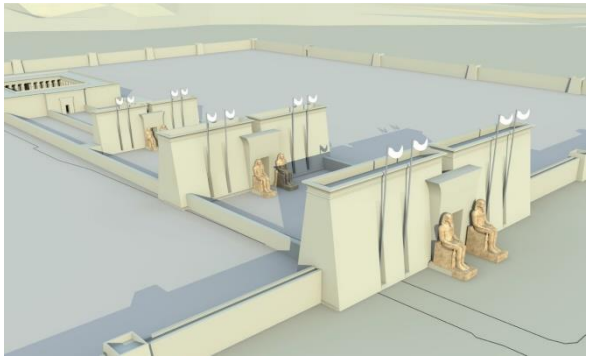

Figure 3 :(a) first picture to the left: Current view of temple of Amenhotep III; (b) second picture to the right: Augmented temple with the rendered model on handheld devices (Hampikian, 2016).

3. Methodology:

The researchers used the descriptive-analytical approach in which they tried to describe the usage of augmented reality technology in the reconstruction of historical sites as they were at the beginning of their construction, in light of the deterioration of the status of some of these archaeological sites and others' destruction, affecting the cultural heritage of the country and losing the luster of archaeological sites. Furthermore, in an attempt to preserve archaeological sites and with the desire to strengthen ways of dealing with, managing, and restoring those sites and in an attempt to provide archaeological sites in a better way, since it is the most appropriate approach to describe the phenomenon in question, In this approach, the researcher is trying to describe the subject of the study, analyze the data, compare, explain and assess hoping to reach meaningful generalizations to increase and enrich knowledge on the subject.

3.1 Data collection

Data has been collected through questionnaires that were prepared in a way that is relevant to the situation so as to decrease invalid responses. They were distributed to all visitors to Luxor, whether foreigners or Egyptians.

3.2 Measures

In this study, data was collected by form of a questionnaire. The form of questionnaire was directed at a random sample of all visitors to Luxor, whether foreigners or Egyptians. The form mainly involved closed and open questions. All sections of the questionnaire included a slew of pertinent questions about virtual reconstruction historical sites in Luxor through augmented reality technology.

The first section includes visitors to Luxor, whether foreigners or Egyptians, and their demographic characteristics (gender, age, educational level, and monthly income). The second section included three variables representing knowledge of augmented reality. The third section included nine variables representing easy-to-use augmented reality. The fourth section, Obstacles to the Use of Augmented Reality, included six variables. The fifth section, on the use of augmented reality at historical sites, included 14 variables. The sixth section included five variables representing the future of augmented reality at historical sites.

The questionnaire items were anchored according to the Five-Point Likert Scale: "1 = strongly disagree", "2 = disagree", "3 = neutral", "4 = agree", and "5 = strongly agree".

3.3 Data Validity and Reliability

Table (2) Cronbach's Alpha value

Variables	No. of items	Cronbach's Alpha Value	Validity Coefficient*
Knowledge of augmented reality	**3**	**0.739**	**0.859**
Easy to use augmented reality	**9**	**0.918**	**0.958**
Obstacles to the use of augmented reality	**6**	**0.815**	**0.903**
The use of augmented reality in Historical Sites	**14**	**0.959**	**0.979**
The future of augmented reality in historical sites	**5**	**0.848**	**0.921**
Total	**37**	**0.947**	**0.973**

* Validity coefficient = $\sqrt{}$ Reliability coefficient

In order to measure the internal consistency and reliability of the study's constructs. Cronbach's alpha (α) measure was used. The scales' reliabilities were measured and the Cronbach's Alpha of all scales in Table (2) ranged from 0.739 to 0.959, and for total questionnaire items was (0.947), this indicate an acceptable Cronbach's Alpha value for each field, whenever Cronbach's Alpha value is acceptable if it's more than (0.7).

4. Results

The following part explains the results concerning the six dimensions representing of exploring the efficiency of using the augmented reality technology at the historical sites in Luxor

4.1 Descriptive analysis

In this section, the researcher relied mainly on the descriptive analysis to get the means and the standard deviations for the study constructs along with their items. The items were measured using a Likert-type scale as follows.

Section One: Demographic Characteristics of Respondents

As depicted in figure (4) shows the discussion of the research findings begins with a brief demographic profile of respondents in terms of gender, the majority of the respondents were male (61%), rather than female respondents (39%) of this sample.

Figure 4. Gender

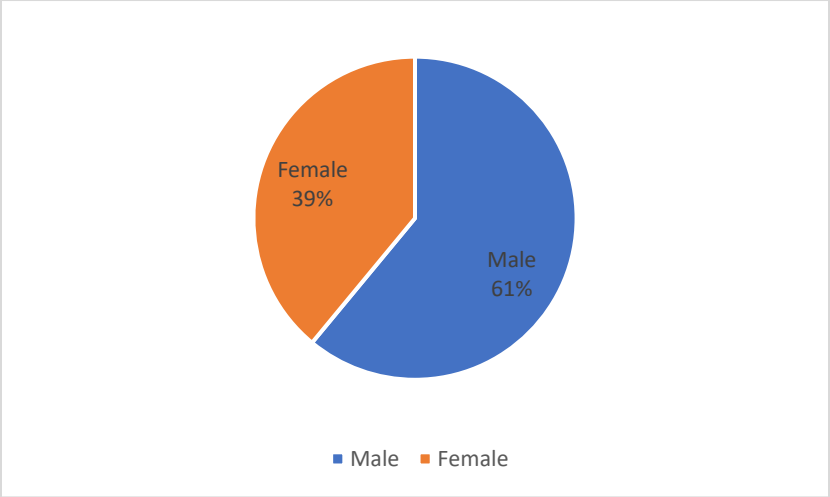

Table (3): Nationality

Nationality		Frequency	Percent
Valid	French	72	16.5
	British	48	11.0
	American	48	11.0
	Egyptian	48	11.0
	Italian	44	10.1
	German	28	6.4
	Indian	12	2.8
	Netherland	16	3.7
	Australian	16	3.7
	Greek	16	3.7
	Canadian	12	2.8
	Polish	4	.9
	Sweden	20	4.6
	Swiss	8	1.8
	Danish	8	1.8
	Portuguese	4	.9
	Brazilian	12	2.8
	Spanish	12	2.8
	Filipino	4	.9
	South African	4	.9
	Total	436	100.0

The table shows the number of tourists to whom the questionnaire was distributed, and the destinations of French nationality are at the forefront, by percentage (16.5%).

As depicted in figure (5) shows the discussion of the research findings begins with a brief demographic profile of respondents in terms of age the age bracket of 29 to 39 had the greatest number of respondents (26.6%), followed by the age bracket of 18 to 28 years old (25.7%).

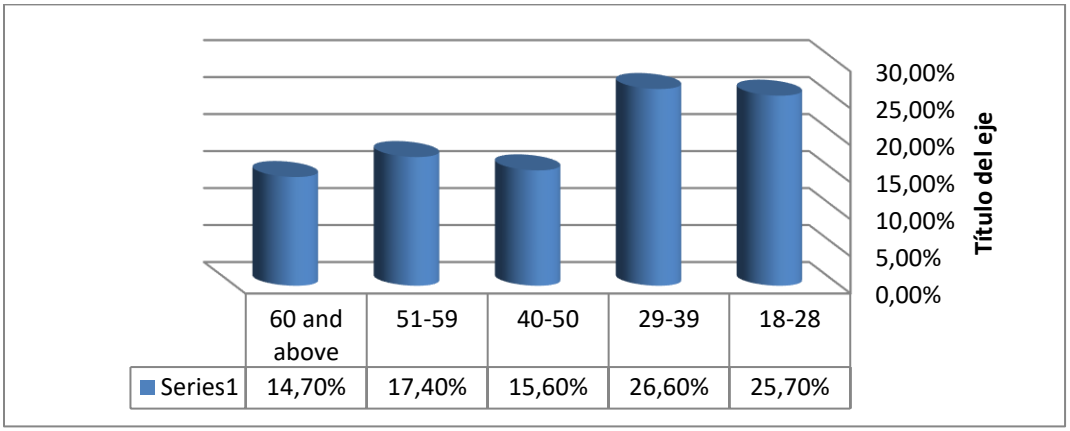

Fig (5): Age

In analyzing the level of education, the most representative degree is Bachelor Degree with (34.90%) of the respondents, whilst (29.40%) of respondents had Middle and high school holders in the sampled as indicated in Figure (6).

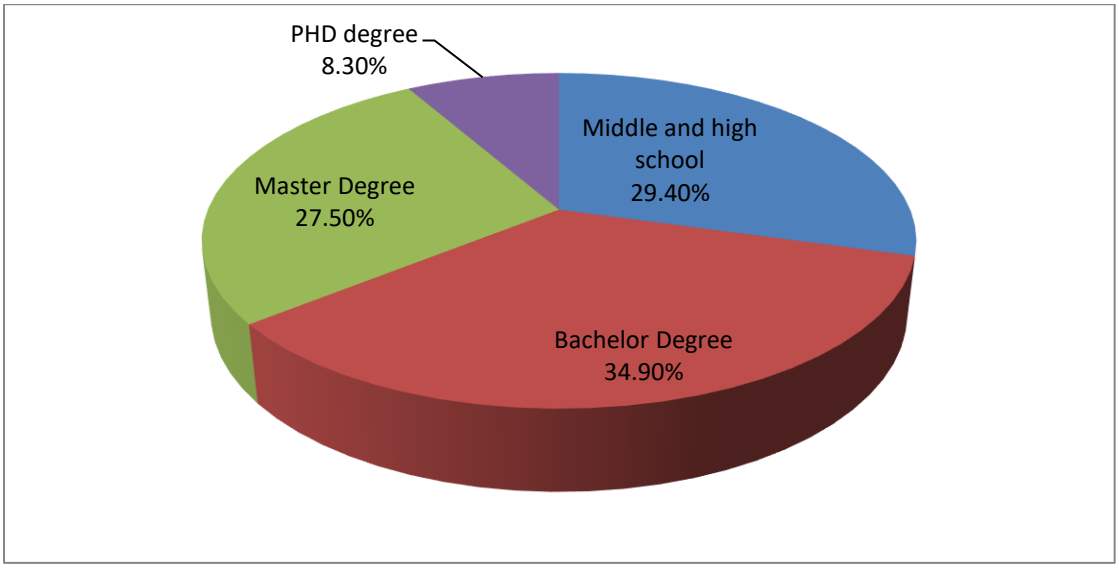

Fig (6): Educational level

As depicted in figure (7) shows the discussion of the research findings begins with a brief demographic profile of respondents in terms of monthly income, the majority of the respondent's monthly income were < 2000$ (36%), followed by 2000-4000$ respondent's monthly income (30.30%) of this sample.

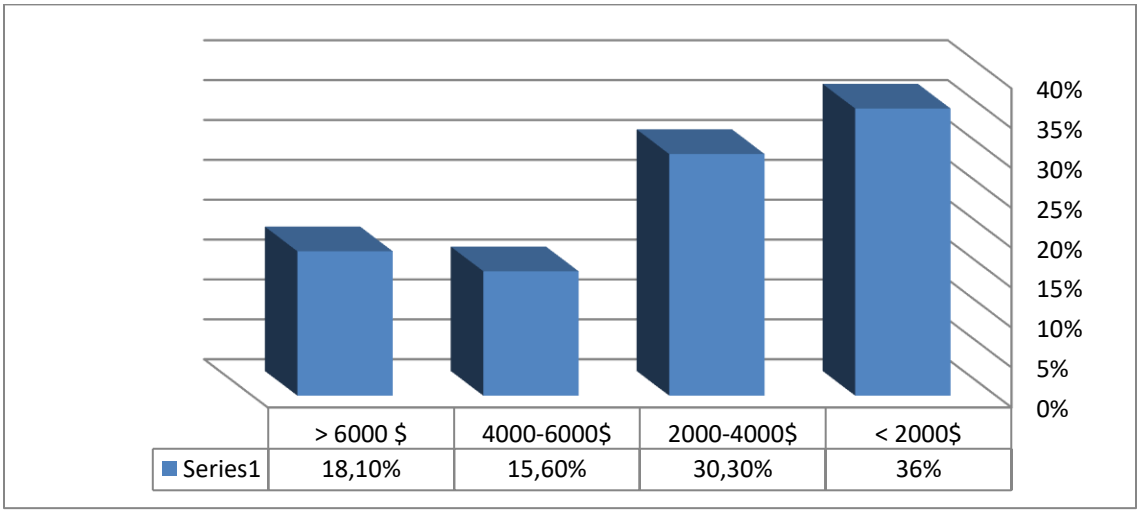

Fig (7): Monthly Income

Section 2: Knowledge of augmented reality

Table (4): Knowledge of augmented reality

Variables	S D	D	N	A	S A	Mean	Std Deviation	Rank	Attitude
I am familiar with the concept of augmented reality	**9.2**	**2.8**	**18.3**	**47.7**	**22**	**3.71**	**1.121**	**2**	**Agree**
I think that interacting with this application does not require a lot of mental effort.	**1.8**	**9.2**	**25.7**	**49.5**	**13.8**	**3.64**	**0.895**	**3**	**Agree**
I would like to use an Augmented Reality application when visit a city (E.g. to learn moreabout the history of the city or discover an alternative route)	**2.8**	**11**	**11.9**	**44**	**30.3**	**3.88**	**1.048**	**1**	**Agree**
Total Mean						**3.74**			**Agree**

Table (4) presents the means and standard deviations of knowledge of augmented reality, where the means ranged between (3.64 – 3.88) compared with the total instrument mean for the domain (3.74). The item “I would like to use an Augmented Reality application when visit a city (E.g. to learn more about the history of the city or discover an alternative route)” ranked first with a mean and standard deviation (Mean=3.88, standard deviation = 1.048) compared with the total instrument mean and the standard deviation. The item "I think that interacting with this application does not require a lot of mental effort" ranked last reached a mean (3.64) and the standard deviation was (0.895) compared with the mean and standard deviation of the total instrument.

By asking visitors to Luxor, whether foreigners or Egyptians, if they had used augmented reality technology before, 51.40% of sample used augmented reality technology before, whereas 48.60% didn't used augmented reality technology, as shown in Figure (8), As a result, this percentage was excluded from answering some dimensions in the survey form.

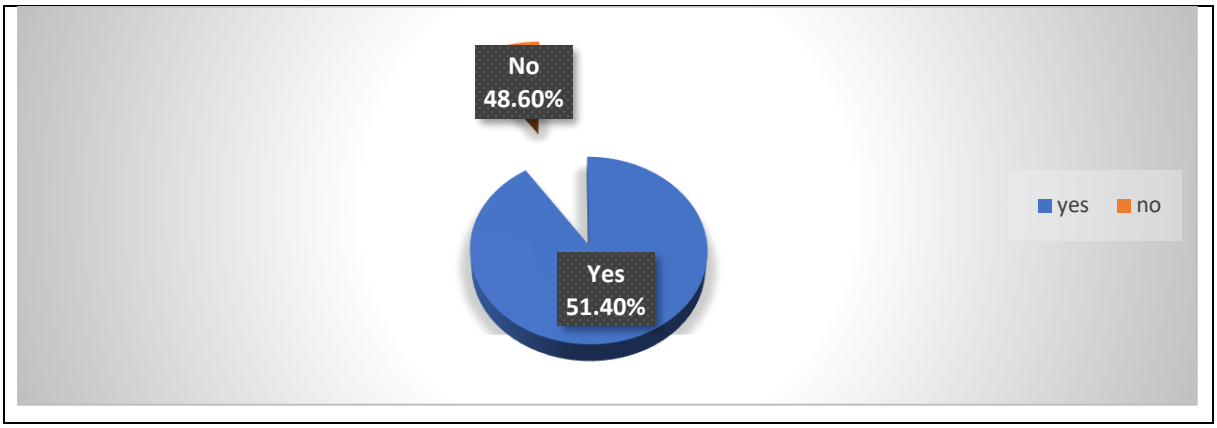

Figure (8) using augmented reality technology

Section 3: Easy to use augmented reality

Table (5): Easy to use augmented reality

Variables	S D	D	N	A	S A	Missing System	Mean	Std Deviation	Rank	Attitude
I have the resources necessary to use augmented reality (e.g. smartphone).	**0.9**	**0.9**	**4.6**	**20.2**	**24.8**	**48.6**	**4.30**	**0.845**	**1**	**Completely agree**
I have the knowledge necessary to use augmented reality.	**0**	**1.8**	**6.4**	**22**	**21.1**	**48.6**	**4.21**	**0..797**	**2**	**Completely agree**
Augmented reality is compatible with other technologies I use.	**1.8**	**1.8**	**9.2**	**21.1**	**17.4**	**48.6**	**3.98**	**0.993**	**5**	**Agree**
I think that the information displayed on screen is easy to read.	**0**	**1.8**	**7.3**	**28.4**	**13.8**	**48.6**	**4.05**	**0.744**	**4**	**Agree**
I think that the information displayed on screen is not confusing.	**0**	**4.6**	**9.2**	**26.6**	**11**	**48.6**	**3.86**	**0.856**	**9**	**Agree**
I can get help from others if I have difficulties using augmented reality.	**0**	**4.6**	**11**	**22**	**13.8**	**48.6**	**3.88**	**0.910**	**8**	**Agree**
I think that augmented reality is easy to use	**0**	**4.6**	**9.2**	**23.9**	**13.8**	**48.6**	**3.91**	**0.894**	**6**	**Agree**
I think that my interaction with augmented reality will be clear and understandable	**0**	**4.6**	**9.2**	**24.8**	**12.8**	**48.6**	**3.89**	**0.882**	**7**	**Agree**
It will be easy for me to become skillful at using augmented reality	**0**	**2.8**	**6.4**	**23.9**	**18.3**	**48.6**	**4.12**	**0.827**	**3**	**Agree**

Total Mean		**4.02**		**Agree**

Table (5) presents the means and standard deviations of easy to use augmented reality, where the means ranged between (3.86 – 4.30) compared with the total instrument mean for the domain (4.02). The item “I have the resources necessary to use augmented reality (e.g. smartphone)” ranked first with a mean and standard deviation (Mean=4.30, standard deviation = 0.845) compared with the total instrument mean and the standard deviation. The item "I think that the information displayed on screen is not confusing" ranked last reached a mean (3.86) and the standard deviation was (0.856) compared with the mean and standard deviation of the total instrument.

Section 4: Obstacles to the use of augmented reality

Table (6): Obstacles to the use of augmented reality

Variables	S D	D	N	A	S A	Missing System	Mean	Std Deviation	Rank	Attitude
Lack of technological awareness	**2.8**	**13.8**	**11**	**15.6**	**8.3**	**48.6**	**3.25**	**1.171**	**1**	**Neutral**
Complexity in AR usage	**0**	**17.4**	**14.7**	**16.5**	**2.8**	**48.6**	**3.09**	**0.933**	**3**	**Neutral**
Lack of accuracy for virtual element positioning	**0.9**	**11.9**	**19.3**	**15.6**	**3.7**	**48.6**	**3.18**	**0.930**	**2**	**Neutral**
I feel nervous about using augmented reality	**10.1**	**20.2**	**11.9**	**5.5**	**3.7**	**48.6**	**2.46**	**1.136**	**4**	**Disagree**
I feel insecure about my ability to use augmented reality	**11.9**	**22**	**10.1**	**4.6**	**2.8**	**48.6**	**2.30**	**1.087**	**5**	**Disagree**
I’m afraid to use augmented reality for fear of making mistakes that I cannot correct.	**16.5**	**17.4**	**9.2**	**4.6**	**3.7**	**48.6**	**2.25**	**1.202**	**6**	**Disagree**
Total Mean							**2.76**			**Neutral**

Table (6) presents the means and standard deviations of obstacles to the use of augmented reality, where the means ranged between (2.25 – 3. 25) compared with the total instrument mean for the domain (2.76). The item “Lack of technological awareness” ranked first with a mean and standard deviation (Mean=3.25, standard deviation = 1.171) compared with the total instrument mean and the standard deviation. The item "I’m afraid to use augmented reality for fear of making mistakes that I cannot correct" ranked last reached a mean (2.25) and the standard deviation was (1.202) compared with the mean and standard deviation of the total instrument.

Section 5: The use of augmented reality in Historical Sites

Table (7): The use of augmented reality in Historical Sites

Variables	S D	D	N	A	S A	Missing System	Mean	Std Deviation	Rank	Attitude

Augmented Reality application is a better medium than the traditional mode to educate visitors about history in the heritage sites.	**4.6**	**7.3**	**13.8**	**18.3**	**7.3**	**48.6**	**3.32**	**1.154**	**14**	**Neutral**
I learn better about history through Augmented Reality in the heritage sites.	**2.8**	**8.3**	**13.8**	**17.4**	**9.2**	**48.6**	**3.43**	**1.118**	**13**	**Agree**
I prefer to come to the heritage sites which provide Augmented Reality application such as virtual tour guide.	**2.8**	**7.3**	**12.8**	**19.3**	**9.2**	**48.6**	**3.48**	**1.104**	**12**	**Agree**
Augmented Reality is an innovative way to conserve the heritage sites.	**0**	**4.6**	**11**	**21.1**	**14.7**	**48.6**	**3.89**	**0.922**	**5**	**Agree**
Including a storyline with Augmented Reality application to conserve the heritage sites would motivate me more to learn about its history.	**0**	**3.7**	**12.8**	**22**	**12.8**	**48.6**	**3.86**	**0.877**	**6**	**Agree**
I would be more interested to the heritage sites with Augmented Reality application.	**4.6**	**4.6**	**11**	**21.1**	**10.1**	**48.6**	**3.54**	**1.167**	**10**	**Agree**
Conservation of the heritage sites using visual technology is highly necessary.	**2.8**	**6.4**	**11.9**	**23.9**	**6.4**	**48.6**	**3.48**	**1.037**	**11**	**Agree**
Informing visitors to the heritage sites is highly effective through visual communication.	**3.9**	**3.7**	**11**	**22.9**	**12.8**	**48.6**	**3.84**	**0.943**	**8**	**Agree**
Visual communication allows a learner to better understand the heritage sites.	**0..9**	**3.7**	**8.3**	**23.9**	**14.7**	**48.6**	**3.93**	**0.944**	**3**	**Agree**
Using Augmented Reality may help me get more information about the heritage sites	**0.9**	**4.6**	**6.4**	**25.7**	**13.8**	**48.6**	**3.91**	**0.952**	**4**	**Agree**
Using Augmented Reality in heritage sites can be fun and exciting.	**0.9**	**2.8**	**5.5**	**23.9**	**18.3**	**48.6**	**4.09**	**0.914**	**1**	**Agree**
With Augmented Reality I will be able to explore heritage sites in a way that wouldn't be possible without it.	**0.9**	**1.8**	**11.9**	**22**	**14.7**	**48.6**	**3.93**	**0.906**	**2**	**Agree**
Augmented reality applied to heritage sites may be credible.	**0.9**	**0.9**	**15.6**	**22**	**11.9**	**48.6**	**3.84**	**0.863**	**7**	**Agree**
Using augmented reality may increase my interest in the heritage sites	**2.8**	**5.5**	**9.2**	**21.1**	**12.8**	**48.6**	**3.70**	**1.119**	**9**	**Agree**
Total Mean							**3.73**			**Agree**

Table (7) presents the means and standard deviations of the use of augmented reality in Historical Sites, where the means ranged between (3.32 – 4.09) compared with the total instrument

mean for the domain (3.73). The item “Using Augmented Reality in heritage sites can be fun and exciting” ranked first with a mean and standard deviation (Mean=4.09, standard deviation = 0.914) compared with the total instrument mean and the standard deviation. The item "Augmented Reality application is a better medium than the traditional mode to educate visitors about history in the heritage sites" ranked last reached a mean (3.32) and the standard deviation was (1.154) compared with the mean and standard deviation of the total instrument.

Section 6: The future of augmented reality in historical sites

Table (8): The future of augmented reality in historical sites

Variables	S D	D	N	A	S A	Mean	Std Deviation	Rank	Attitude
I plan to use augmented reality applied to heritage sites in the future.	**3.7**	**9.2**	**25.7**	**40.4**	**21.1**	**3.66**	**1.026**	**3**	**Agree**
I will always try to use augmented reality when visiting archaeological sites.	**3.7**	**17.4**	**25.7**	**35.8**	**17.4**	**3.46**	**1.081**	**5**	**Agree**
In addition to seeing virtual images with augmented reality, I would like to listen to sounds, smell aromas and feel sensations (e.g. temperature) related to the historical sites.	**4.6**	**6.4**	**10.1**	**43.1**	**35.8**	**3.99**	**1.063**	**1**	**Agree**
I want to attend a historical event using augmented reality technology	**1.8**	**11**	**18.3**	**36.7**	**32.1**	**3.86**	**1.046**	**2**	**Agree**
I would like to use Augmented Reality instead of Replica	**4.6**	**10.1**	**32.1**	**26.6**	**26.6**	**3.61**	**1.118**	**4**	**Agree**
Total Mean						**3.72**			**Agree**

Table (8) presents the means and standard deviations of the future of augmented reality in historical sites, where the means ranged between (3.46 – 3.99) compared with the total instrument mean for the domain (3.72). The item “In addition to seeing virtual images with augmented reality, I would like to listen to sounds, smell aromas and feel sensations (e.g. temperature) related to the historical sites” ranked first with a mean and standard deviation (Mean=3.99, standard deviation = 1.063) compared with the total instrument mean and the standard deviation. The item "I will always try to use augmented reality when visiting archaeological sites" ranked last reached a mean (3.46) and the standard deviation was (1.081) compared with the mean and standard deviation of the total instrument.

4.2 Pearson Correlation

Table (9) Correlation between knowledge of augmented reality and the use of augmented reality in Historical Sites

		The use of augmented reality in Historical Sites
Knowledge of augmented reality	**Pearson Correlation**	**.468****
	Sig. (2-tailed).	**.000**

**Correlation is significant at the 0.01 level (2-tailed).

As described in the table (9), there is a moderately positive and significant relationship between knowledge of augmented reality and the use of augmented reality at historical sites. The value of the Pearson correlation coefficient was (.468** - sig = 0.000). These results showed that there is a moderately positive trend. This positive correlation indicates that as knowledge of augmented reality increases, the use of augmented reality at historical sites also increases.

Table (10) Correlation between knowledge of augmented reality and the future of augmented reality in historical sites

		The future of augmented reality in historical sites
Knowledge of augmented reality	**Pearson Correlation**	**.433****
	Sig. (2-tailed).	**.000**

**Correlation is significant at the 0.01 level (2-tailed).

As described in the table (10), there is a moderately positive and significant relationship between knowledge of augmented reality and the future of augmented reality at historical sites. The value of the Pearson correlation coefficient was (.433** - sig = 0.000). These results showed a moderately positive trend. This positive correlation indicates that as knowledge of augmented reality increases, the future of augmented reality at historical sites also increases.

Table (11). Correlation between easy to use augmented reality and the use of augmented reality in Historical Sites

		The use of augmented reality in Historical Sites
Easy to use augmented reality	**Pearson Correlation**	**.455****
	Sig. (2-tailed).	**.000**

**Correlation is significant at the 0.01 level (2-tailed).

As described in the table (11), there is a moderately positive and significant relationship between the ease with which augmented reality can be used and the use of augmented reality at historical sites. The value of the Pearson correlation coefficient was (.455** - sig = 0.000). These

results showed a moderately positive trend. This positive correlation indicates that as the ease of using augmented reality increases, the use of augmented reality at historical sites also increases.

Table (12) . Correlation between The use of augmented reality in Historical Sites and the future of augmented reality in historical sites

		the future of augmented reality in historical sites
The use of augmented reality in Historical Sites	**Pearson Correlation**	**.745****
	Sig. (2-tailed).	**.000**

**Correlation is significant at the 0.01 level (2-tailed).

As described in the table (12), there is a strong positive and significant relationship between the use of augmented reality in historical sites and the future of augmented reality in historical sites. The value of the Pearson correlation coefficient was (.745** - sig = 0.000). These results showed that there is a very strong positive. This positive correlation indicates that as the use of augmented reality in historical sites increases, the future of augmented reality in historical sites also increases.

5. Discussion of results:

This study aims to shed light on virtual reconstruction the historical sites through augmented reality technology. The research tried to understand the perspective of key organizations towards AR adoption. The literature review focused the definition of AR, differences between AR and VR, the use of AR in tourism and cultural heritage sites, a virtual reconstruction of the temple of Amenhotep III in the west bank guarded by the statues of Memnon which was chosen as a case study.

The practical study has been conducted to achieve the research aim and clarify the importance of this technology for the protect and conserve the historical sites in Luxor and Confirmation of user acceptance to augmented reality technology. In addition to the challenges that facing the implementation of AR and finally provide suggestions that encourage AR implementation in historical sites in Luxor.

The results of the questionnaire confirmed the benefits AR present substantial potential for the preservation of cultural heritage, improving visitor experience, reconstruction, and exploration this result was in line with the studies of Han et al., 2019; Merchán et al., 2021; Okanovic et al., 2022. However, these benefits, the questionnaire finding mentioned that Augmented reality technology is not widely spread and 48.6% of the visitors have not used the technology before (see Fig 6). This result comes to agree with the study of (Chung et al., 2015).

Based on both the literature reviewed and the practical study, the following recommendations could be suggested:

1. Assure that AR is used to improve, maintain, and safeguard historical properties. Increasing the authorities' and stakeholders' understanding of the significance of augmented reality and the potential advantages of its use is necessary to ensure the installation and adoption of this technology in heritage sites.

2- Maintains employee support and make sure they are "kept in the loop" at all times. Participating in implementation is one of the finest methods to inspire stakeholders to develop and propose fresh concepts.

3- Utilise augmented reality to highlight the distinction of Luxor's historical sites and give visitors a sense of what life was like before it became commonplace.

4- Concerned authorities must enhance pre-visit information regarding the variety and breadth of activities available in order to maintain cultural heritage sites' appeal and competitiveness.

5- Integrate AR to improve education, , providing additional information, tailoring information to different interests and knowledge levels, whilst introducing an element of fun and excitement.

6- Use augmented reality to enhance and provide more interpretation across the site, providing historic content and an augmented reality tour, and language alternatives.

7. The Ministry of Tourism and Antiquities gives studies and research on the application of new technology in cultural heritage sites more attention. These studies offer useful information to academics and practitioners alike.

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