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Research Article

The Use of Immersive Technologies as a Representation Tool in the Protection of Archaeological Heritage

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Abstract

The preservation of the archaeological heritage with appropriate techniques and methods ensures that it is transferred to future generations in a sustainable way. Various laws, charters and regulations at the national and international level serve as a guide for the right conservation approaches in these areas. However, ensuring sustainability in the protection of cultural heritage is possible by transferring information to society through correct presentation techniques and creating awareness and consciousness in individuals. With the rapid developments in technology, computer-based visualization techniques are used in the presentation of cultural heritage. It has been seen in digital applications that started to be developed in the 2000's that immersive technologies such as VR and AR, which are applied in fields such as education, health, automotive, entertainment, etc., can be used effectively in the presentation of cultural heritage. In this article, international steps taken in the protection of archaeological heritage and immersive technologies are mentioned, the purposes of using these technologies as a presentation technique in the protection of archaeological heritage are classified and evaluated through examples. Technologies such as VR and AR have been found to be an effective tool in the representation of archaeological heritage and it is aimed that the examples presented will have an encouraging effect for more effective studies in the future.

Keywords: Archaeological Heritage, Conservation, Immersive Technologies, Virtual Reality, Augmented Reality

Arkeolojik Mirasın Korunmasında Saran Teknolojilerin Temsil Aracı Olarak Kullanımı

Öz

Arkeolojik mirasın uygun teknik ve yöntemlerle korunması gelecek kuşaklara sürdürülebilir bir şekilde aktarılmasını sağlamaktadır. Ulusal ve uluslararası düzeydeki çeşitli yasalar, tüzükler ve yönetmelikler bu alanlarda doğru koruma yaklaşımlarının izlenmesi için rehber niteliği taşımaktadır. Bununla birlikte kültürel mirasın korunmasında sürdürülebilirliğin sağlanması, doğru sunum teknikleri aracılığıyla topluma bilginin aktarılarak bireylerde farkındalık ve bilinç oluşturulması ile mümkün olmaktadır. Teknolojide yaşanan hızlı gelişmelerle birlikte kültürel mirasın sunumunda da bilgisayar temelli görselleştirme teknikleri kullanılmaktadır. Eğitim, sağlık, otomotiv, eğlence vb. alanlarda uygulanan VR ve AR gibi saran teknolojilerin kültürel mirasın sunumunda da etkili bir şekilde kullanılabileceği 2000'li yıllarda geliştirilmeye başlanan dijital

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uygulamalarda görülmüştür. Bu makalede arkeolojik mirasın korunmasında uluslararası ölçekte atılan adımlar ve saran teknolojilerden bahsedilmiş, bu teknolojilerin arkeolojik mirasın korunmasında bir sunum tekniği olarak kullanım amaçları sınıflandırılmış ve örnekler üzerinden incelenerek değerlendirilmiştir. VR ve AR gibi teknolojilerin arkeolojik mirasın temsilinde etkili bir araç olduğu görülmüş ve sunulan örneklerin gelecekte daha etkili çalışmaların üretilmesinde cesaretlendirici bir etki oluşturması hedeflenmiştir.

Anahtar Kelimeler: Arkeolojik Miras, Koruma, Saran Teknolojiler, Sanal Gerçeklik, Artırılmış Gerçeklik

1. Introduction

The preservation process, which starts with documentation methods in the protection of cultural heritage, continues with steps such as survey, restoration and reconstruction and ensures the preservation of various objects and structures that form the world heritage through scientific techniques. Archaeological heritage objects have different and unique cultural features belonging to the civilizations that have taken place in the world from the past to the present. Since the last century, various national and international institutions and organizations have taken steps to preserve these elements in their original context.

Advanced documentation technologies such as digital photography, Lidar, Laser Scanning and digital photogrammetry are used in the documentation process of cultural heritage (Güleç Korumaz et al., 2011, p. 71). Numerical data obtained with these techniques allow obtaining various plans, sections, views and 3D models of archaeological heritage elements. It is important that these images, which can be easily understood by experts working in the conservation field, can be perceived and experienced by visitors and users who are not experts in this field. These representation tools which raise awareness in individuals contribute to the process of sustainable preservation of archaeological heritage.

With the developments in technology, immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) have started to be used as a representation tool in archaeological heritage. In the applications produced with these systems, users are also included in the experience interactively and a rich mutual interaction occurs. These virtual environments, including the user, have a high potential for accurately perceiving the archaeological heritage in its context.

Within the scope of this article, first of all, the steps taken by international organizations in the last century to protect the archaeological heritage are explained. Afterwards, immersive technologies were briefly mentioned and the purposes for which these technologies were used in the representation of archaeological heritage were examined and classified by including the most recent studies. It is aimed to determine the usage areas of these technologies by emphasizing its benefit for the protection process of the heritage and to guide future researchers for more efficient studies.

2. Protection of the Archaeological Heritage

Archaeological sites, shaped by intense labor and creative intelligence and sometimes considered sacred, are places that carry the past to the present with their tangible assets. The interest in ancient settlements turned into science as a result of systematic excavations that began in Italy in the 18th century. The science of archaeology has developed with the research and evaluations made to reveal the magnificent traces of a

distant past (Ahunbay, 2010, p. 104). The preservation of archaeological heritage items, which reflect various cultural values created by societies from historical periods to the present, has been an issue that has been emphasized on an international scale since the 20th century. In this context, the principles for the conservation approach to be followed in archaeological sites have been determined and an increasingly comprehensive framework has been presented.

In 1956, UNESCO indicated in its Recommendation on International Principles Applicable to Archaeological Excavations that countries should provide careful supervision for the restoration of archaeological remnants and assure the preservation of the archaeological heritage (UNESCO, 1956).

In 1964, it was stated in The Venice Charter that at archaeological sites it is not permitted for reconstruction and only anastylosis which means bringing existing parts together can be allowed. In addition, material used for this purpose should be recognizable. There should be documents which consist of drawings and photographs related to the excavation (ICOMOS, 1964).

European Convention on the Protection of the Archaeological Heritage (1969, London) by Council of Europe indicates that the first step for the preservation of archaeological sites is to use the tightest techniques in archaeological exploration and investigation. It is noted that places with archaeological attention should be specified and preserved. Contracting Parties should prevent illegal excavations and ensure that excavations are under the responsibility of qualified persons. Archeological finds need to take part in scientific publications related to archaeological studies in order to share this information (Council of Europe, 1969).

In 1990, Charter for the Protection and Management of the Archaeological Heritage indicated that preservation of the archaeological sites needs to be considered with a collaboration between professionals from other necessary fields. Government, academic researchers and public should be included in the process (ICOMOS, 1990).

In 1992, the revised version of European Convention on the Protection of the Archaeological Heritage indicated that archaeological reserves need to be created even if there are no visible archaeological remains in order to be researched later. It is noted that excavations should be with scientific techniques and non-destructive methods should be the priority. The units belonging to archaeological heritage should not be left uncovered without taking the appropriate prevention for the preservation. It is also indicated that it is important to develop methods to raise awareness for the value of the archaeological heritage and the threats against it (Council of Europe, 1992).

In 1996, Charter on the Protection and Management of Underwater Cultural Heritage underlined the protection and management of underwater cultural heritage. Possible threats like construction work and improper way of access are indicated. It is noted that investigations should be done under the responsibility of a qualified underwater archaeologist and the whole process should be documented with the professional documentation standards. Site management should be provided for the protection and presentation techniques should be used to raise public awareness (ICOMOS, 1996).

In the 21st century, the Framework Convention on the Value of Cultural Heritage for Society by Council of Europe and The ICOMOS Charter for the Interpretation and Presentation of Cultural Heritage Sites created an approach that evaluates cultural

heritage directly through the eyes of society. In this period, concepts such as raising awareness in the society and becoming visible were emphasized and an approach such as presenting and sharing information to the public was developed. Although these charters in the 2000s are not directly related to the archaeological heritage, the biggest problem when it comes to the interpretation of cultural heritage is undoubtedly the understanding of the archaeological cultural assets that have survived to the present day only in the form of ruins and explaining them to the public (Eres and Özdoğan, 2016, p. 18).

In the beginning, the basic principles such as the protection of archaeological remains with scientific techniques and methods and ensuring the continuity of this protection have started to focus on issues such as the representation of the archaeological heritage, its experience by the society and raising awareness in individuals.

3. Immersive Technologies as a Representation Tool

Over the past two decades, technology has changed the way of perceiving, visiting, interacting and learning cultural heritage (Pervolarakis et al., 2023, p. 2491). After collecting many documents and data of the architectural heritage, the ways of accessibility to this knowledge have become one of the main topics. Digital tools not only have made it easier to survey and process architectural data but also it has created more detailed forms of presentation (Palma et al., 2019, p. 559). Architects generally use presentation techniques like photographs, videos, physical models or architectural drawings such as plans, sections, elevations. On the other hand these architectural drawings may not be understandable for people who are not experts in this field (Güleç Özer et al., 2016, p. 186). Therefore, it has a big importance to use presentation techniques which are able to create clear reflection of real architectural elements for everybody.

Accordingto UNESCO, digital heritage represents unique resources of human knowledge which includes cultural, educational, scientific, administrative and other types of information produced in a digital way. These resources have a timeless importance and therefore should be protected for future needs (UNESCO, 2003). Digital outputs of cultural heritage have a significant place in terms of documenting, protecting and representing the historical value.

It is seen that using different media tools developed by the latest technology increases the number of people who experience the cultural elements and also the quality of the dissemination of this knowledge. These presentation tools such as augmented, virtual and mixed reality technologies are used in different areas like education, exhibition enhancement, exploration, reconstruction and virtual museums in terms of cultural heritage (Bekele et al., 2018, p. 1). These immersive technologies make it possible to reach cultural heritage in a digital way even if it is not possible or hard to access it physically.

Immersive Technology which refers to augmented, virtual and mixed-reality technologies have been used for several experiences related to cultural heritage since the mid 2000 as these experiences offer completely another innovative way of participation through real and digital environments. To create a virtual environment some devices such as displays, computers, tracking cameras and input devices should be provided (Bekele et al., 2018, p. 2). Recent developments in VR and AR technology created a new visit model for visitors who have a cultural interest for artworks and places. For example, Google Arts & Culture offers a new way to the visitors by letting them access to many museums

and places by using a headset, a smartphone and a cardboard (Spallone et al., 2021, p. 698).

According to Bekele et al. (2018), Augmented Reality refers to superimposing virtual elements into the real world while Virtual Reality refers to getting our presence into a virtual environment which has no connection with the real world. Thus, Mixed Reality involves both real and virtual environments (Bekele et al., 2018, p. 4). Although these technologies have different characteristics in terms of usage and infrastructure, each of them has an effective role in experiencing cultural heritage.

VR technology can not be implemented without the terms “immersion” and “interaction”. A successful virtual reality environment should provide an interaction naturally with our senses (Bekele et al., 2018, p. 4). The developments in VR devices especially with the commercial VR headsets and VR controllers made it effortless to create VR-based experiences with a better interaction through the senses. In addition, another way of virtual reality experience through inexpensive VR headsets which can be connected to smartphones appeared thanks to 360 photography (Pervolarakis et al., 2023, p. 2490). VR technology makes it possible for everyone to be able to access objects or places regardless of time and location. The user can easily become a part of the exploration by interaction with the objects and other users through these systems (De Paolis, 2010, p. 1). With this feature, virtual environments acquire a more permanent place in the user's memory at the point of interacting with cultural heritage.

In addition, AR technology has the potential of making a big contribution to the improvement of experiencing the cultural heritage and perceiving the knowledge behind that especially for the people who are not experts in this field by creating virtual environments with high-quality images of architectural ruins and ancient landscapes. This approach became the purpose by creating 3D models with other interactive tools for the whole area and making a more enjoyable and accessible experience for visitors (Verdiani et al., 2017, p. 179).

Mobile technology have changed how people perceive their surroundings. This technology has made Augmented Reality (AR) applications more common to put some information in a virtual way for the objects or the environment that users experience (Tom Dieck & Jung, 2018, p. 2). It can supply valuable information to the users in the fields of education, medical, military, driving assistance and entertainment (Arena et al., 2022, p. 4). In terms of cultural heritage, it is possible to experience inaccessible places, have knowledge about no longer existing buildings, observe virtual anastylosis and also to see the environment with specific information through AR technologies (Palma et al., 2019, p. 560). Therefore AR technology provides an environment that current conditions cannot offer to the visitors and users.

In general, immersive technologies are used in cultural heritage representation for multiple purposes. They can be used to create awareness for abandoned places (De Paolis et al., 2022, pp. 1-12; Verdiani et al., 2017, pp. 169-183) or places threatened by tourism (Hajirasouli et al., 2021, 140-151) They can create digital reconstruction (Spallone et al., 2021, pp. 697-704; Spallone et al., 2022, pp. 473-480) or can be used for learning purposes (De Paolis et al., 2010, pp. 1-4). They can simply give a chance of a more enjoyable experience to explore a heritage site (Panou et al., 2018, pp. 1-24) or a historical building (Argiolas et al., 2022, pp. 21-29). Thus, they can allow users to explore inaccessible parts of a heritage site (De Paolis et al., 2021, pp. 1-10). With the

developing technologies, the usage areas of these systems are gradually expanding and their usage purposes are diversifying.

4. Purposes of Using Immersive Technologies in Archaeological Heritage Sites

Implementing virtual environments to present archaeological heritage has become more common by the increase of cultural tourism (López-Menchero and Grande, 2011, p. 1). Because of the latest developments in VR technology, it has become easier for tourists to have a virtual visit rather than being in the actual touristic places (Tussyadiah et al., 2017, p. 2). Besides, virtual experiences offer many advantages such as saving time, not standing in queues and traffic, avoiding several kinds of illnesses and accidents, easy communication by using the same language and easy public access (Dewailly, 1999, p. 49). These opportunities offer different experiences and attract more and more users' attention.

On the other hand, the use of immersive technologies as a representation tool in the protection of archaeological heritage has enriched the user experience. Virtual environments create an interactive atmosphere which users can feel as they are a part of the experience (Dewailly, 1999, p. 48). To make people learn about historical places or objects in a joyful way, it is essential to create a virtual environment in a way that users can interact with the content (De Paolis et al., 2021, p. 5).

This experience, which is enriched through the virtual environment, can mean different things for people who are experts in the field, students, tourists and users. It is possible to classify the immersive technologies used in the representation of the archaeological heritage according to their purposes as follows, when current examples are included:

1- Virtual reconstruction as a transfer method from past to present
2- Virtual restoration as a re-creation process
3- Virtual visit experience that provides versatile perception of archaeological sites
4- Virtual experiences that turn the invisible parts to visible parts
5- Discovering underwater archaeology
6- Serious games as an interactive experience tool
7- Enriching museum visits with virtual museums
8- Applications that add a new dimension to archaeology education

Although the purpose of usage of immersive technologies are divided into subgroups, in some cases more than one usage purpose can come together. For example, serious game elements can be used to experience underwater archaeological heritage or virtual restoration or virtual reconstruction applications can be included in the virtual museum experience.

4.1. Virtual Reconstruction as a Transfer Method from Past to Present

Virtual reconstruction is defined as a virtual model which is produced to recover an object or a building from the past based on physical documents belonging to these objects or buildings (López-Menchero and Grande, 2011, p. 2). Visiting the archaeological heritage on site or observing the heritage object in the museum may not be enough to perceive its original state in its own context. Studies created with the help of virtual reconstruction,

on the other hand, provide data on the original state of the heritage and ensure that it is expressed and promoted correctly.

In their study Güleç Özer et al. (2016) used a method named Multirama which was first developed by ARC (Architecture Representation Computation) Group in MIT in 2013 and to represent artifacts and buildings in an interactive AR interface. The study took place in Parion, Biga which is one of the most important archaeological sites in Turkey dating back to 1st-2nd century A.D. The work consisted of 3 stages as documentation, data process and modeling and presentation. The documentation stage was made by using photogrammetric methods. The 3D model from photogrammetry was made in 123D software (Figure 1). Next, 3D images were corrected by an AR application with UNITY. Finally, 3D reconstruction of the site was presented with a viewer AR application. The models, other drawings and 3D models were brought together in an AR environment. The aim was to design a holistic and low cost method to create an accurate reconstruction and representation of Parion Theater. The study created an environment to have a better understanding for the reconstruction of the original structure and it contributed to the presentation of cultural heritage for tourism purposes (Güleç Özer et al., 2016, pp. 2-8). This example shows that a cultural heritage item which cannot be understood clearly when observed in its current state can be perceived better through virtual reconstruction application.

Fifure 1. Left: On site photograph, Right: 3D model from photogrammetry in 123D software (Güleç Özer et al., 2016, p. 191).

4.2. Virtual Restoration as a Re-creation Process

Virtual restoration is defined as a virtual model which is produced to recreate something that existed in the past (López-Menchero and Grande, 2011, p. 2). Virtual restoration works are especially preferred when it is difficult and risky to physically interfere with the heritage item. In this way, the virtual object is preserved in its current form, and on the other hand, a virtual restoration process is applied.

Etruscanning is a project which was generated to make virtual restoration and reconstruction of Etruscan tombs and artifacts by using VR technology. Etruscan Regolini Galassi tomb in Sorbo necropolis in Cerveteri, Italy and its valuable funerary goods preserved in Vatican Museums were the subject of the study. To present the artifacts which were found in the tombs within their original funerary context and place was one of the main purposes of the project. Therefore, besides creating virtual reconstruction of the tomb, virtual restoration was performed for the bronze objects to present their ancient look (Figure 2). By this project, a virtual installation that people can experience was implemented in the Vatican Museums. As the real funerary goods are

presented close to the installation, it is possible to perceive the virtual and original units and compare them with each other (Pietroni and Ferdani, 2021, pp. 17-18).

Figure 2. A) Archaeological artifacts, B) Virtual restoration of the artifacts, C) Virtual reconstruction of the Regolini Galassi Tomb, D) Virtual museum installation (Pietroni and Ferdani, 2021, p. 18).

4.3. Virtual Visit Experience that Provides Versatile Perception of Archaeological Sites

Tourists visit sites with certain expectations especially to experience authentic features in optimum standards. Therefore, it is always a challenge to fulfill tourists' needs with appropriate facilities and also keep protecting the site (Alberts and Hazen, 2010, p. 71). Immersive technologies have provided visitors a richer experience through virtual guidance.

In their study, Pervolarakis et al. (2023) created different forms of interaction and presentation for the digitization of the Palace of Knossos through AR and VR. These alternative ways of visiting a place on a digital platform also provide sustainability of the heritage site which has trouble with over population due to tourism in summer times. For the digitization, aerial photogrammetry and terrestrial laser scanning were used. In addition, panoramic photos and other photos from different points were taken to complete the documentation of the archaeological site. Unity was selected as the game engine as it can provide 3D rendering of graphics for several devices. For this reason, the app was designed for personal computers, Android and IOS-based mobile devices and oculus devices (Pervolarakis et al., 2023, pp. 2491-2492).

It was planned that every archaeological site would have information bubbles on the screen which would provide information about a certain point just by clicking on them. The application consists of four scenes named Introduction, Map 2D, Settings and Information (Figure 3). Introduction scene is the one where the user launches the application. Map 2D scene is the one that the user can choose the point that he/she wants to know more about and also can click on pins which refer to the related section for the information page. Information scene shows up after clicking on a pin from a 2D or AR map. From here, the user can get some information about the related point. At some points, there is also a Virtual Tour option. On the other hand, Setting scene is the one where users can change the language (Pervolarakis et al., 2023, pp. 2493-2494).

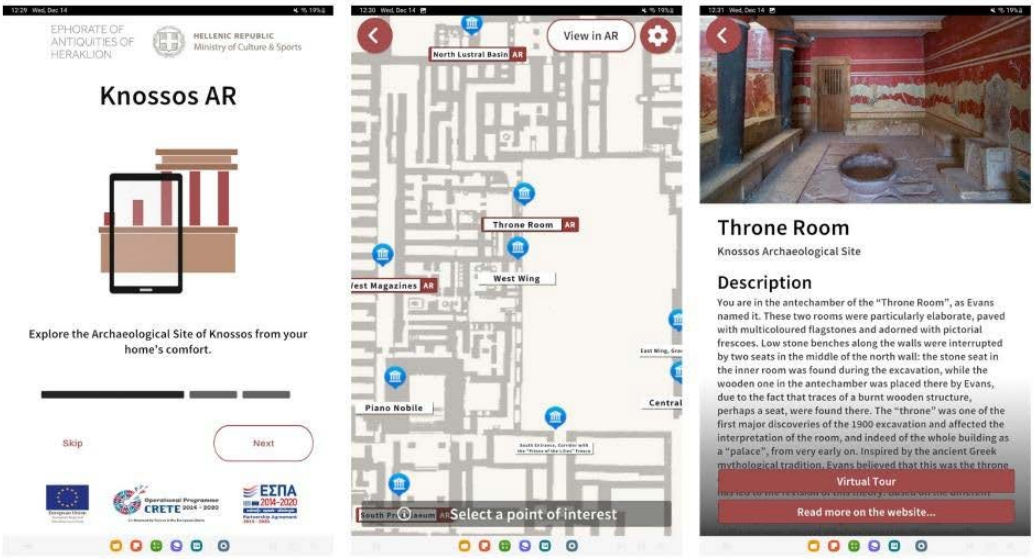
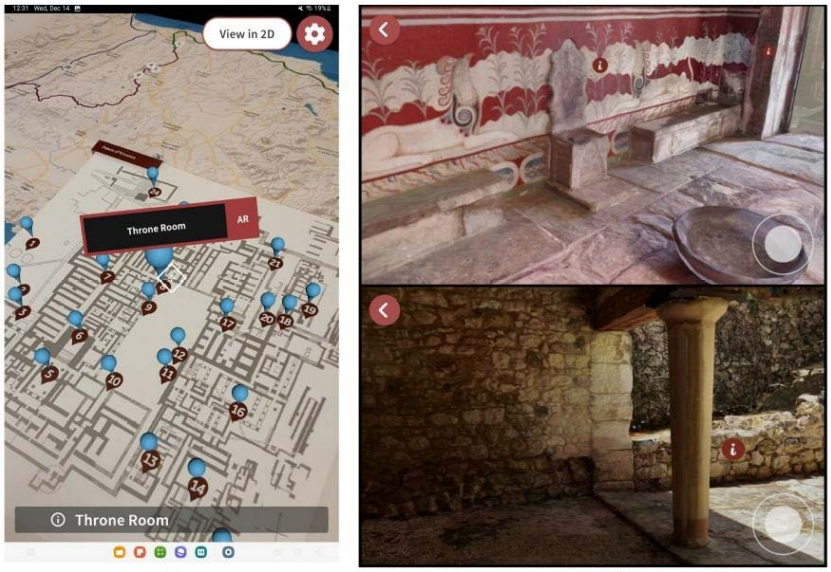


Figure 3. Left: Introduction, Middle: Map 2D, Right: Information (Pervolarakis et al., 2023, p. 2494).

In AR application, the users can easily move their device and the user's movements match with the virtual environment in return. The users also have a small joystick on the screen to go further than their physical body would go in real life. Furthermore, it is possible to get more information about an area in the app by clicking on the "i" letter located in a circle which refers to information (Figure 4) (Pervolarakis et al., 2023, p. 2495).



Fifure 4. Left: Screenshot of the AR, Right: An example of a virtual tour (Pervolarakis et al., 2023, p. 2495).

In the VR application, virtual hands are put in the scene by using the Oculus controllers (Figure 5). The users can walk by pushing the left-hand joystick and change the direction by clicking the right hand joystick. It is also possible to teleport a point by pressing the trigger of the right hand (Figure 6). These features of movement are also designed to prevent people from feeling nauseous. In addition, the user can have an interaction with the 2D interfaces by using the controllers (Pervolarakis et al., 2023, p. 2497).

Figure 5. Virtual hands in the VR (Pervolarakis et al., 2023, p. 2497).

Fifure 6. Teleporting between scenes in the VR (Pervolarakis et al., 2023, p. 2498).

4.4. Virtual Experiences that Turn the Invisible Parts to Visible Parts

In their study, Pierdicca et al. (2015) created a new way of archaeological tourism by giving the chance of being able to see covered findings to the users by using AR technology for the invisible parts of an archaeological site. AR applications offer the possibility of seeing objects that are covered under earth. It is a fact that during the excavation process, if there is not a possibility to protect the findings which are discovered under the earth, a better option is to cover them again for the protection purposes (Pierdicca et al., 2015, p. 1). In this case, AR technology gives us the chance to visualize the findings even if they are not visible.

The study took place at the archaeological complex of Chan Chan located in Peru which is America's greatest pre-Columbian town with mud brick structures. On the site, a main door which was under the earth for centuries showed up for a few hours before it was covered with earth again for the protection (Figure 7). During that time, the door was documented by photogrammetric methods and the data was used in AR application to enable users to see the door on site (Figure 8) (Pierdicca et al., 2015, pp. 3-4). This example shows even if it is not possible to see the real archaeological object on site, virtual environments can provide the chance of perceiving it in its own context.

Figure 7. The main door before and after the excavation (Pierdicca et al., 2015, p. 4).

Fifure 8. Augmented Reality visualization on site (Pierdicca et al., 2015, p. 4).

4.5. Discovering Underwater Archaeology

Experiencing underwater archaeological sites is a challenge especially for people who are not experts at diving and even for the divers as it has difficult environmental conditions to observe. Even if the survey techniques for exploration of underwater cultural heritage are developing, it is not possible to reach many of them because of the depth of the site or laws and regulations. Because of the water turbidity and biological creatures, divers have problems with experiencing the underwater archaeological sites and understanding the environment and there is a possibility to lose the sense of direction. AR technologies are helpful to solve these problems and as they offer a more clear and joyful experience of the submerged archaeological sites by giving important information about the environment (Bruno et al., 2019, pp. 1-2).

iMARECulture project is an example of underwater Augmented Reality (UWAR) technologies which was developed to improve the divers' experience at Underwater Archaeological Park of Baiae (Naples) which is known with its wide underwater area and multiple types of architectural structures such as harbor buildings, thermal baths, houses and villas. The UWAR technology was developed to help divers to know their position underwater and to be able to see current situation of the ruins in the archaeological site and also see the possible reconstruction of a villa structure (Villa with Vestibule) to understand the features it had during the Roman era (Bruno et al., 2019, p. 3).

Two different technologies are used for the site. The first technology used for the project was the marker-based AR system which uses markers as objects that are easy to detect to superimpose virtual objects into the real world (Figure 9). This system provides a fast

and cheap solution. On the other hand, it needs to be calibrated before every dive (Bruno et al., 2019, p. 3).

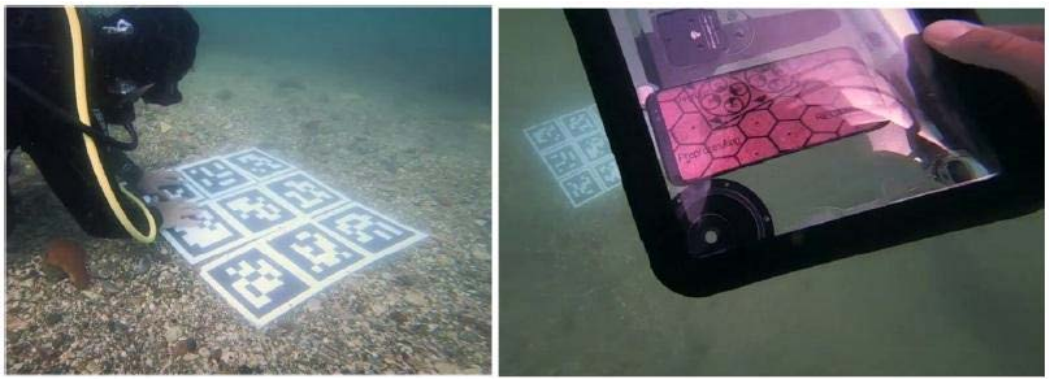


Figure 9. Left: Markers placed on Villa con ingresso a protiro, Right: AR model of the villa by using the markers (Bruno et al., 2019, p. 5).

The other technology is a markerless AR system which provides the virtual environment by a commercial tablet which is placed in a waterproof case. This system does not require fixed markers placed on the site but the quality of the augmented visualization depends on the accuracy of the diver's position tracking and underwater acoustic positioning systems (Bruno et al., 2019, pp. 3-4).

The application on the tablet was provided by Unity 3D. The functionalities are placed on the screen in a way to enable users to find what they need to accomplish the task given. Interaction buttons are placed on the left and right side of the screen by guessing the diver uses the device with one hand. The system provides users information about the dive session at that moment and POIs, control over the map of the underwater site, the camera and AR visualization. The application does not only supply the augmented visualization which shows the current situation of the underwater archaeological site but it also provides the possible 3D reconstruction of the site's previous look in the past during the Roman era (Figure 10) (Bruno et al., 2019, pp. 6-7).

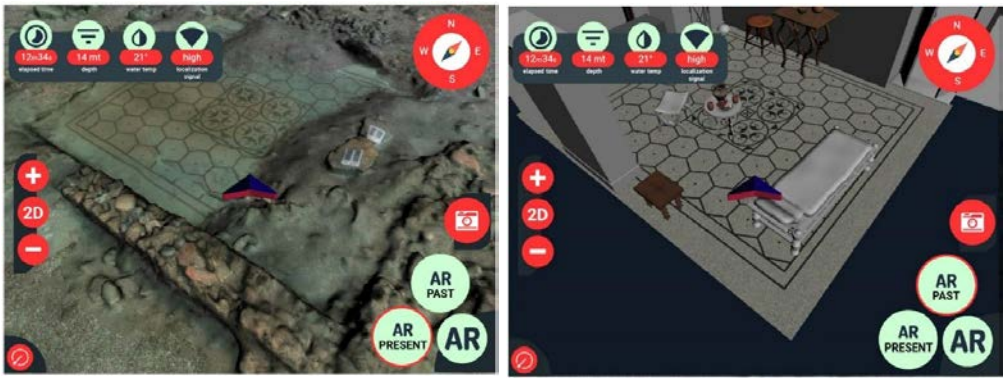


Figure 10. Left: The augmented visualization of the current condition of the underwater site, Right: The possible reconstruction of the site (Bruno et al., 2019, p. 6).

Another example is the study that Plecher et al. (2022) presented a VR system which was developed combining with Serious Gaming elements to provide a virtual visit of an excavation site, the wreck site of Veliki Piruzi in Croatia. As recreational diving requires elements like training, equipment and the possibility to be at the diving site, it is not suitable for everyone. On the other hand, even if underwater heritage sites have valuable

environments and remnants which present human history, it is hard to investigate them because of the access problem (Plecher et al., 2022, p. 2).

The site includes a late roman merchant ship which was damaged in 5th century AD and excavated from 2014 till 2017 and it consists of two parts. On the southeast part of the area there is the ship which was damaged and in the other one there are materials of the cargo which were washed after the accident. At the site users can make research and collect pieces of amphora or other fragments (Figure 11, 12). The player is oriented by a voice narration system throughout the experience when the player interacts with the environment like collecting coins and performing research. The user also has the option of a classical guided tour without gaming elements. In this tour, users hear the voices for explanations at the POIs (Plecher et al., 2022, pp. 13-15). By this technology, users have the chance to experience the wreck site and get cultural knowledge without diving (Figure 13).

Figure 11. Research during the game (Plecher et al., 2022, p. 14).

Figure 12. Amphora at the wrecksite (Plecher et al., 2022, p. 14).

Figure 13. Information screen on the tablet (Plecher et al., 2022, p. 13).

4.6. Serious Games as an Interactive Experience Tool

Serious games make the users get involved into the experience in a much more enjoyable way as they become a part of the atmosphere. An example of a serious game by using virtual reality technology was developed for the Olympic Games in ancient Greece. The game consists of several interactions. Users can experience the Temple of Zeus at Olympia and the famous statue of Zeus which is one of the seven wonders of the ancient world in the virtual environment. Visitors can also make Olympic pottery puzzle (Figure 14). The ink-paintings on the pot surfaces offer valuable information about the rituals, daily lives of the people and the culture they had in the past. When users finish the puzzle, the painting on the pot transfers into an animation of an ancient Olympic competition (Gaitatzes et. al., 2004, pp. 1-2).

Figure 14. The Olympic pottery puzzle (Gaitatzes et al., 2004, p. 2).

Feidias' Workshop is another virtual experience where the famous sculptor Feidias and his team build the statue of Zeus (Figure 15). The visitors can take part in completing the statue by using virtual tools through the navigation controls. By contributing to the statue, users get knowledge about the procedures, materials and techniques of the statues in ancient times (Gaitatzes et al., 2004, p. 3).

In another virtual experience called "A Walk through Ancient Olympia", users can learn more about ancient games by having interaction with the athletes in the game (Figure 16). They can visit the buildings like Heraion, the temple of Zeus, the Gymnasium, the Palaestra and then get a knowledge about their history and for which purpose they were used for. Apart from seeing the games, users can also join them. For instance, they can pick up the javelin and throw it away in the stadium (Gaitatzes et. al., 2004, pp. 4-5). With this experience users learn more about the features of the buildings and the games by interacting with the virtual environment.

Figure 15. Feidias' Workshop (Gaitatzes et al., 2004, p. 3).

Figure 16. A walk through Ancient Olympia (Gaitatzes et al., 2004, p. 4).

4.7. Enriching Museum Visits with Virtual Museums

Virtual museums are another purpose for the presentation of the archaeological heritage. It provides an interaction with the cultural object even if the user is not on-site. For instance, the project named Tiber Valley Virtual Museum, a virtual reconstruction of Lucus Feroniae was created and the virtual model was presented to the public through a virtual reality installation at the Etruscan National Museum of Villa Giulia in Rome, Italy. The installation gives information about the story of the Tiber Valley and its archaeological sites. The visualization consists of three screens which show the archaeological site, its virtual reconstruction in first person and third person. The camera tracking system enables synchronization between screens. In addition, users can make comparisons between the current situation of the archaeological site and its virtual reconstruction (Figure 17) (Pietroni and Ferdani, 2021, p. 18).

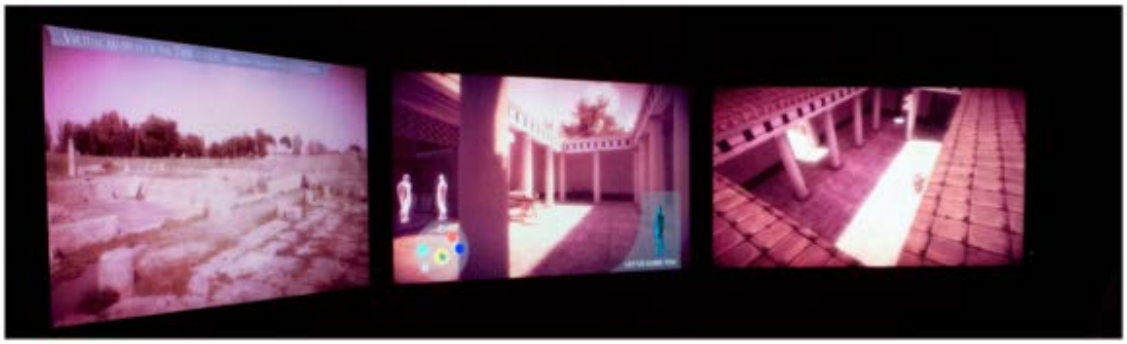


Figure 17. The real archaeological site (left), the virtual reconstruction from the same point (middle), a further view from the site (right) (Pietroni and Ferdani, 2021, p. 19).

4.8. Applications that Add a New Dimension to Archaeology Education

Apart from serious games for a more inclusive experience, immersive technologies can be used to train students for the protection of the archaeological heritage. For example, Shackelford et al. (2019) developed a virtual environment where university undergraduate students can experience archaeological field excavation without being at the real site. The course with an excavation field simulation contributes to teaching archaeological theory to the students in this way (Shackelford et al., 2019, p. 2).

The system is based on a room scale virtual excavation in VR platform. It consists of a PC with a VR-capable graphics card, a wireless VR headset, two base stations and two trackable hand controllers which enable users to interact with the virtual environment. The project is developed by using Unreal Engine 4 to make it look as real as possible. The ground is rendered by texture-mapping techniques and the ceiling and walls are rendered by panoramic video (Shackelford et al., 2019, p. 4). In this environment, students can learn from the presentation of an excavation site in a more interactive way even if they are not on the real site (Figure 18).

Figure 18. Screenshots from the virtual environment (Shackelford et al., 2019, p. 5).

5. Conclusion

The excavations, which started with the interest in ancient settlements, played an important role in the formation of the science of archeology. However, in the 20th century, principles for the protection of archaeological heritage were put forward with national and international charters, laws and regulations. In the 21st century, in addition to basic conservation approaches, issues such as the representation of cultural heritage and raising awareness in the society have started to come to the fore with the developing technological tools.

Immersive technologies such as VR and AR are used in fields such as education, health, entertainment, etc. and provide richer experiences in many different fields. These technologies, which are constantly developing, have started to take place in the representation of cultural heritage since the 2000s. Thus, it has made it possible for people to take part more interactively in the process of experiencing the cultural heritage and become a part of the experience. Virtual environments have enabled individuals to experience the cultural heritage in a richer way and have become an impressive tool for people to gain awareness for the protection of cultural heritage.

Immersive technologies, which have become a representation tool in the protection of archaeological heritage and allow people to interact with heritage items in a more interactive way, are divided into different subgroups according to their intended use. With the developments in these technologies, the purpose of their use is expanding day by day. Including current studies in the literature, the use of immersive technologies such as VR and AR in the protection of archaeological heritage has been determined and examined in this study.

Cultural heritage has a direct relation with user experience in terms of how users perceive the values it has. In this case, comprehensibility, enjoyment and usefulness take important role in improving users' experiences on archaeological heritage. Future tools can be developed in a way to include more joyful usability with more comprehensible visuals. For instance, it can enable the development of a platform where participants can share their views and ideas and not only participate in the experience individuallly but also interact with each other. For example, in terms of education, gamification elements where students can have an interaction with other students may be used in the process in a way to make them learn it fast and more effectively. In this way, the user experience can be further enriched and this will lead a higher level of cultural heritage awareness among society on archaeological heritage.

It is seen that immersive technologies are an effective way of representation in the context of raising awareness in the society and contribute to the pursuit of a sustainable conservation approach. In this context, it is necessary to make virtual environments developed with VR and AR technologies more widespread and to support more original and effective studies for the protection of archaeological heritage.

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