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Presentating Reburied Mosaic through Augmented Reality: A Case Study from the Church of the Lions at the Cultural Heritage Site of Um er-Rasas, Jordan

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Abstract

This study examines the use of Augmented Reality (AR) as a new technique. It focuses on the presentation, interpretation, and protection of the reburied mosaic floors at the UNESCO World Heritage site of Um er-Rasas in Jordan. Although reburial is a good way to preserve mosaics, it also limits the sites' visitors and academics from seeing and interpreting their meaning. Therefore, this paper discusses the development of a prototype based on an AR platform. This system enables the presentation and interpretation of reburied mosaics in situ without damaging them. This study uses high-resolution photogrammetry of the reburied mosaic. These images were used to develop an Augmented Reality application using Unity. The results of this study indicate that the application of AR enhanced visitor engagement. It also improved their cultural understanding of both the mosaic and the site. The paper concludes that the new technology of AR can help achieve a balance between preservation and accessibility of the reburied mosaic.

Keywords. Presentation and Interpretation Augmented Reality (AR), Cultural Heritage, Reburied Mosaics, Um er-Rasas, Digital Heritage, Protection

Introduction

Archaeological sites, especially those with mosaic panels, are considered a significant and invaluable resource of many countries. They have represented the identity of the people from historical, cultural, religious, and artistic perspectives. In the Mediterranean basin countries, such as Jordan, the mosaic is regarded as one of the most significant archaeological elements(Nassar et al., 2021). In general, mosaics are exposed to many forms of deterioration agents that can be either natural or human agents(Stucchi & Elisabetta, 2025). Consequently, it is very necessary to adopt both interventive and preventive conservation to reduce the effects of these factors..

In the past, detaching mosaics from their original locations was considered an effective preservation strategy (Stewart, 2016). The destination for the detached mosaics could have been either to store them or to exhibit the panels on museum walls. Later, the concept of detaching the mosaic panels from their original location has shifted. Some experts considered that such intervention could be a separation between the architecture of the site and its mosaic. Reburying mosaics at their original discovery places has been adopted as a technique for long-term preventive conservation. In addition, it was regarded as an effective approach for preserving the authenticity of these floors. The process includes covering them with layers of sand, soil, and geotextile fabrics as protective coverings. The intervention aims to reduce the aggressive natural and human agents that cause the mosaic deterioration (Negue, 2004; Stucchi & Elisabetta, 2025).

Reburial of mosaics in situ may offer several benefits. However, it can limit the access of visitors and scholars to appreciating the aesthetic, cultural, and religious values of the mosaics. At the beginning of this century, a significant development in the application of various digital technologies. A certain set of technologies has been used to preserve, exhibit, and interpret cultural heritage. One of the most prominent of these technologies is Augmented Reality (AR). This innovation offers unique capabilities that enable the integration of digital content with real-world environments (Boboc et al., 2022; Lian & Xie, 2024). This can allow the site visitors and academics to see either hidden or entirely lost cultural heritage in their original context. Although AR has been extensively used for visible archaeological finds, its application in cases like that of buried mosaics has been relatively understudied. Furthermore, this study seeks to address this gap by designing, developing, and assessing an AR system. The proposed system is intended to present and interpret reburied mosaics at the Church of the Lions within the UNESCO World Heritage Site of Um er-Rasas in Jordan. It also aims to protect the physical condition of the mosaics while allowing visitors and academics to interact with them extensively in their original spatial setting.

Literature Review

The subject of preservation and interpretation of cultural heritage is often addressed. Additionally, partial or full reburial has been acknowledged as a successful preventive conservation technique. In the countries of the Mediterranean basin, a huge number of historical mosaics have been uncovered (Aktüre, 2025). These pavements are exposed to several natural and human factors of damage (Stewart, 2004). Scientific studies have proven that reburial of mosaics through the use of materials such as sand, soil, and geotextiles might help in providing protection for the mosaic in the long run. This intervention may helps to stabilize the rapid of fluctuation of temperature, relative humidity, which leads to lowering the biological growth and other factors (Theodorakeas & Koui, 2010) .

Even though there are many benefits of reburial of mosaic floors, there are some limitations which is limit the visual access of visitors to the mosaic floors (Figures 1and 2) . As a result of this problem, academics are looking at different ways to improve accessibility without disturbing the preservation and integrity of this legacy.

Recently, the use of digital technologies in heritage presentation and interpretation has been widely developed. Among these techniques Virtual Reality VR, Augmented Reality AR 3D modelling, and many others (Bekele et al., 2018). These techniques play a great role in

showing and enhancing the visitor engagement and understanding of the cultural heritage. Augmented Reality has emerged as a distinguished technique in this field. It allows for the incorporation of digital reconstructions into the physical world while preserving a direct connection between visitors and the site context(Jung & Tom Dieck, 2017).

Augmented Reality has been used in museums and archeological sites to improve educational experiences and visualize the different historical eras. Additionally, it is sometimes used to reconstruct missing parts of structures or statues (Spallone et al., 2022). It has been proven to be successful in enhancing visitor comprehension and engagement. However, the majority of these applications are still limited in focus on visible features, and their usage of AR for hidden or reburied historical features, such as buried mosaics. Therefore, this study aims to fill this gap by employing AR to present and interpret reburied mosaics. At the same time, preservation and protection of the physical integrity of the buried mosaic are considered the priority of this study.

(a) **(b)**

Figure 1 (a and b) . Showing a a loss of cultural, aesthetic, and artistic values resulted of covering with debris. Photted by the researcher at the Church of Lions (Um –er-Rasas, Jordan).

Figure 2. Photos showing mosaics buried under the layers of dirt from the ancient city of Perge, Antalya, Turkey (Yeşil, 2021).

A several papers focused on using mobile information technology and three-dimensional simulations (3D) of cultural heritage within museums and historical sites. One of the most significant studies in this field, authored by Anastassia Angelopoulou and others (Angelopoulou et al.), which is addressed "Mobile Augmented Reality for Cultural Heritage ".This paper explores the possibility of implementing augmented reality (AR) in mobile devices that can improve the experience of visitors in cultural settings. Further, the paper shows the possibility of using AR to link the artifacts of the site of Sutton Hoo, which are present in the British Museum, with their original location where they were found. As part of this study, an augmented reality created for iPhones illustrates this method. Other topics covered by this paper include stakeholder requirements, system architecture, results, and future development directions.

Another an essential project in the same filed , the project of ARCHEOGUIDE that includes an early implementation of mobile augmented reality technology, The paper presents ARCHEOGUIDE (Vlahakis et al., 2001), as a European Union project. It was designed to develop a prototype for testing a personalized augmented reality guide. This system aims to facilitate the exploration of cultural heritage sites in Olympia, Greece. The ARCHEOGUIDE system works with the help of the location and orientation of the user. Additionally, AR can reconstruct ancient ruins based on the user's position and orientation. These reconstructions are supported by a multimedia database that provides cultural information and virtual content.

Area of the Study

Um er-Rasas is a an important archaeological site in Jordan which was nominated in World Heritage Sites in 2004 (Moskvina, 2016). It is situated 60 kilometers south of the capital, Amman, 30 kilometers southeast of Madaba, north of Wadi Al-Mujib, in Jordan (Figure.3). The archaeological excavation and expedition have explored a huge of historical remains returned back to different civilizations settled in the site (Ha'obsh; Piccirillo, 2004). From these discoveries were sixteen churches several of them. have paved with an outstanding mosaic such as the mosaic of St Stephen mosaic church (Figure 4). The study focused on the reburied mosaic of the Church of the Lions (Hamarneh & Hinkkanen, 2008).

Figure 3. Location of Um er-Rasas
Source: (Alafi, 2014).

Figure 4 Demonstrate the current condition of the buried mosaic in the Church of Lions –Um er-Rasas. Source: (Photographed by the researcher, 2025).

Methodology

In order to measure the efficacy of Augmented Reality AR in presenting, interpreting, and protecting the buried mosaics of the Church of the Lions at the archeological site of Um er-Rasas. a approach involving technological innovation was adopted.

Proposed AR Framework

This study proposes a structured framework consisting of three stages:

i. **Digital Documentation**
   High-resolution photogrammetry was used to capture mosaic data.
ii. **AR Development**
   Unity was used to create the AR environment with spatial alignment.

iii. **Visualization & Interpretation**

Users access AR via QR codes to visualize mosaics on-site.

AR System Development

An Augmented Reality application was used to visualize the buried mosaics in their original spatial archaeological setting. The following were part of the development process:

i. A photogrammetry image was used to capture high-resolution details of the buried mosaic floor surface. (Figure.5) The images was received from. (Dr. Stefania Chlouveraki with sincere thanks and appreciation – University of West Attica –Greece)
ii. A Part of high digital photo model is being processed and reconstructed (Figure 6).
iii. Integration with an AR environment built on Unity (Figure 7).
iv. The application of spatial alignment and image-based tracking
v. The creation of user interface components, such as zoom and interpretation functions

Figure 5. A high-resolution photo of the mosaics of Church of the lions.
Source: (Dr. Stefania Chlouveraki – University of West Attica –Greece.).

Figure 6 A part of a high resolution of mosaic imports and Prefab Conversion in Unity

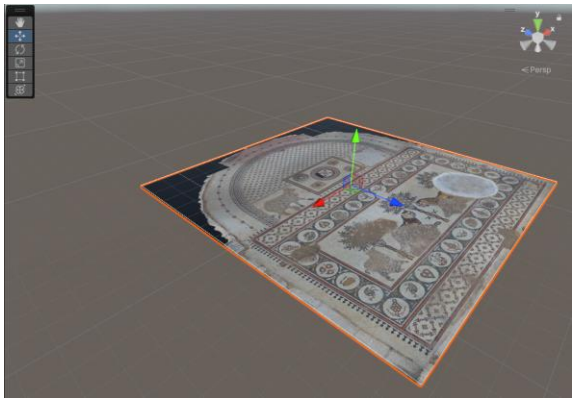

Figure 7 The mosaic image was applied to a flat plane object, scaled to match the physical dimensions of the mosaic.

By scanning QR codes positioned close to the mosaic places (Figure,8), Visitors and academics can access the augmented reality content and examine comprehensive visualizations and interpretive information on the spot.

Figure 1 QR Code that the visitor should scan to see the buried mosaic.

A demonstration videos and photo below (Figue,9), of the developed AR application is provided to illustrate the visualization process of the reburied mosaic in its original archaeological context, Video 1. https://www.youtube.com/shorts/67xFPFZKpR4.

Figure 9 Demonstrates the AR application's capacity to display the buried mosaic within its original archaeological context

Data Collection

Data was gathered using:

i. Photogrammetry data.
ii. AR application testing under field condition.

Data Analysis

A qualitative analysis approach was used to assess presentation and interpretation effectiveness and the usefulness of the visitors' and experts' experience of using the AR application. In addition, the technical aspects of the Augmented Reality system were assessed, specifically its spatial accuracy, usability and visualization quality.

Results

The findings indicate that the Augmented Reality (AR) application successfully achieved the primary objectives of this study. However, it enhanced the presentation, interpretation, and protection of the reburied mosaic. The remarkable success of the AR prototype experience in showcasing the buried mosaics in the video that was filmed at the Um er-Rasas site. It can be viewed via the following link: https://www.youtube.com/shorts/67xFPFZKpR4. reburied mosaics in the Church of Lions at Um er-Rasas.

Technical Performance

The Augmented Reality (AR) system used in this study has proved to have high spatial accuracy. Since it allows the digital images to overlap well with the real environment of the archaeological context. Furthermore, image-based tracking also provided a stable and clear visual presentation of the buried mosaic. Also, the application has proved efficient in the field conditions of the site.

Interpretation and Preservation Outcomes

The AR application played a substantial role in increasing the comprehension of the visitors of the buried mosaic, in relation to spatial relations, symbolism, and architectural setting. The interpretive capabilities of the developed AR application are further illustrated in Figure 10, and the second video can be viewed at the https://www.youtube.com/watch?v=NKevQjWxGl8 which demonstrates how the buried mosaic is visualized and interpreted within its original archaeological context In addition, the AR App's ability to zoom in and explore the details of the buried mosaic has contributed to further enhancing the interpretation process. Moreover, the new technology minimized the subjecting of the buried mosaic pavements to physical damage.

Figure 10 A screenshot from the video demonstrates AR application’s capacity to interpret the buried mosaic in their archaeological context.

Discussion

The findings of this study show the ways in which Augmented Reality (AR) can be used to enhance the display and interpretation of buried mosaics at archaeological sites. Also, the application supports the preservation of these buried pavements. In addition, the application of Augmented Reality could improve tourists' and academics ' access to and understanding of these buried pavements. By using this method of (AR), they will have an opportunity to explore the artistic, cultural, and historical significance of these mosaics.

. These results aligned with those from previous research carried out in museums and heritage sites by using the same technique. In addition, they highlighted its role in improving heritage presentation, interpretation, and protection. In this regard, the current study contributes to the growing body of literature concerned with the use of AR in cultural heritage management.

Despite are many benefits of implementing AR technology in presenting, interpreting, and protecting the buried mosaics, there are several restrictions. These restrictions are connected with the actual usage of the technology. Consequently, these limitations may affect its implementation. Such limitations may have an effect on the process of implementing the technology on-site. Such limitations have an impact on the process of actual usage of the technology. The first limitation has to do with the impact of environmental factors on the effectiveness and precision of the system. This will lead to a reduction in the efficiency of the interactive process. Besides, individual differences in mobile technology literacy may have an impact on the way participants will be able to get the most out of the technology. Such individual differences may influence the process of system interaction and user experience. These restrictions may be overcome through the development of more precise and flexible tracking systems. They may also be addressed through the creation of more user-friendly interfaces.

Conclusion

This research demonstrates that AR offers an efficient and sustainable technique to present, interpret, and protect the reburied mosaics. In addition, the use of AR allows cultural mosaics to be displayed within their original archaeological context. This can be achieved without causing damage to their physical integrity. Furthermore, this study makes a clear contribution to the body of knowledge in digital heritage. It introduces a realistic framework that integrates the use of technology within the preservation principles for presentation and interpretation purposes. These fundamentals enhance the understanding and practice of digital heritage. The AR prototype developed provides a flexible framework that can be applied to other sites as well. Future studies in this area should examine the long-term use of augmented reality technology for heritage management. Additionally, how it interacts with other ongoing development technologies.

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