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Smart system Based on Augmented Reality for Displaying Cultural Heritage in Oman

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Abstract

The preservation and display of cultural heritage are of paramount importance, and the use of technology has provided innovative solutions for enhancing the visitor experience. This paper proposes a smart system based on augmented reality (AR) for displaying cultural heritage in Oman. The system incorporates AR technology with a mobile application to enhance the visitors' experience, making it interactive and informative. The proposed system enables visitors to explore the cultural heritage of Oman in a more immersive way, providing them with a unique experience that allows them to interact with 3D virtual objects, and access information in real-time. The system is designed to be user-friendly, with a simple interface that enables visitors to navigate and interact with the augmented reality content easily. The system's performance was evaluated through user testing, which indicated that the system was effective in enhancing the visitors' experience. The proposed smart system has the potential to be used as a model for the preservation and display of cultural heritage in other regions, providing a new and engaging way for visitors to explore and learn about cultural heritage.

***Keywords**:* Augmented reality; Internet of Things; Human Computer Interactions; IoT evaluation; Communication networks;

1. Introduction

To date, the problem of integrating the latest technical and technological developments into the museum space is one of the most urgent. This is due to a number of reasons: the current socio-cultural situation, the changed type of information perception by a person, the capabilities of modern technologies in comparison with traditional means and forms of visualization, as well as the changing demands of the audience (Zhao et al., 2023).

Modern man is focused on the perception of information in a figurative form. Every day he is surrounded by huge streams of visual information, different in their significance and form, which leads to the so-called clip perception of information (Li. J et al, 2021). A person no longer fully perceives static information presented in the traditional form of a text. Researchers note that about 80% of all information received, a person masters through vision (Lupascu et al, 2021). Consequently, information presented in a visual form is perceived by the viewer faster and causes certain associations, which contributes to better assimilation of the data received. In this regard, the problem of visualization in the modern world is very acute for many organizations. Being one of the most effective ways of presenting information, visualization is also implemented in the museum space (Alifah et al, 2021).

In a museum, visualization can take many forms and perform different functions. Today, exposition activities use both its traditional forms in the form of scientific and auxiliary materials, and innovative ones, implemented with the help of multimedia technologies.

However, the use of only scientific and auxiliary materials in a modern museum is not always able to meet the needs of both the museum itself and the society they serve. They were developed and applied in certain socio-cultural conditions as a response to emerging and changing requirements (del Barrio-Tellado & Herrero-Prieto, 2022). With the passage of time and the development of technology, the requirements have changed so much that interaction with the usual forms of visualization has become unable to satisfy the viewer. For this reason, museums are increasingly turning to modern multimedia technologies, which are becoming an integral part of them, significantly expanding the boundaries of its capabilities, helping to implement several functions and tasks of the museum at the same time with their help: visualization and transmission of cultural heritage, its preservation and accessibility, recreational, educational and informative function.

As a rule, innovative forms of heritage visualization are a complex format, combining several ways of transmitting information and capable of performing several functions at once, which is required from the museum by the modern socio-cultural situation in which it develops. In this case, we are talking about the forms of heritage visualization using augmented reality technology, which began to be used in the museum environment around the end of the first decade of the 2000s. The technology is a real-time combination of virtual and real elements in an interactive form. Virtual elements can be text, graphics, audio, etc.

To reproduce the technology, the user, as a rule, needs special equipment. Initially, such equipment was helmets supplemented by computers, but this method has a number of disadvantages: size, weight, inconvenience of use, inaccessibility to a wide audience, cost, etc. The technological development of portable devices has allowed the technology to spread more widely and massively in the form of a mobile application (Kim). With this approach, no special equipment is required to reproduce the technology other than a regular smartphone, tablet computer, or any other gadget with sufficient power and a camera to play the required application. Another common implementation method is stationary museum equipment.

Augmented Reality technology, once considered the future technology, is now used in all fields, games, medical research, and others. The Internet, virtual reality, and augmented reality have all contributed to attracting tourists and visitors.

Augmented reality in museums is also not to be bypassed, and there are several purposes. It can be used to drop missing, inaccessible objects in 3D as part of past reconstructions. It is also well suited for fun applications with the display of elements in augmented reality, such as characters or points of interest that will enrich the visit and give visitors the opportunity to focus on architectural elements, for example. Thus, the museums aim to offer improved and increased visits by offering enriched content. Augmented reality also serves as an educational tool for children in order to manipulate and play in a cultural context and give them other clues to understanding. Integrated into a fun game, they will come out happy and full of knowledge (Miyata et al., 2011).

The main objective of this work is to create a highly reliable system based on augmented reality; the so-called intelligent system based on augmented reality for the presentation of cultural heritage.

The combination of robotics and enhanced haptic feedback in virtual reality (VR) applications have enormous potential (Yousif, J., 2021). By including robotic devices in VR experiences, users can interact more realistically and immersively with virtual objects and environments (Yousif, J., 2020). Additionally, enhanced haptic feedback

technology provides a heightened sense of touch, allowing users to feel virtual objects' texture, weight, and resistance (Al-Hatmi & Yousif, 2017). Integrating robotics and haptic feedback improves the realism and engagement of VR applications, resulting in a more compelling and interactive user experience (Yousif, M., 2022).

This system allows cooperation with archaeological and historical sites to develop a software interface for both staff and visitors to obtain adequate information and explanation about these archaeological sites, and given the arched budget, the sub-objectives are as follows:

1. Proposing a highly reliable and intelligent system that aims to introduce augmented reality technology to increase the number of visitors and tourists.
2. Provide an opportunity for visitors to the archaeological site to interact with historical events.
3. The visitor gets enough information about the archaeological site without needing a tour guide.

Interest in the tourism sector is important for the diversification of national income. The Sultanate of Oman has many archaeological areas and buildings. Modern technologies must be introduced in order to increase the number of tourists in it. Adding augmented reality technologies to display objects, buildings, and cultural heritage will increase the opportunity to attract visitors. Visitors can also view the museum from a distance as a second option when the museum is closed (during the Corona pandemic, for example).

As we mentioned, Oman has many historical assets, including castles, forts, museums, and other archaeological and tourist sites. The Sultanate depends on a percentage of its national income from tourism. The introduction of augmented reality technology will increase the number of visitors and tourists. The visitor will also get information attractively and smartly. Moreover, the system will be like an electronic guide.

2. Background

Augmented reality overlaps pictures, text, or audio on top of what a person sees already. It uses an app on smart devices to modify an existing image. The user takes a position in front of the stage, holding their device. They will see a distorted picture of reality as a result of this. There are many ways to use augmented reality in museums.

The gaming industry is home to some of the most well-known AR applications. Pokémon Go, for example, is a game in which players "capture" Pokémon hidden in the real world. Players can see animated animals superimposed on what they observe through their device's camera. They appear to exist in the actual world thanks to technological advancements. Nearly 11.5 million people have downloaded the app.

Using experimental and mathematical models in the VR system allows efficient real-time monitoring. These models provide valuable insights and data analytics, allowing continuous VR experience assessment and optimization (Yousif & Abdalgader, 2022). Mobile application developers can quickly identify and address potential issues by combining experimental and mathematical models in the VR system and data analytics. This ensures users a smooth and immersive virtual reality experience, improving overall performance and enjoyment (Yousif et al., 2021).

2.1: Augmented Reality and Virtual Reality:

Virtual reality allows users to immerse themselves in another world entirely. AR, on the other hand, displays both the real world and a modified version side by side. Virtual reality substitutes what the user sees with a different reality. In AR, the user's existing vision. As a result, it can be used to annotate scenes and provide additional information. It's also used to put scenes in context and draw attention to their differences and contemporary reality. VR necessitates using specialized equipment such as headgear, controllers, and sensors. Augmented reality can be downloaded as an app and requires only a smartphone or tablet.

2.1 The use of Augmented Reality in museums:

In museums, there are numerous opportunities to apply augmented reality. The most straightforward method is to use it to add explanations to specific details. This means that when people use augmented reality to see exhibitions, they will get more information. Museums can also use it to display digital replicas of artists alongside their work. These 3D individuals can then provide the narrative. Augmented reality adds a third dimension to displays by bringing objects or situations to life. Many organizations all across the world are already using AR. These efforts add to the existing collections while also attracting a new audience. Here are a few creative ideas to incorporate augmented reality into museums (Kim, J et al., 2011).

2.2 National Museum of Singapore:

The Story of the Forest, an interactive installation at Singapore's National Museum, is now on display. The show features 69 photographs from William Farquhar's collection of natural history drawings. They have been transformed into 3D animations with which viewers can interact. After downloading the app, visitors can examine the artwork using the camera on their phone or tablet.

This family-friendly facility uses technology for learning. Like Pokemon GO, visitors can search for and "catch" items. In this case, these rare plants and animals are in the painting. You can add these to your virtual collection as you walk through the museum. After they are captured, the application displays additional information about them. Users can learn about these species' habitats, diets, and rarity.

William Ferqua's collection of natural history drawings are one of the museum's most important collections. Developed by TeamLab, a Japanese digital art group, this augmented reality project brings graphics to life. Viewers can manipulate and explore the image in new ways (Wang, Y et al., 2018).

2.3 Art Gallery of Ontario, Toronto:

AGO collaborated with digital artist Alex Mayhew to create an AR installation titled ReBlink in July 2017. Mayhew has reinterpreted some of the existing items in the collection. This allowed visitors to see them from a new perspective.

Visitors used their telephones and tablets to bring the object to life, which was carried by the reality of the 21st area. For example, George Agnew REODE indicates three letters to apply "Drawing Area." Her head looked at the game in a quiet place. In Mayhew's modern version, three are separated and consumed by their phone screen. SMO key vehicle returns. Mayhew is interested in invading technology into everyday life. In his opinion, we consume art faster because images constantly attack us.

Using AR for this project, artists wanted to turn technology into a way of engaging rather than distracting—the exhibition aimed to use the app to turn people up instead of down. According to AGO Interpretive Planner Shirali Hudson Hill, 84% of visitors to the exhibition feel a connection to art. 39% revisited the image after using the app (Sekimoto, M.).

2.4 Smithsonian Institution, Washington DC:

The Smithsonian introduced AR technology in 2017, adding a new dimension to one of its oldest and most popular exhibits. Many of the skeletons in the museum's Bone Hall have been on display since 1881. Visitors can now download a new app called Skin-and-Bone that displays these parts in a new light. This app features 13 skeletons overlaid on the image to recreate the creature.

Users can see what the skin and muscles of the bones look like and how the animals move. This gives them insight into the history of art creation and brings the exhibition to life. Visitors may use the system to watch vampire bats take off and anhinga's fishing. This app is designed to share some of the secret stories behind one of the museum's most famous collections.

2.5 Kennedy Space Center, Merritt Island:

Making historical events three-dimensional based AR can help visitors better understand them. A perfect example of this is the Heroes and Legends exhibit at the Kennedy Space Center. Here, the augmented reality experience shows a pivotal moment in the history of the American space program.

In June 1966, astronaut Gene Cernan performed the second spacewalk in history. He later called it "a spacewalk from hell". His spacesuit overheated and he began spinning uncontrollably without being able to see. The display shows the Gemini 9 space capsule, onto which Cernan's hologram is projected using AR. Visitors can watch him try to get back into the capsule. There is also a voice-over from Cernan himself describing his experience.

AR holograms are used throughout the exhibition. This technology gives the people who worked on the space program faces and voices (Sekimoto, M et al., 2017).

2.6 Perez Art Museum, Miami:

Behind the first art exhibition known as "Invasive Species" in cooperation with PAMM artist Felice Grodin, this exhibition was based on augmented reality. In the above example, AR complements the existing work. Despite this, Grodin continued to digitally work on this project. It is designed to perfectly complement reality and create images in space. The application contains a set of opinions and images. These 3D models include backwards reminiscent of jellyfish, creepy crawlies, or mysterious characters. Phyllis wanted to interact with her Transformation of the building structure. This exhibition is a comment on the vulnerability of climate change from our ecosystem. It transports visitors to future versions of buildings that have been attacked by invasive species. For example, "terafish" invade PAMM aerial gardens, which form a jellyfish-like structure that reaches a height of 49 feet. This reminds us of alien species that currently lives in the waters around Miami.

3. Related work

Recently many applications have been developed based on augmented reality. This section will mention some work that contributed to developing augmented reality technologies in museums.

3.1 Service orientation application based on AR platform for museum:

In (Rattanarungrot et al., 2017), A service-oriented mobile AR architecture is developed for multiple applications, such as an interactive museum or web application. The proposed system improves mobile augmented reality applications for the closed platform. The system's primary purpose is to create more flexible AR clients that efficiently support content acquisition and use of third-party digital media content in a real scene. The proposed framework can be used by specialized museums such as the Victoria Museum or a third party such as Google Maps.

A regular media API content material request is dispatched to a content material company to reap a cantered cultural item's related media contents with three-D models, images, text, films, and metadata. Acquired contents are visualized in each VR and AR environment and eaten up by cell users. The gadget layout and cell customer goals a wide variety of museum research and exhibition scenarios. Specific cultural media contents are organized and set up into the lower back cease gadget in advance. Users can use cell gadgets together with an iPad to view associated contents of a cantered cultural item on an AR scene.

In many special packages, augmented Reality (AR) has been implemented as a content material illustration device. Most cell AR packages are presently carried out on closed platforms. Implementing a Service-orientated Architecture on a cell AR platform may want to decorate the adaptability and value of an AR utility. Mobile AR packages carry out AR obligations with tracking, rendering, and visualization. Increasing cell AR structures' capability and cap potential may be accomplished by imposing carrier orientation. The designed carrier orientation for assisting the open cell AR gadget includes an internet carrier framework that exploits carrier APIs from potential cap providers. The cell AR customer might be a utility on a larger display cell tool and iPad. Acquired interactive media contents from special reassess to aggregate and visualize at the cell tool. The net carrier framework is a lower back-cease gadget that concurrently works with the AR utility. SAMARA includes a cell AR customer.

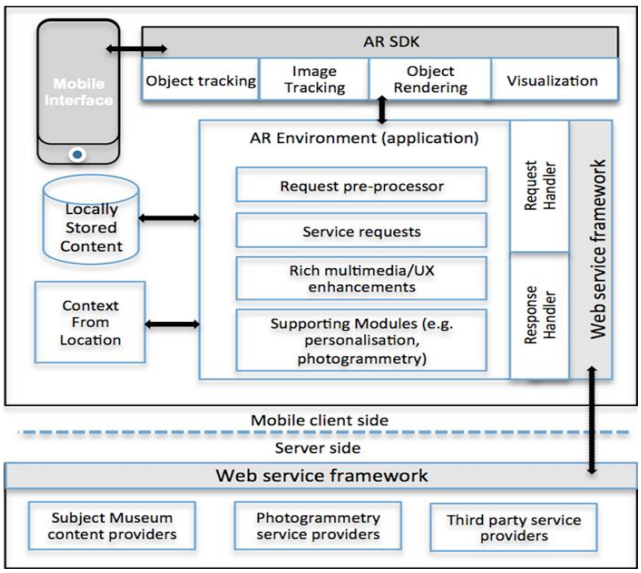

Figure 1. Service Oriented Mobile AR Architecture (Rattanarungrot et al., 2017)

3.2 AR for museum: advantage and disadvantages:

In (Madsen et al., 2012) evaluated the primary factors of iPad AR's utility, which evolved for the museum context. The utility is mainly designed for youngsters from zero to twelve years old. The utility combines augmented facts and sports factors to make historic occasions exciting for youngsters. The sport has been examined for three months, and full-size in-app interest changed into recorded. The authors say that in real utilization of the utility AR, the museum proved much less full-size than envisaged. An AR sport/revel is known as Memories of The Walls, which evolved for Holdings Museum in Denmark. The museum has been handing out iPads with the Memories of the Walls app to traveling youngsters and their households because of its release on February 9th, 2012.

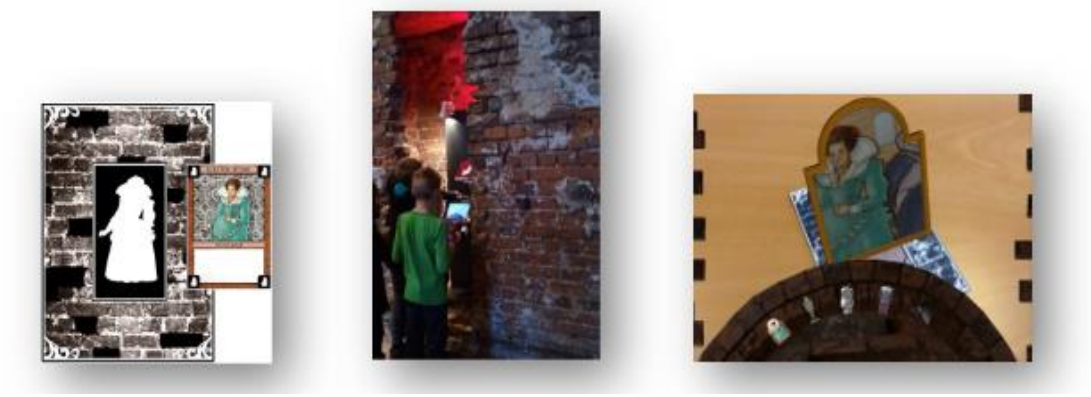

Figure 2. (Left to right: 1) a static frame placed on a stand in the Castle Chapel (Madsen et al., 2012)

Memories of the Walls is a utility for iOS five. Zero iPad 2 tablets. It uses Qualcomm's augmented truth SDK (CAR) for tracking. In-app logging collects time crowning glory for character elements of the recreation, overall playtime, and development in mini-video games. The museum excursion is an orienteering workout centered on mini-video games and getting from station to station. The average gambling time for people on an entire excursion is sixty-five minutes. People who understand their manner across the citadel are envisioned to allow you to stroll that excursion beneath Neath for 10 minutes. Experimental information confirmed that customers no longer visually discover the augmentations in AR recreation of Memories of the Walls. This may be addressed by shifting stands from wall recesses into open ground areas to permit customers to stroll around animations and layout augmentations to offer occlusions. In Memories of the Walls, there are five tiers wherein animations are augmented onto the video feed. Figure three suggests a warmth map of viewing positions for the station, wherein Kirsten Punk is introduced. The plot indicates that customers no longer take advantage of the opportunity to discover the augmentations from arbitrary viewing directions visually. (Jo, D., & Kim, G. J., 2019).

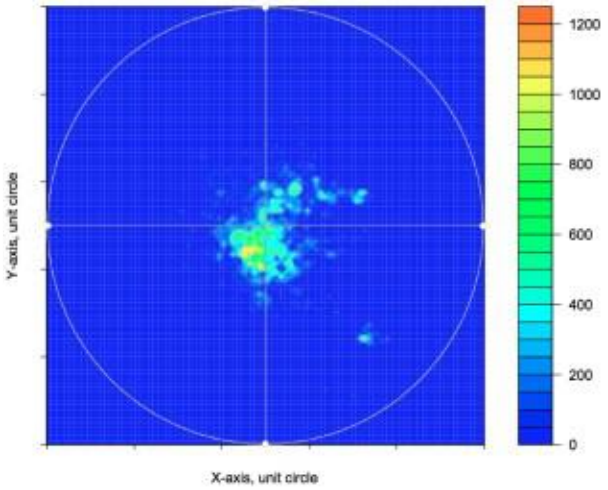

Figure 3. Heat map of viewpoint positions relative to the Kirsten Munk augmentation. (Jo, D., & Kim, G. J., 2019)

3.3 Hands-on display based augmented reality work at a science museum:

In (Takanashi et al, 2013) proposed a clever device primarily based totally on the augmented fact (AR) included with a sensible show from a laser projector. Through the digital facts supplied with the aid of using the augmented fact device, newcomers can get a visible rationalization approximately an item. The authors carried out experiments with the device on kids of site visitors to the Gamma Gore Museum of Earth, Life and Sea. The authors set three standards to make certain the achievement of the device, which might be:

1- The display has to appeal to site visitors and cause them to interested in the displayed item.

2- Ease of handling the augmented fact show.

3-The facts reach site visitors efficiently based at the above standards; the outcomes of the paintings have proven tangible achievement.

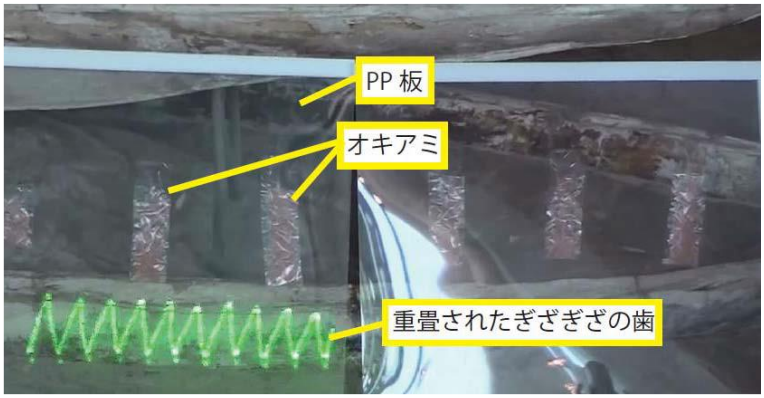

Figure 4. Example of using AR exhibit. (Takanashi et al., 2013)

Moreover, as an evaluation of preceding studies, we infer that there is a hobby using augmented facts in museums and elsewhere. In our research, we can assess an augmented fact-primarily based total device that differs from preceding structures. An AR showcase shows operable content on a duplicate of an actual showcase through the AR device. It permits newcomers to deliver their questioning on an actual showcase through trial and mistake with the AR showcase. Carlton proposed 4 necessities for a hands-on show (Hu M et al. 2021).

The researchers used a laser projection device, Big Fat Wand (BFW), because of the AR device for the proposed showcase. BFW has evolved to explain visible content to deaf and hard-of-hearing students. Users can show contents, which might be drawn with laser mild on a centered item. Learners could be capable of picking out and picking out pictures to show on a centered item in a few steps. BFW is a projection sort of AR device, meaning newcomers can easily percentage their displayed contents. Many AR structures cannot display digital content in a particular position (Takahashi et al., 2013).

4. AR Based Cultural Heritage Framework

The proposed model design is very flexible, allowing adding and removing functions according to future needs. Figure 5 describes the architecture of the proposed model. The proposed system allows visitors to interact with objects

in the targeted places and provide information. It will give the visitors a broad knowledge of the minimum period smartly and interestingly.

The visitor assistance block provides user assisted services by employing AR technology. At the moment, many museums equip their exhibits with QR-codes, which allow visitors to get more information about monuments (Muthanna et al., 2018). The proposed system provides this interaction with visitors by AR based applications that achieve better interaction and information availability.

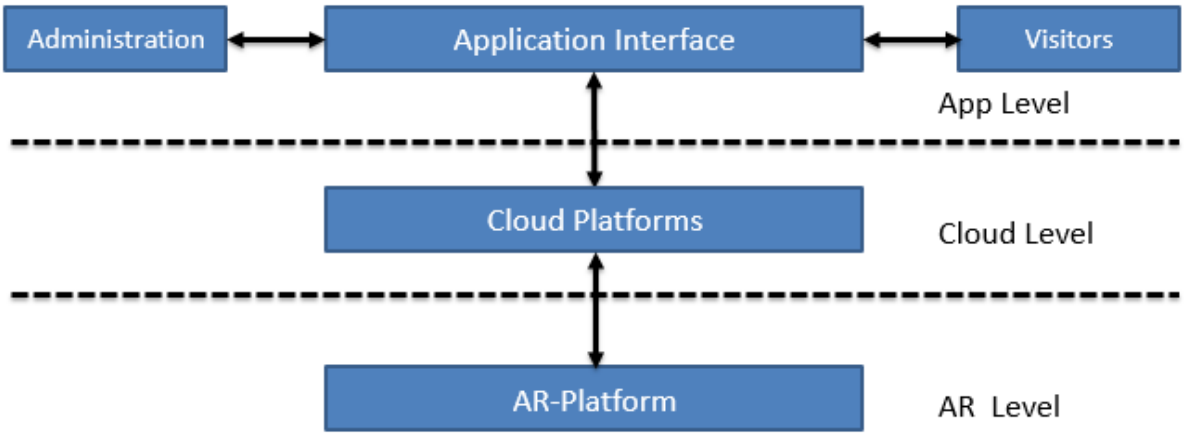

Figure 5. AR Cultural Heritage system.

Visitor assistance services can be implemented in two ways. The first way involves the additional equipment of the exhibits with special marks that, when activated, can open additional interactive possibilities for interacting with the exhibit. The second way is the use of artificial intelligence (AI) (i.e., neural network) to analyze and recognize distributed objects in the museum. Neural network can recognize things by comparing them with a record from the database and activates the same interactive possibilities, as in the first variant (AlKishri et al., 2021). For the proposed work, the second way is chosen as the method for implementing user assisted services (Phupattanasilp et al., 2019).

The simplest example of the additional interactive features is the output message of reference information about the dedicated object. A more complicated variant, for example, for paintings with battle scenes, may be the opportunity to see in real-life the equipment depicted in the picture. For the reproduction of projections, the most interesting is the use of glasses of augmented reality that museums could offer for visitors by analogy with existing audio guides. Moreover, in order to offer more facilitates for visitors, it is proposed to implement a mobile application with similar

functionality (Miettinen et al., 2017). The functionality of the solution can be extended, for example, by adding an interactive map of the museum, which will help visitors better navigate in it, and guides will mark themselves with special tags that will help tourists find them, even if they fall behind the main group (Lund et al., 2020).

5. Experimental Evaluation

The system, which we will call "Visitor Assistant", will provide assistance services using augmented reality technologies. Currently, many archaeological sites use identifiers such as NFC and QR so that visitors can obtain more information. In our project, we will be using augmented reality-based applications that achieve better interactivity and provide information from previous technologies.

There are two ways to implement a visitor assistance system as follows:

- The first method: attaching parts and pieces at archaeological sites with a distinctive mark. Visitor can unlock interactive possibilities around the body with this sign.
- The second method: Using artificial intelligence algorithms to identify objects distributed in archaeological sites such as castles, forts and museums.

In our work we chose the second way to implement the project.

To make the idea clearer, we will cite an example. The Omanis had previously fought battles to expel the occupiers, such as the Persians and Portuguese, as well as to unify the country. There are some museums that display these stories in a traditional and boring way. The visitor finds it difficult to understand the historical story. Using the proposed augmented reality-based system, the visitor will see the story in real life. This can be done by using augmented reality glasses that will enhance the virtual image into reality.

There are several open-source platforms for building applications of the proposed system. Also, to provide information to circles, there is a need to develop augmented reality applications for smartphones and smart glasses.

Below we show you the components of the proposed system:

1. Unity:

Unity is cross-platform computer game development environment. Unity allows you to create applications that run on more than 20 different operating systems, including personal computers, game consoles, mobile devices, Internet applications and more.

2. Vuforia:

Vuforia is an augmented reality platform and software development kit (SDK) for mobile devices developed by Qualcomm. Vuforia leverages the rich 3D capabilities and analytics of the IoT to create immersive augmented reality environments that increase efficiency, help create better products, and improve employee safety and productivity.

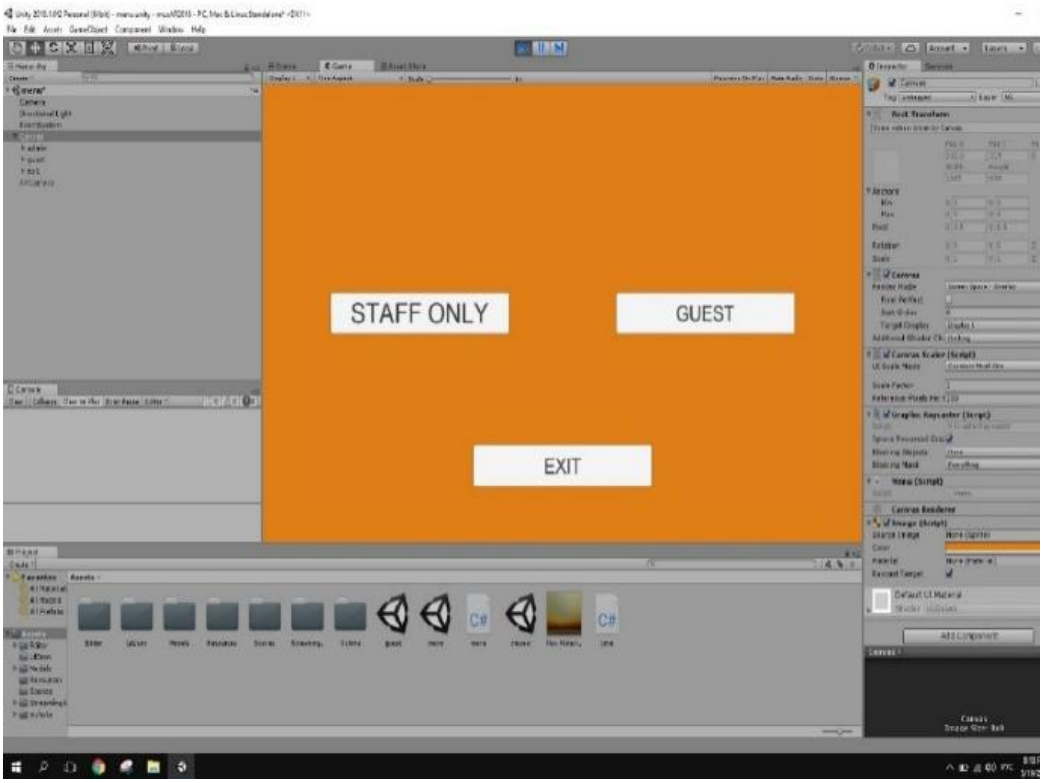

Figure 6. The AR-application Interface

Based on the proposed model, we will design a prototype application. The system interface consists of two parts. Part concerned with visitors and part with employees. Figure 6 shows the application interface. We used an object in our testing to ensure the system was successful. Figure 7 shows the piece of art that we have chosen as the body for system experiments for the National Museum of Oman. The application is divided into two interfaces. One of them is for visitors (guest) to the museum and the second for the staff as shown in Figure 6. The interface for museum staff that have some facilities to manage the activities shown in Figure 7. The corresponding measured data is shown once a staff hovers over the image's virtual blocks.

We build an application for the previously introduced system based on the considered platforms. The application is deployed for both system parts and can be run over any appropriate operating system. Thus, visitors and museum

managers, and employees can use this application. The application defines the two categories of users, visitors, and administrators and offers the appropriate data and services for each category.

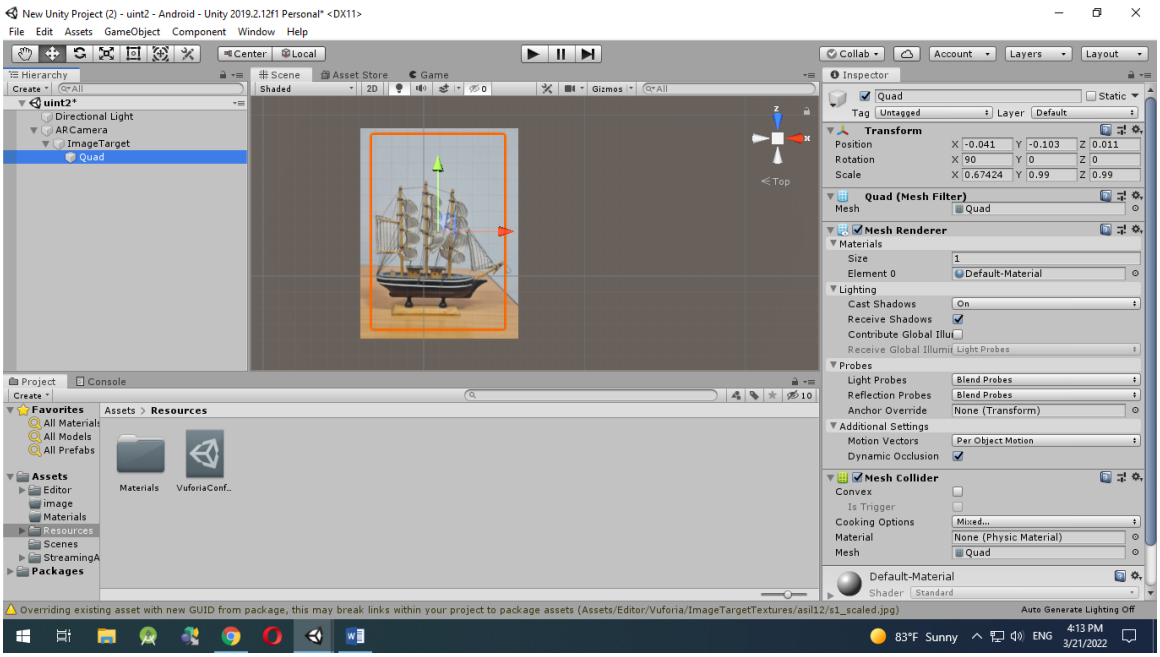

Figure 8. The staff interfaces.

We consider an art object as a prototype for testing the developed application. The art object considered is the image of the painting “Moonlight Night” by Vincent Van Gogh. The application provides two interfaces; one interface for the museum administrators and the other for visitors. Figure 8 illustrates the appropriate interface for museum administrators. Once an administrator hovers over the picture’s virtual blocks, the corresponding measured data is displayed.

6. The Developed application

The developed application is a mobile application that can be downloaded onto a smartphone or tablet. Once downloaded, visitors can use the application to explore the cultural heritage sites in Oman using AR technology. The application would use the camera on the device to overlay digital content onto the real-world environment, allowing visitors to see 3D models of cultural artifacts, buildings, and other objects.

The application would also provide visitors with information about the cultural heritage sites, including historical background, stories, and interesting facts. This information could be accessed by pointing the device's camera at specific objects or locations, triggering AR overlays with contextual information.

The application's user interface would be user-friendly, allowing visitors to navigate easily and find the information they need quickly. The application would also include interactive features like quizzes and games to make the visitor experience more engaging and enjoyable.

Overall, the developed application based on augmented reality (AR) for displaying cultural heritage in Oman would provide visitors with a unique and immersive experience that allows them to explore and learn about Oman's rich cultural heritage.

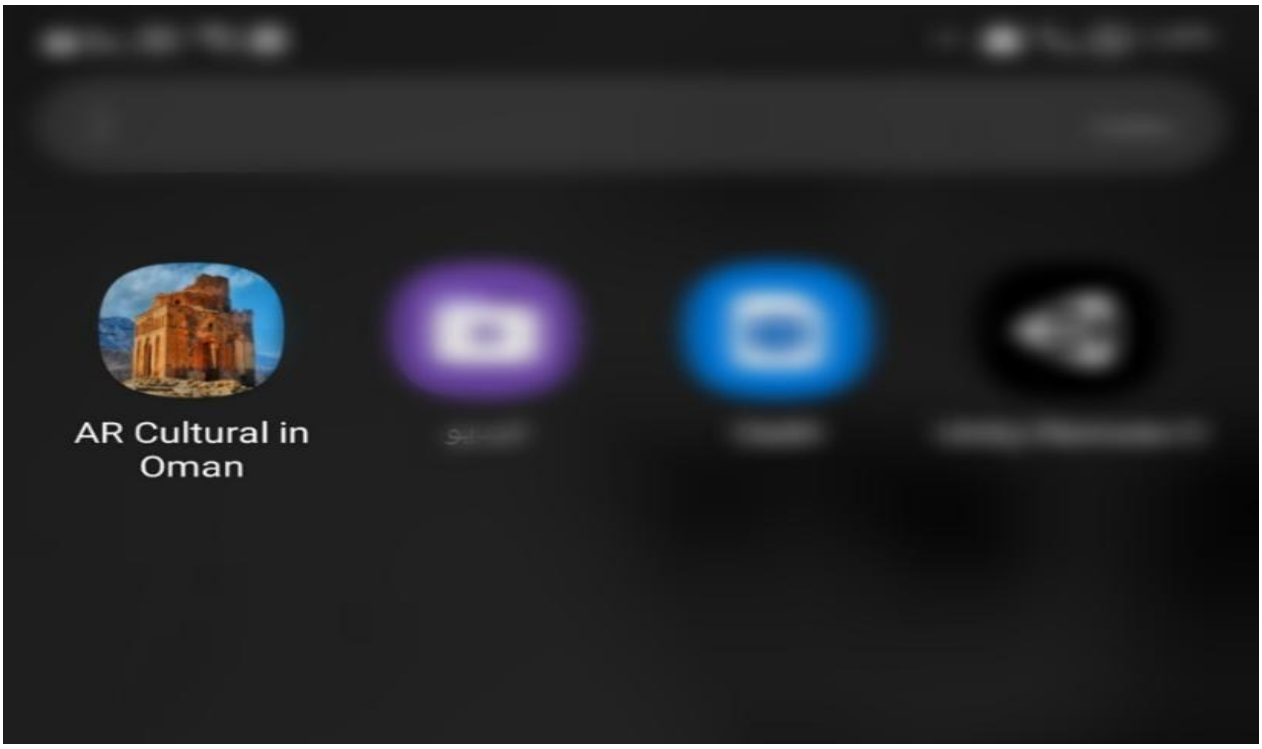

Figure 8. The developed application.

In order to develop the application in the future and add new features, developers must add a number of features to the application, and the display systems must be improved. These are some suggestions for developing the application:

1. add server

Because of the large volume of data, we will need to develop the program by adding many servers covering a lot of information for various archaeological sites in Oman.

2. Survey

The tourist can evaluate the application by expressing his opinion and providing suggestions that support developers in developing the application as it increases its importance and effectiveness in the future.

7. Conclusion

In this project, we have successfully developed a cutting-edge mobile application that showcases the virtual and augmented reality experience of archaeological objects in Oman. The application is a comprehensive platform, providing users with an immersive display of various archaeological artifacts using advanced technologies.

By harnessing the power of virtual and augmented reality, our application goes beyond traditional methods of showcasing archaeological information. Users can now explore and interact with these historical objects more excitingly and efficiently. The application offers a range of features, including high-quality videos, detailed images, and informative descriptions, enabling users to delve deeper into Oman's rich cultural heritage.

One of the significant advantages of our application is its ability to captivate and engage users. The combination of virtual and augmented reality enhances the visual experience. It creates a sense of presence and authenticity, allowing users to feel physically interacting with the archaeological objects. This immersive experience heightens the educational and entertainment value, making it an appealing tool for tourists and enthusiasts of Oman's archaeological treasures.

While developing the application, we considered the potential challenges that tourists might face, especially regarding their familiarity with electronic technology. To address this, we have incorporated user-friendly interfaces and provided virtual tours and guides within the application. These resources aim to assist tourists in navigating the archaeological sites and instruct them on effectively utilizing the application. By offering clear instructions and support, we strive to make the application accessible to users of all technological backgrounds.

Moreover, our project aims to preserve and promote Oman's heritage through modern means. By utilizing virtual and augmented reality technologies, we bridge the gap between the past and the present, ensuring that the cultural significance of these archaeological objects is preserved to time. The mobile application serves as a digital archive, allowing users to experience and appreciate Oman's heritage from anywhere in the world.

However, it is important to acknowledge the weaknesses of our project. One of the primary challenges lies in requiring users to possess compatible smartphones and access reliable internet connections. While smartphone adoption has grown significantly in recent years, there may still be a portion of the population that needs access to these devices or face connectivity limitations. To mitigate this, we aim to explore partnerships with local tourist organizations or museums to provide loaner devices or designated Wi-Fi hotspots at archaeological sites.

In conclusion, our mobile application represents a groundbreaking heritage preservation and tourism initiative. Through virtual and augmented reality, we have created an engaging and efficient means of showcasing Oman's archaeological objects. By addressing the challenges tourists face and leveraging modern technology, we aim to enhance the overall visitor experience and promote a deeper appreciation for Oman's cultural heritage.

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