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Adopting Augmented Reality to Enhance Vernacular Building Preservation and Tourism: Case Study in Matbouli House Museum, Al-Balad

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Abstract: This paper investigates the use of Augmented Reality (AR) in a vernacular building, namely the Matbouli house. The paper studies the potential of vernacular buildings as a tourism source, with a particular focus on the role of AR in preserving historic buildings. A qualitative approach is utilized, which includes a literature review, the documentation of the built and cultural heritage of Matbouli house, and designing an AR app. The app highlights the house's tangible and intangible cultural features. This study seeks to contribute to a comprehensive understanding of the challenges and opportunities associated with vernacular tourism and the integration of technology in preservation pursuits. The findings show that AR apps are becoming increasingly easy to develop and, although costly, they have the potential to reduce renovation costs in the future. Moreover, using AR applications is strongly preferred and tourists are enthusiastic about the engaging, inclusive and memorable experiences they offer. Additionally, AR technology presents a viable way to improve cultural tourism and preservation by bridging the gap between conventional heritage interpretations and modern tourist expectations. Stakeholders are recommended to leverage AR to generate creative and sustainable experiences that draw tourists, spur economic growth, and aid in preserving cultural heritage.

Keywords: Vernacular architecture; Historic Buildings; Technology; Augmented reality; Albalad; Culture; Tourism.

1. Introduction

Al-Balad is one of the kingdom's most notable heritage sites. Heritage sites reflect past traditions, art, and culture (Desai, 2018; Hamza, 2019; Pardo, 2023; Sarah, 2011). As a result of Al-Balad's increasing popularity, touristic endeavors have been made to enhance and preserve the area. There seems to be a lack of technology integration in Al-Balad, and since experience is the essence of tourism (Fan et al., 2022; Jung et al., 2015; Quan & Wang, 2004), this study seeks to address this gap by investigating ways to integrate AR (augmented reality) to maximize heritage preservation and boost tourism, while minimizing the impact of traditional historic building restoration methods. This paper aims to explore the benefits of integrating AR into Al-Balad's vernacular buildings. Although a few international applications have shown and proven AR's promising benefits within the cultural preservation and tourism enhancement pursuits, the paper seeks to investigate this potential in a real-life application in Albalad, as a first of its kind. Conducting a review of the literature for this paper on topics such as vernacular architecture, cultural tourism, and various technologies provided valuable

insights into the benefits of utilizing technology for the conservation and promotion of Al-Balad's unique cultural heritage. As Çizel and Ajanovic (2018) asserts: "Cultural Heritage, both tangible and intangible, represents value systems, beliefs, traditions and lifestyles of one society." This study will investigate the ways in which historic buildings in Al-Balad are being preserved and showcased to the public. Moreover, the positive impacts of these efforts on tourism have been examined, all through a qualitative analysis of a case study, and a review of the relevant literature.

2.Literature Review

The literature review strives to identify the existing gap in literature concerning the integration of AR in vernacular buildings in Saudi Arabia and sets the goal of this research in realizing the importance of using such methods to boost sustainable tourism and increase the level of the heritage and historic preservation of vernacular architecture. The relevant literature is categorized under three main topics: vernacular architecture and tourism, KSA's vernacular architecture, and the impact of technology integration on architecture and cultural tourism.

2.1 Research gap analysis

Comprehensive studies examining the usage of augmented reality especially in Al Balad, historic Jeddah, are lacking. For example, about 214 results appear when searching "augmented reality in Albalad" on Google Scholar, dating back to 2014. Only a few of the papers analyze AR as an emerging tool, and none of them display the real-life application of AR on one of Albalad's vernacular buildings. Studies that already exist frequently concentrate on modern architecture or broad historical sites without exploring the potential and difficulties of vernacular building and heritage preservation through the implementation of an AR app, which this paper seeks to address.

2.2 Vernacular architecture and tourism

2.2.1 Vernacular architecture

Vernacular architecture (VA) has been defined as a construct based mainly on a society's outlooks and religious beliefs (Hamza, 2019; Oliver, 2012; Weber & Yannas, 2013). Hamza (2019) adds that with its layout of spaces and urban designs, VA represents cultural manifestations. Moreover, Olukoya (2021) defines VA as structures that are distinctive, representational, and understood within their local communities; they are buildings made by people in a specific geographical spot that are of the same ethnic background. The author explains that it's imperative to note that the contextualized cultural legacy is the result of individuals functioning within a shared heritage in a given area and time, using their own contextual processes and practices. Additionally, Sarah (2011) points out that although VA originally began at the hands of unschooled architects, this changed after the late 19th century with professional architects adopting the style to present the culture and history of a certain region, as well as the technological and environmental advancements made within a given community. Nevertheless, the previous authors agree that it is made with local and easily found materials. It is an architecture characterized by its dependence on local needs, resources, and traditions, which makes it impossible to copy without losing its essence (Merchán et al., 2021).

2.2.2 VA cultural significance

VA has a rich cultural heritage that embodies the unique traditions of a community, contributing to its wealth of heritage (Azevedo-Salomao & Torres-Garibay, 2016). The authors add that this type of construction has a noteworthy ecological quality that helps the local population as well as the surrounding natural and cultural areas. Correspondingly, it can be said that the way a space is built is correlated to the culture of the geographical region it is built in, and that the space humans occupy is filled with social information pertaining to them. In fact, the traits of a given society can be inferred from the ways that their buildings and spaces are organized (Asif et al., 2018).

2.2.3 Conservation of VA in Saudi Arabia

The MOC - Ministry Of Culture - in KSA has established 11 different commissions governed by the ministry, two of which are for architecture/ design and heritage. Ibrahim (2018) asserts that the KSA has addressed the importance of heritage and identity preservation, therefore, it has taken on many initiatives to promote conservation like the "Initiative to start Center for the National Built Heritage (CNBH)." Mazzetto (2023) emphasizes

the Saudi initiative referred to as Vision 2030. Vision intends to support the growth of the country in many fields by improving the level of awareness of local traditions, heritage and values, all as part of a sustainable approach.

2.2.4 Tourism

Tourism is one of the fastest growing industries in the world, and is one of the most rewarding (Pratheep, 2013). Tourism comes in many types including ecotourism, wellbeing tourism, cultural tourism and rural tourism, as seen in Table 1.

Cultural tourism refers to the forms of art (culture) in the urban and rural area of a region or country, and it is defined as the movement of people to cultural attractions far from their normal place of residence, aimed at assimilating information and cultural experiences (Petroman et al., 2013). Also known as heritage tourism (Pan et al., 2018), it has become the main goal of travel for an increasing number of tourists worldwide, with the United Nations World Tourism announcing that around 40% of international tourists are seeking out cultural tourism (Richards, 2021). It is one of the fastest growing tourism sectors (Han et al., 2013). Culture is considered to be a major asset in the development of the tourism sector. As Mousavi et al. (2016) highlights, both the tangible heritage, present in museums and other attractions, and the intangible heritage that is present in festivals and events, have the power to strengthen the tourism sector.

2.2.5 Tourism and economic development

Although the service sector has been regarded and viewed as static (Faber & Gaubert, 2019), the field of tourism has increasingly developed in the last decade, reaching a staggering 266 million jobs globally supported by the growing sector. The growing demand for tourism and travel experiences has tremendously changed the economy. In fact, Du et al. (2016) declared that the global economy has grown by 9.5% (around US $7 trillion) because of tourism. This goes to show that not only has tourism made tremendous economic gains but it's proving to be the fastest growing sector worldwide. Not only that, but statistics have shown that over 47% of the economies of developing countries have been because of tourism (Pan et al., 2018). In KSA, for example, the economic impact of tourism is evident, with the official Vision 2030 page announcing that since the tourism visa was launched in 2019, over 94 million visits have been made to KSA (Vision2030.gov, n.d.).

Table (1). Types of tourism (comparison). Source (Author,2024)

Aspect	Ecotourism	Wellbeing tourism	Cultural tourism	Rural tourism
Focus	Natural environments, conservation	Personal well-being, relaxation	Cultural experiences,	Rural experiences, local lifestyle
Purpose	Sustainable travel, environmental education	Physical & mental health improvement	Understanding traditions, art, history	Enjoying countryside, local communities
Activities	Nature walks, wildlife viewing etc…	Spa treatments, meditation, yoga etc…	Museums, historical sites, festivals etc…	Farm stays, local food experiences etc…
Impact	Enhancing sustainability	Enhancing mental and physical health	Preservation of heritage – enhancing	Support for local economy, community
Accommodation	Eco-lodges, tents, sustainable resorts	Wellness resorts, spa hotels and retreats	Hotels, homestays, cultural sites	Guesthouses, farm stays, cottages
Experience	Connecting with nature, conservation	Relaxation, rejuvenation, stress relief	Immersion in local traditions and heritage	Authentic rural lifestyle, simplicity
Location	National parks, reserves, eco-destinations	Wellness retreats, spa towns	Historic cities, archaeological sites	Rural areas

2.2.6 Sustainable tourism

Reducing the detrimental impacts of tourism on the environment, society, and economy is the goal of sustainable tourism, which aims to create an environment that is socially and morally successful, just as much as it is economically viable (Pan et al., 2018). In the case of Al-Balad, the balance between economic gains and sustainability comes to fruition with the socio-economic strategies put in place. Achieving economic sustainability may be attained by the business growth options provided to the community, drawing in visitors, raising property values, and utilizing adaptive reuse (Bamuqabel & Golkarian, 2023). The prospects of sustainable ecotourism and digital tourism have garnered global interest. The ministry of communications and information technology in Saudi Arabia published a report commending the benefits of digital tourism and its ties to sustainability (mcit.gov.sa, 2023).

2.2.7 Saudi Initiatives in Smart tourism

Smart tourism is defined by Gretzel et al. (2015) as tourism that is backed by efforts to identify novel approaches for gathering, combining, and utilizing data from various sources. This is done in conjunction with the application of emerging technologies to convert the data into enhanced experiences, with a particular emphasis on efficiency, sustainability, and richer travel experiences. In Saudi Arabia, Mazzetto (2023) informs that the primary government organization in charge of advancing the travel and tourism industry in the Kingdom is the Saudi Commission for Tourism and National Heritage (SCTH). The Commission oversees the upkeep and conservation of Saudi cultural heritage in order to boost domestic and foreign tourism. Additionally, the current minister of tourism in Saudi Arabia, his excellence Ahmed AlKhateeb, revealed the country's plans to initiate and foster digital tourism. The strategy placed focuses on innovation and plans on inspiring other initiatives worldwide. It includes a total of 31 initiatives targeted towards digital tourism, including the use of VR and AR. The minister stressed that the Kingdom welcomes the creativity of smart and innovative minds from around the world (spa.gov.sa, 2022).

2.3 Albalad, Jeddah

Jeddah is a coastal city in the western region of Saudi Arabia, otherwise known as Hijaz. Hijaz region, has long been a cultural hub of diversity and an example of unity; it holds a special place for Muslims around the world and has been an attraction for business ventures and trade, mainly through the coastal city of Jeddah (Abbas, 2016). Since the city turned out to be the main port of Mecca, Jeddah became an important city in the Hejaz region and in the Islamic world (Bagader, 2014). Al-Balad, means 'town' in Arabic. It is the oldest part of the city of Jeddah (Kamal, 2014). Alshehri and Corbell (2016) beautifully add that while (Balad) means town, the prefix (Al) is a definite article that is added to the word Balad to make it Al-Balad, meaning 'The Town'. This simple addition implies that there is one town referred to as 'the' town. Jeddah was indeed worthy of being referred to as 'the' town. Bagader (2014) adds that Al-Balad makes up the historic part of Jeddah and has been there since the city was first built in 646 AD.

2.3.1 Albalad VA

The historic district is a unique and remarkable example of the merging of different styles and backgrounds into one spectacular architectural identity (Sacchi, 2013). As a city that was walled during the 1500s, Jeddah didn't have the capacity to ex,pand horizontally which resulted in the vertical expansion evident in its high-rise building typology (Alshehri & Corbell, 2016)The authors continue to describe the unique design elements and features of Al-Balad's buildings, ranging from the Roshans and engraved doors to the unique natural materials used in the making of the homes. Table 2 shows some of the widely used materials in Hijazi, VA, found in Al-Balad's buildings.

Kamal (2014) explains that some buildings were very high, reaching seven stories, while some were four stories high. Their design and openings allowed for cross ventilation. The layout of the houses was mostly similar; the ground floor would be strictly for welcoming guests and was typically occupied by men to offer privacy to the rest of the

Table (2). Widely used materials in Albalad . Source (Author,2024)

Name	Uses
'Mangabi' coral stones	Construction
'Nura'	Decorative plaster
'Taklilat'	Wooden beams

family in the higher levels of the house. A traditional home in Al-Balad is shown in Figure 1.

Figure (1). Albalad VA. Source (UNESCO)

2.3.2 Influence of climate and geographical location on Albalad's VA

Saudi's traditional architecture has been affected by many things, including the climate, economy, culture, and the presence of natural materials (Dwidar et al., 2020). It can be said that Saudi's VA exhibits a connection between the buildings and the climate, a byproduct of years of experience, the smart use of resources, logical analysis and the application of proper methods (Kamal, 2014). As for the climate, it can be said that the general climate is hot and dry due to the country's desert nature. Temperatures vary significantly in coastal areas, such as Jeddah, only reaching tolerable temperatures during winter (Dwidar et al., 2020).

2.3.3 Matbouli House Museum

The Matbouli House, now a museum in Historic Jeddah (Albalad), is a UNESCO World Heritage Site. (Alshawabkeh et al., 2021). The historical house is one of the oldest buildings in Albalad; where it was built more than 400 years ago. It is characterized by its vernacular style that embodies the old Hijazi architectural identity. The house was restored recently to preserve its rich cultural heritage. The restoration was led by Engineer Samir Asaad Matbouli, who supervised the entire process, which took nearly a full year to complete. Noting that UNESCO visited the house and praised its restoration upon completion (spa.gov.sa, 2016).

2.4 Impact of technology integration on architecture and cultural tourism

2.4.1 AR, VR, and MR

Technological developments, such as augmented reality (AR), virtual reality (VR) and mixed reality (MR), have completely changed how we interact with historic monuments and structures. Several case studies prove their usefulness, as

Table (3). AR,VR,MR comparison . Source (Author,2024)

Aspect	VR	AR	MR
Completely virtual environment	✓	×	×
Mixed environment	×	✓	✓
Real-world elements	×	✓	✓
Virtual elements	✓	✓	✓
Immersive	✓	✓	✓
Projection tools	Headsets	Headsets – portable devices - holograms	
User interface	Isolated	Overlaid, contextual	
Content	Fully simulated	Augmented	
Disorientation	Observed	Could be avoided depending on projection tool	
Headaches, pain			

immersive experiences provide a special chance to close the knowledge gap between the past and present, improving our comprehension of architectural and cultural history. Table 3 offers a concise comparison of all three. Technologies such as AR, AR, and MR are equally interesting and all hold so much potential within the field of cultural heritage, preservation and history recreation (Buhalis & Karatay, 2022; Lalitha & Rajasekar, 2019). They create a captivating virtual universe that extends well beyond what is seen in a typical museum setting. Using technologies such as AR provides users with unique interactions with objects and information (Pedersen et al., 2017). These technologies have garnered global attention and interest, especially for tourism and preservation (Bec et al., 2021). AR is an innovative way to enhance the preservation of history, increase tourist satisfaction, gain positive feedback, and offer better learning experiences. (Tom Dieck & Jung, 2017) but it can still be said that, unfortunately, a huge gap in literature is present revolving around the use of AR for heritage preservation purposes (Aziz & Siang, 2014).

Results of a thorough study indicate that stakeholders in cultural heritage tourism view augmented reality as having many multifaceted advantages, including economic, experiential, social, epistemic, historical and artistic, and educational value. All of which encourage decision-makers and stakeholders to invest and implement this technology in settings where the preservation of history and culture is needed, such as museums (tom Dieck & Jung, 2017).

2.4.2 Impact of technology on tourism

The surge of technology in many fields has revolutionized the world, especially in the tourism sector. Tourists have new-found flexibility and options thanks to the use of phones, tablets and technology (Çınar, 2020). The recent developments made in the field of electronics and ICT (information and communication technology) have aided and boosted the successful transition to a new digital world (Pan et al., 2018). For example, some types of technology such as augmented reality or immersive virtual reality can offer a richer and more engaging tourism experience (Neuhofer et al., 2014). Tussyadiah (2015) adds that smartphones provide access to information, directions and navigation, social networks, entertainment, and other features that facilitate trip planning and improve the entire tourist experience for users. Neuhofer et al. (2014) argues that researching, comprehending, and the making of technology-enhanced experiences is severely lacking in both tourism practices and research/literature alike.

2.4.3 Uses of AR in engineering and architecture

The integration of diverse digital technologies has resulted in a shift within the architectural and construction fields (Gattupalli, 2023). The use of AR in the architectural design field can be dissected into three main categories. The first being the use of AR to address historic buildings for the purpose of conservation and knowledge and enhancement. This category is concerned with cultural heritage and tourism and VA. The second is using AR in the construction phase, and this is concerned with the design and building process, including project planning. The third is using AR for educational purposes, and this includes professional training and any transfer of knowledge regarding architecture (Russo, 2021). HoloLens was recently used in industrial engineering, where it aided in the surveillance of factory robots. Its role didn't stop there, as it was also used as a headset-based AR app that assisted people with RTA (ready-to-assemble) furniture. Users were able to visualize the spatial link between furniture pieces rapidly. Consequently, it was demonstrated that the program was successful in enhancing the user's capacity to solve spatial problems when interacting with RTA furniture that varied in terms of difficulty of assembly. HoloLens was also used to visualize 3D city models in Toronto, Canada, and different kinds of city data (Park et al., 2021).

2.4.4 AR in VA preservation and historic reconstruction

Buhalis and Karatay (2022) emphasized the importance of utilizing technologies to present culture, heritage and history to new generations such as Gen Z and to appeal to their needs. In fact, a staggering 84% of global visitors have shared enthusiasm over using technologies such as VR and AR within their travels, and no less than 42%

of them believe that VR and AR are definitely the future of tourism (Han et al., 2018). The most promising methods of the conservation of heritage sites include augmented reality apps. An AR app was developed to provide a unique experience to view the no longer accessible heritage site (La Matilla) in Spain. The app showcased the Roman building remains found in the area. These remains were buried to allow for roadwork in the area and as of late, the only evidence and visualizations of this site are presented through the AR app. After calculating the cost, time and value of conserving heritage through an AR app, the respective authorities were pleased with the potential and agreed to cover the total costs once the app was done (Merchán et al., 2021). ARCHEOGUIDE is another AR project funded by the EU designed to provide guidance and assistance to tourists of cultural heritage sites (Vlahakis et al., 2001). Other AR apps for heritage sites include Time traveler, Past View Saville, and Street Museum Londinium (Tscheu & Buhalis, 2016). Thanks to these technologies, the "passive" tourist transforms into a "active " one allowed to interact, share and view the preserved objects/sites in a novel way that ensures a memorable experience for them" (Barrile et al., 2022). Overall, proposing AR technologies as comprehensive applications for historic preservation may not only offer an innovative preservation/restoration method that is not invasive but they could also strengthen the travel experience. As a result, in the context of Melaka, which is a UNESCO World cultural site, it is a holistic approach to heritage preservation (Aziz & Siang, 2014). As fascinating as AR is and contrary to popular belief, it is still not being widely used or implemented. This could be for reasons such as the newness of it. Regardless, it is progressing slower than anticipated (Chung et al., 2015). Since some AR projects consist of using a head-mounted display, such as the one seen in Figure 2, and/or an extra backpack, this may result in issues including pain, disorientation and poor depth perception.

Figure (2). Microsoft HoloLens 2. Source (Microsoft.com)

This issue can be circumvented using more current AR systems that are portable, less intrusive and improve the sense of presence and immersion (Wu et al., 2013). In general, it can be safely said that AR is the perfect technology to present historical events and heritage without being invasive to the original architecture and compromising its integrity (Jung, 2016).

3.3.5 Potential role of AI and ML in AR

Cultural heritage around the world is facing dangers of loss and deterioration, therefore, the utilization of technologies such as Artificial Intelligence (AI), and Machine Learning (ML) for preservation has become essential (Das et al., 2022). In the VA and preservation discourse, AI can be used alongside AR to conserve cultural heritage (Aburamadan et al., 2021). As far as tourism, AI Chatbots is also becoming increasingly famous. They can assist tourists in finding answers to their questions and offer immediate customer service. AI can be used in conjunction with other technologies such as AR to elevate tourist experiences and personalize them, making them both memorable and uniquely catered to each tourist (mcit.gov.sa, 2023).

3.Research Methodology

This study utilizes a mixed-methods approach that combines descriptive research, qualitative data gathering techniques, and real-world applications including 3D modeling and AR app implementation, as seen in figure 3.

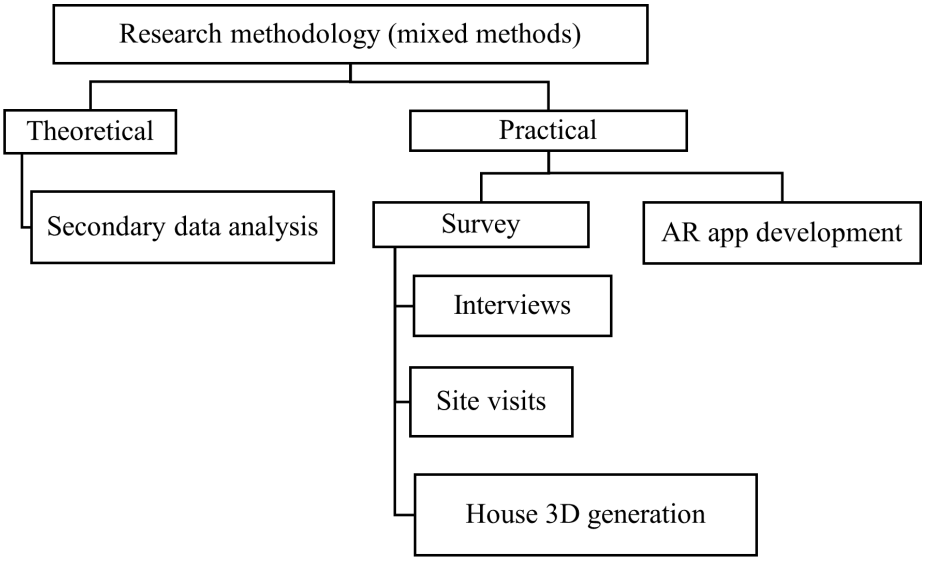


Figure (3). Methodology. Source (Author, 2023)

3.1 Theoretical methods

3.1.1 Literature review

Focused papers on vernacular architecture, tourism enhancement, AR technology, and heritage preservation were studied to obtain insights into best practices and theoretical frameworks. Additionally, the literature review aided the creation of the AR app. This theoretical underpinning drove the design and execution of the AR app, adhering to known principles and adding to the body of knowledge already available in the area.

3.2 Practical Methods

3.2.1 Survey

a. Interviews

The qualitative data was collected through semi-structured interviews with both Mr.Esam Matbouli and Eng.Samir Matbouli. To guarantee the veracity of the data provided in the AR app, newspaper articles about Matbouli House were examined. The interview was conducted with Mr. Esam and Eng. Samir was followed to further ensure the accuracy of the information. Both Interviewees were also asked their opinions on the AR app concept and their recommendations. A summary of their interviews can be seen in Table 4.

b. Site visits

Site visits were part of the observational research, and were conducted continuously throughout the study. The visits were done from October 2023 until March 2024. These visits facilitated viewing the Matbouli house museum, taking its dimensions, capturing photographs, and conducting the interview with Mr. Esam. It was therefore possible to have a thorough grasp of the traditional Matbouli home in Al-Balad, and its cultural significance.

c. Site analysis, historical and cultural significance

The study focuses on Matbouli house museum as the case study. The house is located in Albalad, Jeddah. Albalad is a UNESCO historic site; therefore, its selection adheres to the goals of the paper. Furthermore, few buildings were available and given access for research, as Albalad is undergoing significant renovations. Efforts by the Ministry of Culture are placed on doing so in the most optimum and efficient ways. Nassif House was another building selected by the author but was then written off due to the reasons mentioned beforehand. Matbouli House Museum is a prime example of vernacular buildings that have been restored and presented for tourists to display the rich culture of old Jeddah. After obtaining permission from Mr. Esam Matbouli to conduct

Figure (4). Site analysis. Source (Author. 2023)

the study, it was easily accessible for research and implementation purposes.

Built in Souq Al-Alawi in Harat Al-Yaman, exact location seen in Figure 4, the house stands four floors high and on an area of approximately 350 sqm. It was built more than 400 years ago by Sheikh Mahmoud Al-Matbouli. The house has two entrances, and it also has cisterns to collect rainwater. The main entrance overlooks Souq Al-Alawi, which has nearby historical landmarks such as Bayt Nassif and Ain Faraj. For centuries, the house delivered cultural significance to the area. For example, it housed pilgrims during the month of Dhul Hijja. The Matbouli family would accommodate them and provide them with all necessities to ensure their comfort throughout their stay. Additionally, weddings were hosted in the house where the bride would be for up to 7 nights in a celebratory and joyful atmosphere.

Figure (5). Matbouli house. Source (Author. 2023)

There is even a room dedicated to the sole purpose of preparing ladies for their wedding celebrations including the making of their bridal gowns and the intricate embroidery (Tchalabi, 2023). The home features intricate designs made from natural wood, concrete, and stone, as seen in Figure 5.

d. 3D regeneration

The AR app's creation required the utilization of comprehensive floorplans and schematics of the Matbouli house museum. These architectural drawings offered crucial information on the building's plan, style, and background for both the author and software developer. Unfortunately, the required architectural drawings were not readily available, therefore they were drawn by the author according to the current site.

The Matbouli house has witnessed many renovations and has housed many generations. The purpose of producing 3D visualizations was to utilize another form of technology in documenting the current state of the house digitally, as well as provide clear visualization for the software developer to work on. It is imperative to note that the developer is not a Saudi resident and was unable to conduct a physical site visit. Due to the absence of floorplans and technical drawings and the need for such drawings to communicate to the app developer the location of the features and the dimensions for each, the dimensions were documented through site visits, and the floorplan and elevations were drawn accordingly. The elevations for the room known as Almaqaad can be seen in Tables 4 and 5. The elevations show both the state of the room before the renovation and after it took place. After the floorplans and elevations were determined, 3D scenes were created to mimic how the house could

Figure (6). 3D visualization. Source (Author, 2023)

have potentially looked without signs of decay and erosion. This was done using the software 3dsmax, while Corona was the rendering engine. Figure 6 shows a select few of these 3D shots.

3.2.2 AR App Development

The primary research tool used in this project was an AR app development software. The software, called Unity3D, allowed for of a digital overlay that could be superimposed onto the physical environment of the Matbouli House Museum in Al-Balad. By leveraging this technology, users could interact with virtual elements that enriched their understanding of the historical and cultural significance of the building, in addition to viewing the building's past state, which has long been renovated, of some of the architectural and design elements of the house. The floorplans, elevations, and reconstructed 3D scenes laid out the groundwork for the development and implementation of the AR app. The app's main goal, as Buhalis and Karatay (2022); Lalitha and Rajasekar (2019) suggest is to offer tourists an enriched, immersive, and unique experience, all the while preserving and promoting the cultural value the households, and unique experience, all the while preserving and promoting the cultural value of the households. It is a way to

Table (4). Elevations. Source (Author, 2024)

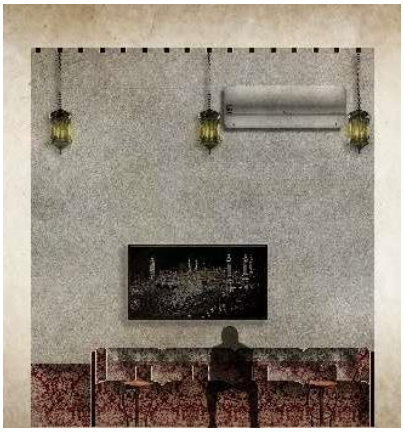
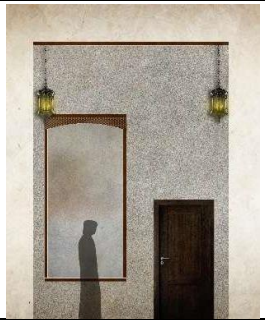
	Before renovation	After renovation
Rendered elevation		
Description	The wall had a hollow space for the TV	The space was filled out and sofas were placed, as well as an AC unit and a painting

Table (5). Elevations. Source (Author, 2024)

	Before renovation	After renovation
Rendered elevation		
Description	A desk used by the homeowner took up the space next to the door	The space is now adorned with a glass window overlooking the hallway

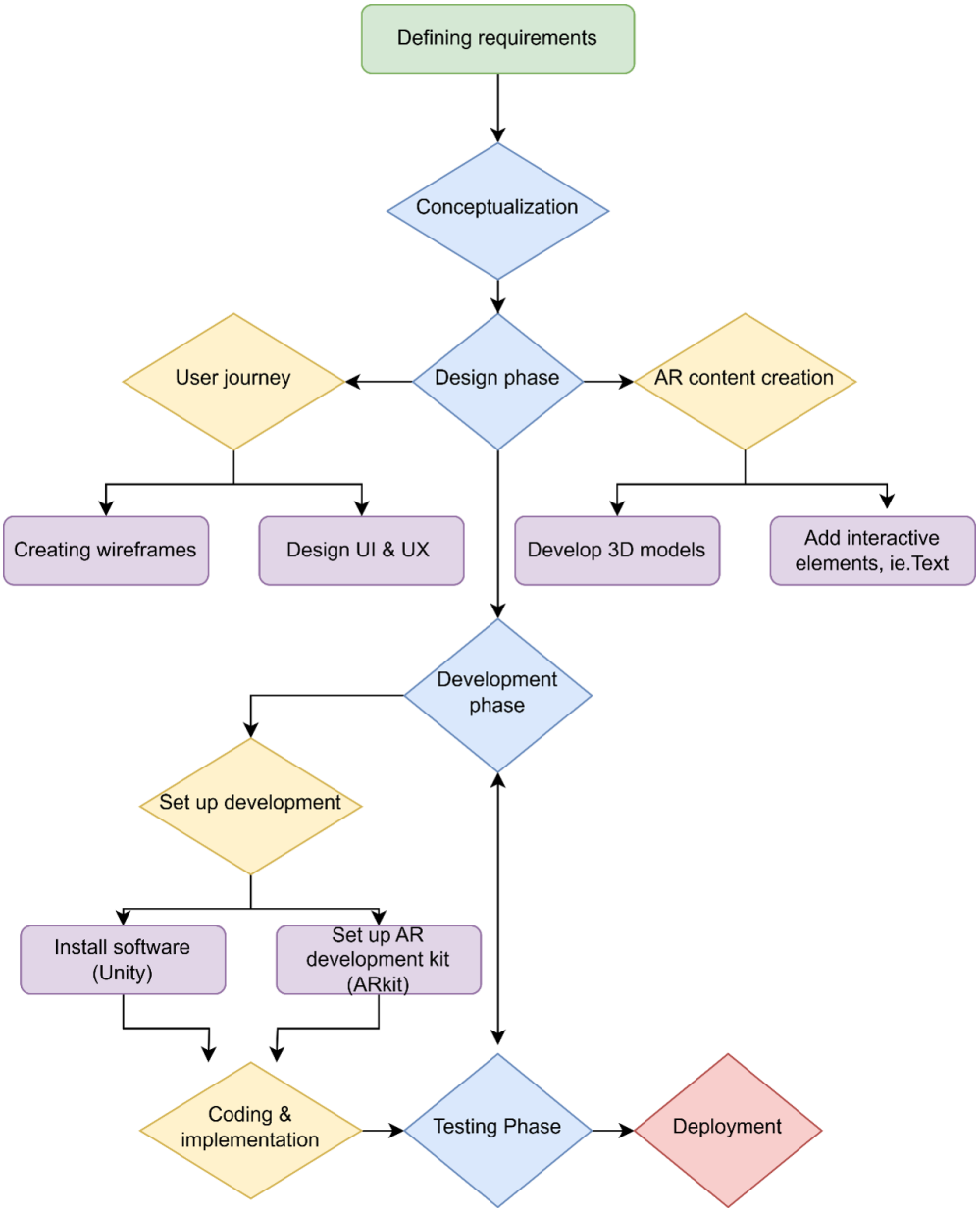


Figure (7). App development. Source (Author, 2024)

give people new approaches to perceive, identify and interact with their surroundings (Chen et al., 2019). Not only that, but as Chung et al. (2015) explained that tourists who use AR can be immersed in valuable experiences without even needing a tour guide. The app also aims to reconstruct architectural elements that have been lost. The development of the app went through a lengthy process, seen in figure.7. It can be summarized under three main phases: planning phase, programming phase, and trial/implementation phase.

3.2.2.1 Planning

This phase consisted of contacting multiple AR app developers and comparing offers. Time, cost and quality were the three main factors assessed. After several meetings, a developer was selected and given a thorough explanation of the project, objectives, and desired outcome. All the schematics, details, images and further dimensions were sent to the developer.

3.2.2.2 Programming

During this phase, the developer and the author signed up and were verified as Apple developers to start making the app. Previous studies that have utilized AR apps were analyzed, as seen in Table 6. This gave a clear direction regarding which methods worked best and aided the programming phase. The initial model of the app took two months to program, and the main software used was Unity 3D. This software, aside from it being cost effective and easy to use, has been used to create many successful AR apps and games such as Pokémon Go. It has also been proven to improve interaction with AR content and user interface clarity (Kim et al., 2014). The app was decided to be a marker-based AR app, where an image (marker) is placed on the floor and scanned to initiate the AR features. The app was named HeritageLens, as seen in Figure 8.

Figure (8). App icon. Source (author. 2024)

HeritageLens includes the built heritage as well as cultural heritage details of the traditions that took place in the house, further conserving the culture as well as the architecture and design of the space. It allows its users to explore these features by pointing their devices (phones and iPad) toward a printed image. The app automatically scans it and superimposes the figures supposed to be in that place. Below is a breakdown of the features added

Table (6). AR apps analysis. Source (Author, 2024)

	Research paper	AR software / type	Site	App's main feature	Future recommendations related to this study
Similar implementations	"The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park" (Jung et al., 2015)	Marker-based AR app and 3D book	Theme Park in Jeju Island, South Korea	Tourists can engage with superimposed characters that engage them in tales surrounding the theme park	- Marker-based apps are recommended
	"Using hologram technology in constructing virtual scenes in archaeological sites to support tourism in Egypt" (Hussein & ElDeen, 2020)	Holograms	Historic site in Egypt	Restoring and conserving the archaeological site and showcasing it in virtual scenes	- Integrating technology into design/engineering fields
	"Value of augmented reality to enhance the visitor experience: a case study of Manchester Jewish Museum" (Jung, 2016)	AR app (was yet to be developed for the study)	Manchester Jewish Museum	Preservation of history and personalized museum tours	- Implementation of an AR app to enhance the visitor experience
	"Good practices in the use of augmented reality for the dissemination of architectural heritage of rural areas" (Merchan & Perez, 2021)	Unity 3D software / Marker-based app	"La Matilla", in Spain.	Shows the archaeological remains of some Roman buildings	- Internet connectivity must always be present - The information presented in the app should be easily understood by users
Result	This paper	Unity 3D software / marker-based app	Matbouli House in Albalad, Jeddah, SA	Preservation of both tangible and intangible heritage	- Recommendations applied

Figure (9). Arabic view. Source (Author, 2024)

to the app. The app has 5 main features: it includes both Arabic and English viewing options as well as a reset button to erase the displayed features and move on to others. This can be seen in Figure 9. The app also utilizes text to further explain the figures, to provide context and to enlighten tourists about the unique heritage of the house. It is important to note that studies have shown that people don't want to read a lot during their museum visits, so text should be kept to a minimum (Gong et al., 2022).

1st feature: Greeting

This feature, seen in Figure 10, includes a 3D figure of a man dressed in traditional Saudi garments welcoming tourists into the house. This feature is meant to be welcoming as well as educational as it provides key information about the house.

2nd and 3rd features: Almaqaad room

These two features, seen in Figure 11, include 3D models of the previous built elements in the room that existed before the current renovation. These elements consist of a desk for the homeowner and a wall with a crevice for an old TV which has now been completely covered and replaced with sofas. The current state can be seen in the elevation in Table 4. The wall structure, TV, and desk are

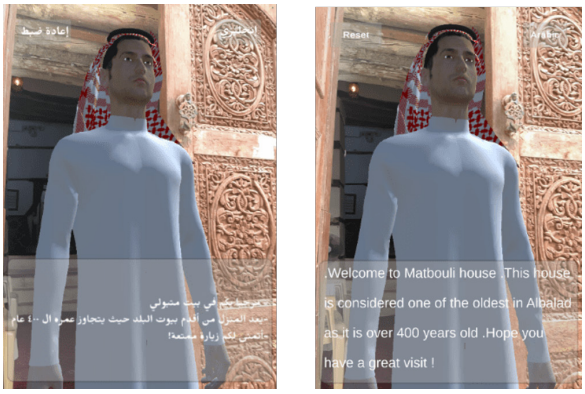


Figure (10). First feature. Source (Author, 2024)

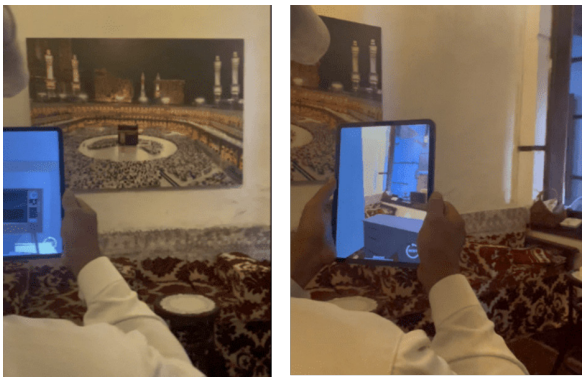


Figure (11). 2nd & 3rd features. Source (Author, 2024)

all tangible elements that give an insight into the function of the space they are in. This function has changed as time has passed and the room was renovated to accommodate these changes.

4th feature: Pilgrims

This feature, seen in Figure 12, includes 3D figures of men dressed in pilgrimage garments. Additionally, it has information on the tradition that the Matbouli family upheld for generations which is welcoming and housing pilgrims during the month of Dhul Hija. This feature, alongside the 5th, are aimed at preserving the intangible heritage of the house.

5th feature: Bride

This feature, seen in Figure 13, includes a 3D figure of a woman wearing the traditional bridal gown called "Masdah Hashimi", as well as information on the cultural tradition of the Hijaz region where weddings were held for up to 7 days in a joyful atmosphere.

Figure (12). Fourth feature. Source (author. 2024)

Figure (13). Fifth feature. Source (author. 2024)

3.2.3 Trial and implementation

The trial of the app was ongoing as various site visits were needed to ensure functionality. This phase included bug fixes and updates made on the app to increase usability, ease of navigation and accuracy. The final version of the app was completed in March. A walkthrough step-by-step of the app is detailed in Figure 14.

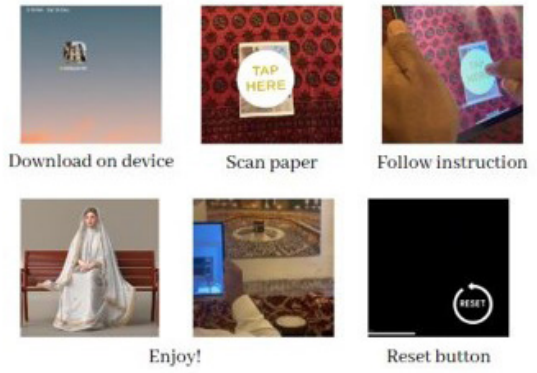


Figure (14). Steps. Source (author. 2024)

4. Results and discussion

The results of this study can be categorized under two main sections: 1. Stakeholder feedback and 2. App feasibility.

4.1 Stakeholder feedback

The semi-structured interviews with both Mr. Esam Matbouli and Eng. Samir Matbouli were of great help for the study. The core questions answered by both stakeholders are displayed in figure.15, where (0=no) and (2=yes). The results of the interviews can be summarized as follows:

Mr. Esam Matbouli's interview: Gave insightful advice about the Matbouli house museum's background, cultural and historic significance, as well as providing the author with the content displayed in the AR app including traditions and pre-renovation state of the Maqa'ad room seen in tables 4 and 5.

Eng. Samir Matbouli's interview:

- Regarding the restoration project:

1. The project took around a year to finish
2. Made valid points on the state of vernacular buildings worldwide and the need for

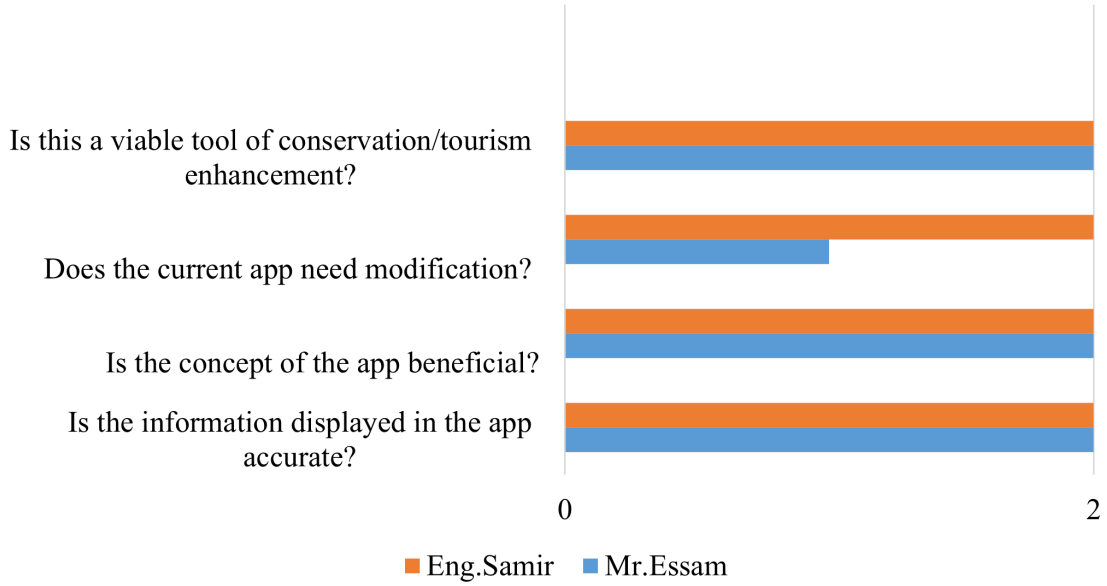


Figure (15). Interview chart. Source (author. 2024)

restoration efforts to safeguard culture and heritage.

3. To ensure authenticity, only natural materials were used in the restoration procedure of the house.
4. Completed the house restoration project without using contemporary materials like metal or cement.
5. Mentioned the use of technologies like scanning and construction software to aid the restoration process.
6. Worked in tandem using traditional Hijazi building techniques and contemporary technologies throughout restoration.

- Regarding the AR app:

1. He has always advocated for the use of new technologies, such as AR, for cultural preservation of historic buildings and tourism enhancement. As indicated in figure.15, and seeing as it is within his field of expertise, Eng. Samir provided valid feedback, including 3 important future enhancements to be considered.
2. Suggested adding audio and music to the app to engage tourists, especially the younger generations.
3. Suggested adding details on traditional building techniques and the unique design aspects of the ceilings, doors and Roshans in Hijazi vernacular buildings.
4. Suggested contacting the Ministry of Culture to enhance and grow the AR app for a more enriched and wide user experience.

They also agreed on the following points:

1. Highlighted the house's cultural and historic significance to them as a family and the historic area.
2. Emphasized how crucial it is to protect and promote the house's legacy through modern technologies.
3. Supported and praised the integration of AR into the house, precisely the concept of the current app for both tourism and preservation. As seen in figure.15, Mr. Esam praised the idea but hasn't provided feedback on suggested enhancements. Therefore, only Eng. Samir's modifications to the current app were discussed.

Both stakeholders expressed gratitude and enthusiasm for selecting the house as a case study, and were extremely helpful and generous with their expertise and feedback. Eng. Samir said: "The idea to use an AR app is excellent and praise-worthy; as it is the first app of its kind that I've seen used in a historic building to preserve it."

4.2 App feasibility

The app development has proven to be a complex process. Yet, it has also proven to be doable and manageable. The challenges faced during this study can be summarized as follows:

- Rarity of specialized AR app developers in Saudi.
- Costly charges for AR app development.
- The app required countless site visits for testing and bug fixes, and given the location of the historic site, these have proven to be strenuous at times.
- Missing documents, plans, and photographs, especially for pre-renovation or old aspects of the house.

When discussing VA, not only traditional styles and materials come to mind, but also traditional construction practices. As Olukoya (2021) mentions that VA is the byproduct of individuals sharing a common heritage and creating their building methods. This point was made clear when restoring the Matbouli house, as Eng.Samir mentioned requesting the assistance of an old contractor familiar with the traditional construction methods of the Hijazi in Albalad.

As a main objective of this paper, boosting tourism is an important aspect to be discussed. The engineer delved into the importance of cultural tourism, as Han et al. (2013); Mousavi et al. (2016) validated the importance and value of culture to the tourism sector. The significance of cultural heritage is also evident through the initiatives made by the Saudi government to enhance, support and highlight this sector.

The same goes for the second objective which is the preservation of heritage, both tangible and intangible. As emphasized by Ibrahim (2018); Mazzetto (2023) regarding the importance the Saudi government has placed on preserving its cultural heritage. Eng. Samir not only validated the significance of VA as noted by Asif et al. (2018); Azevedo-Salomao and Torres-Garibay (2016), but has also stressed on the role technology plays in preserving said heritage. This was highlighted by tom Dieck and Jung (2017) and proven in this study as well.

Given that almost 85% of global tourists are interested in using AR in their visits, as documented by Han et al. (2018), it is rather important to launch apps that utilize this technology, such as the Heritage lens app developed for this study. As suggested by Eng, further developments and updates are needed to expand the app and reach a higher satisfaction rate by users and stakeholders alike. Samir; and as proven by Chung et al., 2015. Although the app proved to be costly and time consuming for the authors of this study, the study done by Merchán et al. (2021) offers the great solution of a sponsor covering the cost and assisting with experts to expedite the development and refinement process. Eng. Samir also noted this as a future step to enhance the Heritage Lens app.

5.Conclusion and recommendations

In conclusion, the integration of AR into vernacular buildings, like the Matbouli house, has been shown to have enormous potential for promoting tourism, strengthening cultural preservation, and offering tourists unforgettable experiences. This paper has demonstrated the substantial influence that technology can have on the travel and tourism sector as well as the architecture/design field through the creation of an AR app that highlights the Matbouli house's tangible and intangible cultural/design features. The study's findings have demonstrated a clear inclination towards utilizing AR apps to explore historical sites and superimpose design features and cultural elements. According to the literature review, AR apps have been well received and they have the potential to change how tourists interact with and learn about cultural heritage. Additionally, the paper's literature review revealed a gap in the literature as well as in the market for AR apps, further highlighting the area's unrealized potential for innovation and expansion. AR apps may also generate economic growth, encourage sustainable tourist practices, and help preserve cultural treasures for future generations by bridging the gap between technology and cultural heritage.

5.1 Recommendations

The study's results and conclusions have led to the following recommendations. They are proposed to maximize better the possibility of incorporating AR into vernacular buildings to improve cultural preservation and increase tourism:

1. Create, fund, and use Augmented Reality apps.
2. Advance research in technology integration into design and architecture.

3. Prioritize user-centered design.
4. Update the app to showcase multimedia content, such as audio and motion graphics.
5. Include educational features to be utilized by teachers and students.
6. Maintain the long-term sustainability of the app through regular updates and support services.
7. Maintain and address ethical considerations about the data within the app and of the users.
8. To increase the app's preservation and usefulness, include educational content about traditional building methods and materials.

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توظيف برامج الواقع المعزز للمحافظة على المباني التاريخية وتعزيز السياحة الثقافية: دراسة حالة في متحف بيت متبولي، البلد

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قدم للنشر في ٦/ ١٠/ ١٤٤٥ هـ؛ وقبل للنشر في ٩/ ٣/ ١٤٤٦ هـ.

ملخص البحث. تعد المباني التاريخية من أهم الموروثات؛ لما لها من قيمة عمرانية وتراثية، لذلك برزت السياحة الثقافية بوصفها أحد أهم أنواع السياحة. وبما أن الدراسات السابقة تظهر ندرة استعمال التقنيات الحديثة، تسعى الورقة إلى التحقيق في دور تكنولوجيا الواقع المعزز في تلك المباني لملء الفجوة العلمية الحالية، مع التركيز بخاصة على الحفاظ على الموروث الثقافي السعودي. وقد وقع الاختيار على منزل متبولي في البلد لإجراء الدراسة؛ لما لتلك المنطقة من تاريخ ثقافي وشعبي ترويه مبانيه، بعد أن سجلت المنطقة بوصفها إحدى المناطق التراثية العالمية في تصنيف UNESCO. تسلط الدراسة الضوء على ميزات المنزل الثقافية والتصميمية الملموسة وغير الملموسة. فقد اعتمدت الدراسة على المنهجين: الوصفي التحليلي والتطبيقي، من خلال استرجاع الأدبيات السابقة وصولاً إلى تطبيق توصياتها على شكل تطبيق واقع معزز. وتوصلت الدراسة إلى أن استخدام تطبيقات الواقع المعزز مفضلة بشدة، وأنها مستقبل السياحة. كما أثبتت الدراسة أن الواقع المعزز يقدم طريقة حديثة وقابلة للتطبيق لتحسين السياحة الثقافية، من خلال سد الفجوة بين نقل التراث ومحاكاة توقعات السياح المعاصرة، كما أنه يعمل بديلاً لطرق الترميم التقليدية ويحافظ على المباني التاريخية. توصي الورقة بقيام صناع القرار في السياحة والتنمية الاقتصادية والثقافة بتطوير تطبيق الواقع المعزز وتوظيفه لجذب السياح وتحفيز النمو الاقتصادي والمساهمة في الحفاظ على التراث الثقافي السعودي.

الكلمات المفتاحية: المباني التاريخية، التراث، التقنية، الواقع المعزز، البلد، السياحة.