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Examination of the Adoption of Augmented Reality in Al Masjid Al Haram in Makkah Al Mukarramah: a TAM Model Approach

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Abstract:

There has been relatively little research done to determine the level of user adoption of augmented reality (AR) innovations in the hospitality and tourism industry, especially in the travel sector of Hajj and Umrah. This is despite the fact that augmented reality (AR) technologies are becoming increasingly important and popular in these industries. Guest perceptions and acceptance intention were investigated and evaluated using structural equation modeling. The research was based on a questionnaire that was distributed to 967 people who went to the Holy Mosque in Makkah (SEM). The technological acceptance model was utilized in order to investigate adoption (TAM). The results of the study showed that the data that was gathered and the model that was employed was able to reasonably fit together: chi2 (1844.91), chi2 / DF (2.5), RMSEA (0.13), CFI (0.75), as well as all scores of internal reliability alpha are greater than 0.70. The perceived value of augmented reality (AR) by Haram visitors, which is determined by the benefits of utility and simplicity of use, coupled with behavior and attitude towards the actual usage of AR, is a factor that contributes to the adoption of AR.

Keywords: Augmented Reality, Wayfinding, Holy Mosque of Makkah, Saudi Vision of 2030.

1. Introduction

Since the 2017 enlargement, Al Masjid Al Haram has witnessed 356,000 square meters of additional construction [1]. The biggest mosque in the world, the Grand Mosque in Makkah, is one of the largest structures in the whole world after the Complex of Boeing and the costliest [2, 3]. Saudi Arabia has sponsored all of the Grand Mosque's development initiatives through improving the navigation experience of the visitors. While those measures are assisting Hajjis, more may be done to satisfy their aspirations. Combining big crowds of Hajj and Umrah, massive and complicated structures, conventional signs, and AR monitoring is one area of development. The difficulty is how a traveler to the Holy Sites may find his/her route and communicate a location in an emergency. It's not simple to read the signage at Al Masjid Al Haram. In case to see your relatives go to a certain area in the Grand Mosque of Makkah, or just to exit the Grand Mosque without the aid of Hajjis, police officials, and big structures around the Haram, etc. Such pathfinding challenges may force Hajis to worry or get frightened, lose associates, or devote extra effort and time to discover a lost family member or an escape door. These inconveniences may ruin Hajis' recollections of Haram.

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In the context of the Saudi 2030 Vision, it is stressed to make the Grand Mosque of Makkah more accessible to better serve the growing number of pilgrims and visitors, as well as promote diversification and economic growth [4]. As a result, the parties involved ought to further explore concerns relating to Haram's visitors and especially to enhance the navigation experience to reflect their expected benefits accurately. Seeking ways to reduce the problems and challenges of Haram tourists will improve their happiness, which will encourage them to revisit Haram in the future.

Current technologies have improved the travel experience for tourists and locals through devices such as 3D screens, Global Positioning System maps, barcode scanners, optical compasses, Wi-Fi, accelerometers, handheld phones, smartphone apps, and AR [5]. Tourism, as one of the most successful economic practices in the world, will benefit significantly from AR technologies. Mobile-driven applications enrich the experience of visitors through a real-time knowledge network, immersive AR, and pervasive social networking, all of which turn tourism activities [6–8]. AR was first used in smartphone settings in the mid-1990s when user experiences with their real surroundings were improved by showing additional visual details [9]. AR applications technology has recently been introduced to the tourism industry [10], merging media with geographical identification metadata for points of interest [11] historical locations marketing [12-13], and museums [14-15]. As a result, visitor satisfaction, engagement, and technology adoption increased.

In this study, we investigated whether or not the usage of augmented reality apps might be considered in Haram. The augmented reality tools are built on the same principle as mobile app development as Google Lens. Together, a Mobile View, GPS, Accelerometer, and Compass, with this application, will be utilized to navigate using Google Maps. The application may function even while disconnected from the internet, eliminating the requirement for internet access, which is a luxury that many hajis might not afford. After the user launches the Haji app and directs their phone toward the traditional signage, the device is able to find the sign and, from that point on, would provide maneuvering help and support to the appropriate location. This could be the Haji's hotel, other locations of prayers, the nearest exit, or any number of other locations. As a consequence of this, there will be less avoidable walking trips all over the places surrounding the Grand Mosque as a result of the incentives offered to Hajis, which will make it a healthier place to go and pray. It would result in a reduction in the number of Hajis who were disoriented and angry, leading to an improvement in the quality of the Hajj and Umrah journeys as well as an increase in the number of Hajis who found the pilgrimages to be well-organized and easy to navigate.

This research is one of the first stages in a scientific investigation into the use and application of augmented reality in the process of navigating to Al-Masjid al-Haram in Makkah Al Mukarramah. The purpose of this project is to develop and test a theoretical framework of the adoption intention of augmented reality (AR) technology for the Grand Mosque of Makkah visitors' experience.

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2. Aims of Research

Many efforts have been made to examine the relevance of improving visitor experiences in order to enhance company services and increase the economic value [16]. Furthermore, debates in the literature have previously addressed the issues related to navigation signage in big structures [17], especially in the Grand Mosque of Makkah [18], as well as the advantages of employing AR to better visitor navigation experience [19]. However, no efforts have been made to evaluate the implementation of AR as assisting aid for navigating huge structures such as Makkah Al-Al Mukarramah's Masjid Al Haram. As a result, the purpose of this research is to assess Haram visitors' approval of the use of AR to assist Haram tourists in traveling within Haram.

3- Literature review

A technology known as augmented reality (AR) adds some kind of spatially recorded improvement to the actual environment. The user may see the environment around him or her in real-time while looking at synthetic items [10,20]. These improved items are integrated into the visitor's surroundings with the aid of external applications for smart devices. Today, the majority of the gear needed for augmented reality is packaged together in a single device, including smartphones, advanced cameras and displays, traffic sensors, and apps for showing directions. These technologies have enhanced how individuals see their final destination by enhancing individual’s knowledge about the current unfamiliar environs and by giving the user great effortlessly usable information. All of which are inaccessible by relying just on our five senses. These tools gave tourists useful visual information about their surroundings while also reducing the mental effort needed to explore and enjoy foreign locales.

AR can connect high-level, abstract concepts with concrete and real contexts by covering knowledge against content, which helps users in constructivist thinking [21]. This connection allows links with both the physical and virtual worlds [22]. AR may provide users with additional visual and auditory knowledge, including scent, palate, and touch, and also provide sensation knowledge. It is claimed that AR rapid developments have contributed to the growing success of AR technologies in projecting expanded knowledge on the immediate surrounding objects [23].

The term "magic lens" was coined to describe the interaction between two portable devices that allows users to see the real world via digital material shown on a screen on the other side of the user's body. There are a variety of methods, further classified into two categories [24], for interacting (manipulating, translating, and rotating) with these virtual contents. The first kind of interaction is "device-centric," in which the user controls the gadget via motion and touch. The second is the identification of natural motions such as those made with a marker, hand, face, or voice. As a result of the promising future, AR holds, several firms including Google and HP are collaborating with numerous academic institutions in advancing the technology. The fields of biology, education, physics and

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even tourism are just a few of the many that may benefit from the use of augmented reality. These major corporations are putting in extensive R&D time and money to create technological gadgets that can handle any of these issues and improve the user's life [25], [26]. Thus, augmented reality may be useful for tourists visiting sacred sites like Haram. Similar to how identifying places of interest (POI) is the most popular function of mobile tourist apps, navigating and getting information about POIs are also quite popular [27].

The globe has seen significant changes in a wide range of kinds and elements in the construction industry during the course of the 20th century and beyond, particularly with regard to the construction of massive structures. The world's construction sector has seen a significant shift and improvement, particularly in the construction of very tall, large, and complicated structures. Through the use of augmented reality (AR), technology has once again contributed its gestures to the construction industry [28]. As a result, the usage of AR may assist in directing individuals in new environments and structures with information enhanced on actual data. The most popular functions in mobile tourist apps are finding places of interest, navigating, and getting information about POIs [27].

Using augmented reality (AR) for navigational purposes is not a panacea by itself [29]. Despite AR's potential, which has been shown in several studies, its practical implementation is still in its infancy at this point [12]. There are various difficulties involved in the design of augmented reality apps and the incorporation of augmented reality into mobile apps. The monitoring of augmented reality is a major problem since it disrupts users' ability to interact with the software. By tracking a user's position and orientation in real-time, AR may better align digital content shown on a mobile device with its physical surroundings. The accuracy of augmented reality apps is highly dependent on the means through which a user is located in his or her surroundings. Some people still rely on older methods of finding their way around (i.e., conventional navigation signs and land/building markers), thus it's vital to think about how mass acceptance of such technologies will be [9]. This might be due to a fear of technology or a preference for old-fashioned signage.

MARS is one of the cutting-edge AR tourist applications, providing 3-dimensional tours from which users may see and download data [30]. CorfuAR was a smartphone AR tour guide that funded customized suggestions for an Island in Greece [10]. A common opinion is that the usage of AR on the smartphone to access appropriate material would improve visitor experiences and add hedonic and practical appeal while increasing familiarity and altering tourist expectations and intentions. But they contribute to a good, genuine destination experience [7, 31]. For example, the Berlin Wall in Germany, the London Museum in the UK, and the Powerhouse Museum in Australia all provide augmented reality services to visitors.

As a result of this integration, travel applications may now use augmented reality (AR) technology to enhance user interactions. For instance, travelers will be able to utilize the camera function on their smart smartphone to point at the items they are fascinated by. They will be given more details, which will be superimposed over the actual world,

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allowing them to interact with what they see [32]. With the use of AR, travelers may have a better and more delightful travel experience [15]. While VR allows for the viewing of high-quality images, audio, and other content, it also provides a completely virtual environment that precludes users from peering through and interacting with the real world [32].

The satisfaction of the company's customers has always been the number one priority, therefore gauging how well employees do their jobs is essential. It's an important indicator of future market growth and a leading predictor of success. To guarantee they continue to deliver high-quality services in the new environment managers and service providers must take much careful attention to client interactions [33, 34]. A growing body of academic literature links improvements in the quality of services provided to visitors with higher levels of satisfaction among both tourists and the local community [16]. Customers who are satisfied with the services they get are more likely to return and to spread favorable feedback about the company to others.

Our everyday lives all include some kind of navigational method. This process might be as simple as moving to a new room, or as complicated as evacuating a burning building. Both situations may become more stressful and uncomfortable due to navigational challenges [35]. To lessen the possibility of visitors having difficulties finding their way around, it is important to understand how they take in the environment. The environment's structure and detailed knowledge are the foundations of a successful wayfinding effort. The spatial content, shape, structure, and circulation of the layout are all used to characterize the design. Information about the surrounding environment, such as buildings and maps, is crucial for discovering solutions to navigational problems [36].

Because of the proliferation of buildings larger than the human visual field, there has been a rise in the need for effective sign systems and navigational aids. Information may be gleaned through the building's architecture and layout, as well as from other sources including information booths, signage, and maps [37]. Static signage [17] is the most often used method for guiding visitors through unfamiliar places. Another challenge for Makkah and Haram's static signage is the high number of languages they must accommodate, which adds complexity [38]. Because of the unfamiliar atmosphere and the lack of helpful indications, it has been observed that visitors in Haram are constantly looking for assistance [39].

Therefore, any instruments used to guide individuals to their desired known or unfamiliar place may include wayfinding. The necessity for navigational designs and practical signs has dramatically expanded with the advent of massive projects that are beyond the limits of human vision. Information may be gleaned through the building's architecture and layout, as well as from other sources including information booths, signage, and maps [37]. Static signage [17] is the most often used method for guiding visitors through unfamiliar places. Supporting a wide variety of languages [38] adds difficulty to the already difficult task of

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creating static signs for the Haram and Makkah. Helping visitors find their way across congested places of worship.

However, the number of navigation markers in the Grand Mosque is insufficient, they are not visible, they are not attractive to visitors, they are not coloured or based on different zones, and they are not mentally recognizable by the Grand Mosque visitors [18]. The design of such signage should attract visitors' eyes to organically connect with the setting and its sacredness, allowing them to navigate their way properly. Along with the normal international organization of these signage, zones, and categories, it is also recommended that such signs be organized into sectors and that such spaces be utilized to direct visitors from one sector to another.

Even though its common knowledge that employing navigation marks in suitable locations is a reasonable effort to avoid an individual from becoming confused, the installation of such signs does not always ensure the outcome that is wanted. The visitors will still be in the same state of confusion regardless of whether or not there are navigational markers present. When there are signage present, typical visitors are less likely to take the incorrect turn as compared to when there is no signage [40]. The outcomes of the study indicate that visual and textual signage may be employed to enhance particular characteristics related to navigation. When buildings become bigger and more complicated, it becomes more challenging to provide obvious signals and cues because the signs and cues tend to disregard the ways in which people navigate and identify the arrangement of their environment [35]. This makes it more difficult to provide clear signs and cues.

Other spatial elements, like the kind of static signage, the length between signs, and the overall shape of the structure, may also be noticed. The capacity of a person to navigate their way through that structure is directly impacted by the elements discussed above [41]. When it comes to navigating your way around the structure, the shape of the construction's volume is one of the most informative features. Users are given directions on the circulation mechanism and the internal arrangement of the resource. Traffic is obviously the most important organizing factor of the plan; it is also the area in which people travel and in which they are required to navigate to their destination. As a result, this is the area that we attempt to study and evaluate so that we can determine how best to maneuver around [17].

People navigate their way through environments that are difficult to comprehend by first attempting to comprehend what the surroundings would be like and how it is constructed. Finding spatial clues is necessary to construct a cognitive drawing of the region. Cognitive visualization relies heavily on the use of spatial structures as one of its essential building pieces. People are only able to recognize these spatial structures if they are distinguishable from their surroundings, or if they are segregated from those places. According to [17], distinguishability may be attained by the arrangement and size of the structure via the use of textures, lighting, colours, and diagrams, which distinguish architectural and ornamental aspects.

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Most architectural settings and large buildings are expected to be too vast to be seen from one place entirely. In several contemporary large buildings, where hallways on different building levels can appear very similar, finding one specific endpoint would be hard. In these cases, it should be easy to store information about specific locations in our minds, the spatial connections between those sites, and these sites about the rest of the house [42]. That is, the information processing capabilities of an individual's mind can be defined as it associates different architectural elements. Nonetheless, difficulties occur when a person receives environmental information and attempts to understand it, and then processes the information as it is acquired.

The notion of legibility has had a major impact on the development of architectural style [43]. The physical layout of a building may include designated regions that are more suited to extracting and interpreting information, in addition to whatever clues the building's design may have provided for navigation. It's called "legibility" when anything has this attribute. The legibility of a location is high if it facilitates access to and understanding of data about the surrounding area. Signage and other built elements may be added or removed to change how easily the site can be read. There is a direct correlation between the visual appeal of a signage system's graphics (such as the variety of letters and the difference generated by the aspects of black and white, location, lighting, and colour) and the improvement of the user's ability to conceptualize and navigate a given space [37].

4. Theoretical Model and Hypothesis

Technology adoption is how much a person or organization prefers a technology. [44] defined IT adoption as using technology and software applications for administration, processes, and executives. In a corporate setting, adopting technology means using its tools and practices to assist business, management, and decision-making. Several hypotheses and models have been developed to explain tech adoption. They include the TAM, TRA, TOE, RBV, and DOI models. TOE, DOI, and RBV tackle organization-level technology adoption. TAM and TRA focus on individual adoption concerns.

[45] suggested TAM by replacing several of TRA's attitude variables with considered ease of use and perceived usefulness. This model indicates that user intention influences real usage (AU) (intention to use or IU). Behavioral intent relies on mood and usefulness. Perceived usefulness and simplicity of usage affect user attitude. These characteristics mediate between external factors (such as design, pre-use, experience, machine autonomy, and technological trust) and their desire to use. TAM predicts PEOU indirectly influences IU via PU. [45, 46].

Several papers discuss using TAM to discover user acceptability criteria for IT systems [47-50]. Others [51-53] discussed TAM in internet Connectivity, multimedia-on-demand, and interactive technologies. [47-48] studied IT adoption in education. Many academics advised using IT experts as respondents for IT research [54, 59]. [60] indicated that company decision-makers determine IT utilization. [49] studied mid-to-top-level managers with IT responsibilities or impacted by cloud computing. They investigated perceived benefits and drawbacks to determine cloud computing's user adoption. [61] studied the

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influence of government technology implementation on civilian acceptability and utilization. All of the following research focused on cognitive and personal variables that affect technology adoption.

Moreover, many studies in the field of hospitality and tourism include the desire to deploy mobile technology as a separate dependent variable. Several follow-up studies discovered new factors and used them in the TAM model. Researchers in [24, 62, 64] classified travelers' smartphone use intentions based on criteria such as their prior experience with technology, their travel history, and their expectations about the device's functionality. primarily focused on booking and hotel management apps for mobile devices. The TAM's original purpose was to foresee the arrival of new technologies inside the company. However, the concept has been questioned since it doesn't explain why customers should accept a product or service in non-mandatory, non-organizational settings. Moreover, TAM failed to appreciate the user's perspective on value [66].

In addition, TAM is advanced by [45] in vast volumes of studies to boost (predictive) validity and applicability in various technologies. It demonstrated, for example, that the structure of the attitude does not substantially mediate the relationship of conviction. [68], suggests a TAM expansion (TAM2) that involves social effect theoretical constructions and cognitive instrumental processes. They find that the implementation and use of "information technology" (IT) directly affect these additional frameworks. In the meantime, 85 scientific publications on TAM have been reviewed by [96] from 1986 to 2013. Studies have concluded that new mechanisms have continuously been established that play a significant role in influencing TAM's core variables (PU and PEOU). In addition, the literature indicates that TAM is the most used to evaluate IT adoption for users because it is reliable, easy, and useful in explaining and predicting the characteristics that affect their actions in adopting the new technologies [46, 51, 69, 70].

In this research, which is based on TAM, there are a total of twenty survey questions designed to operationalize five different variables. The total actual technology usage (ATU) is linked positively and causally to the model's other components, which are behavioral intention to use (BIU), attitude toward utilizing technology (AT), perceived usefulness (PU), and perceived ease of use (PEOU). The remainder of this part will focus on introducing the research constructs in relation to the study purpose, which is to evaluate the usage of augmented reality technologies by Haram visitors in order to navigate throughout Haram. After each set of constructs is finished, the research questions will be formulated next.

4.1. Perceived Ease of Use (PEOU)

According to [45, 46], the physical and psychological exertion effort of users while dealing with the technological innovation under consideration is referred to as PEOU, and user effort is considered to be easygoing. It is a major influence on the acceptability of the technological innovation being considered. According to [71], the ability to acquire

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information quickly and build competence are the aspects that make technology easy to use, along with the user experience of technology. [72] state that the simpler a person perceives the technology to be used, the smoother it is for others to adopt the technology, and the more sophisticated the technology is seen to be, the less the probability of the technology's acceptance. [73] observed that customers typically invest little time into a user-friendly technical instrument, boosting the likelihood of installing and utilizing a given technology. [74] discovered that customers prefer readily comprehended and straightforward technologies that do not need a lot of mental work, and that they are more engaged in and re-use for a variety of reasons.

According to [75], perceived ease of use is going to vary amongst consumers, especially for deliberately accepted products/services. Considering the visitors' voluntary usage of the AR application, their diverse individual histories, and the visitors' dual roles as an individual using the application and Grand Mosque visitors at the same time. This Haram guest scenario is more intricate than the single duty done by workers in a business context. As a result, it is considered that the TAM paradigm may aid in describing the intention of Haram's visitors to embrace AR application technology in this research.

PEOU was measured using criteria such as ease of use, clarity and understanding, flexibility in interaction, requiring less mental effort, becoming skilled at utilizing, and ease of learning to use [45, 46]. The same six elements were used in the current research to analyze users' experiences while navigating within the Grand Mosque of Makkah using the proposed AR application.

4.2. Perceived Usefulness (PU)

Perceived usefulness is the degree to which an individual considers that the use of the investigated IT will enhance the enactment of the activity assigned. It is an essential pointer since users are eager to implement a technology, they consider that using that technology will enhance their situational effectiveness, enactment, and efficiency [67, 76].

According to [45, 46], cognitive ease-of-use has an important impact on observed usefulness. Many studies investigated this relationship and found it robust across various studies: m-learning [77] enterprise resource planning (ERP) [78], Internet-based learning systems [79], healthcare information systems [80], media tablet adoption [81], mobile internet technology [82], knowledge sharing [83], mobile banking [84], electronic mobile wearable devices [85], Internet of Things (IoT) [86], perceived smart home security devices risk [87], and social networking sites [70], [88]. Nevertheless, this claim was not reinforced in research conducted on hedonic and utilitarian incentives of social networking site implementation in Germany [89].

The existence of a link across perceived ease-of-use and perceived usefulness is essential for the model to operate. The impression of ease-of-use by users is a prerequisite for comprehending the utility of the thing. The existence of perceived ease-of-use influences a user's opinion of the new technology's utility. In other words, the less confusing a client's

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job with IT products, the more likely the technology will be considered beneficial. Overall, there seems to be confirmation that PU and PEOU are critical in understanding IT adoption and use behavior, on which the existing model may depend.

Both [45,46] measured perceived usefulness using usefulness, efficiency, productivity, effectiveness, and performance. The present research used the same items as measures of perceived utility based on those things. This is to determine whether or if a person feels that utilizing the proposed AR application would improve his or her Grand Mosque trip experience and performance. As a result, the following articulations have been developed to assess Haram's visitors regarding the proposed AR application:

H1: PEOU and PU are positively correlated.

4.3. Attitude Toward Using Technology (AT)

Attitude is the point of origination for human intention, followed by two interpretations (positive or negative feelings). As a consequence of this, whether the attitude is positive or negative is dependent upon the projection. According to, one definition of attitude is the degree to which a user enjoys the experience of using an information technology application. The TAM contends that people's behavioral intentions to utilize technology are determined by their attitudes rather than their actual behaviors. Attitudes, in turn, are what decide what our intentions will be. An individual's perspective may be defined as the favorable or unfavorable value placed on a certain activity. Attitudes held by people will be the primary factor in determining whether or not they want to use that tool. Positive attitudes are correlated with increased usage of various forms of technology among individuals. Individuals who have negative views about technology, on the contrary, are not compelled to utilize it [45].

To evaluate the extent of attitude's effect on behavioral intention, numerous theories, including TRA and TPB by [90] and TAM by [45], have relied on one's attitude. According to the findings of a number of studies [91–93], customers' attitudes about the use of innovation are directly influenced by their perceptions of how easy it is to use a product. When the user is able to navigate around the program without encountering any obstacles, they will get the impression that it is simple to use. As a direct consequence of this, individuals will be more likely to make frequent use of that application.

Items such as that the proposed AR application will save efforts and time as well as being beneficial, pleasant, and user likes are used to measure this construct as suggested by [90, 93]. The hypothesis developed based on this theoretical background is as follows:

H2: PEOU and AT are positively correlated.

H3: PU and AT are positively correlated.

4.4. Behavioral Intention to Use (BIU)

According to behavioral decision theory, BIU is a user's mental perception and belief in the person's capacity and usefulness to utilize a technology [94-95]. Many research [67, 68,

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91] propose the PU of TAM as a behavioral intention factor. That is, an individual's own beliefs shape his or her actions. According to the existing research, PU has both direct and indirect favorable effects on users' BIU [68, 91, 96].

When compared to PEOU, PU is a far more powerful motivator of use intention. When a user's performance is improved as a result of using a system, that system is said to have a positive PU. According to a number of empirical research concerning advertising and information technologies [68, 95, 97], it has been proposed that the importance of PEOU decreases as the user gets more skilled at using the system. In some research, on the other hand, PU has been shown to be an unreliable predictor of future drug use (i.e., social media IT applications). This might be due to the kind or type of information management that is being researched, which could be either hedonistic or pragmatic [89, 98].

In addition, investigations have supported the idea that attitude has a substantial influence on BIU in regard to the adoption of new technological systems [99–101]. In the context of public administration, a number of researchers concluded that there is a substantial connection between attitude and intention [80, 102]. In light of the goal to make use of e-government services, it is important to acknowledge the significance of emerging technologies. As a result of the above, the two theories that have been offered to reflect the impacts of PU and AT on BIU's decision to employ AR are as follows:

H4: PU and BIU are positively correlated.

H5: AT and BIU are positively correlated.

4.5. Actual Technology Use (ATU)

ATU variable is the eventual objective construct of this study (i.e., Haram visitors who perceived that the use of AR application is easy to use and useful will use the technology to navigate inside Haram). Based on TRA and TAM, behavioral intention to use (BIU) is a crucial determinant of actual technology use (ATU) [45].

In fact, BIU is favorably associated with ATU in the usage of technology sense [51, 88, 103]. Article [104] reviewed 79 observational experiments and concluded that behavioral purpose is a significant determinant of the real use of technology. The strong behavioral purpose of use may also justify higher use levels for social networking sites such as Facebook [70]. Both [105, 106] confirm this connection in other studies on social networking sites. Together, these research articles provide acknowledgment to the suitability of TAM in the IT adoption field. Therefore, it is hypothesized that:

H6: BIU and ATU are positively correlated.

5. Data collection and Results

Data were gathered using questionnaires that were based on the questions presented and tested by [45, 46]. The majority of the questions asked for responses on a four-point Likert scale, with one being "strongly disagreed" and four being "strongly agreed." Direct distribution of the questionnaire through different digital networking such as WhatsApp

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and electronic mails and collection of responses using google forms were used to reach out to visitors to Haram. 5,000 visits are thought to make up the successful survey sample, with a response rate of roughly 19%. (967 returned surveys). If early responders differ from late responders is assessed using wave analysis. 483 early responders and 484 late respondents were divided into two groups, and the author performed a wave analysis for each group. The statistical analysis did not uncover any changes that were statistically significant across the different samples.

The Cronbach alpha technique revealed that the results were higher than 70%. Additionally, all variables had average variance explained (AVE) values higher than 0.7 and element loads of at least 0.6, indicating good model item dependability. The corrected item-total correlation (CITC) results for each scale item were all higher than 40%, indicating a strong validity for the research model's components they depict. All pathways were shown to be significant after the SEM investigation. See Table 1 and Figure 1. Also carried out was the GOF analysis, which produced the following results: chi2 (1844.91), DF (165), p-value 0.05, normal chi2 (4.19), CFI (0.74), and RMSEA (0.12). These results led the researchers to the conclusion that the model's overall fitness was fair.

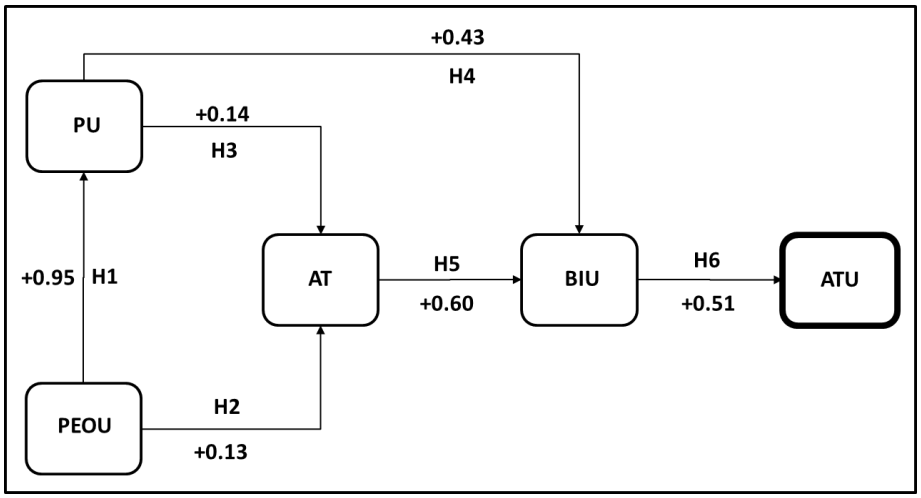

Figure 1. Structural results of the proposed Haram's AR application model.

Path	Hypothesis	S.E.	P	Decision
PEOU -> PU	H1	0.95	<0.001	Accepted
PEOU -> AT	H2	0.13	<0.001	Accepted
PU -> AT	H3	0.14	<0.001	Accepted
PU -> BUI	H4	0.43	<0.001	Accepted
AT -> BUI	H5	0.60	<0.001	Accepted
BUI -> ATU	H6	0.51	<0.001	Accepted

Table 1: Model's path coefficient values and decisions

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6. Discussion

One of the biggest obstacles that Haram's visitors may confront is the huge and intricate Haram structures, which make mobility difficult [17, 18]. Furthermore, the research suggests that augmented reality (AR) may give options for improved visitor mobility [10, 20]. According to certain research [46, 71, 72, 75], visitors' perceptions of technology's ease of use and utility are important factors in technology adoption. There is, however, a scarcity of literature analyzing the issues that Hajis have while moving within Haram and if the introduction of AR would raise visitor happiness and, as a consequence, improve the services provided to Haram visitors. This is the first study to employ TAM to investigate the quantitative relationships between perceived utility, ease-of-use, and purpose of usage of AR guidance apps with Haram visitors.

This research was performed on the Grand Mosque of Makkah's visitors to assess their perceived experience with the proposed AR navigation tool. It supports the growing literature suggesting that an increasing number of tourists, including those visiting the Grand Mosque of Makkah (Haram), are fascinated by experiencing and are previously using different applications to help be able to complete their visit [5, 7, 18, 23, 32, 107].

The statistical results reveal that all the coefficients of the research construct relationships based on TAM were accepted, see Table 1. The relationships between PEOU and BIU is better represented via PU instead of via AT. Still, both ways are statistically valid. This is aligned with the TAM and previous work, suggesting that the perceived value determines technology acceptance and degree of burden [61, 67, 76].

Visitors between the ages of 40 and 60 make up the majority of the AR adopter visitors, perhaps because this demographic is more comfortable using technological innovations like augmented reality (AR) and is more likely to be responsible for their families. Even though augmented reality (AR) other smartphone devices are technically feasible, they cannot easily remove the risks associated when the innovation is not endorsed (e.g., when the smartphone battery is dead, when there is no Internet connection, when there is no mobile software available, when there is an absence of technological knowledge or skills). This outcome is consistent with the findings in [108], which posits that user familiarity with related technologies is a necessary condition for their acceptance. Users with greater experience with computers are more willing to adopt cutting-edge tools.

The results also showed that people were more likely to keep using AR if they thought it was both beneficial and easy to use. Because of its many benefits, including portability, reduced need for physical exertion, and the chance to network with others, augmented reality is likely to increase the number of visitors dramatically. Through the usage of AR, visitors to Haram may improve their productivity, expertise, and awareness of their exact position. Users found AR to be more relevant and helpful in their pursuits related to visiting Haram. Perceived usefulness, which is influenced by the simplicity of use, directly increases visitors' desire to use AR. It seems that visitors to Haram find using augmented reality to be a simple and effective method of navigating complex grounds. Due to the portability of mobile apps, users may take their personal assistant programs with them

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wherever they go [8]. According to the findings, the route through attitude toward utilizing technology as a mediator has less of an influence on behavioral intention to use the technology than does the perceived ease of using the technology. It's possible that after a given number of trips, guests have a sophisticated understanding of IT and no longer see AT as having much of an impact on BIU.

In fact, Haram visitors are no different from other contemporary day tourists in that they make use of cutting-edge information technology like augmented reality (AR) and navigation apps to familiarize themselves with the surrounding environment. To better comprehend where they are and to communicate their position with others, visitors may use handheld devices equipped with augmented reality (AR) and navigation systems to superimpose Haram's virtual items on top of Haram's real-world view on their smart devices. Vacationers and business travelers alike may benefit from this innovative fusion of augmented reality and navigational aids [109].

In terms of perceived usefulness, participants in this research suggested that the use of AR is much easier than following the traditional Haram signing system. However, elderly men (i.e., 60+ years old) and women visitors are less likely to use AR-suggested tools. This may be explained as those two categories are most likely to be taken care of by mature males or assigned tour guides. Older adults, individuals with a particular religious' school of thought, first-time visitors, and illiterate people are unlikely to adopt technologies in general either because smartphone applications are not easy to use for them or some other religious issues.

However, some participants indicated that AR would be helpful for elderly people. Although the study did not follow up to acquire a better understating of what the participants meant by this, elderly people may advantage from using AR. There are pieces of evidence confirming the rapid increment in IT use among older adults [110, 111]. A few studies indicate that older adults may have negative perceptions and, in some cases, physical and mental difficulties to handle modern technologies [112, 113]. While elderly people with some serious illnesses could be targeted for modern technology adoption, little is known about AR application use for elderly people. Therefore, tourism-related agencies in Saudi Arabia should obtain ongoing feedback from older people and other Haram visitors with application use when developing new IT tools and updates. More research is needed to determine the best strategies for promoting AR tools to engage elderly men and women while visiting Haram.

An inclination for this research used methodology maybe also a shortcoming to cognitive usefulness and an obstacle to visitors' AR intention to use. Some visitors highly valued using the traditional signing system and/or asking others about directions while navigating in Haram. With these numbers, AR tools would evaluate the inclusion of attributes that inspire visitors to make use of the current traditional signage system within the AR application. In this study, the AR application and its features were not used primarily to replace the current traditional signing system.

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7. Summary, Limitations, and future research

This research lends theoretical support to the technology acceptance model (TAM) theorized by [67, 68]. It adds to the increasing number of studies in the literature stressing the need to evaluate visitors' uptake of augmented reality technologies at iconic attractions like the Grand Mosque of Makkah Al Mukarramah. This research adds to the existing literature on wayfinding and augmented reality by demonstrating how this technology may be used to improve the navigation experience, leading to a higher uptake of AR technologies among Haram's visitors.

This study provides several fundamental takeaways. In the first place, it is difficult to quantify solid conclusions from any examination of navigation in large, complex structures and congested public spaces. Second, in order to accurately assess the impact that the current wayfinding signs have on the hajis who visit the Grand Mosque of Makkah, an even bigger sample is needed. This is because there are a variety of demographic factors (such as gender, age, ethnicity, education level, and experience level) that influence the navigation experience. In order to make the spiritual experience of Hajis more meaningful and encourage them to return in the future, the research found that offering a better navigation system (i.e. AR tools) can guarantee a smooth and constant flow throughout Haram and so considerably boost their happiness.

Despite these advances, several difficulties remain in this line of work. The information was collected from internet services such as social media and questionnaires. This might limit the generalizability of the findings since it would favor responders with technical expertise. Paper and pencil questionnaires and interviews with Haram visitors are thus recommended for additional investigation and to verify validity and dependability. In addition, as this study relies on the feedback of a single source, it may suffer from the problem of common-variance bias. Researchers should separate the scale into two halves, one for Haram tourists and one for Visitor agents. As a result, we'll have a better idea of how visitors and agents alike interact with the augmented reality tools utilized in Haram Wayfinding, and we'll be able to eliminate the usual variance bias that arises as a result. It would be advisable to re-analyze the data as part of a longitudinal study to verify if the outcomes of this research can be generalized over different situations. Future work may include further stratifying these tourists into many groups according to demographic characteristics like age, gender, and country of origin in order to better understand the effects of these factors.

There may be differences in user behavior and experience amongst AR tools, despite the fact that this research provides an in-depth investigation of how Haram visitors feel about AR tools for navigating the Haram. Quantitative survey methodology was employed to learn about visitors' PEOU, PU, AT, and BIU of AR tools and only responses from those with a passable comprehension of technology were included. Other data sources, such as monitoring and interviewing Haram visitors, might have enriched this analysis. Participants from many different age groups were sought out, however, the research did not ensure that each age group was represented with an equal number of participants. In

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addition, the sample was skewed toward the educated, the middle class, and the users of technology; members of the underserved who are more likely to lack access to such tools were underrepresented.

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