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Research paper

Pilgrims' Acceptance of Using Augmented Reality Applications While Performing The Hajj

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Abstract

The majority of pilgrims do not speak Arabic and may encounter difficulties performing Hajj in terms of appropriate procedures and places due to their unfamiliarity. Most pilgrims are there for the first time. Researchers and practitioners have sought to develop mobile-based applications to assist pilgrims in various tasks such as finding their way and avoid becoming lost, and to perform Hajj procedures properly based on guides on their mobiles. Among the developed applications, a few are based on augmented reality. Many remain in the research phase. However, the problem with many augmented-based applications developed for Hajj is the lack of user acceptance investigation before implementation. This study found that the applications developed for Hajj practices based on augmented reality lacked user acceptance test. This study proposes a model for user acceptance for mobile augmented reality applications developed for Hajj. It found that pilgrims' motivations to use this type of application were ease of use and enjoyment, with little focus on its utility. This result is interpreted as meaning that the participants have yet to appreciate the utility of mobile augmented applications.

Keywords: *Hajj, mobile augmented reality, pilgrim, acceptance*

1. Introduction

Hajj is a religious journey to Makkah performed by Muslims at least once in their life [3]. This Islamic practice involves many steps [3]. Pilgrims come from all over the world to Saudi Arabia. Most do not speak Arabic. The Saudi government encounters a considerable challenge to serve almost two million pilgrims in a limited space, i.e. Makkah. Among the challenges that pilgrims may face is the language barrier and failing to identify signage for significant places and services. Many pilgrims spend some time trying to identify the spots where they are supposed to perform the required rituals within the correct time. Human guides are often in charge of large groups and are surrounded by many other groups. The noise and confusion can easily cause a person to become lost. Technology could help pilgrims overcome such challenges. In this regard, mobile technology is promising as the majority of pilgrims have cell phones which are easy to carry and use [3]. Several technologies use augmented reality with/without GPS to help pilgrims navigate their way around Makkah and perform Hajj-related procedures in the appropriate time and place. This study investigates the applicability of such applications within the context of pilgrimage in terms of the pilgrims' acceptance of augmented reality.

2. Literature Review

Limited mobile-based applications exist that relate to pilgrimage [3]. Many mobile applications have been developed for Hajj and Umrah services [3]. For instance, many mobile applications have been developed for pilgrims to guide them in the pilgrimage process [4-8]. Al-Massre [9] proposed the pilgrims' guide based on augmented reality. Many applications have sought to develop solutions for the problem of crowdedness during the pilgrimage. Hamhoum and Kray [10], Hj Mohamed, et al. [11] and Ahmad , et al. [12] proposed a framework that uses mobile sensory data to define the context of the users and guides them to avoid crowdedness [3]. Amro and Nijem [13] and Mohandes [14] developed applications that use location to recognise pilgrims' location and guide them to the correct places to perform their pilgrimage.

The available mobile applications related to pilgrimage and Umrah can be categorised into applications related to prayers and how to perform Hajj procedures, applications related to locations and how to avoid crowdedness, and those related to health, language, and a few applications related to augmented reality [3]. This study focuses on services related to location. The majority of applications reviewed by Khan and Shambour [3] concern using GPS to guide pilgrims to reach their destination. Very few applications use augmented reality [15], or augmented reality with GPS.

This paper examines the studies related to using augmented reality in Hajj. There are two Master theses on this issue [6, 9]. Al-Massre [9] focused on using augmented reality to assist pilgrims to find their way peacefully out of crowded places. The prototype accommodates the native language of the pilgrim. The prototype was tested by 40 pilgrims and aimed to be used for crowd management. Al-Massre (2011) concentrated on the technical aspects of augmented reality, and no particular theory of acceptance or use was followed. Almoaid [6] investigated using augmented reality to assisting pilgrim to avoid crowds and prevent them from becoming lost. Almoaid [6] surveyed 104 staff involved in the pilgrim-

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age in Saudi Arabia. His findings showed that those staff welcomed the idea of using augmented reality by pilgrims.

2.1. Acceptance of Augmented Reality

Many mobile Hajj-related applications were developed to teach pilgrims how to perform Hajj and communicate with local society. Some also guide them using GPS. Despite the popularity of this type of application and the fact that user acceptance of technology has been of interest for both researchers and practitioners, little has been done to study pilgrim's acceptance or willingness to use this type of application. There is a paucity of studies that investigate users' acceptance and use of augmented reality [15]. Many studies have inspected the acceptance of mobile applications and services in several domains [15-23], with some adding items to the traditional technology acceptance model (TAM) to overcome the limitations of TAM for mobile applications [2, 24]. Few studies examined the acceptance of mobile augmented reality applications [2, 25]. Acceptance studies of mobile augmented reality applications, and GPS with Hajj are rare.

This paper aims to report on the factors influencing the acceptance of augmented reality supported by GPS to assist pilgrims and determine the extent to which there seems to be interest in these types of applications.

2.2 Augmented Reality Application

Augmented reality (AR) helps enhance the users' view of the world by overlaying virtual objects onto the real world in a way that encourages the user that the virtual object is part of the real environment [2, 26]. Mobile AR systems provide the same services as AR systems without constraining the individual's location to a particularly equipped area [27]. Mobile AR is a rapidly growing research area [28] resulting from the rising and widespread uptake of smart-phones with the capability to support AR on a mobile platform [2]. Currently, smart-phones and tablets have processors, graphics hardware, a large touchscreen, and related embedded sensors such as camera, GPS, Wi-Fi, compass, and accelerometer, making them ideal for both indoor and outdoor AR [2, 29].

AR has been experienced in many domains. For instance, the Archeoguide system [30] is a mobile augmented reality system for cultural heritage sites since 2001 [2]. The system provides tourists information based on the current location and orientation in the historical site of Olympia, Greece. However, its laptop version requires many tools and equipment. Another instance is AR under the iTacitus project for remote cultural heritage sites [31]. The system renders augmented information on top of the camera feed of a commercial device [2]. When walking in the city, the CityViewAR [29] is used to assist students to see buildings in the city of Christchurch as they were before the 2011 earthquake [2].

2.3. Pilgrims' Acceptance of AR

This study investigates the user acceptance of mobile AR applications presenting the correct Hajj procedures and places in Makkah. It adopts the questions of Haugstvedt and Krogstie [2] related to using AR with historical places and the extent to which people are interested in using such technology. It constitutes an acceptance model for accepting the use of augmented reality for historical sites. Makkah is a religious and historical place. Moreover, pilgrims may show interest in AR application to assist them to perform their Hajj accurately and navigate Makkah while overcoming the language barrier. To this end, the questions by Haugstvedt and Krogstie [2] for the use of AR with historical sites were adapted: 1. Do the previously established relationships between the constructs in the TAM hold for AR applications for performing Hajj and navigating Makkah? 2. Is there an interest in using AR applications for performing Hajj and navigating Makkah?

The first question concerns the relationship between the constructs in the acceptance model. Heijden [1] and Haugstvedt and Krogstie [2] showed that perceived enjoyment and perceived ease of use were stronger predictors of intention to use an entertainment system than perceived usefulness. There is little variance within the context of Hajj as visiting for pilgrims is not only for enjoyment but performing religious practice and using AR applications to perform Hajj and navigate Makkah is critical. Therefore, the acceptance model helps to find ways to make this sort of application more acceptable to pilgrims.

The second question focuses on the interest in using this type of application [2]. It determines the levels of interest among pilgrims and if people want to use this application in their Hajj or when roaming Makkah. Meraj, et al. [32] proposed utilising AR with historical sites in Makkah. However, Meraj, et al. [32] called for using AR with Makkah as a historical site without having acceptance model or practical prototype. This is only one task that AR could do for pilgrims. These studies are indicators of welcoming use of AR in pilgrimage. However, pilgrims' acceptance of this technology was not tested.

To develop a model for AR use in pilgrimage to assist pilgrims to avoid crowed and find the ways to their destination, along with other purposes (learning, finding services, places, etc.), there is a need to investigate utilising acceptance theory such as TAM with AR pilgrimage.

Sumadio and Rambli [33] experienced potential usage of AR in the education environment. Even though their study sample (students and teacher) was limited [33], the participants were happy to use AR. Similarly, regarding the acceptance of the students to utilise AR with visual art, Di Serio, et al. [34] showed that the enthusiasm of middle-school students outweighed the barriers in using AR. This could enlighten us that even though students have only just started using AR, they easily overcome difficulties. This could happen within the context of pilgrimage. Haugstvedt and Krogstie [2] developed an acceptance model-extended for AR. The findings showed that perceived usefulness and perceived enjoyment influence the intention to use mobile AR applications with historical pictures and information. Pantano, et al. [35] and Yim, et al. [36] used extended TAM to measure customer acceptance and use for AR with their online retailing, Besides the "enjoyment" construct, they included: aesthetic quality, interactivity, response time, and information quality. According to Heijden [1], the original TAM scale was developed for utilitarian applications, and the measure for perceived usefulness was problematic because of the concentration on improved job performance [2]. This led Heijden [1] to develop new items.

Our model comprises four constructs: perceived enjoyment, perceived usefulness, perceived ease of use and behavioural intention. The strength of the paths might change with pilgrimage context, but the structure of the relationships from TAM is expected to hold for this model. However, Rauschnabel, et al. [15] followed a different approach to measure what users use or are willing to invest money in AR applications on mobile phones. The approach was based on three theories: uses and gratification, technology risk research, and flow. The findings showed that hedonic, emotional, and social bene**fi**ts and social norms drive consumer reactions. However, those factors might change depending on the form of user behaviour [15]. This framework focuses on hedonic applications, which is closely-related to mobile games and partially related to augmented mobile-based applications related to religious practices. The main drivers of that model are hedonism and investing money, while the majority of pilgrimage-related mobile applications are free and are designed to assist pilgrims to perform the pilgrimage. Rauschnabel, et al. [15] and Pantano, et al. [35] highlighted the importance to measure users' reaction towards the AR applications. This is a drawback of current studies investigating AR with pilgrimage. The Hajj-related studies went directly to development or communicated with people in Hajj management, instead of involving with real or potential pilgrims.

3. Research Model

This study investigates the application of mobile AR to assist pilgrims with their pilgrimage procedures and navigate Makkah. TAM is a well-known theory used to measure users' acceptance of technology, including AR. This study seeks to understand the established relationships between the factors of extended TAM with perceived enjoyment maintained for AR application with Hajj and Umrah? The second objective is to know whether pilgrims are interested in using AR application during performing Hajj and touring Makkah?

To answer the first question, this study is guided by the model proposed in [1, 2], which empirically showed that perceived enjoyment and perceived ease of use are stronger predictors of intention to use systems such as AR than perceived usefulness. Similarly, this study seeks to determine if the same goes for using mobile AR to assist pilgrims to perform their Hajj. Answering this question will assist in the development of applications that are more acceptable.

The answer to the second question will help determine the levels of interest among pilgrims using AR in their mobile devices, and the intention to use this application in their pilgrimage. The pilgrims were asked about using AR in mobiles to serve pilgrim's needs while performing Hajj. A few mobile AR application solutions designed for other domains were administrated such as the one in [2] to the pilgrims demonstrated to the pilgrims in order to map their possible applications in the domain of Hajj. The feedback from pilgrims might help establish the ground for future mobile AR applications dedicated to Hajj. Then the various models for technology acceptance theory were reviewed, and a questionnaire was designed to measure pilgrims' acceptance of mobile augmented applications for Hajj. The questionnaire has six parts: (1) demographic; (2) pilgrims' expectations and perspective for using mobile AR with Hajj; (3) perceived usefulness; (4) perceived ease of use; (5) perceived enjoyment; and (6) behavioural intention.

The measure of perceived usefulness, perceived ease of use, perceived enjoyment and behavioural intention were developed in line with [1, 2]. Most of the measurements are similar to the originally proposed measurements of acceptance models. However, a new set of items for perceived usefulness were proposed by [1, 2], due to his argument that those items are more appropriate for hedonic systems. The scales used to measure the four constructs are based on a five-point Likert scale.

Surveys were conducted during Hajj season 2017 with pilgrims while they performed the pilgrimage. Data were collected from 382 participants, but after removing incomplete data and outliers, 340 responses remained. The participants before answering the questionnaire were presented videos illustrating the use of the AR in situations similar to those they encounter while performing Hajj. This survey was initially used to examine the acceptance research model to inspect the factors influencing the intention to use this type of system. Similar surveys have been used successfully [2, 37] to validate such research models in order to collect sufficient feedback from users to be able to apply the prescribed statistical techniques. Respondents were real pilgrims who were surveyed when close to completing all Hajj procedures. The data from the survey was used to assess the interest in mobile AR applications with Hajj procedures and places. Figure 1 displays the research model used in this study. This is the TAM with perceived enjoyment borrowed from [1, 38].

Based on the previous studies, it was likely that the structure of the relationships from TAM is maintained for this model. However, the strength of the paths may change. This study tested the hypotheses:

- H1 There is a positive relationship between perceived ease of use and perceived enjoyment.
- H2 There is a positive relationship between perceived ease of use and perceived usefulness.
- H3 There is a positive relationship between perceived ease of use and behavioural intention to use.
- H4 There is a positive relationship between perceived enjoyment and behavioural intention to use.
- H5 There is a positive relationship between perceived usefulness and behavioural intention to use.

4. Results

The data collected showed that the majority of respondents were aged 40 years and above with 249 respondents (72.7%), followed by 31-40 years with 75 (21.9%), and 20-30 years with 16 (4.7%). In terms of gender, males represented 302 (88%), and females 38 respondents (11.1%). The education levels were PhD with 23 (6.7%), Master 41 (12%), Bachelor 46 (13.4%), Diploma 147 (42.9%), and 83 (24.4%) with high school.

30% of respondents were familiar with AR applications, while 40% had heard about AR and its applications. This reveals that pilgrims have some experience with AR applications. Almost all pilgrims own mobiles with 75% of them being smart-phone with various capabilities. Regarding the difficulties pilgrims encountered during Hajj, 20% reported they lost their way, and 46.4% reported they were confused with directions and places while performing Hajj. They reported that finding facilities such as restrooms required effort. They required a complete a map of all places of interesting either religiously, spiritually or for tourism. Additionally, they reported difficulties finding buses to move around or returning to hotels, difficulty finding the designated tent camp, finding other groupmates in the crowd, and inadequate signage. The next question was, have you used any application on your mobile to guide yourself or get help? Only 14% reported they have applications related to Hajj and some related to GPS. 80% reported their acceptance to use mobile applications including augmented reality as long as it makes performing Hajj easier.

Table 1 shows the descriptive results of responses on perceived usefulness. The responses to useful1 ("By using the augmented application with Hajj, I can more quickly and easily access Hajj-related locations and information about those locations and Hajj-related procedures"); useful2 ("By using the augmented application with Hajj, I learn more accurate information about the places and procedures"); Useful3 ("By using the augmented application with Hajj, I can quickly find information related to facilities nearby") and Useful4 ("By using the augmented application with Hajj, I am more likely to find pictures and information that interests me") all have means between 4.2 and 4.67.

Table1: Descriptive statistics related to items of perceived usefulness

Item	N	Min	Max	Mean	Std. Deviation
useful1	340	1.00	5.00	4.4382	.70335
useful2	340	1.00	5.00	4.6706	.66320
useful3	340	1.00	5.00	4.3294	.74688
useful4	340	1.00	5.00	4.2500	.81604

Table 2 shows the descriptive results of responses to perceived ease of use. On perceived ease of use, all the items have a mean between 4.35 and 4.59.

For perceived enjoyment, all means of all items range between 4.13 and 4.41 as presented in Table 3. Table 4 shows the descriptive results of responses on intention to use. The mean of behavioural intention of all items ranges between 4.30-4.50. Two

items from Heijden [1], Haugstvedt and Krogstie [2] are related to using AR in the user's home city, which is not applicable in this study as the context is using AR in Makkah and Madinah.

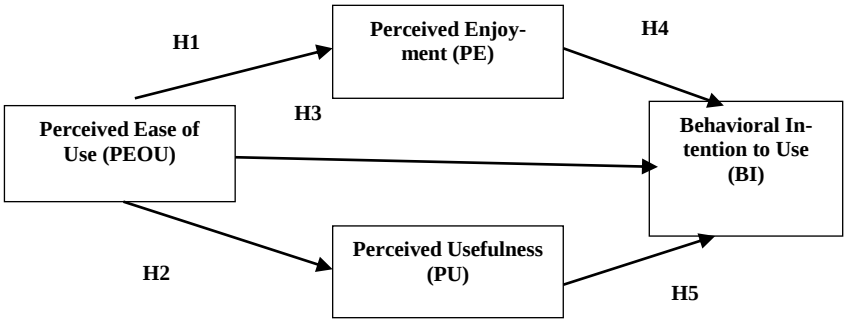


Fig. 1: proposed model for AR with Hajj adopted from [1, 2]

Table 2: Descriptive statistics related to items of perceived ease of use

Items	N	Min	Max	Mean	Std. Deviation
easy_to_use1 (Interaction with the Augmented App is clear and understandable)	339	2.00	5.00	4.3510	.80168
easy_t_use2 (Interaction with the app does not require a lot of mental effort)	340	1.00	5.00	4.5912	.66557
easy_to_use3 ("I see the Augmented app easy to use)	340	1.00	5.00	4.4000	.80118
easy_to_use4 (I find it easy to get the app to do what I want it to do)	340	.00	5.00	4.3618	.80651

Table 3: Descriptive statistics related to items of perceived enjoyment

Items	N	Min	Max	Mean	Std. Deviation
enjoy1(disgusting-enjoyable)	340	1.00	5.00	4.4147	.74574
enjoy2 (dull-exciting)	340	1.00	5.00	4.1324	1.00301
enjoy3 (unpleasant-pleasant)	340	.00	5.00	4.2588	.73518
enjoy4 (boring-interesting)	340	1.00	5.00	4.1412	.88785

The items were analysed using the statistical software Smart [39]. The composite reliability of four constructs range between .79 and .95 and are above the 0.70 threshold for composite reliability (see Table 5). They also showed high internal consistency within the range 0.78-.936, which is above the 0.70 threshold for confirmatory research. The lowest average variance extracted was AVE = 0.638, which is also above the suggested limit of 0.50. The four constructs showed strong convergent validity. The lowest of the outer model loadings is 0.716 (intention5← behavioural intention).

Table 4: Descriptive Statistics related to items of behavioural intention

Items	N	Min	Max	Mean	Std. Deviation
intention1 (I intend to use the app on a smart-phone)	340	1.00	5.00	4.3382	.71664
intention2 (I predict that I will use the app on a smart-phone)	340	1.00	5.00	4.4559	.68343
intention3 (I intend to use the app on a mobile)	340	1.00	5.00	4.4147	.71751
intention4 (I predict that I will use the app on a mobile)	340	1.00	5.00	4.5059	.74269
intention5 (I intend to use the app in a Makkah and Madinah)	340	1.00	5.00	4.3059	.81684
Intention6 (I predict that I will use the app in a Makkah)	340	1.00	5.00	4.3412	.70486

Table 5: Reliability of the items of this study

Factor	AVE	Composite Reliability	R^2	Cronbach's Alpha
Easy	0.6385	0.9461		0.9365
Enjoy	0.6384	0.8753	0.5868	0.8104
intention	0.6617	0.7944	0.361	0.783
Useful	0.7036	0.934	0.4162	0.9157

T-statistics show that all loadings are significant at the $p < 0.001$ level. The measurement model meets the first criteria for discriminant validity. The cross-loadings between measurement items and their theoretically assigned factor are consistently greater than the cross-loadings between the measurement items and the other factors.

Figure 2 presents the structural model. In that model, path coefficients, t-statistics showing levels of significance (in parentheses), and R^2 values (in the circles). The structural model shows that all five hypotheses - except one - were supported. The paths perceived ease of use →perceived usefulness and perceived ease of use → perceived enjoyment were significant at the $p < 0.001$ level. The paths between perceived ease of use → behavioural intention, and perceived enjoyment→ behavioural intention were significant at the $p < 0.05$ level. However, the path perceived usefulness → behavioural intention was insignificant. Overall, the model explained about 36% of the variance in behavioural intentions.

5. Discussion

The proposed model with five hypotheses explained pilgrims' adoption of mobile AR applications with Hajj performance. Table 6 summarises the results from the hypotheses-testing.

Table 6: Summary of hypothesis test

Paths	Estimate	Significant
H1: Perceived ease of Use →perceived Enjoyment	0.766	Significant
H2: Perceived ease of Use → perceived Usefulness	0.645	Significant
H3: Perceived ease of Use → Behavioural Intention to use	0.307	Significant
H4: Perceived enjoyment → Behavioural intention to use	0.268	Significant
H5: perceived usefulness → behavioural intention to use	0.083	Insignificant

Based on this study, the TAM for hedonic systems was found to fit the data. The model was tested with data collected from pilgrims and accounted for 36% of the total variance in behavioural intention to use. In comparison, the variance with Heijden [1] was 35% in behavioural intention to use, 62% of the variance with [1, 40], and 57% variance in the study of Haugstvedt and Krogstie [2].

Previous studies revealed that perceived usefulness is the strongest predictor of user acceptance and the effect of perceived enjoyment is steadily the weakest among the three factors [38, 41, 42], but in [2] the weakest was perceived ease of use. Moreover, the study of Heijden [1] of user acceptance of a pleasure-oriented information system showed that perceived enjoyment and perceived ease of use were stronger elements of behavioural intention to use than perceived usefulness. Chesney [40] repeated this research with a dual system (utilitarian and hedonic) and found that perceived usefulness less dominant predictive compared to the perceived enjoyment and perceived ease of use. In this study with pilgrims, the strongest predictor of behavioural intention was perceived ease of use with 0.307, and the weakest determinants were perceived usefulness (0.083).

The hedonic nature of mobile AR applications have dual purposes; people enjoy using this type of application and also it has some benefits in real life [2]. However, the findings of this study reveal that pilgrims tend to use it more because it is easy to use, enjoyable, and are less concerned with its utility while performing Hajj. This might be due to the fact that the majority of respondents might not have been exposed to real experiences with this type of application so that they may appreciate its utility. Nevertheless, they appreciate its ease of use and enjoy using it.

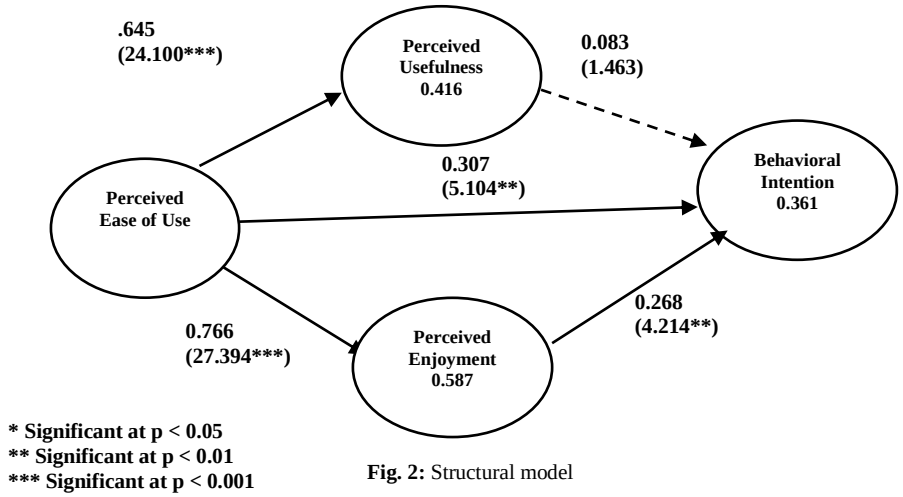


Fig. 2: Structural model

6. Limitations

This study has some limitations. First, the respondents watched a video exemplifying the use of the application and using some exist AR, but they have not been exposed to real experience. Their answers are reflected in Figure 2. The input would be more meaningful when respondents' experience the application in real Hajj scenario, and may show more interest to use the application and appreciate its usefulness [2]. Second, the majority of respondents were above 40, so they are less exposed to mobile technology compared to young people. Hence, there is a possibility the result might differ (higher variance, and more determinants for behavioural intention to use) than current findings if the number of younger respondents was higher.

7. Conclusion

This study has investigated the applicability of a TAM for hedonic systems to examine the determinants of intention to use an AR application for Hajj and Umrah. The data were collected during the 2017 Hajj season. The participants watched a video-presentation of mobile AR and the possible uses of the application to facilitate Hajj performance before answering the questionnaire. A partial least square (PLS) analysis was conducted to estimate a structural equation model for the acceptance of this type of application.

The results revealed that both perceived ease of use and perceived enjoyment are essential determinants of behavioural intention to use AR applications in Hajj. In contrast to previous studies, perceived usefulness was less significant, as discussed previously and interpreted as respondents have not used it in real life scenario to appreciate its usefulness. The result suggests that interested parties developing this type of applications can take advantage of the fact that mobile augmented application is fun and useful to deliver more attractive applications. The next step is testing a prototype in real life scenario with pilgrims to measure its effectiveness and usefulness.

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