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Research paper

A Proposed Model of Acceptance for Smart Glasses based Outdoor Augmented Reality Applications at UNESCO World Heritage Sites

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Abstract

With the advancements in the recent mobile and wearable technologies, opportunities in the digital tourism sector are on an all-time high. Although, there is only limited research on users' acceptance of Augmented Reality (AR) in the cultural tourism context, previous researchers have explored the opportunities of using AR in order to enhance user acceptance and adoption. Recent AR research lack empirical studies and works that integrates dimensions which are specific to cultural heritage tourism and smart glass specific context. Hence, this work proposes an AR acceptance model in the context of cultural heritage tourism and smart glasses capable of performing augmented reality. Therefore, this work aims to discuss the methods needed to map the requirements and propose an AR acceptance model for Smart Glasses based wearable outdoor AR applications. The proposed model can be used to understand the AR usage behavior and visiting intention for tourists who use Smart Glass based AR at UNESCO cultural heritage sites in Malaysia. Furthermore, this work identifies technology readiness, visual appeal, information quality, and facilitating conditions as external variables and factors that may influence beliefs of visitors, their attitudes and intention of usage.

Keywords: *Technology Acceptance Model, TAM, Smart Glasses, Outdoor Augmented Reality, Cultural Heritage.*

1. Introduction

Modern day technologies including mobile devices have changed the way people interact with their surroundings. The rise of new communication and information technologies has tremendously influenced how tourists interact with tourist attractions. Such developments have resulted in increased popularity of augmented reality (AR) applications to project augmented information on objects or users' immediate surroundings. In order to enhance the overall tourism experience, a number of recent works have highlighted the opportunities of using outdoor AR or navigation based AR systems [1, 2]. Due to the development of AR, tourists using AR can acquire valuable knowledge and experience without the need of any tourist guide. Hence, a variety of AR usage examples can be seen in the domain of tourism in general. In particular, diverse applications tools for mobile devices with outdoor AR features have been devised. New AR tour guide applications are efficient in providing helpful information thereby maximizing tourist satisfaction. This is based on the assumption that many tourists actively accepts and use such AR tour guides.

Without examining the user acceptance and user behavior, it becomes a difficult task to measure the potential of emerging technologies. To carry out the task of measuring how emerging technologies and innovations are accepted by the masses, majority of the researchers use a widely known measurement model called the technology acceptance model (TAM). Generally researchers adopts a positivistic view towards TAM and tend to associate TAM with external variables found only in recent literature. Some researchers do suggest the use of increased qualitative techniques in TAM to in order to better understand the perception and behavior of users. This is extremely important when doing research related to a technology which has not been widely researched before. A recent work by [2] proposed a theoretical model for the acceptance AR in which they discussed mainly about external variables used in previous AR acceptance and emerging technologies literature. The authors recommend an investigation based on qualitative techniques to measure the effect of potential external variables in this context.

Surprisingly, in the recent past the market has not been able to produce many successful applications based on AR. Specifically in the field of tourism, most scholars still hold a view that the utilization of emerging technologies such as AR is an untapped issue as the technology has not been perfected yet. Majority of the empirical studies conducted in the context of AR and tourism have failed to discuss the effects of AR on the behavior of tourists and their intention to visit tourism destinations. Interestingly previous studies on similar subjects focuses of technology-specific, individual, environmental and situational factors that are capable of

influencing the acceptance of new technologies [3]. Some factors that may describe the tendency to avoid AR technology may include the following; the technology isn't good enough and incapable of solving real world problems, the users are not yet ready and prepared to use AR, the content quality experienced by the users is extremely poor and unable to satisfy the user's expectation [4]. Moreover, since AR is a technology with robust visual stimuli characteristics, people wouldn't get attracted towards if its visually unappealing [1]. The purpose of this research is to understand how context-aware adaptive smart glasses based tourism applications of the future will tackle the challenges haunting the augmented reality research community; challenges related to content, graphical user interface and experience design, and new hardware devices. This paper presents the methods and steps required to propose acceptance model and to understand the AR usage behavior and visiting intention of visitors who use Smart Glass based AR at UNESCO cultural heritage destinations in Malaysia. Furthermore, this work identifies technology readiness, visual appeal, information quality, and facilitating conditions as external variables and factors that may influence beliefs of visitors, their attitudes and intention of technology usage.

2. Ackground Study

During the course of the study, previous works on concepts such as outdoor AR, AR Smart Glasses, AR in the domain of tourism, technology acceptance and AR acceptance models are studied.

A. AR Smart Glasses

Although there is a recent flux of smart glasses proof of concept models in the tech market but only a few are available for commercial use. Google Glass, and Mircosoft Hololens, Vuzix m300 are some the smart glasses that are marketed for commercial use. AR Smart glasses are defined as regularly worn wearable AR devices that are capable of merging virtual and physical information within the users field of view. A number of smart glasses comes equipped with a variety of sensors such as camera, GPS, microphone, gyroscope etc. and are capable of integrating the information received from users mobile phone. Unlike Augmented Reality Smart Glasses, where digital content is overlaid onto the real world, Virtual Reality Glasses present a closed virtual view where the virtual object aren't connected with the real world. Another type of wearable devices which have become extremely popular in the recent times are smart watches such as Apple Watch and Samsung Gear. Although some researchers have tried implementing AR interfaces on smart watches, they lie beyond the scope of this research.

Application based researches have examined how wearable devices like smart glasses can benefit various domains and contexts. A recent study by [14] revealed the potential of using smart glasses for collaborations among doctors. Recent studies conducted in the domain of cultural heritage found smart glasses to be more flexible and easy to use when compared with more traditional tourism tech devices such as audio books, audio guides, websites, and custom made mobile devices [15]. Another recent work on the topic [16] acknowledged the benefit of smart glasses in the cultural heritage domain. They suggested that the direct overlaying of the virtual content onto visitor's natural view may increase their interest in cultural heritage and make it more interesting for them. In their experiments visitors were found to view and appreciate paintings without any disturbances in a hands free style.

Interestingly, the literature from the fields of information systems and marketing discusses studies with behavioral perspectives such as the user acceptance of a new technology and its implications on user's behavior. Many researches in the past have shown that innovative users show higher rates of adoption intention. Such users foresee the functional benefits of emerging technologies such as smart glasses and AR and also realize the various social conformities and social pressures that may arise due to the usage of such technologies [13]. In a recent research conducted by University of Michigan-Dearborn and Morpace Inc. nearly 1000 consumers were asked about their feelings and perceptions towards emerging technologies and smart glasses [17]. It presented very interesting results which suggested that 25% of the respondents believed people look strange with smart glasses, 30% believed people privacy is threatened by smart glasses, 16% believed in the advantages offered by smart glasses and mere 12.4% believed using smart glasses was easy. An interesting thing to note is that almost all the participants were consumers and not employees which might have affected the results slightly. However, such research in the domain of tourism are very scarce. To the best of the authors' knowledge, no prior empirical study based research can be found which investigates behavioral aspects of AR smart glass users in the domain of tourism. It is surprising to see such a gap exist because generally emerging technologies such as smart glasses are considered one of the most exciting and promising technologies in professional settings.

B. AR in the Context of Tourism

Recent advancement in technologies and the emergence of AR/VR have allowed tourism sectors to move ahead from the traditional sources of tourist information providers such as tourist websites, tourist guides, and mobile applications etc. to further enhance a tourist's experience [1]. Such technologies are a perfect fit for navigation and way finding and also for gathering information regarding unfamiliar places. Hence these features are very popular and widely used and therefore consist of majority of the applications developed in research and commercial settings. In addition to these features, it can be argued that AR applications in the domain tourism have the potential to effect user's behavior while doing mentally stressful tasks of navigation and way-finding. It also presents tourist with opportunities to explore unknown surroundings by overlaying context based digital content.

To protect the World Cultural and Natural Heritage, the General Conference of UNESCO adopted a Convention *(UNESCO 1972)* in 1972. The convention aimed at the ''identification, protection, conservation, presentation and transmission to future generations'' *(UNESCO 1972, p. 3)* of the world's cultural and natural heritage of outstanding universal value, and to encourage nations to achieve this goal by cooperating with each other. According to [6], cultural heritage sites are inherently very important as they are one of the key sectors in the domain of tourism and culture. Some of the examples of the organizations which holds the responsibility of conserving monuments and heritage sites around the world are the International Council on Monuments and Sites (ICOMOS) and UNESCO. It is essential for a cultural heritage site to acquire the status of a UNESCO World Heritage Site because it increases tourists intention to visit these destinations [7]. Cultural heritage sites have been very successful in generating longer stays, expanded customer base, increased commercial activities thereby having a positive impact on economies. Cultural heritage based AR applications shows digital content on top of the preserved sites and lets tourist interact with them in real time. These applications also increase the awareness relating to historic architecture and historic events of the past in a way that make it easier to understand for those who are not experts of the fields [8, 9]. Recent works support the potential of emerging

technologies including AR and smart glasses for the creation of a networked cultural heritage area. Combining this idea with the latest trends of tech devices such as smart glasses and head-worn displays, AR can be used to engage tourists by providing feature rich applications to explore tourist destinations [2, 11]. It is evident from the recent literature on digital tourism that use of emerging technologies to enhance tourist behavior and experience in the domain of cultural heritage tourism has received very limited research [10].

Overall, the main aim of the cultural heritage based AR applications is to create satisfactory and enjoyable experiences by presenting valuable digital content. A popular AR gaming application called TimeWarp is developed to let players reconstruct historic events and buildings and send players on missions within a tourist destination [12]. Games like these serve educational purpose, eases the learning process and also lets the players interact with the historic data enjoyably. Since the valuable information is presented in a manner that is new to the user, many studies supports the potential of using such engaging and interactive content in smart glasses and wearable AR applications. This novel aspect of the AR technology and the smart glasses is capable of capturing attention and create novel tourism experiences.

C. Models of Technology Acceptance for AR

To determine if a technology has been successfully implemented or not, user acceptance is generally used the key indicator [18]. According to [19], the Technology Acceptance Model (TAM) is one of the most popular and predominant model that is used to measure technology acceptance since 1986 [20]. To account for various technological characteristics the identification of external variables and their contexts is extremely important. An example of this can be seen in [21], where researchers used context-specific external variables and proved their importance to ensure their applicability. It was evident in the study of the recent literature that research focused on a company's internal IT acceptance, found social influence as a key external variable whereas research focused on consumers and e-commerce acceptance found playfulness as a key external variable. Hence, when dealing with the context of tourism and AR and smart glasses, accurately applicable external variables must be identified.

Research in the field of user acceptance of smart glasses based AR application is still in its infancy. Due to the recent technological advancements compelling use cases of AR can now be achieved however, end user services, accuracy and usability remains huge challenges. Hence, to ensure that the new applications consider the features demanded and accepted by the tourists, it has now become even more important to measure tourists acceptance. AR application design and development becomes complicated as the paradigm of what users think of human computer interaction, changes. Both academia and the industry have shown equal interest in the design and development of new AR applications however, the approaches used by them are different. Some have focused from purely technological perspective while others from behavioral [22]. Interestingly recent researches found very clear signs that external variables such as enjoyment [23], innovativeness [22], perceived benefits and information quality [24], among others, affect the acceptance of AR and smart glasses based applications. Although a number of AR applications based on smartphones can be found in the market now, recent technological advances have made other forms of AR such as smart glasses based AR possible.

3. Methods

A. Scope of Study

This study is subjected to take place at the UNESCO World Heritage Sites in Malaysia. This research aims at smart glasses based AR applications to make the whole tourist experience more enjoyable and also to promote educational awareness about these cultural heritage destinations in Malaysia. The study is aimed to utilize AR as an enhancement tool for tourists as well as to promote the sites as the cultural heritage tourist destinations. As part of the project, a Smart Glasses based wearable AR application is developed these sites. The Smart Glasses based, Touristic AR application is a marker less location based application specially designed for tourists. The application includes way finding and navigation functions such as the display of personalized POI's, videos, audios and texts.

B. Data Collection

Since the objective of the study is to map the requirements and identify the factors affecting the acceptance of Smart Glasses based wearable AR applications and suggest an AR acceptance model in the context of cultural heritage tourism, a mix of quantitative and qualitative approaches are adopted. To map the requirements, a purposive quota sampling method is used to collect the data of 20 participants. Purposive quota sampling is a non-probability sampling technique where the researcher selects participants based on certain characteristics such as knowledge, gender, age, etc. This method is used often in preliminary studies where the feasibility of the study is assessed. Research in [25] revealed that purposive sampling is the most commonly used form of non-probabilistic sampling, and the size of sample relies on "theoretical saturation" which is considered the point at which no new themes are observed in the data. To gather in-depth information about external dimensions in this research, 6 focus groups of tourists of 5 tourists each were analyzed. A focus group is a special kind of group interview conducted to collect detailed knowledge about a topic [26]. Unlike traditional one-to-one interviews, interviews of the likes of focus group offer many advantages. They bring upon various different opinions emerging from a discussion among the group participants [27]. Some scholars also suggest that qualitative research based on focus groups is considered strong due to richness of the information generated resulting from the discussion among the participants [28].

C. Data Analysis

The requirement data gathered after conducting purposive quota sampling is analyzed using an affinity diagram. Data analysis through affinity diagrams is a common analysis technique within the discipline of human–computer interaction. Using affinity diagrams allows a graphical representation of categories and constructs and is becoming a more and more popular way to analyze data, as it enables a number of research experts to analyze the data at the same time. This reduces bias, thus enhancing the reliability of findings. A technique known as thematic analysis is used in this research to devise the focus groups in the sight of external variables and sub themes. This technique is found helpful in creating themes before the analysis and sub themes are emerged during the analysis of the focus groups data. External variables are coded reviewing previous literature and conducting affinity mapping experiments. In a recent research enjoyment and personal innovativeness were declared as themes relevant to the domain of tourism [29]. The literature and the affinity diagrams are analyzed again to generate a thematic map. Table 1. Presents the outcomes of the thematic analysis. After the implementation of the model in the form of a Smart Glasses wearable AR application, to test the proposed research model with the derived constructs, a SmartPLS 3.0 based partial least squares

(PLS) regression analysis is conducted. PLS regression analysis is a widely used technique which offers many advantages. Some notables ones are working with small sample size, and few assumptions about measurement scale and normal distribution [30]. The sample size used during this research is relatively small. Therefore, SmartPLS 3.0 is used for the measurement model and structural model testing. However, remaining in the scope of this study, we mainly focus and elaborate on the constructs proposed for the acceptance model.

Table 1: Thematic Analysis

Themes	**Key findings**
External dimensions	
• Information quality	Gathering of information
	Timeliness of information
	Relevance of information
	Reliability of information
• Visual Appeal	Attractiveness
	Presentation
	Look and Feel
	Personalization
• Technology Readiness	Innovativeness
	Optimism
	Cleverness
• Facilitating conditions	Availability of hardware
	Battery life
	Connectivity
	Assistance
Perceptions	
• Perceived usefulness	Efficient Seamless
	Convenience of gathering
• Perceived ease of use	Instructions
	Costs of effort
Attitude	Favorable
	Unfavorable
Behavioral intention	
• Intention to use	Use application Download application
• Intention to visit	Favorable Unfavorable

4. Proposed Smart Glasses Augmented Reality Acceptance Model for Cultural Heritage Tourists

This study focuses on describing the methods and acceptance models of new technologies such as AR and also the attitudes and beliefs of tourists who use these technologies at UNESCO world heritage sites in Malaysia. Hence, this work explains tourist's acceptance of AR using TAM in the sight of the recent works of research of [2, 30]. After the preliminary analysis, this work also identifies technology readiness, visual appeal, information quality, and facilitating conditions as external variables and factors that may influence beliefs of visitors, their attitudes and intention of usage (Figure 1).

D. Information Quality and AR technology perception

Many researchers in the TAM related domain have affirmed the significance of information quality for perceived usefulness and perceived ease of use. While studying the impression of early adopters concerning AR benefits, the authors of [24] uncovered that "the most valuable mobile AR services were those demonstrating pragmatic usefulness for the user, e.g. by saving time and effort". They found out that AR adopters like extremely rich and high quality information based on contextual data. Quality dimension is of great significance and this has been supported by many recent works [24, 30, and 31]. The importance of information quality for users' acceptance of AR specifically, has been emphasized by the authors of [24]. As a result of the thematic analysis in many studies, themes relating to information quality have been found. It is noted that the importance of gathering information through the AR application, its relevance, attractiveness and specially its timeliness is highlighted by the participants. Some authors suggest the business must focus on creating content that is visually attractive and based of accurate information to create engaging experiences for the tourists [35]. During the recent research conducted on TAM, a number of researchers confirmed that perceived usefulness and perceived ease of use are directly proportional to the information quality. This can be seen in an example of a research on electronic cheque clearing systems acceptance where authors reported a higher effects of information reliability and quality on perceived usefulness and ease of use [36]. Similar conclusions have been made in the fields of mobile-service acceptance and tourism augmented reality [34, 37]. Based on the results gathered during the preliminary analysis and the study of the recent works, the research proposes its first two hypothesis as following:

H1a: Perceived Usefulness will be influenced by information quality.

H1b: Perceived Ease of Use will be influenced by information quality.

E. Visual appeal and AR technology perception

Visual appeal improves the overall look and feel of an information system. It relates to the presentation of colors, fonts and other graphics present in the system. During the research it was found that visual attractiveness could possibly be key factor to improve the overall tourist experience, especially in case on emerging technologies such as smart glasses and AR [38]. It is also evident from the literature that more enjoyment can be derived interacting with an information system which is visually appealing. Therefore, it can be concluded that visual appeal is a construct that must form among the basic elements of an information system. Some of the recent studies have introduced newer constructs such as perceived visual appeal and showed how such contracts effect the use of perceived usefulness and perceived ease of use[30].

As discussed earlier in this work, emerging technologies such as AR and smart glasses have become very popular and have been used in various domains. These have also been used in some of the application relating to the domain of tourism. The literature suggest that these applications reshape the users world view by overlaying digital content and that the UI and interactive mechanisms and their familiarity with them can directly affect perceived usefulness and perceived ease of use of AR applications [24, 30 and 32]. Hence, two hypothesis have been proposed to carry forward this research. They are:

H2a: Perceived Usefulness will be influenced by visual appeal.

H2b: Perceived Ease of Use will be influenced by visual appeal.

F. Technology readiness and AR technology perception

A number of crucial works of the past counts Technology Readiness (TR) as a predictor of TAM beliefs [30]. According to TAM, users

beliefs directly effects the usage behavior and intention thereby effecting the acceptance of an information system. In a voluntary environment, TAM has sometimes been found insufficient to measure the acceptance of technology. Hence, in addition to that, TR has been introduced which is based on the propensity of the users to accept the use of new technology in the domain of tourism. It consists of two major elements which are: innovativeness and optimism. Although TR's original dimensions also include discomfort and insecurity but most of the literature on the subject focuses on innovativeness and optimism due to their positive aspects and higher impact rates [39]. Hence, in this study also these two positive aspects of TR considered. A recent research extended TAM with TR to address personal differences by introducing a new model of acceptance called TRAM [40]. This model suggests that due to the interaction of a user with other emerging technologies, the user general perception towards a new technology if affected. Considering these arguments in this research, following two hypotheses are proposed:

H3a: Perceived Usefulness will be influenced by TR.

H3b: Perceived Ease of Use will be influenced by TR.

G. Facilitating conditions and AR technology perception

The necessary conditions in the context of new technology usage are called facilitating conditions as they are essential to support the use of a new technology [41]. AR is a front line technology, and individuals will think that it is less demanding to interact with AR given better facilitating conditions. In this study facilitating conditions are defined as the "the degree to which the user believes that usage of AR and smart glasses is supported by the technical infrastructure surrounding it". By the nature of these conditions they are considered as an external control and can be tricky to measure in unappropriated situations. In other words, it can be said since facilitating conditions support the use of new technology, they are considered as the key factors in the context of usage of new technologies. Hence, it can be concluded that since AR and smart glasses are cutting-edge technologies, tourists will definitely be able to use them better under supportive facilitating conditions. Many recent studies have concluded that users perceived ease of use can be influenced facilitating conditions [33]. Also, it is evident from the study of the literature that the beliefs about the technology are also influenced due to better facilitating conditions they enhances users desire to carry out a task. Hence, it can be concluded that those users who perceive high facilitating conditions are more likely to perceive AR and smart glasses as an easier to use technology. Therefore, the following hypothesis are proposed in the light of above discussion:

H4. Facilitating conditions will influence AR perceived ease of use.

H. AR technology perception and AR attitude

Perceived usefulness, perceived ease of use and attitude to decide one's intention to use the technological instrument can all be considered as variables of TAM. TAM assumes that individuals are probably going to adopt a new technology to the extent that they believe it would help them to perform their duty and to the extent they believe interacting with a new technology would be free of cognitive effort. Perceived usefulness is the case to which a person's expectation that using a particular technology will enhance his or her task efficiency. Perceived ease of use refers to the state that using a particular technology will be free of effort. Perceived usefulness and perceived ease of use are essential creation in the TAM that create a critical impact on approach toward technology use, which influences the behavior of the users to use the technology. Therefore, the following hypothesis are proposed in the light of above discussion:

H5. AR perceived ease of use will influence AR perceived usefulness.

H6. AR perceived usefulness will influence AR attitude.

H7. AR perceived ease of use will influence AR attitude.

I. AR attitude, AR usage intention, and destination visit intention

The attitude of the user towards new and emerging technologies have been found capable of influencing the decision making abilities the user. Similarly in the domain of information systems, tourism and hospitality, the intention to use a technology and the attitude of the user towards a new technology has also been found to influence each other directly. Hence it can be concluded that the behavioral intention to use new technology is directly determined by the users attitude towards it. In a recent work, researchers found out that in the domain of consumer generated media and tourism, behavioral intention and attitude have significant influence on each other [21]. This work defined the positive feelings for AR as the attitude towards AR. They concluded

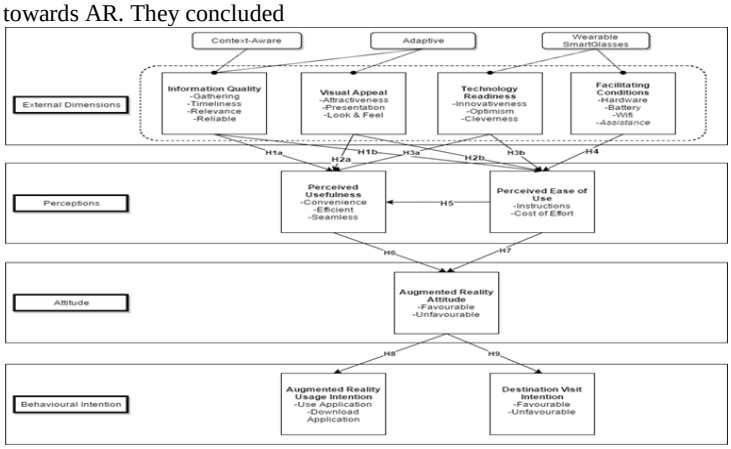

Figure 1: Proposed acceptance model

in their experiments that If those users whose scores high for positive feelings towards were more likely to experience AR and new technologies again. Hence it is evident that AR usage intention can be enhanced by improving the attitude towards AR.

Emerging technologies such as AR and smart glasses are crucial elements in the new tourism era, hence many recent works have attempted to link tourism and emerging tech together. This work is focused on measuring its utilization effects on tourist' experiences and behaviors. Similar to any other form of tourism, tourists at heritage sites and destinations form either positive or negative attitudes toward AR. Travel intention of tourists is influenced by a tourists' image of a destination or country. In addition, some researchers insisted that using traditional technologies like a travel diary, a tourist website or a travel guide is a motivation for tourists to visit that destination. Hence, using AR and emerging technologies creatively as an educational, promotional or marketing tool to form positive image about the destinations can increase their willingness to visit these destinations. Therefore, the following hypothesis are proposed in the light of above discussion:

H8. AR attitude will influence AR usage intention.

H9. AR attitude will influence destination visit intention.

5. Conclusion and Future Works

This paper aims at figuring out the gaps in the current smart glasses AR acceptance research implemented in the domain of tourism. It also identifies various external variables and explains their importance in order to prove their importance for AR and smart glasses acceptance and enhancing the overall tourism experience. The research area of this work is still in its infancy and hence carries a great potential. Therefore the indication of the external variables can be of immense value towards increasing the AR acceptance rates. Figure 1 above presents the AR acceptance model including external variables found applicable for the AR applications to be implemented in the domain of tourism. In the proposed model, technology readiness, information quality, facilitating conditions and visual appeal influence the perceived ease of use and perceived usefulness. Moreover, the proposed AR acceptance model, similar to the previous research of [30] and [34] suggests that' perceived ease of use and perceived usefulness has a positive effect towards user's attitude. This attitude has direct effects over the behavioral intention to use these new technologies and hence it can influence the actual usage behavior and intention to visit behavior. As this work aimed to discuss the methods needed to map the requirements and propose an AR acceptance model, we aim to implement and validate the model in the next phase of this study by developing a wearable Smart Glasses based AR application for tourists visiting the UNESCO World heritage sites in Malaysia.

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