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Predicting the Application of Huawei Augmented Reality on Media Façade: Using the TAM Model

Yan Chen [1,2], Shanshan Liu [3,*], and Jong Yoon Lee [4]

1 SangMyung University, Korea, Ph.D Student; 269663313@qq.com
2 Zhejiang University of Finance & Economics, China; 269663313@qq.com
3 Nanyang Institute of Technology, Lecturer; shanshan892@hotmail.com
4 SangMyung University, Korea, Professor; jongyoonlee1@smu.ac.kr
* Correspondence

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Abstract: *In recent years, large-scale and high-density use of LED on facades has exposed some disadvantages, such as light pollution, high energy consumption, unsustainability, and poor interactivity. Because of the development of smartphones and augmented reality (AR), AR has emerged as a new technology available to users to interact with the media façade. As an augmented reality app for public space, the AR map app can superimpose virtual images on the surface of a building to form an AR media façade, which can be applied in the fields of navigation, advertising, interactive public art, smart retail, etc. This study establishes the variables influencing usage intention and the consequent outcomes of Huawei AR map app and uses the technology acceptance model (TAM) to discuss their relationship. Results show that consumer innovativeness, information quality, and design quality have a strong influence on perceived ease of use. Information quality has a positive impact on perceived usefulness, but design quality has a weak influence. Also, the design quality of Huawei AR map app and consumer innovativeness have a higher effect on perceived enjoyment than information quality. Users' usage attitude and perceived usefulness when using Huawei AR map app are key factors determining their usage intention. This study inspires city planners, architects, developers, and designers of AR apps that augmented reality can partly replace media façade, and that investment in augmented reality will achieve significant sustainable economic and social benefits.*

Keywords: Media Facade; Mobile Application; Augmented Reality; Technology Acceptance Model; Huawei

1. Introduction

In the early 2000s, media facade, as a medium, mainly refers to the integration of LED display and architecture skin, which is used to attract residents, visitors, and tourists in the hours after dark. And it mainly functions to enrich the nighttime image of a city by creating a visually stimulating atmosphere. However, large scale and high-density use of LED on the facade has some disadvantages, such as light pollution, high energy consumption, unsustainability, and poor interactivity. With the development of mobile devices, AR apps can be used to interact with media façade. The video on a smartphone can be a substitute for the one on media façade via AR. Therefore, multi-media screens which combine AR with media façade can partly avoid the above shortcomings.

Two primary kinds of AR apps have been used to enhance the function of the media façade. One is the comprehensive application based on social media, such as Tiktok and Snapchat. The other is the extended application scenarios based on AR maps and AR navigation, such as Huawei, Google map, Nokia, etc. Nokia has shown off the "city lens" in 2012. Google combined VPS with Google Maps in 2017. However, previous explorations of many companies were not successful in business. As a provider of mobile devices and related services, Huawei launched the AR map app powered by Cyberverse technology, on Apr 8th, 2020. This app aimed to seamlessly combine the real world with the virtual world and to realize the commercial application of 5G. Spatial computing of Cyberverse enabled the smartphone to calculate centimetre-level positioning, and therefore realize many application scenarios, such as navigation, tourism guide, and intelligent retail.

Furthermore, because of the ban by the US government, Huawei has to self-rescue to unveil a batch of new innovation plans to build its independent ecosystems and plans constantly improve and update Cyberverse, which will be applied in wearable devices, electric vehicles, etc. The Cyberverse will be the milestone AR technology of Huawei's independent ecosystems. Thus, the Huawei AR map app can be analyzed as a case in the transitional stage of AR devices from smartphone to wearable device and electric vehicle.

Figure 1. AR map app supported by Cyberverse technology

Huawei AR map app couldn't be defined separately as a map, navigation, public art, nor interactive games, etc., but an AR ecosystem application integrating all functions above. Some inserts of virtual visible information via Cyberverse technology look like existing in the space alone, and some look like superimposing on media facades or other surfaces of urban space. The superimposed one could functionally replace or augment the media facade. When aimed at a landmark, AR content on the phone can be clicked to get more information or to activate the image attached to that landmark facade. Huawei AR map app has been widely used to replace the functions of media façades in tourism, business district, and urban public space. In the tourism scenario, it is used in Mogao Grottoes in the Northwest of China. In the business scenario, it is used in the commercial space of Beijing, Shanghai, and Shenzhen. AR map app is not as enforced as traditional media façade with high brightness and large scale which is too compulsive to be ignored for one who will be attracted by it for a while, so that people can choose whether to use this app to see the virtual image superimposed on media facade via AR. Therefore, this study intends to find out whether AR is effective in replacing or augmenting the media façade. Moreover, to improve the usage of this type of apps, it is necessary to analyze the use intention and related variables of the AR map app by TAM.

On a theoretical level, the present study will contribute to the existing stream of technology acceptance research by providing insights for AR as an essential trend in the media facade. From a practical perspective, this study provides valuable insights for the further development and commercialization of AR.

2. Literature Review

2.1. The Disadvantage of Traditional Media Facade

The concept of media facade emerged in the 1990s.It is defined by Heausler M. Hank as any external building surface with an integrated capacity to display dynamic graphics, images, texts, and spatial movement[1]. The disadvantages of media façade are emerging with the rapid and large scale use of it.

- Energy consumption

Menéndez found that media façade requires more energy consumption, which represents a higher cost in the building management, and must get to grips with ecological compatibility issues[2].

- Visual and light pollution

Seung Ji Lee argued that artificial lighting of media façade which is designed without considering the characteristics of the site could cause visual and light pollution[3]. This light pollution is harmful to human health and potentially causes long-term harm to animals and plants[4]. When displays are visually too bright compared to the surroundings, they will restrict the pupil in the eyes of human and negatively affect movement of pedestrians and drivers[5].

- Obvious risk investment

Marcus Foth et al. mentioned that establishment of an urban screen is significantly associated with investment into human resources, technology platforms and support, screen operations and maintenance, client liaison, content curation and developing content partnerships, content licensing costs, and investment in events around these screens. This amounts to millions of dollars in highly visible risk investment over the life of any one screen. [6].

Thus, the International Commission on Illumination (CIE) requires immediate action to reduce the impact of artificial light at night (e.g., media facade) on all end-users (flora, humans, and fauna), to encourage respect for the nighttime urban landscape, while at the same time, to support business and event advertising, and ensure easy navigation and wayfinding in cities[7]. With the continued improvement of AR devices and apps, AR can be considered as an additional option to nullify the disadvantages of media façade by replacing or augmenting media façade. Căplescu proposed that bringing new media in architecture will offer an alternative but doesn't mean the end of previous ones[8]. In other words, using AR in public space does not put an end to the media façade but will offer an opportunity to rethink and redefine the media facade.

2.2. Augmented Reality

Milgram first proposed the concept of "virtuality continuum" in 1994 to separate the terms of augmented reality, augmented virtuality, and mixed reality to explain the relationship between the real environment and virtual environment, as illustrated in Figure 2.The term augmented reality is used to refer to any cases in which an otherwise real environment is "augmented" through the virtual object (e.g., computer graphic)[9].

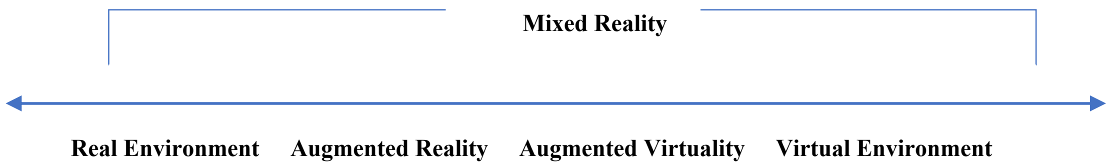

Figure 2. Milgram's Reality-Virtuality Continuum (1994)

Additionally, Lev Manovich first coined the term augmented space in 2002. He defined it as the physical space overlaid with dynamically changing information[10]. He mentioned that the vast electronic screen on the building and small screen on the mobile device could be interfaces of "data-dense" augmented space to communicate and interact, allowing architects to rethink the practice. The relationships of media façade augmented reality and augmented space is briefly summarized in Figure 3. Meanwhile, in augmented space, leveraging existing visual and spatial skills to increase the user's interaction capabilities is more important than enhancing a user's perception of the real world by superimposing generated digital information[11]. Thus, interaction design and information quality are two key factors of augmented space which combines media façade and augmented reality.

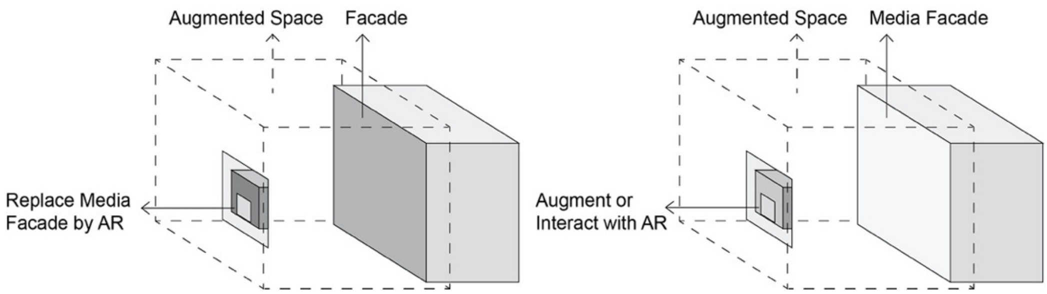

Figure 3. Augmented reality, augmented space, and media façade

In the tourism scenario, AR technology can play a significant role[12, 13]. Andreas et al. explored the use of handheld AR for outdoor navigation and superimposed AR imagery showing 2D or 3D virtual images on the live camera view. They found that the interface in which users could switch between AR and Map views was rated by the participants as the most helpful in finding points of interest in their surroundings[14]. Philipp and Rauschnabel argued that AR can replace physical things and add new functions that the replaced one doesn't have. For example, a wall painting in AR may be less expensive (i.e., "better"), and it may also have additional features that physical counterparts typically do not have (e.g., interactive content)[15]. Media façade is used for advertising and marketing frequently. Therefore, media façade could be replaced by AR to reduce light pollution and the waste of electricity.

IT companies believe that AR will experience a breakthrough in the market once it is integrated with wearable devices that users can operate "hands-free" [15]. That easy handling plays an essential role in accepting technologies means that the beneficial usage of AR should not require a high cognitive effort[16]. AR map app will be transferred from smartphones to wearable devices in the future. This study aims to find the relationship between variables and critical factors, and how they impact the usage intention.

2.3. Technology Acceptance Model（TAM）

Davis et al.（1989）built TAM to assess and forecast users' acceptance of the IT system[17]. Some scholars have studied and amended the original model and strengthened its explanatory power on the app and device of AR. Claudia and Timothy proposed an AR acceptance model in the context of urban heritage tourism, including information quality, system quality, costs of use, recommendations, personal innovativeness, and risk, as well as facilitating conditions[18]. Hui Fei and Chi Hua added media richness and self-efficacy variables to the existing TAM to examine user attitudes and behavioural intention toward the use of AR in a virtual museum[19]. Other previous studies have shown the general applicability of TAM in the context of AR [16, 20-22]. In summary of findings from the above literature, it can be concluded that fit, reliability, and validity of TAM when applied to AR tourism and navigation are all highly suitable, our study therefore adopts it as the research framework.

3. Research Framework and Hypothesis Development

3.1. Research Framework

After propounding TAM in 1989[23], Davis et al. has added perceived enjoyment as the third element to TAM to explain user acceptance. And they concluded that perceived enjoyment has a significant effect on the intended use of new technologies[24]. In 2007, Kim et al. built a value-based adoption model to study the user behavior of mobile Internet[25]. Kim divided perceived gains into usefulness and enjoyment, both of which will impact behavioral intention to use. Verkasalo combined perceived enjoyment with TAM and found that perceived enjoyment is directly related to intention to use smartphone applications [26]. Ji-Won Moon et al. added perceived playfulness to TAM and found that perception of playfulness appear to influence user's attitude toward using the World-Wide-Web[27]. The AR map app has an entertainment function, so perceived enjoyment is also included in the variable factors. With TAM as the basis, this study introduces design quality as a new variable. It takes this new model to explore the level of use of AR map apps by users when searching for tourism information or navigating with AR technologies.

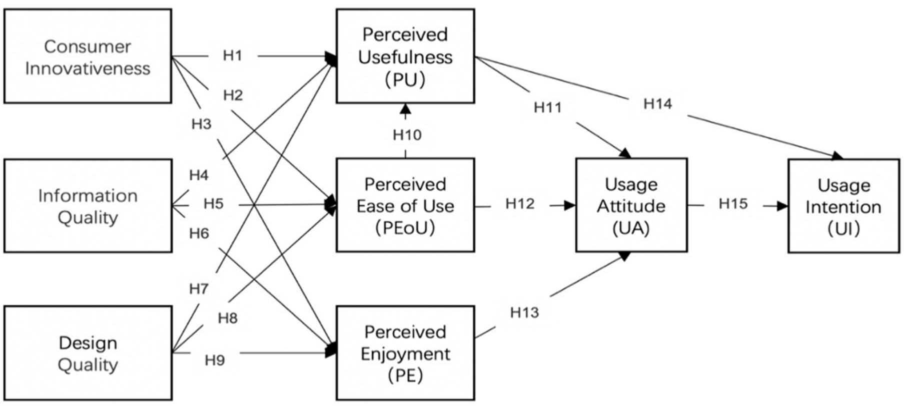

Figure 4. Modified technology acceptance model (TAM) framework

3.2. Consumer Innovativeness

Customers should have a degree of innovativeness in order to adopt this AR app. Manzano et al. confirmed that consumer innovativeness accelerates the adoption of new technologies[28]. Consumer innovativeness has a positive impact on innovation adoption behavior[29]. Venkatesh et al. found that consumer innovativeness affects new product adoption[30].

Hypothesis 1 (H1). Consumer innovativeness positively affects perceived usefulness towards AR map application.

Hypothesis 2 (H2). Consumer innovativeness positively affects perceived ease of use towards AR map application.

Hypothesis 3 (H3). Consumer innovativeness positively affects perceived enjoyment towards AR map application.

3.3. Information Quality

Concerning AR applications, Olsson et al. regard the usefulness of information (perceived informativeness) as well as their entertaining effect providing fun (perceived enjoyment) as two important factors[20]. Rese et al. argue that perceived informativeness influences the mobile IKEA catalogue app's perceived usefulness with AR features[21]. The study of Kim and Hyun shows that information quality is an important antecedent of usefulness in the revised TAM model and has indirect effects on the intention to reuse AR[31]. In summary, we propose Hypotheses 4, 5, and 6.

Hypothesis 4 (H4). The information quality of the AR map app positively affects perceived usefulness.

Hypothesis 5 (H5). The information quality of the AR map app positively affects perceived ease of use.

Hypothesis 6 (H6). The information quality of the AR map app positively affects perceived enjoyment.

3.4. Design Quality

Hall and Hanna argued that the aesthetic factor score of design quality proved to be significantly related to behavioral intention[32]. Jennings noted that principles of aesthetics in design focus principally on visual perception, which is important because they create first impressions that result in the desire to explore further[33]. Tony et al. [34] mentioned that design quality as a measure of system quality provides users with more convenience, enhances privacy, and reduces information-seeking time.

Hypothesis 7 (H7). The information quality of the AR map app positively affects perceived usefulness.

Hypothesis 8 (H8). The information quality of the AR map app positively affects perceived ease of use.

Hypothesis 9 (H9). The information quality of the AR map app positively affects perceived enjoyment.

3.5. Perceived Usefulness, Perceived Ease of Use, and Perceived Enjoyment

TAM shows that perceived ease of use affects perceived usefulness because easy-to-use technology may be more useful[35]. It has been found that perceived ease of use also has a direct impact on perceived usefulness. Therefore, we determine that perceived ease of use positively affects perceived usefulness. Davis et al. found that perceived usefulness and perceived ease of use both have a significant influence on usage intention through usage attitude[17]. They also found that perceived enjoyment had a significant effect on users' intention to use computer programs in the workplace[24]. El Shamy and Hassanein stated that perceived enjoyment is one of the key variables in the intention to use innovative wearable devices[36]. Shin found that the pleasure of using AR improves satisfaction[37]. Park et al. also found that perceived enjoyment impacts usage attitude about mobile games[38]. Therefore, based on the existing literature, we propose the following hypotheses.

Hypothesis 10 (H10). The perceived ease of use of the AR map app positively affects perceived usefulness.

Hypothesis 11 (H11). The perceived usefulness of the AR map app positively affects usage attitude.

Hypothesis 12 (H12). The perceived ease of use of the AR map app positively affects usage attitude.

Hypothesis 13 (H13). The perceived enjoyment of the AR map app positively affects usage attitude.

Hypothesis 14 (H14). The perceived usefulness of the AR map app positively affects usage intention.

3.6. Usage Attitude

That usage attitude directly affects usage intention was found by Davis et al. in 1989[17] and has been a common theme among many academics[39, 40]. Therefore, we propose Hypothesis 15.

Hypothesis 15 (H15). The usage attitude of the AR map app positively affects usage intention.

4. Research Methods

4.1. Sampling Design and Data Analysis

This study aims to examine the usage intention and the usage attitude of users on Huawei AR map app. Because of the unpopularity of this app, all respondents selected have been asked to watch the demo video? and then try out this app. The data were gathered from 305 persons who lived in China between November and December of 2020. Following data cleansing and removing those questionnaires that obtained missing values, the sample consisted of 271 valid responses. The survey used Wenjuanxing app, which provides functions equivalent to Amazon Mechanical Turk. The demographic characteristics of the respondents are shown in Table 1.

Table 1. Demographic characteristics of respondents

Group		Frequency	Percentage
Gender	Male	124	45.8
	Female	147	54.2
Age	18~29	135	49.8
	30~39	106	39.1
	40~49	24	8.9
	>50	6	2.2
Education	High school	7	2.6
	Junior college	46	17
	Bachelor degree	140	51.7
	Master degree	57	21
	Doctor degree	21	7.7
Job	Student	61	22.5
	Company employee	72	26.6
	Civil servant	72	26.6
	Private owner	30	11.1
	Housewife	13	4.8
	Others	23	8.5
Annual salary	Less than 50 thousand CNY	74	27.3
	50-100 thousand CNY	57	21
	100-200 thousand CNY	78	28.8
	200-300 thousand CNY	34	12.5
	More than 300 thousand CNY	28	10.3

Note: All currency is given in CNY (Chinese Yuan); CNY 6.5 = US$1 (Date: Jan 1st, 2021).

4.2. Questionnaire Design and Operational Definitions

This study considers the constructs of consumer innovativeness, information quality, design quality, perceived usefulness, perceived ease of use, perceived enjoyment, usage attitude and usage intention to analyze

AR map app adoption. Three or four items from previous studies were used to measure each construct. The questionnaire items are shown in Table 2. All items are measured with a five-point Likert-type scale ranging from 'strongly disagree (=1)' to 'strongly agree (=5)'. Four scholars in the field of AR and media facade were invited to review the questionnaire for content validity, and the research questionnaire has 31 questions in total.

Table 2. Questionnaire items in the main survey

Construct	Item	Measurement items	Reference
Consumer Innovativeness	CI1	I'm open-minded toward new products and product innovations.	Thomas et al. [41], Jon-Chao et al.[42]
	CI2	I have a positive attitude toward innovations.	
	CI3	I would be willing to renounce well-established products for new product innovations.	
	CI4	I would be interested enough to use it when I heard a new app is available in the app store.	
Information Quality	IQ1	The AR map app can provide useful information.	Rese et al.[21], Choi & Choi [43]
	IQ2	The AR map app provides information that helps me in my decision.	
	IQ3	The AR map app can provide immediate information.	
	IQ4	The AR map app shows the information I expected.	
Design Quality	D1	The design of the AR map app is as accurate as it should be.	Juyeon et al.[44], Tony et al.[34], Ahn et al.[34]
	D2	AR map app has a refined interface design.	
	D3	The visual presentation (graphics, video) of the AR map app is attractive.	
	D4	AR map app has an appropriate interaction design.	
Perceived Enjoyment	PE1	Using the AR map app is really fun.	Rese et al.[21], Junghyo et al.[39], Kim et al.[45], Holdack et al.[22]
	PE2	It is fun to discover the scan function and the elements of AR.	
	PE3	The function of the AR media façade of the AR map app is really fun.	
	PE4	Using AR map app to watch videos embedded on the building façade is funner than that on the traditional LED media façade.	
Perceived Usefulness	PU1	Using the AR map app would be useful in my daily routine.	Davis[17], Rese et al.[21]
	PU2	Using the AR map app can improve my efficiency.	
	PU3	For me, the AR map app has greater value than traditional LED media façade.	

	PU4	Using the AR map app would improve the quality of my navigation and tour.	
Perceived Ease of Use	PEoU1	It's easy to learn how to use the AR map app.	Davis[23], Venkatesh and Davis[46]
	PEoU2	Using an AR map app does not require much mental effort.	
	PEoU3	Interacting with the AR map app would be clear and understandable for me.	
	PEoU4	The AR map app is easy to use.	
Usage Attitude	UA1	I want to learn more about the AR map app to watch videos embedded on the building façade in the future.	Junghyo et al.[39], Porter and Donthu[40]
	UA2	Compared to the time spent, the AR map app will be useful to me.	
	UA3	The use of the AR map app to watch videos embedded on the building façade in the future will be valuable.	
	UA4	Compared to the effort put into it, the AR map app will benefit me.	
Usage Intention	UI1	I will use the AR map app regularly to watch videos embedded on the building façade in the future.	Davis[23], Junghyo et al.[39], Sohn et al.[47]
	UI2	I would like to use the AR map app as first choice of navigation and tour app.	
	UI3	I will recommend AR map app to my friends.	

5. Empirical Analysis and results

5.1. Reliability and Validity Analysis

The reliability and validity of the data should be tested before the model is constructed. Cronbach's alpha is used as the criterion for reliability, and its values range from 0.891 to 0.942. Therefore, the questionnaire is considered highly reliable. The convergent validity can be texted by using average variance extracted (AVE), composite reliability (CR), and component loading. The component loadings are between 0.612–0.885, and put another way, they all meet the component loading standard of 0.5 and above. The analysis results also show that each research variable has AVE > 0.685 and CR > 0.896, as shown in Table 3. Therefore, research variables of our study are considered to have good convergent validity.

Table 3. Reliability and validity analysis results

Construct	Item	Estimate	S.E.	C.R.	P	Cronbach's α	Component Loading	CR	AVE
Consumer Innovativeness	CI4	0.718				0.894	0.781	0.896	0.685
	CI3	0.85	0.086	13.342	***		0.840		
	CI2	0.863	0.091	13.517	***		0.885		
	CI1	0.871	0.091	13.631	***		0.856		
Information Quality	IQ1	0.937				0.936	0.833	0.937	0.788
	IQ2	0.928	0.036	27.719	***		0.845		
	IQ3	0.823	0.045	20.063	***		0.771		

	IQ4	0.859	0.041	22.299	***		0.808		
Design Quality	DQ4	0.913				0.923	0.763	0.924	0.755
	DQ3	0.901	0.042	23.08	***		0.818		
	DQ2	0.846	0.048	20.01	***		0.808		
	DQ1	0.812	0.053	18.366	***		0.765		
Perceived Usefulness	PE1	0.923				0.924	0.767	0.926	0.759
	PE2	0.925	0.04	25.981	***		0.765		
	PE3	0.765	0.044	16.824	***		0.762		
	PE4	0.864	0.045	21.769	***		0.696		
Perceived Ease of Use	PU4	0.894				0.937	0.833	0.936	0.787
	PU3	0.896	0.047	22.006	***		0.761		
	PU2	0.868	0.047	20.509	***		0.796		
	PU1	0.892	0.047	21.78	***		0.780		
Perceived Enjoyment	PEoU1	0.899				0.942	0.822	0.943	0.805
	PEoU2	0.925	0.04	24.618	***		0.812		
	PEoU3	0.935	0.04	25.322	***		0.820		
	PEoU4	0.828	0.049	19.034	***		0.739		
Usage Attitude	UA4	0.86				0.891	0.720	0.896	0.685
	UA3	0.701	0.068	13.273	***		0.701		
	UA2	0.873	0.052	18.766	***		0.612		
	UA1	0.866	0.055	18.504	***		0.692		
Usage Intention	UI1	0.916				0.937	0.777	0.936	0.831
	UI2	0.915	0.043	24.479	***		0.745		
	UI3	0.904	0.044	23.779	***		0.823		

*p <0 .05, **p <0 .01, ***p <0 .001

CMIN=769.842(df=406, p=0.00), CMIN/DF=1.896, RMR=0.026, GFI=0.845, NFI=0.91，

IFI=0.955,TLI=0.948,CFI=0.955, RMSEA=0.058

Generally, the value range of inter-factor correlation should be between - 1 and 1. The larger the absolute value is, the more stable the correlation between variables is. Based on this standard, this study analyzes the relationships of eight variables. From table 4, we can see that most potential factors were significantly correlated at the level of 0.01, indicating that all of them were significantly correlated.

Table 4. Internal consistency and correlations between constructs

	Consumer Innovativeness	**Information Quality**	**Perceived Enjoyment**	**Design Quality**	**Perceived Usefulness**	**Perceived Ease of Use**	**Usage Attitude**	**Usage Intention**
Consumer Innovativeness	1							
Information Quality	0.170**	1						

Perceived Enjoyment	0.389**	0.445**	1					
Design Quality	0.272**	0.509**	0.619**	1				
Perceived Usefulness	0.251**	0.643**	0.518**	0.481**	1			
Perceived Ease of Use	0.422**	0.523**	0.492**	0.451**	0.615**	1		
Usage Attitude	0.262**	0.552**	0.556**	0.579**	0.629**	0.604**	1	
Usage Intention	0.353**	0.462**	0.447**	0.466**	0.566**	0.547**	0.600**	1

Note: *Correlation is significant at the 0.05 level (1-tailed).**Correlation is significant at the 0.01 level (2-tailed).

5.2. Structural model evaluation

After the initial assessment of the measurement model, the structure equation modeling (SEM) is conducted to test the proposed paths by maximum likelihood estimation (MLE). The fit measure CMIN / DF is 1.967, which conforms to the standard of CMIN / DF < 3. RMR is 0.037, which conforms to the standard of RMR < 0.05. GFI is 0.836, which doesn't conform to the standard of GIF > 0.9. NFI is 0.904, which conforms to the standard of NFI > 0.9. IFI is 0.95, which conforms to the standard of IFI > 0.9. TLI is 0.944, which conforms to the standard of TLI > 0.9. CFI is 0.95, which conforms to the standard of CFI > 0.9. RMSEA is 0.06, which conforms to the standard of RMSEA < 0.1. Except GFI, which is close to the standard of larger than 0.9, all the other fit indexes meet the standard, as shown in table 5. The research results indicate that the model established in this study has a high degree of the fitting. Conclusion from the model is reasonable.

Table 5. Structural equation model (SEM) analysis

Hypothesis	Relationship			Estimate	Standard Estimate	S.E.	C.R.	P	Assessment
H1	Perceived Usefulness	<-	Consumer Innovativeness	-0.049	-0.055	0.058	-0.958	0.338	Not Supported
H2	Perceived Ease of Use	<-	Consumer Innovativeness	0.282	0.318	0.062	5.095	***	Supported
H3	Perceived Enjoyment	<-	Consumer Innovativeness	0.233	0.275	0.062	4.449	***	Supported
H4	Perceived Usefulness	<-	Information Quality	0.392	0.45	0.07	6.448	***	Supported
H5	Perceived Ease of Use	<-	Information Quality	0.369	0.422	0.069	6.075	***	Supported
H6	Perceived Enjoyment	<-	Information Quality	0.13	0.156	0.067	2.326	0.02	Supported

H7	Perceived Usefulness	<-	Design Quality	0.177	0.177	0.058	3.073	0.00 2	Supported
H8	Perceived Ease of Use	<-	Design Quality	0.276	0.275	0.061	4.5	***	Supported
H9	Perceived Enjoyment	<-	Design Quality	0.552	0.577	0.066	8.75	***	Supported
H10	Perceived Usefulness	<-	Perceived Ease of Use	0.362	0.364	0.066	5.507	***	Supported
H11	Usage Attitude	<-	Perceived Usefulness	0.373	0.355	0.061	5.793	***	Supported
H12	Usage Attitude	<-	Perceived Ease of Use	0.311	0.297	0.061	4.839	***	Supported
H13	Usage Attitude	<-	Perceived Enjoyment	0.275	0.251	0.048	5.186	***	Supported
H14	Usage Intention	<-	Perceived Usefulness	0.233	0.264	0.078	3.379	***	Supported
H15	Usage Intention	<-	Usage Attitude	0.582	0.692	0.087	7.912	***	Supported

*p <0 .05, **p <0 .01, ***p <0 .001

CMIN=818.176(df=416, p=0.00),CMIN/DF=1.967,RMR=0.037, GFI=0.836, NFI=0.904, IFI=0.95,TLI=0.944,CFI=0.95, RMSEA=0.06

5.3. Results

SEM is used to calculate path coefficients, standardized regression coefficients estimates, and critical ratios, as demonstrated in Table 5 and Figure 5. When the consumer innovativeness corresponds to perceived usefulness, the pathway coefficient is -0.05, and the p-value (0.338) is more significant than 0.05, indicating that the impact of this variable is not supported. The p-value of H6, H7 are from 0.002 to 0.023, which means the relationships of those variables are weak. Other variable relationships all show good and significant influences. Therefore, all the hypotheses are supported except H1.

Consumer innovativeness, information quality and design quality have a great influence on perceived ease of use, which means the higher consumer innovativeness, information quality and more attractive design of Cyberverse AR systems will lead to the better perceived ease of use of the consumer. Consumer innovativeness doesn't have a significant impact on perceived usefulness. Information quality has a positive effect on perceived usefulness, but design quality has a weak influence. In other words, user experiences greater perceived usefulness when the AR map app provides a higher quality of information. From H3, H6 and H9, we can find that the design quality of AR map apps and consumer innovativeness have a greater influence on perceived enjoyment compared with information quality. Hypothesis H10 indicates that the perceived ease of use of the AR map app influences a consumer's perceived usefulness with the new technology. The results of H11, H12 and H13 show that the degree of usage attitude of the user with the AR app increases with increasing perceived usefulness, perceived enjoyment and perceived ease of use. The results of H14 and H15 confirm that users' usage attitude and perceived usefulness when using the AR map app are important factors in determining their level of usage intention of this app.

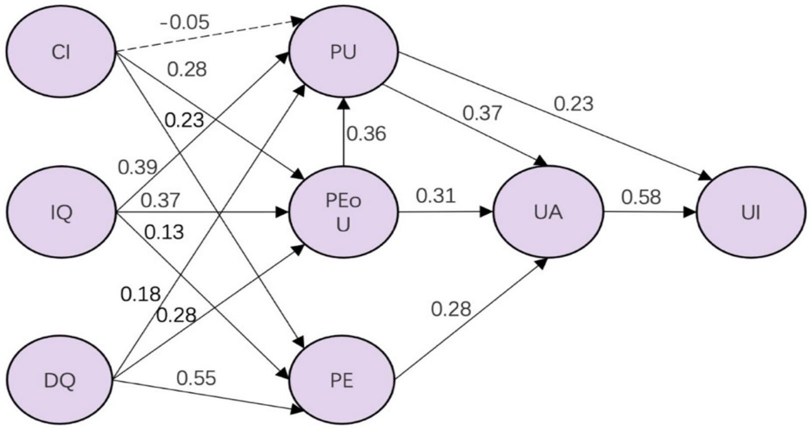

Figure 5. Path relationships between variables

6. Conclusion and limitation

6.1. Conclusion

Although the application of AR regarding media facades is in its infancy, this research provides developers and researchers with practical and theoretical insights for the use of AR to augment or partly replace the traditional LED media facade. Firstly, users with higher consumer innovativeness feels easier and funnier to use the AR map app to watch videos embedded on the building façade. This inspires designers of AR map app that users who have higher consumer innovativeness are potential users. Secondly, designers can raise perceived usefulness by improving the perceived ease of use and information quality. Thirdly, design quality can make users more immersed while using the app and feel more enjoyable. Fourthly, that perceived usefulness, perceived enjoyment and perceived ease of use positively affect usage attitude inspires city planners and architects that AR map app can partly replace the traditional LED media façade. Thus, if such an AR app is well accepted and widely used to replace or augment the media facade, energy consumption, light pollution, and visible risk investment on the media façade will be reduced to a certain extent. Finally, this AR map app is designed as an AR platform in public space. It is equipped with navigation, map, interactive public art, advertising, billboard, media façade, etc. In a nutshell, the results above remind developers to pay more attention to design quality when used for entertainment scenarios, such as interactive advertisements superimposed on media facade, and also pay more attention to information quality when used for functional scenarios, such as navigation.

6.2. Limitations and future research

This study has some limitations. Because the data used in this study were collected only in China, the generalization of the results regarding the acceptance of AR map apps may be limited. Further studies in various countries will contribute more generalized conclusions. In addition, we find that there are two more factors that will potentially affect the usage intention of the AR map app, namely, the completeness of the navigation map and the degree of the AR map ecosystem. Due to the limited test points and the limited use of other mobile phones（e.g. Apple and Samsung）, it is possible to reduce users' continuous use intention if the complete AR navigation map and ecosystem are not established quickly. In the future, these two variables will be further explored. Furthermore, the content and service providers of the AR app ecosystem are core stakeholders, and participants whose intentions to use the software are important factors for the success of the AR app. Whether they are willing to update content and service continuously will also users' willingness to use this app. Therefore, further study on the usage intention of content and service provider of AR app ecosystem will be needed.

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