Virtual Reality and Augmented Reality Combination as a Holistic Application for Heritage Preservation in the UNESCO World Heritage Site of Melaka

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***Abstract*—Issues relating to the importance and purpose of heritage preservation have been widely discussed in tourism research. Due to natural degradation, development activities, and the overcrowding effect, heritage preservation efforts are becoming more critical to ensure the sustainability of heritage sites. UNESCO's world heritage committee listed 38 heritage sites and properties as being in danger. In response to the problems, numerous advancement in digital technologies such as virtual reality (VR) and augmented reality (AR) now offer useful applications in heritage preservation. The efforts in preserving heritage sites and objects through VR is not something new as more and more heritage sites and objects from around the world are rendered as 3D models and made virtually accessible. However, a combination of VR and AR may provide alternative form of access to threatened heritage sites and objects that lessen the impacts of visitors' overcrowding effect but at the same time heightens the overall experience. As such, this conceptual paper aims to propose a conceptual model of VR-AR technological combination as a holistic application for heritage tourism and preservation within the context of the UNESCO world heritage site in Melaka as well as the framework for determining the technology's potential.**

***Index Terms*—Virtual reality, augmented reality, heritage tourism, heritage preservation, Melaka.**

I. Introduction

Unescapably, heritage sites and objects may suffer from natural degradation and damages with the passage of time [1]. In addition, the popularity of heritage tourism, especially those sites listed by UNESCO, may be particularly threatened due to their world heritage status that attracts significant number of visitors to the point of detriment [2], [3]. For instances: rapid growth in tourism at Cambodia's Angkor temples reported a variety of damages, including the increased of air pollution level to threatening levels [4]. As such, heritage preservation and restoration efforts are needed to account for environmental and human factors occurred on heritage sites and objects [5].

II. Literature Review

A. Technologies in Heritage Preservation

Although many are not available to the public, more and more heritage sites and objects from around the world are now virtually accessible as those are digitized as three-dimensional (3D) virtual models [5], such as Michelangelo's statues of David [6] and the Florentine Pieta [7], the Great Buddha carving from Afghanistan [8], the Terra Cotta Warrior statues in China [9], and many others. Literatures on benefits of digitizing historical sites and objects as 3D models have revealed that virtual 3D models' capability in storing and providing extremely precise and accurate data sets that are useful in monitoring degradation and providing a blueprint for restoration [1], [10].

B. Virtual Reality (VR)

Virtual reality (VR) is defined as "the use of a computer-generated 3D environment – called a virtual environment (VE) – that one can navigate and possibly interact with, resulting in real-time simulation of one or more of the user's five senses" (p.638) [5]. VR hit the headlines in the mid of 1980s; now we have virtual objects (universities, offices, studios, museums, shopping, graveyards, wind tunnels), virtual characters (actors, doctors, pets), virtual events (exhibitions), and even virtual sex [11]. The key characteristic of VR is that the users enter an entirely immersive world fabricated by the computer system, without seeing the real world around them [12]. This may display inside a blank room, headset, or other devices that allow the users to experience the VE. Increasingly, VR applications now also offer features like feedback in the form of sound or touch to allow the users to interact with objects and spaces. This simulates real-world experiences in an artificial environment. In preserving heritage, VR offers realistic experience without risking and damaging the heritage sites and allow "visitations" to sites with sensitive environment or situation that are not suitable for crowds [5], [13]. It had been recognised that in order to decrease site degradation, virtual tours can be used as an alternative to real visitation as a solution to the overcrowding effect [1], [13].

C. Augmented Reality (AR)

Augmented reality (AR) is the fusion of real and VR, creating an illusion that virtual elements generated by computer are overlapped with real world, in real time [12]. Despite of the similarities shared between AR and VR [14], AR differs from VR [15]. One of the most significant differences is that while VR completely immerses users inside a VE so that they cannot see the real world around them; AR permits users to see the real world, with two-dimensional (2D) or 3D images overlapped upon the real-world images or videos [16]. AR elements are invisible to one's naked eyes; display devices are needed to aid users

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in viewing the AR elements. The display devices can be as simple as a computer monitor or a television; or it could be something more advanced, such as a see-through eyepiece on a head-mounted display (HMD), or AR glasses. New options are now becoming available such as handheld devices, webcams, and more advanced HMDs. There is paucity of literatures on AR application in heritage preservation. Reference [17] identified a few archaeological projects that have incorporated AR such as the Archeoguide project at Olympia, Greece; Vita project, Sicily; and their own VENUS project. According to them, AR is applied in two ways; "first and most obvious way is an "on-site" or outdoor augmentation performed on mobile devices as an ''augmented walkthrough'' (p. 314) [17]; "second way to apply AR to the archaeological field is an "off-site" or indoor augmentation" (p. 315) [17].

III. Melaka - The UNESCO World Heritage City

Dubbed as the historical city, Melaka is enriched with the most valuable historical values. It is the third smallest state in Malaysia which located at the southern region of the Peninsular of Malaysia, on the Straits of Malacca. As in 2010, the total population size is 788,706 people, with population density of 474 residents per square kilometer (km^2) [18]. Melaka is known for its connection with the history of the Malay Sultanate of Melaka which traced its origin back to some 600 years ago. During the 16th century, Melaka became famous due to its strategic location as a major regional commercial port. This has made Melaka a coveted possession among the western powers of that era and was subsequently seized by the Portuguese, Dutch and, English. Being a major trading port of international importance means that Melaka was a melting pot of numerous cultures that were brought by the traders and colonizers, leaving abundance of heritage assets in Melaka. This has led to Melaka being inscribed by the UNESCO as one of the world heritage sites on 7th July 2008, together with George Town, the capital of Penang [19].

TABLE I: Tourist Arrivals and Tourist Receipts in Malaysia (2008-2012)

Year	Tourists arrivals (million)	Change (%)	Tourist Receipts (RM billion)	Change (%)
2012	25.03	1.30	60.6	3.95
2011	24.71	0.53	58.3	3.00
2010	24.58	3.93	56.6	6.00
2009	23.65	7.26	53.4	7.66
2008	22.05	5.15	49.6	7.59

Source: Adapted from Tourism Malaysia (2012)

In 2012, Malaysia attracted 25.03 million of tourist arrivals and generated RM 60.6 billion of tourist receipts [20]. Tourist arrivals and tourist receipts in Malaysia have been consistently increased from 2008 to 2012 (see Table I). The national trend is mirrored at the state level. Reference [21] revealed that tourist arrivals in Melaka had almost doubled within the last five years (see Table II), where 7,205,492 and 13,711,134 of tourist arrivals recorded in 2008 and 2012, respectively. The sharp increment in tourist arrivals signals the state government on the importance of striking a good balance between further exploiting the heritage tourism goldmine and ensuring preservation of the heritage assets for future generation.

TABLE II: Tourist Arrivals in Melaka (2008-2012)

Year	Domestic	International	Total
2012	10,198,855	3,512,279	13,711,134
2011	9,070,901	3,094,965	12,165,866
2010	8,177,869	2,176,792	10,354,661
2009	7,293,762	1,1611,511	8,905,273
2008	6,004,105	1,201,387	7,205,492

Source: Adapted from Melaka Chief Minister's Department (2013)

Next, this paper proposed a conceptual model of the technological combination of VR and AR applications as a holistic application which is hoped in providing desired solutions for heritage preservation within the context of the UNESCO world heritage site of Melaka.

IV. A Conceptual Model

Firstly, VR technology will be integrated in governmental websites, displayed in the form of virtual tours featuring 360-degree panoramic images where tourists could explore the selected travel destinations. The virtual tour could be designed to embed text, animation, and original sound tracts; providing a more attractive and interactive platform of marketing and promoting the tourism in Melaka.

On the other hand, AR technology will be adopted in an application where tourists can download from the governmental website into their 3G mobile devices. The downloaded AR application is only applicable for use when tourists are in the tourism spots in Melaka. Characteristics of the VR-AR technological-combo application are summarized below (see Table III).

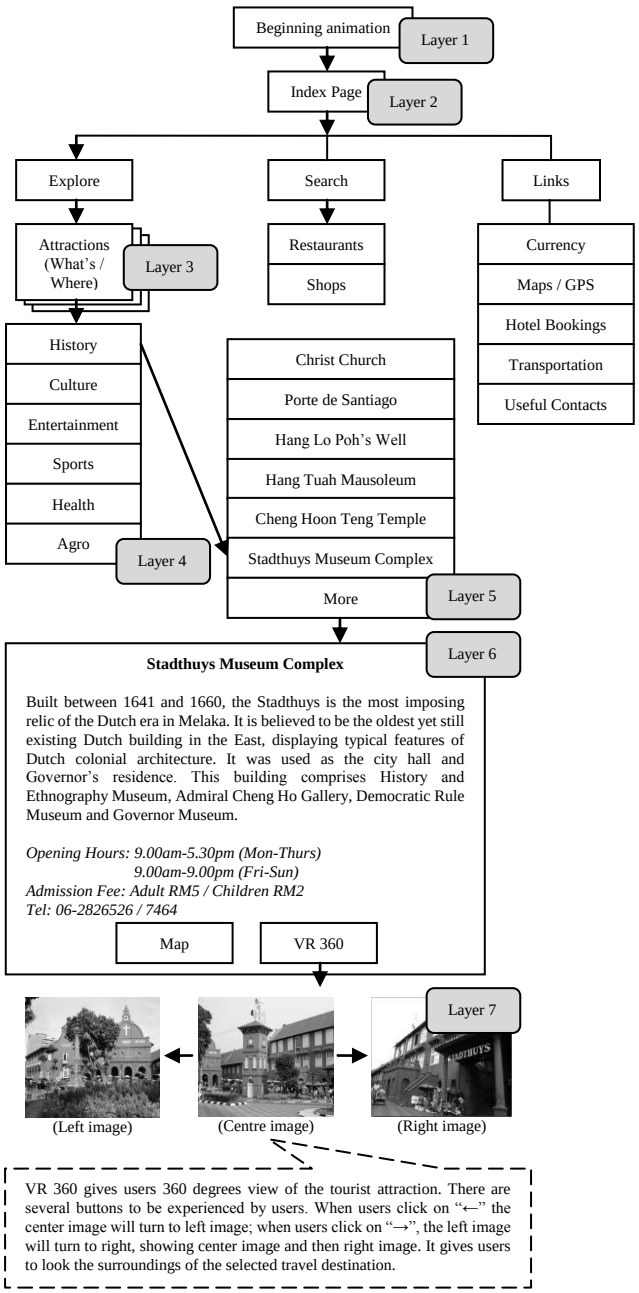
TABLE III: Characteristics of the VR-AR Technological-Combo Application

	Characteristics	
Technologies	virtual reality	augmented reality
Location	Off-site	On-site
Visitation	Before and after actual visit	During the visit
Platform	website	IOS or Android
Devices	PC, HMDs, etc.	3G mobile devices
Content	Large information (text, animation, video, audio, virtual tour featuring 360-degree panoramic images)	Bite site information (text, animation, video, audio, images of early years, suggestions on where to go next, what to do next)
Nature	Informative, interactive, immersive	Informative, interactive, immersive
Functions	Marketing tool to attract tourists, tour planning prior to visit, informative and educational, virtual visits, post-visit updates	Marketing tool to attract tourists, informative and educational, interactive actual visits, virtual tour guide

Source: Developed for this study

A. The VR Portion

The VR portion is proposed and resided in governmental websites, with specified system architecture linking several layers (see Fig. 1). When users access the portal, it first displays eye-catchy animation of images of Melaka's travel-related products (layer 1), follows by index page which consists of "Explore", "Search", and "Links" (layer 2). "Explore" allows users to browse and search for information as well as visit the travelling sites via virtual tours of 360-degree panoramic images; "Search" enables users to look for restaurants and shops; "Links" offers hyperlinks to useful and collaborative websites or applications.



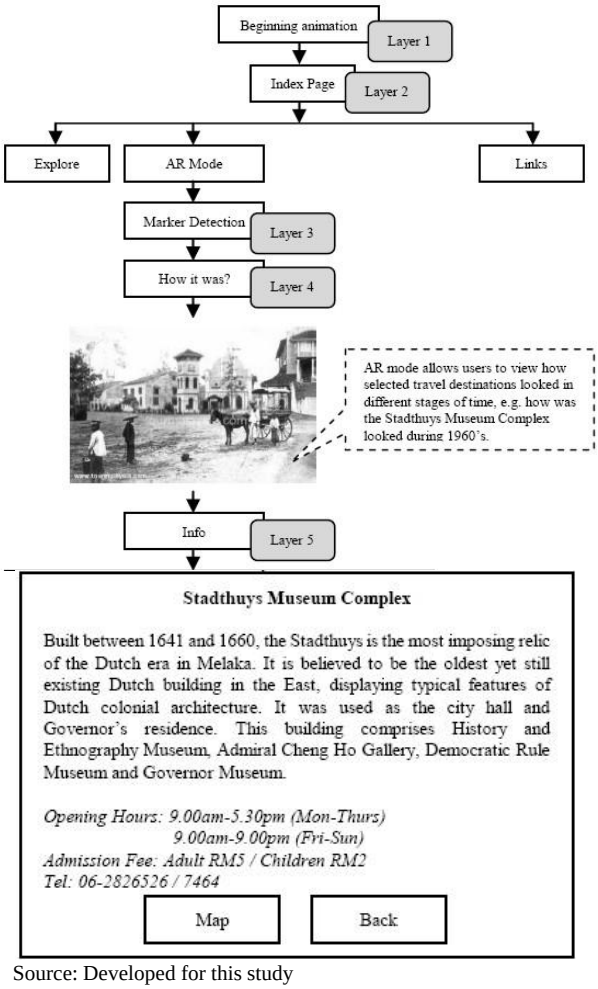
Source: Developed for this study.

Fig. 1. The VR portion.

Travelling sites are classified into several categories for users to explore: namely "Attractions", "Restaurants", "Food Districts", "Shops", "Malls and Street Markets" and, "What's on" (layer 3). If user selects "Attractions", sub-categories of tourist attractions are available, such as "History", "Culture", "Entertainment", "Sports", "Health", and "Agro" (layer 4). Users who are interested in visiting heritage sites, "History" provides a long list of popular historical places in Melaka (layer 5); one of those is "Stadthuys Museum Complex". The application will provide a brief introduction of history and uniqueness of the particular heritage site (layer 6). Useful information such as opening hours, admission fees and contacts will be provided too. "Map" and "VR 360" are available at the bottom of layer 6. "Map" displays the direction to selected travel destination, estimated distance from the users' point, and suggested transportation mode to get there. On the other hand, "VR 360" provides virtual tours to users, featuring 360-degree panoramic images of the selected travel destination (layer 7). With this function, users are able to look around the environment, side-attractions and available facilities surround the selected travel destination rather than 2D images in tour brochures and tourist guide books.

B. The AR Portion

On the other hand, the AR portion is proposed and resided in governmental websites, where it is downloadable into users' 3G mobile devices. Similarly, it has specified system architecture linking several layers (see Fig. 2).



Source: Developed for this study

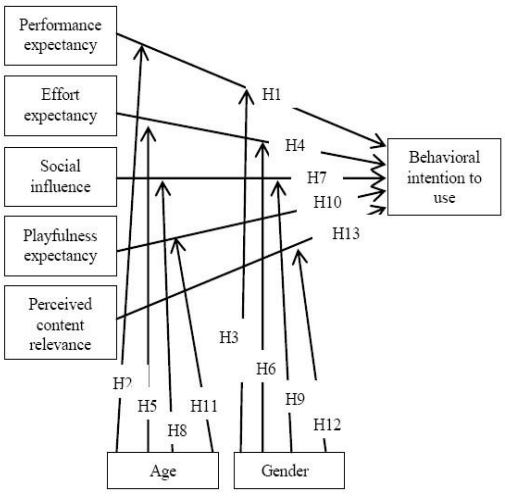
Fig. 2. The AR portion.

How can the AR application be configured? Users who own 3G mobile devices can use the application during their

actual visit in Melaka. The first 2 layers are similar as described in previous section. When users select the "AR Mode", they can use their mobile phone to scan the surrounding; the AR application recognizes what the camera is seeing and detects the predefined markers (layer 3). The system will alert the users of marker detection and AR function availability by activating the options for users to get further information of the object detected or even provide option to view the object as how it was years ago (layer 4). Upon users' selection, the system may provide images, information and directions depending of where and what they are viewing through their display device (layer 5).

V. Gauging the Potential

This study aims to explore the potential of VR-AR technological-combo application for heritage preservation in Melaka. It is assumed that its potential could only be realized in the light of users' acceptance. Accordingly, this study adopted the UTAUT developed by [22] as a primary theoretical framework to examine users' acceptance of the application. However, since the research scope of the study is in some way varies from the conventional context of users' acceptance of information technology (IT), the original determinants of users' intention to use in the UTAUT do not fully reflect the specific influences of the proposed VR-AR technological-combo application. As such, this study incorporated two additional determinants, namely playfulness expectancy (PL) and perceived content relevance (PCR). The inclusion of PL into the model is consistent with [23] in their work to investigate users' acceptance of mobile learning (m-learning); while the addition of PCR in the UTAUT is in line with [24] in their work to investigate students behavioural intention to use a computer based assessment. Fig. 3 illustrates the research framework developed for this study, where performance expectancy (PE), effort expectancy (EE), social influence (SI), PL and PCR are hypothesized to be direct determinants to users' behavioural intention (BI) to use the VR-AR technological-combo application. It is also hypothesized that gender and age differences would moderate the influence of these determinants on users' BI to use.



Source: Developed for this study

Fig. 3. Proposed research framework.

A. Performance Expectancy (PE)

PE is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance (pp. 447) [22]. PE is theorized as the most powerful determinant in understanding and predicting an individual's BI to use ITs [22], as supported by prior studies [23]-[27]. However, literatures also revealed a contradicting result where PE has an indirect effect on BI to use [28], [29]. Interestingly, the relationship between PE and BI to use will be moderated by gender difference, where PE is more salient to male users and strongly influence their decisions regarding the use of new ITs [22], [26], [30], [31]; but opposed by [23] when no gender difference was found to exist between PE and BI to use. In addition, the relationship between PE and BI to use will be moderated by age difference where PE is more salient to younger users than older users [22], [30], [31], but opposed by [23], [26] when no age difference was found to exist between PE and BI to use. The following hypotheses thus ensue:

- H1: There is a positive relationship between PE and BI to use VR-AR technological-combo application.
- H2: PE influences BI to use VR-AR technological-combo application more strongly for male users than for female users.
- H3: PE influences BI to use VR-AR technological-combo application more strongly for younger users than for older users.

B. Effort Expectancy (EE)

EE is defined as "the degree of ease associated with the use of the system" (p. 450) [22]. EE is theorized as a direct determinant of individual's BI to use ITs [23]-[26], [28], [29], [32], [33]; but opposed by [27], [34] where EE is found to have no direct effect on BI to use. Notably, the relationship between EE and BI to use will be moderated by gender difference, where EE is more salient to female users and strongly influence their decisions regarding the use of new ITs [22], [31], but opposed by [23], [26]. Furthermore, the relationship between EE and BI to use will be moderated by age difference, where EE is more salient to younger users than older users [22], [30], [31], but opposed by [23], [26]. Hence, the following hypotheses are generated:

- H4: There is a positive relationship between EE and BI to use VR-AR technological-combo application.
- H5: EE influences BI to use VR-AR technological-combo application more strongly for female users than for male users.
- H6: EE influences BI to use VR-AR technological-combo application more strongly for younger users than for older users.

C. Social Influence (SI)

SI is defined as "the degree to which an individual perceives that important others believe he or she should use the system" (p. 541) [22]. SI is theorized as a direct construct of individual's BI to use ITs [23], [25]-[27], [29], [32], [34], but opposed by [24], [28] where SI is found to have no direct effect on BI to use. Remarkably, an unexpected finding was found by [23] where SI is more significant for male users than female users, which contrary with prior research where

SI is found to be more salient for female users than male users [22], [26], [30]. Moreover, the relationship between SI and BI will be moderated by age difference where SI is found to be more salient to older users than younger users in the use of new ITs [22], [23], [30], [31], but opposed by [26]. Hence, the arguments lead to the construction of the following hypotheses:

- H7: There is a positive relationship between SI and BI to use VR-AR technological-combo application.
- H8: SI influences BI to use VR-AR technological-combo application more strongly for female users than for male users.
- H9: SI influences BI to use VR-AR technological-combo application more strongly for older users than for younger users.

D. Playfulness Expectancy (PL)

The studies of the influence of PL on users' BI to use new ITs have been validated in a variety of applications: m-learning [23], web portal [35] and World Wide Web [36]. Past researches have confirmed that PL has a strong influence on BI to use ITs [23], [28], [35], [36]. Prior studies suggested that there is significant gender difference in attitudes towards computer, with male users performing better than female users [37], [38], but opposed by [23]. Therefore, it is believed that PL of VR-AR technological-combo application will influence BI to use more strongly for male users than female users. Likewise, prior studies investigating computer use among adults revealed that the older the individual, the less interest they are likely to have [39]. Consequently, it is expected that the influence of PL on BI to use will be moderated by age, such that the effect will be more strongly for younger users than older users; but opposed by [23] where no age difference was found to exist between PL and BI to use. Thus, the following hypotheses are developed.

- H10: There is a positive relationship between PL and BI to use VR-AR technological-combo application.
- H11: PL influences BI to use VR-AR technological-combo application more strongly for male users than for female users.
- H12: PL influences BI to use VR-AR technological-combo application more strongly for younger users than for older users.

E. Perceived Content Relevance (PCR)

PCR must be precise [40]-[42], meet users' needs [40], [41], [43], sufficient [40], [41], [43], [44], up-to-date [42]-[44], and useful [28], [43], [44]. To our best knowledge, incorporating in UTAUT model, content is a determinant that was initially introduced to examine students' acceptance of computer based assessment, but the study found that there is no direct effect of PCR on users' BI to use [28]. A recent study tested users' satisfaction on virtual tours of selected tourist attractions in Thailand revealed that users were found to be highly satisfied with the accuracy, current and reliability of the content displayed [42]. As such, it is worthy to study the impact of PCR in VR-AR technological-combo application. However, there is absent of literature investigating on the gender and age difference on PCR. It is reasonably due to PCR is objective rather than subjective measurement, where gender and age has insignificant impact on the judgement of PCR. As such, in the context of our study, the impact of gender and age difference is eliminated. Hence, one hypothesis is developed:

- H13: PCR has a positive effect on BI to use VR-AR technological-combo application.

VI. Conclusion

The proposed VR-AR technological combination as a holistic application for heritage preservation in Melaka not only may provide an alternative form of access to threatened heritage sites and objects that lessen the impacts of visitors' overcrowding effect, but at the same time heighten the overall travelling experience. The combined-technologies offer interactions before, during and after the visits; online and offline access; real, augmented and virtual feeds; as well as preservation, marketing and educational tools. Thus, it is truly a holistic solution for heritage preservation in the context of UNESCO world heritage site of Melaka. The proposed research framework will help to determine the application's potential by determining the target users' acceptance level.

References

[1] E. Paquet and H. L. Viktor, "Long-term preservation of 3-D cultural heritage data related to architectural sites," presented at the ISPRS 3D Virtual Reconstruction and Visualization of Complex Architectures, Mestre-Venice, Italy, August 22-24, 2005.

[2] A. Drost, "Developing sustainable tourism for world heritage sites," *Annals of Tourism Research*, vol. 23, no. 2, pp. 479-492, 1996.

[3] M. Li, B. Wu, and L. Cai, "Tourism development of world heritage sites in China: a geographic perspective," *Tourism Management*, vol. 29, no. 2, pp. 308-319, 2008.

[4] M. Furuuchi, T. Murase, S. Tsukawaki, P. Hang, S. Sieng, and M. Hata, "Characteristics of ambient particle-bound polycyclic aromatic hydrocarbons in the Angkor Monument area of Cambodia," *Aerosol and Air Quality Research*, vol. 7, no. 2, pp. 221-238, 2007.

[5] D. A. Guttentag, "Virtual reality: applications and implications for tourism," *Tourism Management*, vol. 31, no. 5, pp. 637-651, 2010.

[6] M. Callieri, P. Cignoni, F. Ganovelli, G. Impoco, C. Montani, P. Pingi, F. Ponchio, and R. Scopigno, "Visualization and 3D data processing in David's restoration," *IEEE Computer Graphics & Applications*, vol. 24, no. 2, pp. 16-21, 2004.

[7] F. Bernardini, H. Rushmeier, I. M. Martin, J. Mittleman, and G. Taubin, "Building a digital model of Michelangelo's Florentine Pieta," *IEEE Computer Graphics and Applications*, vol. 22, no. 1, pp. 59-67, 2002.

[8] A. Grun, F. Remondino, and L. Zhang, "Photogrammetric reconstruction of the great Buddha of Bamiyan, Afghanistan," *The Photogrammetric Record*, vol. 19, no. 107, pp. 177-199, 2004.

[9] J. Y. Zheng and Z. L. Zhang, "Virtual recovery of excavated relics," *IEEE Computer Graphics and Applications*, vol. 19, no. 3, pp. 6-11, 1999.

[10] P. Cignoni and R. Scopigno, "Sampled 3D models for CH applications: A viable and enabling new medium or just a technological exercise?" *ACM Journal on Computing and Cultural Heritage*, vol. 1, no. 1, pp. 2-23, 2008.

[11] J. Vince, *Introduction to Virtual Reality*, United States: Springer, 2004.

[12] S. Cawood and M. Fiala, *Augmented Reality: A Practice Guide*, United States: Pragmatic Bookshelf, 2007.

[13] R. Cheong, "The virtual threat to travel and tourism," *Tourism Management*, vol. 16, no. 6, pp. 417-422, 1995.

[14] S. K. Ong, M. L. Yuan, and A. Y. C. Nee, "Augmented reality applications in manufacturing: A survey," *International Journal of Production Research*, vol. 46, no. 10, pp. 2707-2742, 2008.

[15] R. T. Azuma, "A survey of augmented reality," *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 4, pp. 355-385, 1997.

[16] L. Kerawalla, R. Luckin, S. Seljeflot, and A. Woolard, "Making it real: Exploring the potential of augmented reality for teaching primary school science," *Virtual Reality*, vol. 10, no. 3-4, pp. 163-174, 2006.
[17] M. Haydar, D. Roussel, M. Maidi, S. Otmane, and M. Mallem, "Virtual and augmented reality for cultural computing and heritage: A case study of virtual exploration of underwater archaeological sites," *Virtual Reality*, vol. 15, pp. 311-327, 2011.
[18] Department of Statistics, Malaysia. (2011). *Population Distribution and Basic Demographic Characteristics 2010*. Putrajaya: Department of Statistics, Malaysia. Department of Statistics Malaysia Official Portal. [Online]. Available: http://www.statistics.gov.my/portal/download_Population/files/census 2010/Taburan_Penduduk_dan_Ciri-ciri_Asas_Demografi.pdf
[19] United Nations Educational, Scientific and Cultural Organization. (2008). Melaka and George Town, Historic Cities of the Straits of Malacca. [Online]. Available: http://whc.unesco.org/en/list/1223.
[20] Tourism Malaysia. (2012). Tourist Arrivals & Receipts to Malaysia. [Online]. Available: http://corporate.tourism.gov.my/research.asp?page=facts_figure.
[21] Tourism Promotion Division, *Kedatangan pelancong ke Melaka 1998-2012*, Melaka: Melaka Chief Minister's Department, 2013.
[22] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS Quarterly*, vol. 27, no. 3, pp. 425-478, 2003.
[23] Y. S. Wang, M. C. Wu, and H. Y. Wang, "Investigating the determinants and age and gender differences in the acceptance of mobile learning," *British Journal of Educational Technology*, vol. 40, no. 1, pp. 92-118, 2009.
[24] H. S. Martín and A. Herrero, "Influence of the user's psychological factors on the online purchase intention in rural tourism: Integrating innovativeness to the UTAUT framework," *Tourism Management*, vol. 33, no. 2, pp. 341-350, 2012.
[25] B. Kijsanayotin, S. Pannarunothai, and S. M. Speedie, "Factors influencing health information technology adoption in Thailand's community health centres: Applying the UTAUT model," *International Journal of Medical Informatics*, vol. 78, no. 6, pp. 404-416, 2009.
[26] Y. S. Wang and Y. W. Shih, "Why do people use information kiosks? A validation of the Unified Theory of Acceptance and Use of Technology," *Government Information Quarterly*, vol. 26, no. 1, pp. 158-165, 2009.
[27] T. Zhou, Y. Lu, and B. Wang, "Integrating TTF and UTAUT to explain mobile banking user adoption," *Computers in Human Behavior*, vol. 26, no. 4, pp. 760-767, 2010.
[28] V. Terzis and A. Economides, "The acceptance and use of computer based assessment," *Computers & Education*, vol. 56, no. 4, pp. 1032-1044, 2011.
[29] J. C. Pai and F. M. Tu, "The acceptance and use of customer relationship management (CRM) systems: An empirical study of distribution service industry in Taiwan," *Expert Systems with Applications*, vol. 38, no. 1, pp. 579-584, 2011.
[30] M. G. Morris and V. Venkatesh, Age differences in technology adoption decisions: Implications for a changing work force," *Personnel Psychology*, vol. 53, no. 2, pp. 375-403, 2000.
[31] V. Venkatesh and M. G. Morris, "Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behaviour," *Management Information Systems Quarterly*, vol. 24, no. 1, pp. 115-140, 2000.
[32] I. Im, S. Hong, and M. S. Kang, "An international comparison of technology adoption: Testing the UTAUT model," *Information & Management*, vol. 48, no. 1, pp. 1-8, 2011.
[33] T. Casey and E. W. Evered, "Predicting uptake of technology innovations in online family dispute resolution services: An application and extension of the UTAUT," *Computers in Human Behavior*, vol. 28, no. 6, pp. 2034-2045, 2012.
[34] Y. Lu, T. Zhou, and B. Wang, "Exploring Chinese users' acceptance of instant messaging using the theory of planned behavior, the technology acceptance model, and the flow theory," *Computers in Human Behavior*, vol. 25, no. 1, pp. 29-39, 2009.
[35] C. S. Lin, S. Wu, and R. J. Tsai, "Integrating perceived playfulness into expectation-confirmation model for web portal context," *Information & Management*, vol. 42, no. 5, pp. 683-693, 2005.
[36] J. W. Moon and Y. G. Kim, "Extending the TAM for a World-Wide-Web context," *Information & Management*, vol. 38, no. 4, pp. 217-230, 2001.
[37] A. Durndell and K. Thomson, "Gender and computing: A decade of change?" *Computers & Education*, vol. 28, no. 1, pp. 1-9, 1997.
[38] B. E. Whitley, "Gender differences in computer-related attitudes and behavior: A meta-analysis," *Computers in Human Behavior*, vol. 13, no. 1, pp. 1-22, 1997.
[39] S. H. Billipp, "The psychosocial impact of interactive computer use within a vulnerable elderly population: A report on a randomized prospective trial in a home health care setting," *Public Health Nursing*, vol. 18, no. 2, pp. 138-145, 2001.
[40] W. J. Doll and G. Torkzadeh, "The measurement of end-user computing satisfaction," *MIS Quarterly*, vol. 12, no. 2, pp. 259-274, 1988.
[41] A. Ilias and M. Z. A. Razak, "A Validation of the End-User Computing Satisfaction (EUCS) Towards Computerised Accounting System (CAS)," *Global Business and Management Research: An International Journal*, vol. 3, no. 2, pp. 119-135, 2011.
[42] J. Singthongchai, E. Naenudorn, N. Kittidachanupap, N. Khopolklang, and S. Niwattanakul, "Virtual 3-D animation for tourism," presented at the 2012 International Conference on Computer Science and Automation Engineering (CSAE), Zhang Jia Jie, China, May 25-27, 2012.
[43] Y. S. Wang, "Assessment of learner satisfaction with asynchronous electronic learning systems," *Information & Management*, vol. 41, no. 1, pp. 75-86, 2003.
[44] D. Y. Shee and Y. S. Wang, "Multi-criteria evaluation of the web-based e-learning system: A methodology based on learner satisfaction and its applications," *Computers & Education*, vol. 50, no. 3, pp. 894-905, 2008.

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