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Geovisualising 3D Cultural Heritage Building for Urban Tourism Via Mobile Augmented Reality Application

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Abstract. Augmented Reality (AR) is a virtualization technology, contributing to visual contents without completely replacing the user's field of view. Tourists can visit interesting areas and explore their surroundings while AR technology that displays information and material relevant to them. Combining these two elements can enhance travel experiences and provide more information about particular locations and features. The study aims to develop a mobile AR apps of a 3D urban heritage building at Sarawak Cultural Village. The first objective of this study has been achieved by conducting a survey on the user requirement of the proposed AR app, and the findings revealed that the local communities need the apps for urban cultural tourism destinations. The second objective is to design and develop the apps using SketchUp, Unity 3D, and Vuforia, and the result show that it could offer several special features and functions of a practical system for visualising the 3D cultural heritage building in Sarawak. While the last objective has proved that this proposed AR apps are developed with aligned to the user requirements and system testing for the local tourism and heritage departments.
Keywords: Heritage building, cultural tourism, mobile augmented reality (AR), geovisualisation, 3D GIS, information management.

1 Introduction

Tourism is one of the world's largest industries and one of the largest contributors to a country's economy. By the end of 2014, over 1.1 billion international tourists have travelled around the world in a single year, which is setting a new record and by the first ten months of 2014, the number of international tourists increased by 5% (UNWTO, 2014). The United Nations (UNWTO) defines tourism as a social, cultural, and economic phenomenon that involves people traveling to countries and places

outside their usual environment for personal or business/professional reasons. Visitors (tourists or excursionists; residents or non-residents) are referred to as visitors, and tourism has to do with their activities, some of which include tourism expenditure.

Malaysia has recognized tourism as one of the important sectors for the economic generator since 1990, with the success of the Visit Malaysia Year Campaign (Mohamed et al., 2006). In 2018, tourism contributed approximately 94.5 billion Malaysian ringgits to its GDP, employed approximately 3.5 million Malaysians, and generated approximately 86 billion Malaysian ringgits in tourism receipts (Statista, 2021). One of tourism that can be obtained in Malaysia is cultural and heritage tourism.

Malaysia has a long history of tourism, attracting visitors who are drawn to the country's art, architecture, handicrafts, traditional attire, music, and dance, which reflect a diverse heritage and culture (Ismail N. et al., 2014). Malaysia consists of various races such as Malays, Chinese, Indians, Orang Asli (Peninsular Malaysia), and for East Malaysia, races in Sabah and Sarawak alone consists of 59 races (Jabatan Penerangan Malaysia) such as Dayaks, Kadazandusun, Melanau, Murut, and others.

With technological advancements like smartphones, it would not be long before the device is used to facilitate tourism-related activities. Due to the mobile nature of smartphones, they are ideal for tourism-related activities as tourists move from location to location. Additionally, a smartphone's capacity to install any mobile application that can benefit its user makes it a practical tool for use in tourism-related activities Cultural buildings are an important part of cultural and heritage property. All buildings have their history and stories to tell. However, the traditional method of tourist travel is to navigate through the places using a map pamphlet or travel guidebook. According to research, this method appeals to the elderly, and they have a positive experience using it in their travel activities (Hanrahan & Krahenbuhl, 2012).

However, this traditional method is not relevant since the map pamphlet rarely gets updated. For example, there are new attractions, or the tourist destination has been closed or renovated. By using technology all the problems can be handled since the user can get the update on the latest news. The creator can be added or remove the content anytime without a hassle. The user can receive updates on the most recent news and data related to their vacation destinations at that time without having to wait. The development of web technology has made it possible for users and service providers to share content creation duties anytime and anywhere.

AR is a technologically enhanced version of the real world that is achieved through the use of digital visual elements, sound, or other sensory stimuli. It's a growing trend among businesses that deal with mobile computing and business applications (Hayes, 2020). Around the end of the 1990s, the concept of AR emerged as a new field of virtual reality and computer technology, and it has spread to a wider area (Pagani et al., 2016).

In this era, with technological advancements such as smartphones, devices have become one of the tourism enablers. Since smartphones are designed to be mobile, it is ideal for tourism activities where tourists travel from place to place (Hanrahan & Krahenbuhl, 2012). Other than being mobile, the ability of the smartphone that can install any application that can benefit the user, makes it more convenient to use it in tourism activities. For that, this study focuses on AR technology as the base and

develops the mobile AR 3D urban heritage application. This study is needed to determine the requirements to develop a mobile AR tourism application purpose.

2 Literature Review

2.1 Tourism Growth in Sarawak Malaysia

Tourism growth is driven by three main factors: demand for tourism, travel technology, and tourist comfort while traveling. Factors such as an increase in tourism demand, the high use of technology, and tourist convenience while traveling enable technology such as AR applications to be used as one of the travel utility tools. Today's AR applications include a variety of features such as information, navigation, place recommendations, and many others that can make traveling easier and more convenient. These technological advancements have made the tourist AR experience more user-friendly and enjoyable, which contributes to the application's overall acceptance (Tom Deick & Jung, 2015).

Malaysia tourism launched a successful tourism marketing campaign called "Malaysia Truly Asia" in 2007, which reflects the country's racial and cultural diversity. Using this slogan, it was able to attract 20.97 million in tourist arrivals and RM 46.1 billion in tourist receipts (Tourism Malaysia). As a result of this success, the Malaysian Tourism Promotion Board (MTPB) continues to conduct an annual review of its strategies to promote Malaysia to ensure that tourism promotion is as effective as possible in attracting tourists. Malaysia, located in Southeast Asia, is known for its preserved traditional lifestyle and natural resources as well as its unique multiracial and cultural heritage that attracts tourists especially with a particular interest in heritage arts (Ismail N. et al., 2014). Other than breath-taking scenery of beaches, wildlife, and other adventurous fun activities Malaysia also introduces Muslim-friendly tourism. Even though this Islamic tourism is still new in Malaysia, it still has the potential to attract tourists since that the official religion of Malaysia is Islam. This advantage will attract Muslim tourists because of the abundance of halal food and places to worship.

A tourist is related with tourism industry, which is a person who travels to and stays in places outside of their usual environment for more than a day for leisure, business, or other reasons. According to Camilleri (2018), there are two types of travellers which are business travellers and those who travel for personal reasons such as visiting friends and relatives, studying, and so on. Advancements in technology are in line with the tourism industry has made Information Communication Technology (ICT) particularly mobile technologies has become one of the ways to enrich tourist experiences when traveling (Anuar, 2013).

According to Pai et al. (2020), tourist usually uses their smartphones to look up a local restaurant review, navigate the location, and even make mobile payments. Pai et al. also added that along the travel process, tourists used tourism apps, social media, and virtual reality to help them ease during their journeys. E-tourism is the use of information and communication technology (ICT) by tourists and businesses (Pan, 2015). Pan (2015) also added that there are three sub-areas in e-tourism which are operational tools and systems that are used to improve efficiency; user platforms that are used to

find information, plan the trips other; and distribution and trade tools that mediate transactions between tourists and businesses.

Due to the mobile nature of smartphones, 2 they are ideal for tourism-related activities as tourists move from location to location. Additionally, a smartphone's capacity to install any mobile application that can benefit its user makes it a practical tool for use in tourism-related activities. Every year, the number of smartphones increases and by 2021 it already surpasses six billion. In the coming years, the number of smartphone users worldwide is expected to increase by several hundred million (Statista 2021). In a survey of 2401 respondents conducted in 2018, the Malaysian Communication and Multimedia Commission (MCMC) discovered that 78% of users use smartphones, which are the most popular when compared to feature phones (MCMC 2018). As a result, it can be concluded that users rely on an application installed on their smartphones while traveling and they are an essential tool for finding directions.

2.2 3D modelling and Augmented Reality in Tourism

AR technology may be a new term for some, but it was created in 1968 by Ivan Sutherland and has since been widely used in various industries (Jung et al., 2013). The demand for developing interactive applications has increased as technology has advanced in recent years, particularly smartphones. Many parties, especially in the tourism industry, have been enlightened by this situation as they have begun to understand the opportunities for combining digital content in a real environment when traveling (Jung et al., 2015).

Nowadays, smartphones such as Android and iOS devices have enough processing power to match that of a computer enabling AR to be used in a wide range of applications and functions. The technology advancements that have made the tourist AR application are useful information systems with a variety of functions that are both user-friendly and convenient (Dieck and Jung, 2015).

However, every technology that exists has been developed with a variety of requirements while for AR one crucial element in the development is the software requirement. Han et al. (2014) mentions the lack of research exposure to software requirements, particularly in the field of augmented reality, and go so far as to create their own. With only minor modifications, this study can implement their suggested user requirement.

According to Rauschnabel et al. (2015), AR is the digital stacking of information into a user's physical environment, allowing additional information to co-exist in the environment using devices like smartphones and smart glasses such as Google Glass. While there are numerous AR concepts, the following characteristics should be present in AR applications (Rebbani et al., 2021):

i. Combination of real and virtual objects in the real environment
ii. Act interactively in real-time
iii. Real and virtual objects are stored (aligned) together

These three characteristics must contain in an AR application to be considered complete. In augmented reality, the systems combine real and virtual objects in a real

environment, where they enable real-time interaction and can also record virtual objects in 3D space. According to Verykokou et al. (2014), for the exposure of cultural heritage, historic materials, and the interactive representation of historical pieces, AR has provided intriguing potential and practical uses. By definition, a 3D idea demonstrates that an object or space has three geometric dimensions, which are depth, breadth, and height. Additionally, three spatial dimensions are referred to as three-dimensional (3D), and 3D displays X, Y, and Z Cartesian coordinates (Hendajani et al., 2018).

According to Saymote (2016), the 3D market has been booming for the last ten years. The software industry was incorporating new approaches and strategies in line with the advancement of technology. By using specialized visualization software, 3D modelling creates a graphical model of any 3D surface of an item. AR technology has created something new and exciting that can be used in the tourism industry. The AR tourism application has made traveling more enjoyable and convenient. There has been studying done to show that AR can be used as a learning and teaching tool particularly in heritage and historical tourism industries (Chung et al., 2015; Deick & Jung T., 2015). Unfortunately, despite having numerous historical sites, traditional costumes, and diverse cultures, the AR technology in tourism in Malaysia is still poorly exposed to the public. However, there are already countries that use AR in tourism specific to certain geo-location such as Dublin, Ireland (Dieck and Jung, 2015) and Jeju Island (Jung et al., 2015), and Deoksugung Palace, South Korea (Chung et al., 2015).

In Malaysia, there are not many mobile AR applications that available in the market. Lacking exposure and interest among developers make AR technology less popular in Malaysia. Tinka Malacca apps were developed to provide users with AR capabilities on the company souvenir. Using the app can recreate a 3D model of the buildings, giving the user a new perspective on the history and heritage of Malacca. An observation study is conducted to determine which applications are currently available on the market. Applications were chosen based on their category (travel and local) and can be found in the Google Play Store. Two applications that have been chosen are Agoda and Foursquare. Both are well known and developed by the top developer. This app is useful however it might not be suitable for those that prefer backpacking instead of having a tour guide. Foursquare is a social networking app created by the Foursquare Company this app is useful for finding activities and attraction places based on the review and ratings. Beside this, Yelp and Street Lens were chosen as the applications. The categories that are also available in the apps such as close by, food, shopping, and other more categories.

3 Methodology

Figure 1.1 shows the flowchart of the methodology used in this study. It covers preliminary studies, conceptual design, data collection, data processing and analysis, and the output of the product as the results. The first step is preliminary studies where the topic, aim, the objective selection including the study area are chosen based on the selected topic. For data collection steps, the data are collected by using questionnaires and Google Images, or other open sources. The third step is data processing which going to use software such as Unity 3D Editor, Vuforia SDK, and Sketchup. The last step

is data analysis and results. The analysis is done to study the user requirements for mobile augmented reality (MAR) before developing the application and also to develop the prototype of the application.

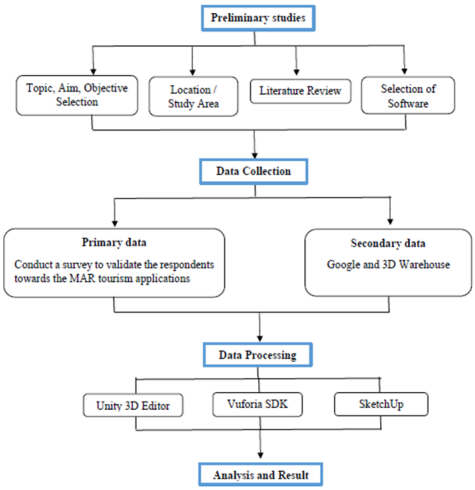

Figure 1: Flowchart of Methodology

The first phase of the research is preliminary studies, mainly the aim of this study is to develop a mobile AR heritage app as a tourist guide application and the selection of the Sarawak Culture Village located in Kuching, Sarawak. It is chosen as the study area because as the topic chosen is related to urban heritage tourism and its abundance of cultural heritage sites. This location contains several structures that represent the various races that exist in Sarawak. The study location is not far from Pantai Damai Santubong, Kuching, Sarawak (Figure 1.2). They take up 17 acres of land. Sarawak Culture Village is located at coordinates 1.7502° N, 110.3160° E.

For data collection, the primary data were collected by distributing forms to the public on the requirement for AR tourism applications and by asking relevant questions about their tourism application expectations. The respondents will submit their feedback via a Google form link. Three sections will be included in the form. The first section is demographic, the second focuses on features that are useful when traveling, and the third is the user feedback about mobile augmented reality (MAR) in tourism applications. The questionnaire respondent is distributed at random to various social media sites such as WhatsApp and Telegram. Location is not restricted to any state in Malaysia. The questionnaire has been checked and verified by the supervisor and as the feedback is obtained, the change is made to bring the questionnaire to a final. While the Secondary data are obtained from 3D Warehouse where a 3d object can be obtained from the website.

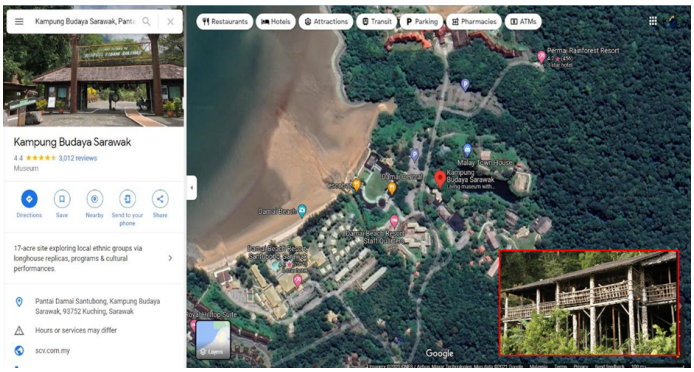

Figure 2: Sarawak Culture Village (Source, Google Map, 2022)

For data processing, Unity is used to make 3D, 2D, VR, and AR games, as well as other simulations. The engine currently supports more than 25 different platforms, including mobile, desktop, consoles, and virtual reality such as iOS, Android, Windows, and AR platforms such as Google ARCore and Apple ARKit. Vuforia is a MAR software development kit (SDK) that allows developers to create AR applications The virtual object then tracks the image's position and orientation in real-time so that the viewer's view of the object matches the target's perspective. SketchUp is used for 3D modelling of the building and other feature elements. Lastly is analysis and result, in this study, a qualitative study is used to describe and explain the requirement and user perspective on MAR in tourism applications.

The final step in the methodology is to create a prototype of MAR. The study's final phase is the analysis and results wherein in the following chapter, all of the analysis and results are connected.

4 Result and Discussion

4.1 Evaluation of Proposed Requirement for Mobile AR Tourism Application

This section evaluates the suggested requirements for a MAR tourist application. The evaluation's objective is to determine whether the suggested requirements align with user needs and expectations for tourism-related activities. The questionnaire will be employed as a tool to confirm the component meets the needs of the software. The requirements pyramid, a framework presented by Hoffmann (2010), serves as the foundation for the software requirements. User, technical, and system design requirements for software act as layers layered on top of one another. The user's demand can be realised in the finished product thanks to this flow, which enables user-centred design.

4.2 Demographic Analysis

According to the demographic research, the most of respondents are between the ages of 21 and 30, contributing 46.6%, with less than 21 years old contributing 36.2%. While those between the ages of 31 and 40 make up 10.3% of the population, those aged 41 and above make up just 6.9%. The male and female distributions are 65.5% for females and 34.5% for females. In regards to general understanding about AR, the majority of respondents (46.4%) have no idea what AR is. While 35.7% voted yes and 17.9% said no. According to the data, people have limited knowledge of AR technology and how to use it. According to the responses, which of the following gadget that you use the most when you travel there appears to be no doubt that the use of a smartphone facilitates travel (94.8%). Other devices, such as GPS (3.5%) and laptops or PC (1.7%) have low response rates (3.5%).

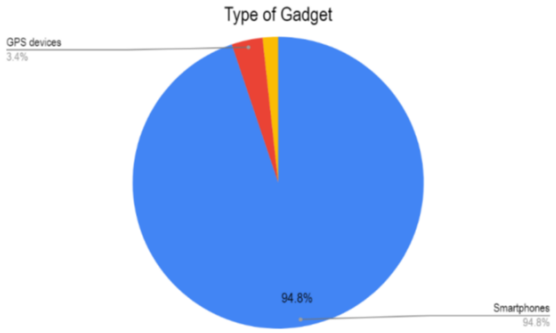

Figure 3: Type of Gadget by Percentage

According to respondents' responses which of the following sources that you use to find important information when going to an unfamiliar location. maps (65.5%) is the most important information sources when planning a trip, followed by travelling websites (29.3%), travel guidebooks (3.5%), and pamphlet/brochures (1.7%). This means that the convenience of using the internet outweighs the use of traditional modes of travel where tourists can access digital maps and travel websites. The data for information sources are shown in Figure 4.

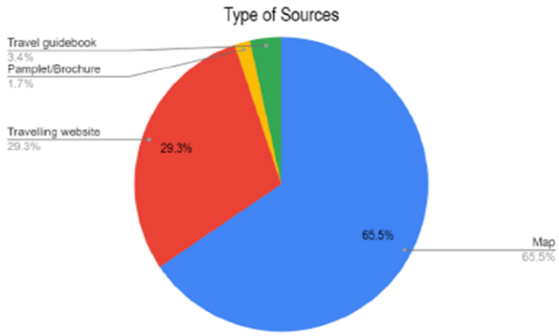

Figure 4: Information Sources by Percentage

Descriptive analysis on Likert scale is made up of four or more Likert-type items that represent similar questions, all of which are combined into a single composite score or variable. 1- Strongly Disagree to 5 - Strongly Agree. In this analysis, a measure of central tendency and a measure of variability is used. Constructive data can be interpreted using the proposed requirements for mobile AR tourism application components as a variable. The outcome will show how well each component met the user's needs and expectations. Table 1.1 show the frequency table of the variable. Overall, based on Analysis of System Requirement for Mobile AR Application, most of the respondent agreed with the creation of the mobile AR tourism application framework takes into account user feedback based on the questionnaire procedure used during data analysis. A functionality questionnaire's goal is to determine whether the functional need aligns with the suggested requirement developed using literature.

Table 1: Frequency of Variables Statistics

	Personalization	Search & Browse	Navigation	Map	Location Aware
N Valid	58	58	58	58	58
Missing	0	0	0	0	0
Mean	3.47	4.05	4.09	4.09	4.05
Median	3.50	4.00	4.00	4.00	4.00
Mode	3	4	5	5	5
Std. Deviation	0.922	1.016	1.113	1.064	1.016
Variance	0.850	1.032	1.238	1.133	1.032

	E-Commerce	Tour Planning	Context-Aware	Social Network
N Valid	58	58	58	58
Missing	0	0	0	0
Mean	4.02	3.86	3.88	3.86
Median	4.00	4.00	4.00	4.00
Mode	4	4	4	4
Std. Deviation	1.051	1.034	1.140	1.067
Variance	1.105	1.070	1.300	1.139

	AR in Tourism	AR used in Travelling	AR Beneficial to Tourist	AR is Interactive
N Valid	58	58	58	58
Missing	0	0	0	0
Mean	3.95	3.97	3.95	4.05
Median	4.00	4.00	4.00	4.00
Mode	4	4	4	5
Std. Deviation	1.016	0.973	0.999	0.999
Variance	1.032	0.946	0.997	0.997

4.3 AR System Design and the Prototype Development

The product that has been developed as a mobile AR application called the "Urban Heritage" app. Urban Heritage was an android application that focused on showing heritage building in 3D and AR. The 3D model does not follow the exact measurement as it does not have a specific scale. Figure 5 shows the prototype of the Urban Heritage application screenshot. The objective was met by analysing the requirements from the previous study and also from the survey that has been conducted. User, technical, and system design requirements are the three basic categories that form software requirements. User requirements are concerned with what the user wants and expect from the product. Functional and non-functional requirements were two additional distinct requirements for technical requirements. Functional requirements are concerned with the functionality of the application, whereas non-functional requirements refer to the developed program's quality aspect.

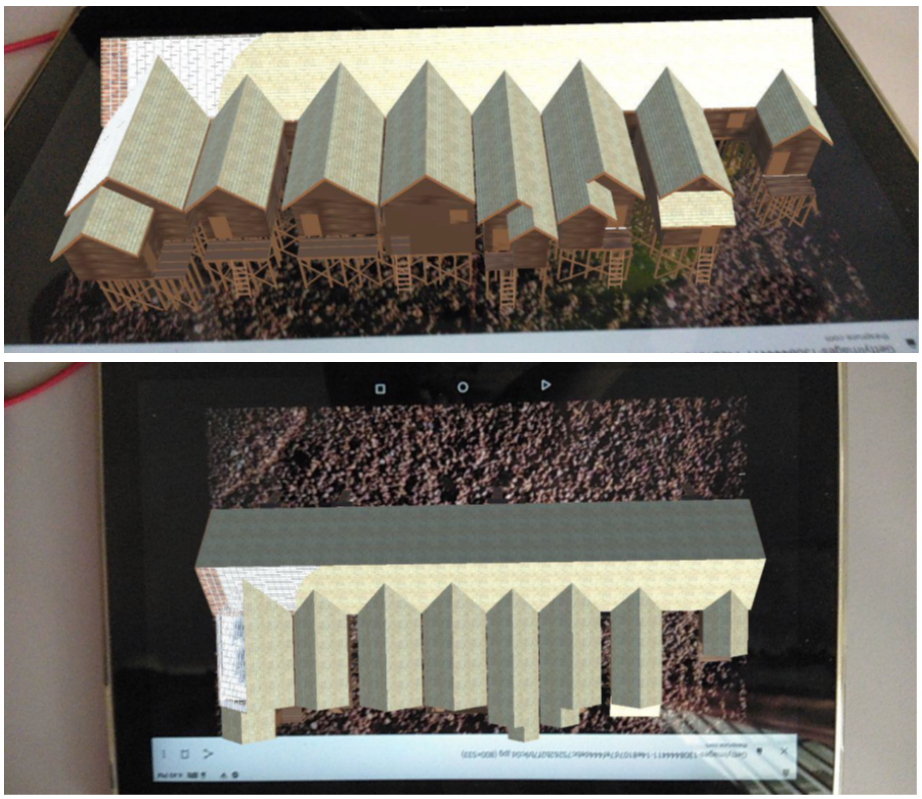

Figure 5: Urban Heritage App Screenshot of Sarawak Cultural Village

5 Conclusion

Augmented Reality (AR) is a virtualisation technology that can give visual content without completely replacing the user's field of view. Tourists can visit interesting areas and explore their surroundings while AR technology displays information and material relevant to them. Combining these two components can improve travel experiences will increase information about a specific location of heritage building. Based on the tourism purpose of the AR Cultural Heritage in Sarawak, the respondents said the proposed framework has been fulfilled the requirements which enabled the development of the prototype for a mobile AR tourist application. The prototype has several special features such as having navigation and multimedia attached in the heritage building mobile AR application. The developed mobile AR tourist application is in parallel with the requirements of the framework and user requirement to demonstrate how well user wants and expectations can be captured. AR is a suitable platform especially for tourism sector as the information is visually appealing and interactive can be delivered through the use of geovisualization. This is because the MAR application adds content to the user's range of view rather than replacing it, and can work best in the context of tourism promotion.

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