JOIV : Int. J. Inform. Visualization, 5(4) - December 2021 354-359

INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION

journal homepage : www.joiv.org/index.php/joiv

Virtual Campus Tour Application through Markerless Augmented Reality Approach

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***Abstract*—Augmented Reality (AR) technology has been widely used on campus tours by universities all around the world. However, the students that stay very far away do not have a chance to visit around the campus. Also, the information that is available on the official website is static, resulting in the visitors feeling less engaged with the information. Hence, the virtual campus tour application using the markerless AR technology, namely AR-UTHM Tour is proposed to be developed on the Android mobile-based platform to visualize the buildings and facilities that are available in the university, specifically Universiti Tun Hussein Onn Malaysia (UTHM). This approach allows the users to visualize the 3D models by pointing the camera at any flat surface. Then, the feature point will be generated to generate a virtual plane. The information about the facilities was obtained from the UTHM official website and the 3D models of the buildings were referred to the floor plan and the actual images. The user acceptance test has been conducted on 30 students of UTHM using Technology Acceptance Model (TAM). The result shows that more than 50% of the respondents have successfully executed the AR session without any error. Overall results show that the users are satisfied with the AR-UTHM Tour application. In conclusion, this application is suitable to be used as a medium to introduce and promote UTHM virtually. Future improvements in terms of detailing the aesthetic of the 3D model will be taken into consideration.**

***Keywords*— Virtual campus tour; markerless augmented reality; UTHM; virtual plane.**

Manuscript received 8 Feb. 2021; revised 21 Apr. 2021; accepted 29 Oct. 2021. Date of publication 31 Dec. 2021.

I. Introduction

In this era of technological advancement, Augmented Reality (AR) has become one of the greatest technology trends in this world. AR is a technology that combines actual items with virtual information in a real-world setting. AR is a system that meets three essential requirements which are the mixing of real and virtual things in a real environment, real-time interaction, and precise 3D registration of virtual and real items [1]. AR enables the virtual object to harmonize with the actual environment. With AR capability, users capable of seeing the virtual object are in the real environment thus it enriches the interface of the system [2]. AR uses computer graphics technology to overlay virtual information in real-world situations in real-time [3]. AR systems can be divided into marker-based AR and markerless AR. Marker-based AR [4] necessitates the use of a visible static marker as a spatial reference to display the digital picture when the camera is pointed at the marker. Therefore, marker-based AR relies on image recognition algorithms, which are assisted by the camera and the markers [5]. Meanwhile, markerless AR [6] uses positional information received from mobile devices' accelerometer, digital compass, and Global Positioning System (GPS) to identify the position of the device pointed to in the actual world by assigning the virtual objects' longitude and latitude [7].

AR technology has been widely employed in a variety of industries in recent years, including retail [8], construction [9], healthcare [10], education [11], entertainment [12], edutainment [13], and edu-tourism [14][15]. Moreover, an edu-tourism such as virtual campus tour is one of the studies involved with the tourism sector in the university which can be implemented by using AR technology. In the tourism sector, tourists may improve their tour experience by using

AR technology. With the aid of AR, tourists may obtain information in real-time while touring a place.

In Malaysia, Universiti Tun Hussein Onn Malaysia (UTHM) is a well-known Malaysian Technical University Network (MTUN) that offers a variety of courses to students. UTHM additionally provides facilities for students to perform their tasks in their learning process. With the huge campus area, it is difficult to explore every single area of the campus in a single day trip. A campus tour usually will be organized to help the new students to know about the facilities and environment on the campus. However, the students have to be physically present in the campus vicinity. Recently, the pandemic of Covid-19 caused the education sector to close. Thus, they are not allowed to enter university and are not able to visit around the campus physically. To address this problem, a markerless mobile AR application namely AR-UTHM Tour is developed. This application allows users to explore the campus and know about the courses and facilities provided by the university.

Currently, there are several campus touring systems that use AR technology that has been developed and published such as iMAP-CampUS [16], Mobile Campus Touring System for Beijing Normal University [17], and NUS AR Map [18]. These existing applications are reviewed based on the features and the drawbacks of the system. The comparison between these three existing applications and the proposed application in terms of different features such as AR-type, 3D model visualization, individual campus building visualization, and applications presentation is presented in Table 1.

TABLE I
COMPARISON BETWEEN THE EXISTING APPLICATIONS AND DEVELOPED APPLICATION

Features	**iMAP-Camp US**	**Mobile Campus Touring System for Beijing Normal University**	**NUS AR MAP**	**AR-UTHM TOUR**
AR-type	Marker less AR	Marker less AR	Marker-based AR	Marker less AR
3D model visualization	Do not provide 3D visualization			Visualize a 3D building on a virtual plane
Individual campus building visualization	Unable to visualize individual campus building			Visualize the individual campus building in AR
Application presentation	Users present physically in the campus vicinity			Does not require to be physically in the campus vicinity

These existing campus touring systems utilize AR technology to help the freshman by improving their campus navigation experiences in the campus. These applications also can help the users determine their places of interest and navigate to the places. However, some limitations exist in the existing applications where they do not provide 3D visualization. Also, these applications could not visualize individual campus buildings and require the students to present physically in campus vicinity to use the application. Thus, the proposed AR-UTHM Tour application is developed to overcome those limitations by applying simple markerless AR. With this markerless AR, the users could visualize the 3D buildings on a virtual plane in the AR session by pointing the camera on any flat surface. Thus, they do not require to be presented physically in the campus vicinity.

The rest of the paper is organized as follows: material and method describe the design and development process, followed by the results and discussion section from the user acceptance test. Finally, the last section concludes the work and highlights the possible future improvement on the application.

II. MATERIAL AND METHOD

AR-UTHM Tour application is developed using the Agile Software Development Life Cycle (SDLC) model [19]. This methodology is the most suitable methodology to use in developing this project because it focuses on process adaptability and the requirements of the target users by rapid delivery of an operational product.

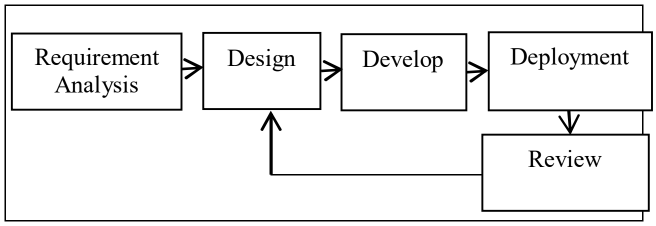

Fig. 1 Adapted from Agile Software Development Model [19]

Fig. 1 shows the adapted Agile SDLC [19] phases that consist of requirement analysis, design, develop, testing, deployment, and review. Each phase is discussed in the following topic with a detailed explanation.

A. Requirement Analysis

In this phase, user requirements were collected by performing a user analysis. This analysis could help the developer to gather the target user's behaviour and their requirements toward the proposed application. Questionnaires were distributed to 30 students of UTHM, and their responses from the questionnaires were considered in the development of AR-UTHM Tour application. The results showed that more than 50% of the respondents agreed that AR campus tour applications could provide dynamic information and an immersive experience while exploring the campus virtually.

B. Design

The activities performed in this phase are designing the overall system and the objects. The application was designed based on the overall system design as shown in Fig. 2. The flowchart and storyboards were drawn in this phase. The overall system design was divided into two parts: campus overview and individual building view. Campus overview shows the location of the building in UTHM together with its history and description while individual building view provides the information about facilities and AR view experience on the faculty buildings.

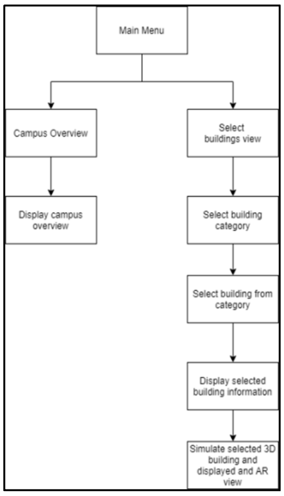

Fig. 2 Overall system design

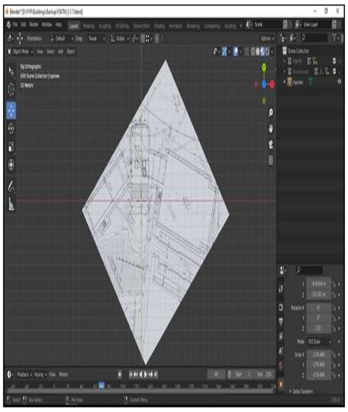

Fig. 3 Outline the shape of the building from the floor plan

Meanwhile, the objects' design involved creating the interface and interaction buttons. These objects were designed using Adobe Photoshop 2021 and saved in Portable Network Graphics (.png) file format. To enhance and ease the user navigation experience, the buttons were designed based on the principle of affordances and consistency [20], which is simple and clear.

C. Develop

Develop phase includes the model object and integration in Unity software with scripting to allow the interaction and functionality of the application. The model object explains the modeling process, the building of 3D models, and assigning the texture and material to the 3D models using Blender software. The integration in Unity involved scripting and the implementation of markerless AR functions. In this paper, the Faculty of Computer Science and Information Technology (FSKTM) building was chosen to be modeled and displayed in the AR session. The building objects were modeled based on the actual floor plan [21] as well as the actual images of the building. All objects were modeled separately. The floor plan was imported into Blender to build up the actual image as shown in Fig. 3.

Then, the shape of the building was outlined and produced a wireframe. Next, the aesthetic value was added to the 3D models with texture and material as shown in Fig. 4. All the models and assets were integrated into Unity with scripting. The scripting of the objects and system function was written in the C# programming language. The features such as show and hide the panel, load scene function, exit function, and implementation of markerless AR session were created to help AR-UTHM Tour application functioning.

Fig. 4 Modeling the building and assigning texture and material to the model

D. Deployment

To enable the markerless AR function in the application, Wikitude Augmented Reality Software Development Kit (Wikitude AR SDK) [22] was implemented into the application. With the aid of Wikitude AR SDK, the phone does not require very high specification and the support of the Google ARCore as well as the Google Play Services for AR. Fig. 5 shows the flow of generating a virtual plane on markerless AR to display the 3D model.

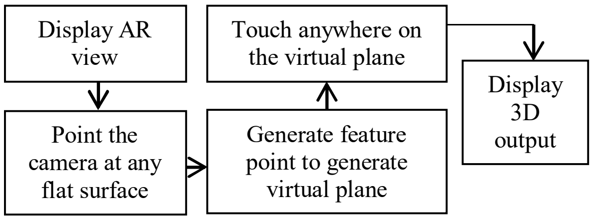

Fig. 5 Generate virtual plane on markerless AR

To enable the markerless AR view session, the Wikitude Camera Script was attached to the game object of Wikitude Camera as depicted in Fig. 6. The camera frame rate was set to 30 frames per second for better display. The Wikitude License Key can be requested from the Wikitude official website. Meanwhile, Android SDK, JDK, NDK, and Gradle must be downloaded and installed before building the project and publishing the application into Android Application Package (.apk) file.

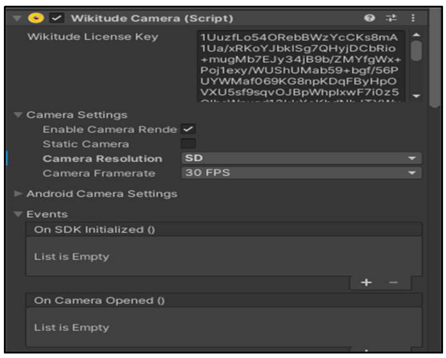

Fig. 6 Wikitude Camera Script

Then, Unity will build up all the scenes based on the build settings once the build button is pressed. The functionality of the built application is tested on an Android mobile phone, as shown in Fig. 7.

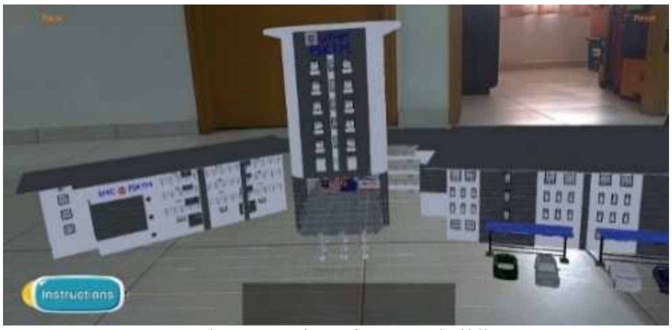

Fig. 7 AR view of FSKTM building

TABLE II
TECHNOLOGY ACCEPTANCE MODEL FOR EVALUATING APPLICATION QUALITY

Construct	Evaluation variables	Measured item
Perceived of usefulness (PU)	Information	PU1: I found that the information about facilities is complete. PU2: I found that the 3D building model of the Faculty of Computer Science and Information Technology (FSKTM) is similar to the actual building. PU3: I found that the information can make me understand more about the facilities.
Perceived ease of use (PEOU)	Usability	PEOU1: The button is simple and easy to understand. PEOU2: The navigation through the application is clear and simple. PEOU3: The application is easy to use.
User satisfaction (US)	Overall performance	US1: The buttons are compatible with their respective function. US2: I was completely satisfied when using the AR session. US3: I found it is easy to get the information about facilities from the application.
Attribute of usability (AU)	Functionality	AU1: The AR session is stable. AU2: The building can be placed on a virtual plane. AU3: The integration of assets such as buttons and 3D building models are implemented well.

III. RESULT AND DISCUSSION

AR-UTHM Tour application has been successfully developed with a resolution of 2240 x 1080 pixels and a memory capacity of 505 MB. To evaluate the usability of the application, the .apk file was released to 30 students of UTHM via Google Drive together with the questionnaire in Google Form. Technology Acceptance Model (TAM) [23] was adopted to measure user acceptance towards the application based on four constructs and three evaluation variables [24][25] as tabulated in Table 2. Each construct consists of three questions where these questions were designed based on the evaluation variables.

Based on the respondents' profiles, 73.3% of the respondents know about AR technology, while 56.7% are very familiar with the AR application and used to it. Thus, the knowledge of AR and the experience might affect the results of the testing on the AR-UTHM Tour application.

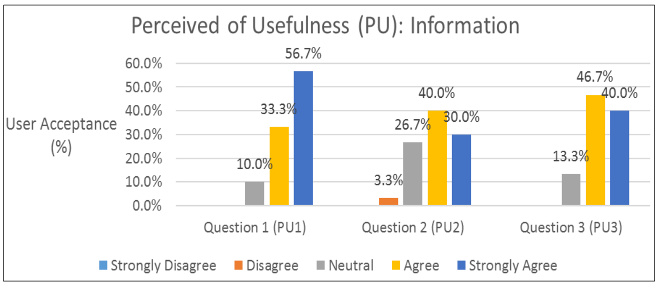

Fig. 8 Analysis of Perceived of Usefulness (PU) on Information

In terms of PU on Information, Fig. 8 shows that 56.7% of respondents strongly agreed and 33.3 % agreed that the information about facilities is complete. Besides, 30.0% of the respondents strongly agreed and 40.0% agreed that the 3D model of FSKTM is similar to the actual building. Conversely, only 3.3% of the respondents feel the 3D model is not similar to the actual building. Thus, some improvement in detailing the presentation of the 3D model will be taken into account. Furthermore, 40.0% of the respondents strongly agreed while 46.7% agreed that the information provided in the application could help them more understand the facilities.

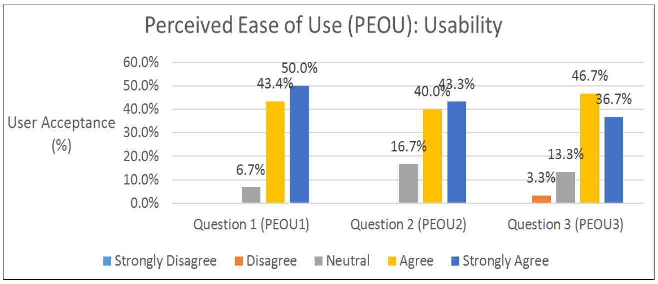

Fig. 9 Analysis of Perceived Ease of Use (PEOU) on Usability

Meanwhile, Fig. 9 shows the results of PEOU to determine the usability of the application. 50.0% of the respondents strongly agreed and 43.4% of the respondents agreed that the buttons are simple and easy to understand. Besides that, 43.3% of the respondents strongly agreed and 40.0% of the respondents agreed that the navigation through the application is clear and simple. Moreover, 36.7% of the respondents strongly agreed and 46.7% of the respondents agreed that the application is easy to use. Instead, only 3.3% of the respondents feel some difficulties due to the unfamiliarity with the AR application. Based on the overall results, it can be said that the usability of the application is acceptable.

In order to obtain user satisfaction towards the overall performance of the application, Fig. 10 reveals that 50% of the respondents strongly agreed and 43.3% of the respondents agreed that the buttons are compatible with their respective functions. Also, 26.7% of the respondents strongly agreed and 33.3% of the respondents agreed with the satisfaction of the AR session. This shows that more than 50% of the respondents successfully executed the AR session. Conversely, only 10.0% of the respondents are not satisfied with the AR session due to unfamiliarity with the system and difficulties while scanning and maintaining the virtual plane. Meanwhile, 36.7% of the respondents strongly agreed and 60.0% of the respondents agreed that they could get information about facilities easily from the application. According to the overall results of this construct, it can be said that most of the respondents are satisfied with the overall performance of the application.

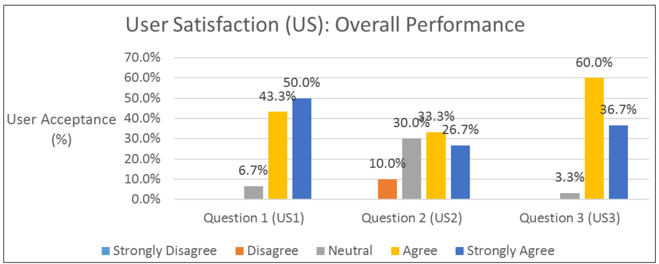

Fig. 10 Analysis of User Satisfaction (US) on Overall Performance

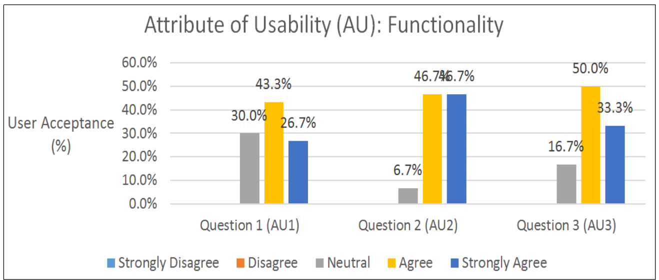

Fig. 11 Analysis of Attribute of Usability (AU) on Functionality

Furthermore, the result of construct AU that determines the functionality of the application is depicted in Fig. 11. It is seen that 26.7% of the respondents strongly agreed and 43.3% agreed that the AR session is stable. Furthermore, 46.7% of the respondents strongly agreed and agreed that the 3D building model could be placed perfectly on the virtual plane. Moreover, 33.3% of the respondents strongly agreed and 50.0% of the respondents agreed that the integration of assets such as buttons and 3D building models are implemented well.

Based on the overall result of the user acceptance test, the AR-UTHM Tour application shows positive responses from most of the respondents. Although most of the respondents know about AR technology and some of them are less familiar with the AR application, the results proved that the application has passed all the constructs in the user acceptance test with positive outcomes from the respondents.

IV. Conclusion

In conclusion, the AR-UTHM Tour application has been developed successfully and has the potential to increase the interest of the visitors and new students to enroll in UTHM with a more interactive and immersive experience. Furthermore, the AR-UTHM Tour application is suitable for users that are staying far away from the UTHM or the new students that want to enroll in UTHM. The application is provided with a simple markerless AR implementation that allows users to access UTHM information without having to be there physically. Although the form of visualization cannot provide a full touring experience as realistic as an actual visit, it could help the visitor's desire to visit from a distant destination by implementing markerless AR. Some future improvements can be implemented in the future to improve the AR-UTHM Tour application and address its existing limitations. One of the future improvements could be made to include more 3D building models to be displayed in the AR session. Besides, more interaction can be added in the AR session to increase interactivity. Lastly, the application could include more information about facilities that are available in the university.

Acknowledgment

We would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support and encouragement throughout the process of conducting this study.

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