Mobile Augmented Reality (AR) Marker-based for Indoor Library Navigation

Rusnida Romli¹, Amir Firdhaus Razali¹, Nur Hafizah Ghazali¹, Nik Adilah Hanin¹ and Siti Zuraidah Ibrahim¹

¹Centre of Excellence Advanced Communication Engineering Centre (ACE), School of Computer and Communication Engineering, Universiti Malaysia Perlis (UniMAP), Pauh Putra Campus, 02600 Arau, Perlis, Malaysia

rusnida@unimap.edu.my

Abstract—This paper presents the development of Augmented Reality (AR) for smart campus urbanization using library as the environment for the demonstration of the AR prototype. The main goal of the AR development is to help users to get information and direction easily using AR based mobile application when walking inside the library. In normal circumstances, users typically walk around and explore the library area before reaching their targeted destinations. Depending on the library size and number of reading corners, exploration and walking in the library can be time consuming. Therefore, an AR technology is introduced in this paper to improve the user experience inside the library in the right direction and information instantly. This application is developed using Vuforia software to set the image marker-based and process the output into Unity3D software, Android Studio for the Main Menu interface and IBM Watson for voice recognition. The final form of the application is successfully generated from the development of Augmented Reality (AR) application for the smart campus by using a library for the demonstration of the AR prototype. A series of application tests are conducted in each corner of the library to evaluate the effectiveness of developed AR.

1. Introduction
A smart campus is a campus that has innovative frameworks in relatively all aspects of lives. A smart campus presents industrial answers for understudies in a considerable measure of fields that are the sustainable power source, digital resistance, innovative strength, wi-fi focuses, e-government and e-region applications, portable applications and different fields. These facilities have been made for students to make their daily activities easier. Smartphones and mobile applications are increasing the time by time, and better applications emerge evolving with mobile technology. New mobile application growing while becoming the primary usage on campus every day. These applications are very important for the campus to become a smart campus. One of the most prominent mobile technology for the smart campus is Augmented Reality [1].

Augmented Reality (AR) is a new technology that implemented the view of the physical world and computer graphics overlay, which is one of the significant advancements combining the real world and computer at a time. That technology can generate almost every content such as video, 2D or 3D image. Content activated when an image or location information is collected. Meanwhile, the virtual content and real environment will exist on the same screen or in the same space, and this technology is making
impossible things happened in the real world [2]. Most of any devices such as smartphones nowadays contain a camera and screen to display, which is one of the elements for visualizing augmented reality. Smartphones technology has been refined with higher level making it production parallel with the technology of computer functions. Therefore, making it prime for the AR application.

Augmented Reality integrates the surrounding environment of a user with a digitized live image or image in real-time, generating a spectacular virtual outcome. Recognition using images is an indispensable component of augmented reality systems. By recognizing visual markers that are already integrated within the scheme, real-world objects are identified to superimpose the virtual objects. In order tom implement the AR, the camera's orientation and position need to be estimated through the detection of actual-world image. Generally, the optical square marker is a black square within a predefined size white box. It is the black square encoded with the marker's identity. There is a range of methods that decode the marker by matching it.

By applying adequate and high-quality technology to both ordinary and online facilities in the library, and by developing 3D library and AR navigation would help users find books accurately and rapidly. Users can see where the books are located, and the application scheme will help user to navigate in the unfamiliar area inside the library. [3]. In addidton, AR application can be a tool to increase the usability of the library, where interactive applications can enhance the user experience and encourage users to visit the library more often. For instance, the usage of virtual banner in library area and interactive book searching system could attract more users such as students to go to the library as the main destination of attractive and exciting learning environment for the students to learn and gain knowledge.

1.1 Marker-Based AR

Once the developer starts using a device with the marker-based augmented reality scheme, the picture of the physical environment captured by a camera is transformed into a grey-scale picture to accelerate the algorithm for image processing [4]. Marker-based AR is a type of augmented reality that uses the recognition of images, eyes, or other real-world objects in real-time to provide the user with additional digital data. A handheld device, such as a smartphone with the right software, could use a marker to read product bar codes and provide relevant information, such as reviews and prices, or to read faces and then connect to an item[5].

1.2 Markerless Based AR

The Markerless Augmented Reality technique enables any and all sections of the physical setting to be used as the goal or base for the positioning of virtual objects superimposed. Markerless AR depends not on the identifying markers, but on the natural characteristics of an environment. Some markerless systems have the capacity to collect and store data and features about the areas on which they are used for subsequent use. Typically, when used in smartphones and other digital devices, the markerless AR system uses the GPS function built-in to find and communicate with the accessible augmented reality resources [3]. Markerless Based Augmented Reality is used to indicate an AR application that does not require an understanding of a user's surroundings in order to overlay 3D material into a scene and keep it at a fixed spatial location [4].

1.3 Location-Based AR

Location-based AR is also known as Augmented Reality without marks, position-based and geo-based. It depends mainly on GPS, accelerometer, digital compass and other techniques to define the place and position of the telephone with a high precision level. Augmented truth is accessible for every mobile device owner because all modern devices are fitted with these sensors.

2. Related works

Table 1 shows the comparison of the previously published works related to Augmented Reality
As can be deduced in table 1, the AR applications are developed for various applications with different software and hardware tools. For example, in [7], AR is developed for construction project using Unifeye SDK and 4D CAD. In [8], AR for campus navigation is developed using a few software tools such as AutoNavi MAP API, Vision-based AR API, and OpenGL. Then, Vuforia and Unity3D with C language are used as software tools to develop the design of VR (Virtual Reality) headset using AR. In turn in [10], the AR is implemented to See-Through Cars application, and the program is controlled by the Robot Operating System (ROS) software, and its hardware consists of D-GPS/LIDAR, PointGrey Flea, and Picostation M. Finally, for the AR of 3D Ping-Pong Game System, the application is developed on Android Mobile Platform using Eclipse with the assistance of Wi-Fi Direct to connect to other devices. In summary, software tools that are suitable for creating AR Application are Vuforia and Unity3D, as it can improve the views of virtual and real objects that displayed on the device. Furthermore, Android Studio also suitable to be used for developing the application as it supports the C language. Thus, using this software to create the application would create a realistic graphic of virtual objects.

Table 1: Comparison of Previously Published Works on AR

| No | Titles                                                                 | Software/Hardware Implemented                        |
|----|------------------------------------------------------------------------|------------------------------------------------------|
| 1  | Application of Augmented Reality Object in Construction Project[7]     | -Unifeye SDK                                        |
|    |                                                                        | -4D CAD                                              |
| 2  | Campus Navigation System Based on Mobile Augmented Reality[8]          | -AutoNavi MAP API                                    |
|    |                                                                        | -Vision-based AR API                                 |
|    |                                                                        | -OpenGL                                              |
| 3  | Design of VR Headset using Augmented Reality[9]                        | -Vuforia                                             |
|    |                                                                        | -Unity3D                                             |
|    |                                                                        | -C language                                          |
| 4  | A Real-time Augmented Reality System to See-Through Cars[10]           | Hardware:                                            |
|    |                                                                        | -D-GPS/LIDAR                                         |
|    |                                                                        | -PointGrey Flea                                      |
|    |                                                                        | -Picostation M                                       |
|    |                                                                        | Software:                                            |
|    |                                                                        | -ROS (Robot Operating System)                        |
| 5  | An Augmented Reality 3D PingPong Game System on Android Mobile Platform[11] | -Eclipse with Wi-Fi Direct                           |

3. Proposed Framework

The tools used to develop and register the marker and how the AR application is designed are described in this section. Figure 1 shows the flowchart of the AR application. Since the camera is the main component of this AR technology; hence, it needs permission to access and activate the camera located on the Smartphone. After that, it gains access to the data from the camera and gains control to change the display of the camera. The virtual objects will be triggered when the tag with markers are detected by written codes. Once the marker is identified by the camera, the 3D objects will directly display on the device’s screen to indicate the marker is now recognized. If the marker is not detected, the camera will continue capturing images, and the application will try to search for the edges or marker to trigger the AR objects. The block diagram of the AR application is shown in figure 2.
3.1 System Planning
The application includes a menu interface to ease the user for their direct guidance. Figure 3 shows the main menu interface of the AR application. It includes navigation to Lobby, Books, First or Second Floor, Direction and Open Camera. Icon is used for navigation so that the interface looks more straightforward and easy to use. Then, the image is snapped to be registered as markers.
3.2 Registering Image Target

AR-markers are visual indicators that trigger virtual information display. Markers are standard images or small objects that are trained in advance to be recognizable later in the stream of the camera. Upon recognition of a marker, its position, scale and rotation are derived from visual indications and transferred to practical information. Different images at different library areas are chosen as the image marker-based for the AR objects to be triggered. The collected images are the input images and set as a tag. Figure 4 shows one of the examples of the image target registration to trigger AR objects.

3.3 Designing AR Objects

By registering a target image to the Vuforia, the pinpoint for the virtual object to trigger was made and what left is to design the virtual object that will appear after scanning the target image. For examples, figure 5 shows the virtual objects that appeared above the image target. Vuforia database needs to be downloaded first and imported into the Unity3D libraries. Assets also need to be imported outsource since Unity3D provides limited 3D objects, and some come with a price. Animation needs to be scripted into the movement of the 3D model, making the presentation of the AR more advances.
Figure 5: Virtual objects designated to appeared above image markers

Figure 6 is included with the audio source, and if the user tilts their device's camera to the markers towards the image target, a voice starts to sound as such “Please scan your ID here” and prompted them the correct machine to scan their ID card. This scene is scripted in the Unity3D with an audio source to enhance the presentation of the augmented reality.

Figure 6: Directional Guide to User with Audio Source

4. AR Application Result
This project is focused on the development of the AR application for urbanization area by using Unity3D, and the library is chosen as a demonstration environment of the AR prototype. Vuforia has been used to set the image markers for the scenes, and each of the markers is being rated on how it can easily be triggered.

Several tests have been conducted to make the AR application more appealing and the virtual objects to stay robust from the original positions. As such, a test of multi-image to trigger the virtual objects have been conducted, and the results are shown in figure 7. The test is to validate the effectiveness of actual virtual objects in real surrounding with different scenes.
16 students and 4 librarians have been chosen to experience the AR applications at different scenes using their own smartphone device. This application only supports the Android Operating System Oreo 8.0 and above as it has the new features from the Unity3D SDK and some of the participants does not meet the specific requirement thus need to use developer’s device to experience the AR application. There are 14 questions for them to answer directly using provided google form after the test are conducted. The questionnaires include the user profile background, the usefulness of the application, the ease of using the application, satisfaction of the application, representation of the user interface, and comment on how to improve it. The result of the questionnaires is shown in table 2 where it indicates a positive response.

| Features       | Percentage of strongly agree |
|----------------|-----------------------------|
| Usefulness     | 75%                         |
| Easy to use    | 80%                         |
| Satisfaction   | 60%                         |
| Representation | 70%                         |
| **Average**    | **71.2%**                   |

Three from four evaluated features achieved more than 70% of agreement from respondents, while Satisfaction features only achieved 60%. This is due to lack of creativity of AR design in a certain area, where the user satisfaction is lower compared to other features. Most of the respondents suggested to put extra 3D models so that the scene looks more entertaining to users. They also suggested to increase the usage of voice recognition features to all area, as it will be more helpful and appear more attractive for the user to control the animation using their voice. More scenes using voice are demanded to make a virtual object appeared in various area. In addition, visual motion is also suggested as additional feature that can be implement in future to enhance the navigation system. Overall average percentage achieved from the conducted survey is 71.2% for all evaluated features, which indicates positive impact of implementing marker-based AR in indoor navigation system in mobile application.
5. Conclusion
This project main contribution is to design and produce mobile application consist of interfaces of Augmented Reality on Android open-source system to testify the proficiency of virtual information shown on the screen and the viability of augmented object plotted at every section of the library. After applying the user testing such as multi-image target and choosing random participants to try the application with several questionnaires provided, the outcome is generated accurately as the virtual image are displayed with a sharp movement and stay at the right location. Hence, implementing this system into the library could reduce the usage of plastic things such as banner and stickers leading toward a go green campaign. Users can easily find sections that they wanted to go, as every area already stated in the AR apps. Hence, a more entertain way of presenting information could lead more students to try new features in the library. A variety of background and colours of the information is presented with more visibility to users includes with 3D effect for user to move freely. Furthermore, the resolution of the application is adjusted to perfectly fit into the user device display so that users able to view the virtual object working fully functional.

The access of the camera also required as it is the leading hardware that been used to detect the scene and every device nowadays includes with a decent quality camera which is making the scene easier to be detected. User will experience a different surrounding and more entertain when using this application to explore the library. It includes an interface where users can react to it and gain information from it. The virtual objects are triggered by detecting the pinpoint of every scene and its edges of 2D images from the camera. The markers that been register at the Vuforia developer web are the primary image processing that generated the virtual objects to appear. The image for the markers needs to choose wisely as it will create a tag for the base on edge inside the image. Then the image will be rated, and perfect markers will be rated as 5 stars. Based on evaluation done through users’ written survey, overall result shows positive response from the respondents where average response achieved is 71.2% for four different features, which indicates promising potential for AR based indoor navigation system.

Acknowledgement
This research was supported in part by Internal Social Project Via Research (INSPIRE) 2019, Universiti Malaysia Perlis.

References
[1] Musa S (2016), Smart City Roadmap. [Online]. Available: http://www.academia.edu/21181336/SmartCityRoadmap (accessed on January 14, 2017).
[2] Mehdi M and Lemieux A (2014) “Augmented Reality : Applications, Challenges and Future Trends.” Applied Computational Science, p 205-214.
[3] Jomsri P (2018) “Implementing Virtual 3D Model and Augmented Reality Navigation for Library in University,” 8(6), p 315–317.
[4] Levski Y (2019) “[Online] available: https://appreal-vr.com/blog/markerless-vs-marker-based-augmented-reality/”. [Accessed: 09- Jul- 2019].
[5] Fleck S, Hachet M, and Bastien J M C, “Marker-based augmented reality,” 25(5), p 21–28, 2015.
[6] Schechter S (2019), “What is markerless Augmented Reality?”, Marxent, [Online]. Available: https://www.marxentlabs.com/what-is-markerless-augmented-reality-dead-reckoning/. [Accessed: 09- Jul- 2019].
[7] Kim H, Kim C, and Kim Y (2013) “Application of Augmented Reality Object in Construction Project”, Third World Congress on Information and Communication Technologies (WICT) p 117–120.
[8] Qin Y-X, Liu J-M, Qiu H, Yan B, and Jin C-X (2013) “Campus Navigation System Based on Mobile Augmented Reality,” 2013 6th International Conference on Intelligent Networks and Intelligent Systems (ICINIS), p 1–4.
[9] Aloor J J and Thomas S (2016) “Design of VR Headset Using Augmented Reality,” 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT)
p 3540-3544.

[10] Rameau F, Ha H, Joo K, Choi J, Park K and Kweon I S, "A Real-Time Augmented Reality System to See-Through Cars," IEEE Transactions on Visualization and Computer Graphics, 22(11) p 2395-2404.

[11] Gao X, Tian J, Liang X, and Wang G (2014) “ARPP: An augmented reality 3D ping-pong game system on Android mobile platform,” 23rd Wirel. Opt. Commun. Conf. (WOCC 2014), p 1–6, 2014.