AR@UNIMAP: A Development of Interactive Map Using Augmented Reality

Rusnida Romli, Muhammad Afiq Aznan, Lip Zhong Xian, Nur Anis Alia Bakhoruddin, Fatin Nur Hazwani Binti Mohd Wazir and Amar Raaj Singh A/L Gurdial Singh

Advanced Communication Engineering Centre (ACE), School Computer and Communication Engineering, Universiti Malaysia Perlis, Malaysia

rusnida@unimap.edu.my, AfiqAznan.it@gmail.com, lipshuting97@gmail.com, alibiakhoruddin98@gmail.com, fatinhazwani1602@gmail.com, amarraaj97@gmail.com

Abstract. Moving towards a modern age, Augmented Reality (AR) can be considered as one of the fastest developing technologies every year wherein it is enhanced by computer-generated perceptual information and sometimes across multiple sensory modalities, including visual and text. However, students have not been exposed to this technology since they are stuck with a narrow-minded conception of using papers even though it can be too overwhelming for them since they have to read the study books, brochures, and pamphlets to get information about their universities especially for the new students who recently registered and for the visitors. To overcome this problem, we are developing an application “AR UniMAP: Pauh Putra Residential College Interactive Map”. This project aims is to develop an informative ARMap along with some additional information about the campus for the students and visitors through interactive communication through the proposed system. Smartphone with the support of ARCore is used as the main platform for the application to be implemented in such a way to display the visuals of the buildings and each room in the campus through 2D and 3D along with some additional information through text pop up on the left and right side of the smartphone screen. The key to this architecture is to expose university students with the AR technologies and to make it easier for them to access information about their university.
1. Overview

In this era of modern technology, new designs and innovations of devices have been used feasibly to improve our quality of life. The computers have been increasing in power yet decreased in size in which it is promising the users to access through online resources easily anytime and everywhere as long as they bring their devices with them. Augmented Reality (AR) has been invented as a wearable computing of technology in a lot of modern applications. AR is an emerging form of experience in which the real world is enhanced by computer-generated content which is tied to specific locations and/or activities [1]. To put it simply, it blends between the real and virtual within a real environment in a real-time interactive and it is interpreted in 3D. There are many applications of AR are coming into view based on the characteristic of integration between virtual and real scene, such as in the field of education, medical treatment, and entertainment [2]. However, in this project, we will be focusing more on ARMap since this application will be implemented in our daily life at the campus and to make it more convenient to the users.

ARMap is an important application and one of the fastest developments of AR technologies since it is focusing on the augmentation of physical maps with some useful and interesting real-time information. Paper maps have a large static surface and AR can provide a see-through lens without forcing the user to watch the map manually from the display [2,3]. As a result, ARMap uses virtual imagery of the users’ surrounding and implements into augmenting it lives. It recognizes the current position by just lifting the rear camera of the users’ devices to the surrounding. The navigation usually provides some guidance on real-time images to reach the target. With the devices supported by ARCore, the users will be able to have a good experience through this platform. According to the market demands, smartphones can be considered as the most suited devices to be used for the implementation of ARMap since they have become the greatest essential components in our daily life. Plus, with all the advanced features built-in the smartphones, of course, they are mostly compatible with ARCore due to their flexibility. Mobile AR has been largely evolved over the last decade and the first instance of it certainly be as associated with the development of wearable AR during locomotion (mobile as motion) [1,4]. With the growing speed of technology, this application can be easily applied for our project in which it will give the most beneficial to the users since smartphones are handy and easy to be brought with the users everywhere.

This research incorporates Android’s Smart Phone supported by ARCore as the platform for creating the Augmented Reality software since Android is an open-source framework. The software chosen for the demo and visual design is Android Studio, Blender, Vuforia, and Unity. Users can easily scan the marker prepared and the model of PFII2 and rooms will be displayed immediately on the screen. Moreover, the users can read the details of each building and room through their smartphones’ screens in an interactive way once they clicked on the model.
2. Brief review

2.1. AR features

Augmented Reality (AR) is a type of technology whereby a view of real, physical world allows users find elements enhanced by computer-generated input. Layers of digital information is added to expand our physical world. For example, a view of physical real-world environment with superimposed computer-generated images. Augmented Reality is not the same as Virtual Reality (VR) as AR does not create the whole artificial environments to replace real with a virtual one. AR appears in direct view of an existing environment and adds sounds, videos, and graphics to it [1,5]. AR is one of the future-centric technology as it allows people to design to decrease the interaction costs and users’ cognitive loads as information sources is combined and attention switches is minimized [2].

2.2. Types of augmented reality

AR is divided into several types:

2.2.1 Marker-based augmented reality. Marker-Based AR provides information about the object after it focuses on the recognition of objects. Marker-based AR detects the object in front of the camera or is being scanned using the camera. This provides information about the object on the screen. For the recognition, marker-based AR replaces the marker on the screen with a 3D version of the corresponding object. This allows users to be able to view the object in more detail and from various angles since the AR device also calculates the position and orientation of a marker to position the content. Besides, 3D imagery can also be rotated by the marker user [2,6].

2.2.2 Marker-less augmented reality. Marker-less AR is being one of the widely implemented applications in the industry. Known as Location-based AR, it has easy availability of features in devices that provide location detection. This style of AR is more versatile than marker-based AR since there is no need for an image cue to deploy. Marker-less AR relies more on the positional information gathered from a device’s camera, GPS, digital compass, and accelerometer. Data that is inputted builds a 3D space, whereby space is processed to Simultaneous Localization and Mapping (SLAM). SLAM places content directly into the users’ view of the world and places it into the environment. SLAM algorithm brings augmentation to new spaces, although it is currently limited to flat surfaces [2,5].

2.2.3 Projection augmented reality. Projection Augmented Reality is the projection of light on a surface. This AR is appealing and interactive whereby light is blown onto a surface and interaction is done by touching the projected surface with hand. Users can interact with virtual objects without cumbersome devices that obstruct face-to-face interaction [2,5].

2.2.4 Superimposition based augmented reality. Superimposition Based AR provides a replacement view of the object in focus. This works by replacing the entire or partial view with an augmented view of the object. Object recognition plays a vital role when replacing a view of an object with an augmented view is done. For example, the superimposed augmented reality is widely used in the
IKEA catalog application, allowing users to place the virtual items of their furniture catalog in their rooms [2].

2.3. Existing ARMap Projects

Technologies spread quickly in this modern world and so is augmented reality, with most of the augmented reality running on an android-based system these days as it is simpler and more accessible to build. In many projects of augmented reality by different classes based on android different approaches and limitations are introduced.

| No | Title of Project                                                                 | Advantages/ Features                                                                                                                                                                                                 | Tools used                        |
|----|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| 1  | Mobile campus touring system based on AR and GPS: a case study of campus cultural activity [7]. | -Discover the complexities of the campus environment  
- Learning more about outdoor cultural activities                                                                                                           | Wikitude, Eclipse platform, Android SDK, MySQL                                      |
| 2  | Development of Anchoring Support System Using AR Toolkit [8].                    | - Help inexperienced pilot to perform exact anchoring                                                                                                                                                                  | 3D model, web camera, AR toolkit   |
| 3  | Implementation of Augmented Reality System for Smartphone Advertisements [9].    | - Conveying accurate information on advertisements  
- Make two-way communication services like booking system                                                                                                     | Vuforia SDK, MySQL, Unity          |
| 4  | A Tour Guiding System Of Historical Relics Based On Augmented Reality [10].      | - Improving learning motivation, guidance system and authentic feeling of tourists  
- Experience AR technology by game-based learning theories                                                                                                  | Mobile phones, GPS, camera, MAGIC EYES                                            |
| 5  | Location Based Augmented Reality Game Using Kudan SDK [11].                     | - GPS data give monster’s location  
- User get notified if there is a monster nearby                                                                                                                                                                    | Unity 3D, Kudan SDK, Android, GPS                                                |
| 6  | Geo-Location Based Augmented Reality Application for Cultural Heritage Using Drones [12]. | - Reconstruct ancient building without physical intervention by using drone  
- Drone rotation and orientation help to track                                                                                                                                                                      | Drone, Unity 3D                    |
Based on Table 1, there are some existing projects that revolve mainly around the usage of ARMap. The feature most of these projects have in common is to give information to the user while providing guidance. One of these projects, Location-Based Augmented Reality Game Using Kudan SDK, even utilized AR in creating a game that uses GPS as a guide for the players. On the other hand, GeoLocation Based Augmented Reality Application for Cultural Heritage Using Drones, uses this technology to recreate augmented images of ancient structures without tempering with the physical intervention. As for the tools used, most of these projects, if not all, used Unity 3D or alternatives of it to create the application, and used mobile phones as the platform for the application.

2.4. ARMap in Campus

Technologies spread quickly in this modern world and so is augmented reality, with most of the augmented reality running on an Android-based system these days as it is simpler and more accessible to build [3]. In many projects of augmented reality by different classes based on android different approaches and limitations are introduced. This project aims to design an ARMap that can be used by all the visitors to guide themselves on the campus. This project provides information for the visitors to avoid them from getting lost and causing mass traffic congestion since everything can be worked smoothly by using this AR application. The main objective is to develop an informative AR map along with some additional information for the students and visitors in an interactive way and to improve the quality of plant efficiencies and the environment on the campus.

3. Methodology

For this project, a marker-based technique is chosen for the ARMap system. From Figure 1 shown below, the block diagram for the ARMap System consists of 1 input and 1 output. The input will be the smartphone. The output will be the software as a process which is shown in the detailed block diagram in Figure 2 below.

Figure 1. Block diagram of the ARMap.
Figure 2. Map System Detailed Block diagram of the AR Map System.

Based on the detailed block diagram, the user will initiate input to the ARMap in the smartphone and the AR Map will give the output to the user. Input to the AR Map will be the interaction of the user whereby the user clicks on the ARMap. The output will be the result that the user wants from the ARMap. For the system to be built, a certain number of programs, tools, and peripherals are used:

- Android devices
- ARCore
- Unity
- Vuforia
- Blender
- 3D Model
- Database
- C# coding language

The usage of Blender, Unity, and Vuforia is important as they are the main cores that help in the creation of the AR Map system [13,14]. Figure 3a to Figure 3f will show the flowchart for the AR Map. The process will be explained in detail.
From Figure 3a, the user will be directed to the Main Menu after the introductory trademarks (Unity, Vuforia, etc) is shown. In the Main Menu, the user will be given two choices where one of them is “PFI2 Augmented Map” and the other is “RoomView”.

**Figure 3a** Flowchart for Main Menu AR application
If the user selects “PFI2 Augmented Map”, the user will be prompted to scan the marker as shown in the process flow in Figure 3b. The marker is prepared to be scanned to show the “PFI2 Map Model”. If the marker is not available, then the application will continue to search for the marker until the marker is found or user prompts for exiting directly.

**Figure 3b.** Flowchart for the PFI2 Augmented Map
When the map model appears, the user will be able to move the model and view them based on the structure of the model. Data is already put into the model based on the database for each building. When a building is selected, the database will appear at the side to show the details of the building. The database will include images where users can view them. After the user is done viewing them, they can press the “Back” button to be brought back to the main menu unless they want to continue to view the model.
Besides “PFI2 Augmented Map”, the user can also choose “RoomView” to view the room model in PFI2. Similar to Figure 3b, the user will be prompted to scan the marker as shown in the process flow in Figure 3d. The marker is prepared to show the “RoomView” when scanned. If the marker is not available, then the application will continue to search for the marker until the marker is found or user prompts for exiting directly.

**Figure 3d.** Flowchart for the RoomView
Figure 3e. Flowchart for when the RoomView is selected

When the map model appears, the user will be able to move the model and view them based on the structure of the model. The room model also contains the database where the details of the room section is available to be viewed. When a section of the room is selected, the database will appear at the side to show the details of the room section. The database will include images where users can view them. After the user is done viewing them, they can press the Back button to be brought back to the main menu unless they want to continue to view the model.
4. Design and development

Android devices are widely used in this project as a testing tool for AR systems due to the availability of AR Core applications that can be interfaced through Android and Windows. ARCore, which is an SDK developed by Google, allows AR applications to be built through different APIs. Game engine such as Unity is used for designing a virtual 3D object. Besides, Unity is also used to create AR simulation with the availability of suitable library components. Vuforia is also used to enable the creation of ARMap application [15]. Since it has the feature that is used in this project, Image Targets. Then, Blender is used to create a 3D model that is used in this project. 3D Model is created to recreate the map of the place that is chosen for this project, which is Kampus Tuanku Tengku Fauziah (PFI2) of UniMAP Pauh Putra Main Campus. Through the 3D model, users can observe the detailed map of PFI2 and will be able to learn information that is related if needed. The details are listed through the database. For this project, the database that is used is XML, which allows simplification of data sharing and data availability. Moreover, C# coding language is also used to enable interaction in the ARMap system.
4.1. Modeling

For the ARMap system, the 3D model is created to show the full scale of the PFI2 map as shown in Figure 4. The models that are used are based on the buildings available in PFI2. The models that are used in Blender are combinations of different shapes and small models together to create a full model. For the model to be built, a plane is added as the main ground for the map. Then, different shapes of blocks are also added as a determination for buildings available. Models that show roads, fields, fence, and trees are also added. The addition of shapes of blocks is then followed by resizing to a suitable length to reflect the scale size of buildings in PFI2. Colours are added to add discretion that the buildings are different for every part of PFI2. Upon completion of 3D model creation, the model is exported as an FBX file to allow the import of the 3D model into Unity. The FBX file is imported to Unity to allow scenes to be added to the model as shown as in Figure 5.

![Figure 4. Complete model used in AR Map.](image)

![Figure 5. Completed Map (Top View).](image)
4.2. Image target design (marker)

Vuforia engine is used to add image target or marker for the model as shown in Figure 6. The image marker is designed so that the image is recognizable using a camera that is available on the smartphone [4]. Based on Figure 7a and Figure 7b below, the Vuforia engine will detect and track the features found in the image by comparing the database that is set using Unity. The targeted image is tracked as long as it is at least partially in the field view of the camera. The recognition of marker depends on its position, scale, and rotation as the model are movable depending on the user's point of view, which means the user may be held in a good manner, which allows full view of the model, or an acceptable manner, which allows a partial view of the model. This denotes that Some parts of the model may appear depending on the scanned parts of the marker. Image targets are ranked with stars. The higher the star rating, the easier the detection, and more accurate tracking. The image that is rated will be determined by Vuforia. The completion of the rating will determine the completion of the database. An image marker is designed for the target and added for the creation of the database. In Figure 7b the database is downloaded and imported into Unity.

![Figure 6. Adding a target and choosing its type in Vuforia Development page.](image)

![Figure 7a. Image target rating and detection point.](image)
4.3. Programming

XML Database is created for storing details about buildings and places that are available in PFI2. Refer to Figure 8 below, header encoding is inserted with tags and details added for the details of the buildings which is represented by the 3D Model created earlier. C# programming codes and script are created using a text editor and added to use Unity engine for enabling interaction in the AR Map system.

Figure 8. The XML Database.
5. Result and Discussion

Upon opening the AR application, user will be given two option either to RoomView or PFI2 Augmented Map. User need to scan the marker as shown in Figure 9. There is two ways user can scan the marker either directly from screen monitor or by scanning the marker on the piece of paper. Figure 10 show scanning interface once option in Figure 11 have been selected. Once user scan the marker, the map model or the room model will load depending on your first selection as shown in Figure 12. User can click the building or using the drop-down box to view information. Information will be obtained from XML database and display it on screen as shown in Figure 13 below.

![Figure 9. Application interface](image)

![Figure 10. A prepared marker](image)
Figure 11. Model of PFI2 and Room appearing on the marker

Figure 12. Model of PFI2 and Room Information shown to user.
Figure 13. Using Drop-Down Box

Figure 14. User can move the marker freely
Figure 14 is the example of Motion tracking, it allows the user to move freely the marker or the phone camera while the virtual object is in a static position as long as the camera phone can track the detection point of the marker as shown in figure 7a. ARCore uses a process called simultaneous localization and mapping, or SLAM, to understand where the phone is relative to the world around it. The combination hit testing to take an (x, y) coordinates corresponding to the phone's screen allows users to interact with virtual objects with any angle or position.

Using the C# code as the backend to collect data and give respond from user interaction, we can change the colour of the virtual object and show the information box on the screen when the virtual object is clicked. Rather than creating an information box for every virtual object, XML Database is used to reduce the load time, it just needs to retrieve data from the XML database and show on a single information box.

For the implementation of the AR application, there will be a need for verification based on user testing to identify the effect of virtual objects appearing in real environment situations. This is because the actual environment is different than that of the image marker as the image marker is set in virtual situations and real-life situations are unpredictable. To counter this problem during testing for the project, several images based on different angles and calculations are used. The testing process involved 20 users where they are asked to participate in a survey by answering a questionnaire regarding user experience and performance of the application. Those who participate in the survey are asked to fill the satisfaction scale for survey criterion that is prepared which is 1 to 5, with 5 having the highest scale. The survey is divided into 2 sections. The sections include user demographic information and the performance of the AR application. Table 2 shows the survey analysis that is taken from the second section of users’ testing.
Table 2: Analysis based on survey of user testing AR applications

| No | Survey Criteria                                                                 | Percentage Based on Satisfaction Scale |
|----|---------------------------------------------------------------------------------|----------------------------------------|
|    |                                                                                 | 1      | 2    | 3    | 4    | 5    |
| 1  | AR application is user friendly for first time users                            | 0%     | 0%   | 10%  | 50%  | 40%  |
| 2  | AR application is very innovative and novel                                     | 0%     | 0%   | 20%  | 30%  | 50%  |
| 3  | The instructions of using the AR application is clear and making it easy to use | 0%     | 0%   | 0%   | 50%  | 50%  |
| 4  | Information that is hard-to-find can be acquired easily                          | 5%     | 5%   | 15%  | 50%  | 25%  |
| 5  | Using this application has developed a feeling of connectedness with other users of the application | 0%     | 10%  | 20%  | 40%  | 30%  |
| 6  | Application efficiently helped in making decisions while on mobile              | 5%     | 5%   | 10%  | 20%  | 60%  |
| 7  | It is worth to use the AR application                                           | 0%     | 5%   | 5%   | 5%   | 80%  |
| 8  | I will recommend others to use the AR application                               | 0%     | 5%   | 10%  | 55%  | 30%  |

Based on the survey conducted for user satisfaction of the AR application, the criteria most users are satisfied with is that the application is efficient in helping to make decisions while using mobile and it feels worthwhile to use the application. The majority of the users are satisfied with the user-interface for first-timers as the application provides instructions for new users. The only two criteria that had scale of satisfaction of ‘1’ are “Information that is hard-to-find can be acquired easily” and “Application efficiently helped in making decisions while on mobile”.

6. Conclusion

We are inviting ourselves into the future of the world, where it will be operated with the Internet. With the Internet, everyone can have access to tons of information. In our project, by constructing the ARMap, it will great to be developed by a reputable company. This is because ARMap has proven to be able to make users’ life easier and therefore lessen the stress that is developed in them, as they do not have to deal with problems university students and visitors encounter in the past. Moreover, ARMap has proven to be environment- friendly, since there is not a wastage on non-renewable resources. To make this report, an abstract is stated to explain the overall purpose of this project. The
purpose is to design an application that can be built to help in navigating university students and visitors in PF12, Kampus Pauh Putra, Universiti Malaysia Perlis (UniMAP). By using applications such as Blender, Unity, Vuforia, ARCore, and implementing XML and C#, the purpose has been achieved. Throughout the project, several issues were found during the development of the ARMap. One of the biggest issues is that integrating unity objects with XML data. Once the issue had been solved, we can test and retest the program so that the program works as intended. Since this project is accomplished, there is still more stuff that can be added. One of them will be the implementation of navigation. As of now, the AR Map that we make is concentrated in the PF12 Residential area, which will be used mostly by residents of the PF12 Residential area. We hope that the application can be improved with more features in the future that will allow more usage by not just PF12 students, but students from other Residential area, lecturers, visitors and other people who are interested in UniMAP.

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