A Guidance Application for Historical Routes and Location Area with Augmented Reality

M F Syahputra¹, U Andayani¹, S Efendi¹, D Arisandi¹, D Abdullah², S Sriadhi³, E Mouw², H Biso⁴ and M Y Ririhena⁴

¹Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan, Indonesia
²Department of Computer Science, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan, Indonesia
³Department of Electrical Engineering, Universitas Negeri Medan, Indonesia
⁴Department of Social and Human Sciences, Universitas Halmahera, Indonesia

E-mail: nca.fadly@usu.ac.id

Abstract. Indonesia is a cultural and historical diversity country. The Indonesian national culture is an analogous multicultural, rooted in older societies and interethnic relations caused the national culture is most easily observed in cities but aspects of it now reach into the countryside as well, for example, capital of Sumatera Utara, Medan. Indonesia's borders are those of the Netherlands East Indies, though Dutch imperialism caused nation and many of its institutions should be able to preserve and introduce their culture and history to future generations. One way that can be done by involving the development of Augmented Reality. Augmented Reality (AR) is a technology that can be developed by creating 3D (Dimensions) of each created object such as a historic place. In this study, the object to be constructed is the 3D object of the historic building in Medan city which is a historic city in North Sumatra. In addition to historical sites there is a city tour service with the location of the historic building nearby with the location point of reference based on the current location. In addition, the user interaction can be done with 3D objects using Augmented Reality technology and information about historic buildings and the use of virtual reality technology in creating 3D visuals of extinct historic locations. This research is expected to attract users of heritage traveler applications and educate the community in preserving the cultural heritage with the help of Augmented Reality (AR) and Virtual Reality (VR) technology.

1. Introduction

Indonesia's geographical location is a country that is between 2 (two) continents namely Asia and Australia and is in 2 (two) oceans, namely the Indian and Pacific Oceans. Indonesia is also an archipelago and country with the largest tropical climate in the world. Based on these geographical facts, Indonesia has a wealth of archipelago with a diversity of cultural heritage. Factors affecting the wealth of the archipelago, including the entry of foreign culture from the colonizing countries that entered Indonesia caused the colonies to have a blend of local culture and foreign culture so that cultural diversity emerged. Cultural heritage includes objects or attributes that are not fines that are the identity of a previous society's habits that need to be preserved to future generations, including monuments, buildings, artifacts, traditions, languages or rituals.
In the city of Medan, there are still many historical buildings of the Dutch colonial heritage which are historical evidence of the many series of events that occurred in the past that we can still see and where we can inherit to the next generation as historical evidence in Medan[1].

The built buildings in the city of Medan are the Lonsum Building, Post Office, Masjid Raya, Tjong A Fie Mansion, Istana Maimun, Bank Indonesia, East Gunung Vihara, Tirtanadi Tower, Shri Mariamman Temple, and Cathedral Church (Santa Maria). (Medan City Spatial Planning and Building Service Website). With the utilization of Augmented Reality and Virtual Reality technology, historical buildings in Medan City, both those that still exist and those that have died and city tour facilities in the Heritage traveler Medan application that will be built, can be part of the conservation of Medan's cultural heritage.

Augmented Reality (AR) is a variation of Virtual Environments (VE) where user can see real world and virtual object superimposed upon or composited with the real world[2]. Technological developments that are already familiar in the minds of people today are mobile phones, which currently lead to smartphone devices[3]. VE technology will bring users into a synthetic environment that is designed to resemble the real environment, but AR will bring users more to be able to imagine detailed objects in 3-dimensional images in the real world[4]. As AR and its supporting technologies continue to flourish, so does its applications across different fields. The ability to augment computer generated entities (3D objects and data) into real world scenes makes AR an ideal platform for enriching historic architecture and the remains of cultural heritage[5]. Augmented reality (AR) promises to bridge the gap between the physical and virtual worlds. AR would allow users to interact with mobile devices in novel and intuitive ways, and would allow better integration into everyday life, as users would not have to look strictly at a handheld device with limited screen and input space, and could instead essentially interact with the world in front of them[6]. Research on the use of augmented reality (AR) and virtual reality (VR) has been made in developed countries to introduce the city and its cultural heritage but in Indonesia it is still little developed. Therefore, it is necessary to have city tour facilities by utilizing the use of AR and VR in Medan City as well as those developed with developed countries. The government's focus on the tourism sector and infrastructure development in Indonesia, especially North Sumatra is also a strong reason why applications with AR and VR technology need to be developed in Medan.

The research objective is the use of augmented reality (AR) and virtual reality (VR) in an effort to promote historical sites in the city of Medan to attract the attention of the public and tourists to visit Medan and help the Medan City government as a form of concern for the cultural heritage in Medan.

2. Methodology

This stage is carried out by the system design analysis process based on the results of the analysis of the literature study that has been carried out in the previous stage. The processes and stages carried out include general architecture, data collection and system interface design as shown in Figure 1 below:
The general architecture in this study consists of several stages, the following is the explanation of the stages to be carried out in this study:

2.1. Input
Users see historical buildings that are objects in this study, then using a smartphone the user will open the application provided. The user will direct the smartphone towards the specified point of view, then the building in 3D will appear on the screen. Users can also see some 3D displays of 3D models of buildings before reconstruction occurs or changes occur in building objects and display information on the building accompanied by media images and text about the building. Then mapping will be used to provide information through digital maps that aim to present information on the location of historic buildings in the form of 3D virtual content in real-time. Furthermore, the process of capturing the real environment using a camera followed by the process of detecting the coordinates of the use of GPS by determining the direction and rotation of the mobile device that is directed by the user using a compass and accelerometer sensor. The camera, GPS, compass, and accelerometer sensors used are default features.

2.2. Process
The system starts when the user opens an application which is an Augmented Reality application with the camera feature to be able to detect markers based on the user's point of view so that it displays a 3D model of the building. After that the marker will match the marker detected with the 3D object that will be displayed. The 3D object will adjust the position and orientation of the marker and will then appear on the user's smartphone screen.

System design is divided into two parts:

2.3. 3D object making
The following is an explanation of the steps taken in 3D modelling:

a. Data collection
To collect and complete data related to the topic, the data obtained is based on books, field surveys and direct observation such as the appearance of photos to find out the condition and shape of objects to be converted to 3D.

b. Pre-processing
After the data about this research has been collected, the next step is to process 3D objects modelling of the object of the building that has been determined. The 3D model built is the main asset in the
Augmented Reality application. 3D modelling is done by imitating the shape of the building based on the 2D Picture Capture Model produced by the existing photo.

d. **Modelling**
   After data - data collected based on field surveys have been obtained, modelling steps are taken using photos that have been obtained. The 3D object modelling process is carried out through mesh modification stages and mesh optimization.

   The modelling process of heritage buildings is done by modifying the existing basic mesh such as, cube, plane, circle, sphere, cylinder, torus, and cone, and to modify certain models is done by using several modifiers in modelling techniques, namely mirrors, Booleans, bevels, and arrays.

   With a series of modelling processes with these modifier techniques, then these complete model sample of the Medan City heritage building are Masjid Al - Mashun and Kerapatan Deli.

![Figure 2. Masjid Raya Al – Mashun.](image)

![Figure 3. Kerapatan Deli.](image)

![Figure 4. Models of Medan City 3D heritage after materializing.](image)

e. **Materializing**
   At this stage, the optimal model will be given the addition of color, texture and some material so that the model looks more realistic and better, so that the 3D model that previously still has abstract material becomes visible. In this process, the color, type and nature of the object in the 3D model is determined. In Figure 4.3, you can see an illustration of a 3D model after the Materializing process.

f. **Lighting**
   The addition of lighting or lighting to give a more tangible effect on the object being built. Where when the side of the object with the light will be given a brighter and brighter color compared to the back side that is not exposed to light will be given a slightly darker color to look like a shadow effect.

g. **Rendering**
   The final process after all data that has been entered in the modelling process, texturing, lighting which will then be displayed as output.
2.4. Making building labels and routes using geo-tagging
The following is an explanation of the steps taken in making labels and building routes using geo-tagging:

a. User
When using the application, the user will interact with real-life objects, then use a smartphone and open the application to capture the real reality used with the camera and detect the coordinates of the user with GPS.

b. Processing
First, to do the scanning process, to detect the coordinates of the user with GPS, this process is done repeatedly so that the system finds the closest coordinates of the user's position. If the system does not find the appropriate coordinate point, this process will be carried out until the appropriate coordinates are obtained, but if there are several coordinates that are appropriate then this process will be stopped by the system and do the comparing process. The process of comparing, will receive the results of scanning coordinates and will adjust them to the coordinates of the database. The comparison process will be carried out continuously if the system has not found the appropriate coordinates, but if the coordinates according to the GPS feeding stops the process and performs the positioning process. The positioning process calibrates the digital compass with augmented reality video to adjust the orientation and position of the camera to the direction of view of the user. Then the position and orientation of the added virtual counter is determined.

c. Scanning
In this process GPS scanning is carried out. GPS will detect the user's coordinate points repeatedly until the system gets an accurate coordinate point.

d. Comparing
In this process, the results of scanning the user's coordinates will be checked, whether the coordinates of the user are in the closest range of the building coordinate points in the database.

e. Route Setting
After the results of comparing the coordinate points are obtained. Then the route will be calculated from the coordinates of the user to the coordinates of the nearest building. The resulting route will form a straight line that is connected from the point of the user to the point of the building, then the straight line of the route will be broken down / separated into several nodes / points so that it forms a graph. After that some coordinates obtained from the results of the route splitting / splitting in the form of several coordinates will be saved to the database.

f. Positioning
The process of doing compass calibration and accelerometer sensor of mobile devices with Augmented Reality camera to match the position and orientation of the mobile camera to the direction of the user's view. After that the position will be determined based on the results of the process of the Route Setting that has been obtained and the orientation to display the virtual route object to be added.

g. Rendering Process
In the labelling process it will work if the scanning, comparing and positioning processes are complete. This process will display the output in the form of virtual content in the form of 2D objects combined
with real reality. This 2D object displays information viewed in real-time. In the process of giving the
direction of the building the rendering process will be carried out, namely the process of displaying
virtual objects by combining them into the real environment in real-time. The virtual objects displayed
in this application are in the form of 3D objects, children, and directions.

2.5. Output
The output will be displayed in the form of an application in the form of 3D Augmented Reality object
where the rendering process is in the form of 2D virtual content from building label information and
arrows that will show the route in real-time that can be seen clearly through the user's device's camera
screen.

3. Result
Each application display will discuss how the display process and its users.

3.1. Main Menu Display
The main menu display is the display that first appears when the application is run. In accordance with
the design in chapter 3, there are five main menus and two sub menus to start the virtual tour. The main
menu display can be seen in Figure 5 and Figure 6.

3.2. Display of Augmented Reality Tour
When trying an Augmented Reality Tour, the application will access the location of the user’s location
and when the user opens the guide menu the user will see there are about 31 points of tourism created
in the MedanCitar application. In the Guide menu there is also a list of 31 historical objects that are also
accompanied by short photos and information such as Figure 6 and are already connected to Google
Maps. When the user opens maps in the Guide menu the display will look like Figure 7 After that, when
the point is clicked, the name of the tourist spot will appear. To make it easier for users in the journey
this application will also display the icon of the historic Augmented Reality (AR) building that is located
within a distance of 1 Km from the user like Figure 8.
Figure 8. Brief information on historical building.

Figure 9. Draw historical building objects when positioned far and near.

Figure 10. Augmented reality appears at the Masjid Raya.

If later the distance from the 3D building object will appear. If the position of the user farther away the distance that will be displayed will be even greater, and vice versa if the position of the user is closer to the distance will be smaller. The Augmented Reality Tour display can be seen in Figure 9 is a test on the object of the main mosque building and figure 10 is a test at the Istana Maimun.

4. Conclusion

4.1. Making 3D objects of historical buildings
In making 3D objects of historic buildings, through stages consisting of:

- Data collection was carried out both in the field survey and literature study.
- Pre-processing with the drawing steps back from 2D to 3D with the Picture Capture Model tool.
- Modelling is divided into mesh modification and mesh optimization. In the modification section the mesh consists of mirror, Boolean, bevel, and array stages.
- The process consists of materializing, lighting, and rendering.

4.2. Labelling using geo-tagging
- The labeling process consists of 2 stages, namely:
  - Processing consists of scanning, comparing, and positioning.
  - Object Rendering.

References
[1] Surapati S 2014 Sejarah bangunan-bangunan bersejarah sebagai sumber pembelajaran sejarah di Kota Medan
[2] Azuma R T 1997 A survey of augmented reality 6 355 – 385
[3] Pramono A 2013 Media pendukung pembelajaran rumah adat Indonesia menggunakan Augmented Reality
[4] Ardhianto E, Hadikumiaawati W and Winarno E 2012 Augmented Reality objek 3 dimensi dengan Perangkat Artoolkit dan Blender
[5] Chen C, et al 2009 Applying augmented reality to visualize the history of traditional architecture in Taiwan
[6] Brotos A 2015 Interactive Augmented Reality Panel Interface for Android