

THE VISUALIZATION OF BRIDGE 3D MODELS USING PHOTOGRAMMETRY AND AUGMENTED REALITY (AR) TECHNOLOGY

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Abstrak

Perkembangan kemajuan teknologi serta ilmu pengetahuan sangat berpengaruh bagi kehidupan manusia. Dengan perkembangan sarana media digital dalam menyampaikan informasi, media dapat memvisualisasi suatu objek dengan penggunaan alat seperti kamera yang digunakan dalam menangkap suatu objek yang berada pada permukaan bumi. Fotogrametri merupakan bidang yang sesuai dalam melakukan pemvisualisasian data foto dimana dengan menggunakan drone atau yang bisa disebut Unmanned Aerial Vehicle (UAV) akan dihasilkan data foto udara sebagai media untuk perekaman objek dan lingkungan dalam memperoleh informasi. Untuk menghasilkan produk fotogrametri 3 Dimensi (3D) melalui metode fotogrametri yang dapat dikombinasikan dengan teknologi Augmented Reality (AR) dilakukan melalui penggunaan metode marker based tracking dengan marker sebagai image target untuk memunculkan visualisasi model serta penggunaan beberapa perangkat lunak (Software) dalam pengolahan datanya. Produk fotogrametri 3 Dimensi (3D) yang dihasilkan ini merupakan objek yang sebenarnya sehingga sesuai dengan penampakan di lapangan yang lalu dikombinasikan penggunaannya dengan Augmented Reality (AR) sebagai teknologi yang interaktif dan fleksibel. Dengan menggunakan fotogrametri dan AR telah dihasilkan sarana teknologi yang memudahkan interaksi antara manusia di dunia nyata dengan dunia maya berupa digital dalam menyampaikan sebuah informasi dari suatu objek yang divisualisasikan.

Kata kunci: Augmented Reality (AR), Fotogrametri, Visualisasi, 3 Dimensi

Abstract

The development of technological and scientific progress is very influential on human life. With the development of digital media facilities in conveying information, the media can visualize an object by using tools such as cameras that are used to capture an object that is on the surface of the earth. Photogrammetry is an appropriate field in visualizing photo data where using a drone or what can be called an Unmanned Aerial Vehicle (UAV) will produce aerial photo data as a medium for recording objects and the environment in obtaining information. In order to produce 3-Dimensional (3D) photogrammetric products through photogrammetric methods that can be combined with Augmented Reality (AR) technology, it is done through the use of marker-based tracking methods with markers as image targets to bring up model visualization and the use of three pieces of software in the data processing. The resulting 3-Dimensional (3D) photogrammetry product is an actual object so that it matches the appearance in the field which is then combined with Augmented Reality (AR) as an interactive and flexible technology. By using photogrammetry and AR, technological means have been produced that facilitate interaction between humans in the real world and the virtual world in the form of digital in conveying information from a visualized object.

Key words: Augmented Reality (AR), Photogrammetry, Visualization, 3 Dimensions

INTRODUCTION

The development of technological advances that are very influential, especially in digital media, makes information much more flexible and informative. AR is a technology that interacts with an object or object originating from the virtual or real world which will later be made into two dimensions and or three dimensions and then combined with the real world so that projecting virtual objects is done in real-time (Ginting et al, 2017).

The development of photogrammetric technology in the use of using one of the vehicles, namely the Unmanned Aerial Vehicle (UAV) in data collection on a small or large scale can assist in data processing with the help of special software that can make 3D modelling (Tjahjadi & Djauhari, 2017). UAV is an unmanned aircraft that is controlled by a remote control operator (Basyuni et al, 2021). In 3D modelling of aerial photo data integrated with AR technology that will produce a certain object. Aerial photo data can be obtained using UAV facilities. The resulting aerial photo data can be processed for 3D modelling and will produce a 3D model of a predetermined object (Fidera & Ihsan, 2020).

The bridge is one of the important transportation infrastructures in people's daily lives. With changes in the condition of the bridge over time and changes in the appearance of the condition of the bridge due to natural and artificial disasters that can damage the condition of the bridge, it is necessary to do 3D modelling on the bridge using the Close Range Photogrammetry (CRP) method for observing the 3D model of the bridge. Furthermore, the 3D model will be visualized with AR technology which will provide the latest (existing) conditions of the bridge via Android

smartphone devices. Visualization using AR is used for the reconstruction process on the surface condition of the 3D model obtained from several digital images so that it can determine the condition of the object (Tjahjadi, 2017).

Previous research entitled "Presentation of Existing Architecture Objects Using Augmented Reality" by (Pejić et al, 2015) has conducted research that uses aerial photo data to generate 3D models of bridges which are then visualized with AR technology. Even so, this study does not show the natural environment that the author replaces with a base map.

Based on the facts and problems above, as well as from the research that has been done previously, this research is expected to be able to produce a 3D model of the bridge using AR technology that can be used to determine the condition of the bridge in a more practical way that also contributes to its natural environment.

Before discussing the research methods in this study, the discussion now will be focused on concepts and further explanation of the few pieces of software that are utilized in this study. First is Augmented Reality (AR) which can be defined as a technology that integrates two-dimensional or three-dimensional virtual objects into the real world to create a mixture of mixed reality and in the process of projecting it in real-time. Connecting the virtual world (virtual world) with the world (real world) can convey information in real-time (Ramadhan et al, 2021).

In addition, AR can also be interpreted as a design that combines the virtual world with the real world to be able to generate data from a system on a real object where the boundary between the two becomes minimal (Ilmawan, 2016).

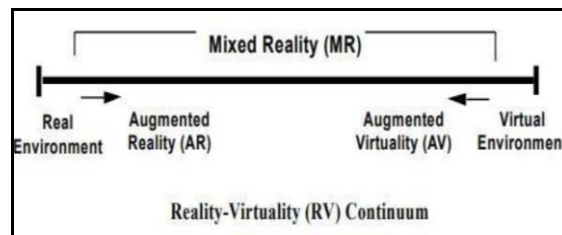


Figure 1. Augmented reality illustration

AR is not only used to display objects that interact with the world but is also being used in various fields such as entertainment, medicine, learning media, factory repair, and design and planning of robot parts (Mustaqim & Kurniawan, 2017).

One way AR works are by detecting marker images using a camera that has recognized or marked the marker pattern. The camera will detect whether the marker has a database or not, if it matches the marker information, then AR can show 3D objects or animations that have been made previously so that it can display information in real-time (Ginting et al, 2017).

According to (Rayda et al, 2017) AR technology has characteristics in the application of the concept, which combines the interaction between the real world and the virtual world in real-time and displays it in 3D.

In addition, this study also uses one of the methods used in AR which is Marker Augmented Reality (AR) or namely marker-based tracking which in the process of displaying the shape of an object requires a marker that is useful as a marker or command to bring up 3D model objects.

A marker in AR is a place to display the results of visualization of AR technology so that two-dimensional or three-dimensional markers will appear. A marker model created in the image design can be recognized by an optical sensor or camera that will read a marker easily under any conditions in the AR method (Setiawan et al, 2016).

AR with markers has a way of working by detecting marker images using a camera that has recognized or marked the marker pattern. The camera will detect whether the marker has a database or not, and if it matches the marker information, a 3D object or animation that has been created will display information in real-time (Ginting et al, 2017). In the process of displaying AR, a camera or webcam is needed to load images from the real world, then the images recorded by the camera will determine the position and location of the x, y and z fields with the help of making markers and markerless which will retrieve the database. After that, through the screen, the camera will recognize the mark (Yuhanto & Miyosa, 2022).

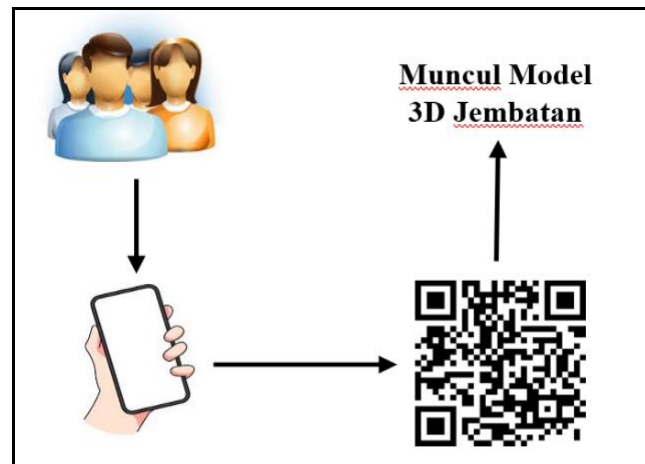


Figure 2. Augmented reality workflow

Such as previous research (Pejić et al, 2015) which used the marker-based tracking method to create AR models, as well other studies that used marker-based tracking, as well as other studies that used the markerless method (Fidera & Ihsan, 2020) models from aerial photographs and (Karundeng, Mamahit, & Sugiarso, 2018) models, were made using their applications where both do not use markers in displaying AR models.

Furthermore, modelling is shaping an object or object so that the object looks like life. Through the concepts and processes of the data and its basis, objects can be shown in 3D, so many call the results Three-dimensional modelling (3D Modeling) (Nalwan, 1998).

Making 3D models can use photogrammetric technology, namely by UAV aircraft, by using software in processing the results of shooting data. This technology can help to show that 3D modelling can be done using photo data, besides that the use of this technology also does not cost a lot. Modelling using photo data can also produce 3D models that resemble the original form (Tjahjadi & Rifaan, 2018).

Using a UAV will produce an aerial photo, from two photos that overlap each other so that the results from two different shooting positions are useful for making 3D modelling. This model will be represented by points in the form of (x, y, z) (Bayuaji et al, 2015).

Then, there is also Vuforia which is an AR Software Development Kit (SDK) for mobile devices that help build AR applications. Vuforia, which will later merge into Unity, called Augmented Reality Extension for Unity, provided by Qualcomm to assist development in making AR applications on smartphones (iOS, Android) has been successfully used for both platforms. Vuforia also has various capabilities and features that help developers in conveying their thoughts or ideas without any restrictions (Oktavia et al, 2019).

Vuforia uses Computer Vision technology on the camera to recognize and track images (Image Target) which will later read the database from markers and will display 3D objects in real-time [20] AR Vuforia provides a way of interacting through a mobile phone's camera which is used as a visualization device where the AR Vuforia will recognize certain markers so that the screen can display a combination of the real world and the world drawn using the application (Husnandhiya et al, 2021).

Besides Vuforia, there is also Unity 3D which is software that is used to create games and applications from various consoles, desktops and mobile platforms. Even so, if you want to make a design or a 3D modelling asset, other software is needed to help create 3D models such as 3D blender, 3D Max and many more (Nurrisma, 2021). Game engines are part of the foundation of every video game. Mesh

is the basic form of a 3D object (Rachmanto & Noval, 2018). In Unity 3D, the script features available are JavaScript, C# and Boo (Mongi et al, 2018).

RESEARCH METHODS

In making AR, it takes a model that will interact with the real world, a 3D model object that will be used in the visualization of this research, namely a bridge (Figure 3) which is located in Pandansari village in the Selorejo dam area.

The following is a photo of the bridge (image size 5472 x 3648 pixels) taken using the DJI Phantom 4 Pro drone, with the specifications listed in (Table 1).

In collecting the data, a photogrammetric method using UAV was used. The data obtained are in the form of aerial photos, totalling 987 photos consisting of top, bottom and side photos of the bridge.



Figure 3. Bridge photo

Table 1. Drone Specifications

DJI Phantom 4 Pro Specifications	
Sensor Camera	1-inch Exmor R CMOS with sensor 20 MP
ISO Range	Photo: 100 - 3200 (Auto) 100- 12800 (Manual) Video: 100 - 3200 (Auto) 100 - 6400 (Manual)
Weight Battery	1388 g 6000 mAh (in flight: 5870 mAh)
Image Size	3:2 Aspect Ratio: 5472 × 3648 4:3 Aspect Ratio: 4864 × 3648 16:9 Aspect Ratio: 5472 × 3078
Photo	JPEG, DNG (RAW), JPEG + DNG
Video	MP4/MOV (AVC/H.264; HEVC/H.265)

The data processing technique in this study uses three pieces of software that have their respective functions. Aerial photo data processing is carried out using agisoft metashape free edition software (<https://www.mazterize.com/agisoft->

[metashape-professional-full.html](https://www.mazterize.com/agisoft-metashape-professional-full.html)), for database creation on markers using vuforia and the last one using unity 3D to combine 3D models with markers which are also combined with the help of visual studio.

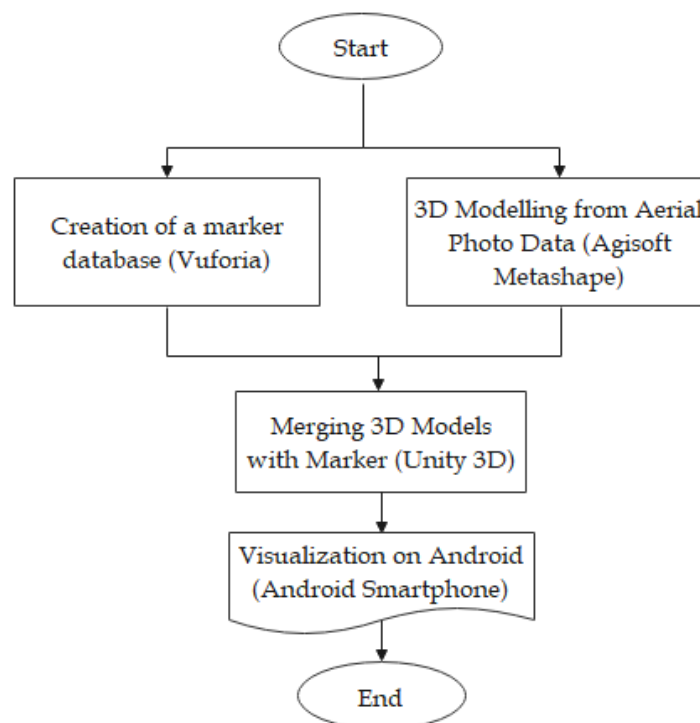


Figure 4. Flowchart of data processing methods

In AR processing there are several stages such as a flow chart (Figure 4) which has 4 sub-processes in the data processing. The discussion will now focus on the data processing process.

The initial process of processing aerial photo data is carried out in several stages. The first is align photo which turns aerial photos into point clouds. Then the dense cloud is used to multiply the point cloud by thousands so that it is close to the shape of the object and the last is the building mesh, namely, the process of pointing the point so that it forms an object. Furthermore, the 3D model is imported into a .fbx format file and the colour or texture model is imported in a .jpg file format.

Vuforia will create a marker database that has been determined as the target image so that markers that already have the database can be brought to Unity which will be used to detect markers to be responded to by a vision camera.

For the final process in processing the visualization of making AR using Unity 3D which combines 3D models with markers. The results of the Unity

application have an .apk format that will be inputted into Android for the visualization process.

While the visual studio is useful for scripting in Unity 3D, at the beginning of the script opening (Figure 5) there will be a *public class Menu_Manager: MonoBehaviour* where Menu_Manager is the name of the script file created and MonoBehaviour is the default editor of unity. In the script there is a *public GameObject MenuPanel;* and *public GameObject InfoDevelopers;* which will be the main panel data type as well as the button that has its function to run it, namely *public void PlayButtomClicked()* for the Start AR button then *Application.LoadLevel("Bridge");* used to visualize ar models that have the name of the Bridge scene. *public void DevelopmentInfoClicked()* for the Application Info button *MenuPanel.SetActive(false);*, *InfoDeveloper.SetActive(true);* which means the view will focus on the Development Info panel. which contains the maker's information as well as the location of the bridge and the original photo of the bridge. *public void Quit_Clicked()* for the Exit button

and *Application.Quit()*; useful for getting users to exit the application. *public void BackButtonClicked()* for the Back to Menu button then for *MenuPanel.SetActive(true);*,

DevelopmentInfo.SetActive(false); which means the display will refocus on the MenuPanel.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Menu_Manager : MonoBehaviour
{
    public GameObject MenuPanel;
    public GameObject DevelopmentInfo;

    void Start()
    {
        MenuPanel.SetActive(true);
        DevelopmentInfo.SetActive(false);
    }

    void Update()
    {
    }
}

public void PlayButtonClicked()
{
    Application.LoadLevel("Jembatan");
}

public void DevelopmentInfoClicked()
{
    MenuPanel.SetActive(false);
    DevelopmentInfo.SetActive(true);
}

public void Quit_Clicked()
{
    Application.Quit();
}

public void BackButtonClicked()
{
    MenuPanel.SetActive(true);
    DevelopmentInfo.SetActive(false);
}
}
```

Figure 5. Main menu script

After the "Start AR" button is pressed, the android camera will automatically activate to detect the marker, if you want to return to the main menu there is a Back to Menu button. To run the button requires a script (Figure 6). using *UnityEngine.SceneManagement*; is useful for

setting the scene in unity. *public void LoadScene(string scenename)* for the button to the main menu as well as *SceneManager.LoadScene(scenename)*; useful for entering the name of the scene you want to run.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class AR_Camera : MonoBehaviour
{
    public void LoadScene(string scenename)
    {
        SceneManager.LoadScene(scenename);
    }
}
}
```

Figure 6. Script to return to the main menu

In presenting AR technology, it is done by pairing the bridge AR application on Android as a medium for visualizing it which is obtained from Unity. Furthermore, using the camera on Android will detect markers so that they can display 3D models.

RESULTS AND DISCUSSION

The results of processing aerial photo data using special software produce a 3D model of the bridge and the appearance of the surrounding environment. The 3D model of the bridge has a shape and color that almost resembles its original appearance because the photo data used is the original state of the field which can be seen in Figure 7(a). and 7(b). Therefore, the final result of the

modelling will be able to display the 3D model and the surrounding environment well and clearly. After you have finished

creating the 3D modelling, the next step is to export the model in .fbx and .jpg formats.

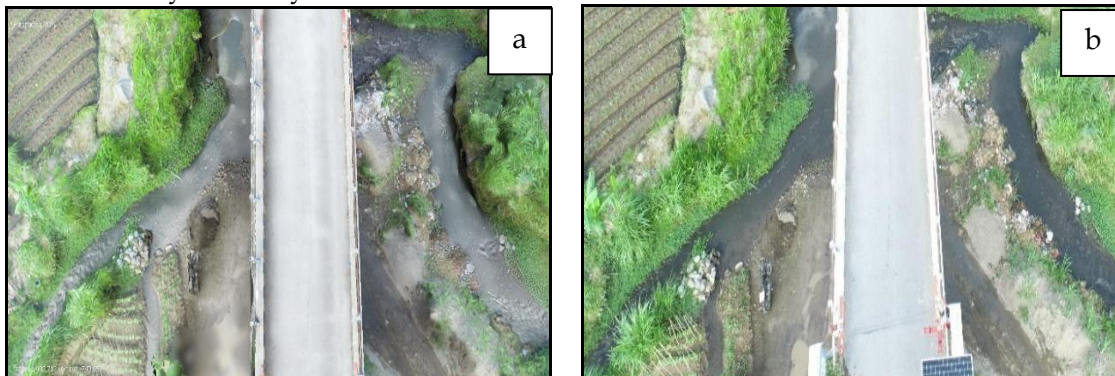


Figure 7. (a) Photo processing results and (b) Original photo of the field

In making AR with the marker-based tracking method, it is done using Unity 3D software. To combine markers with 3D models, it is necessary to first enter the marker database package containing the target image and license key so that the camera can detect the contents of the

marker database obtained from Vuforia. After that, the step that must be done is to enter the bridge model into the target image in the form of a marker which can be seen in the following image (Figure 8).

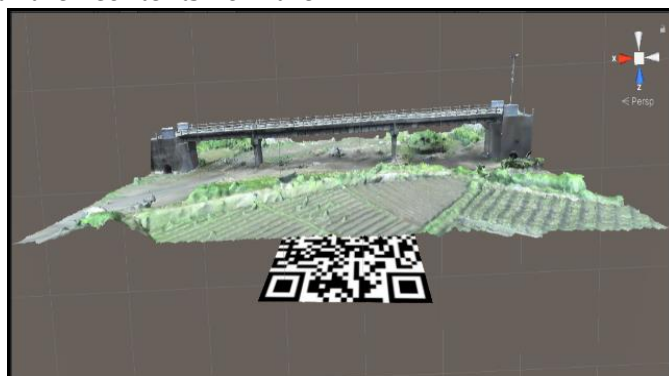


Figure 8. Merging 3D models and markers in unity 3D

The identification of the marker can be done by pressing the play button in Unity so that the camera on the laptop/computer will be active so that it

can be used to scan markers. If the 3D model of the bridge can be displayed (Figure 9) then the process of merging the marker with the model has been verified.



Figure 9. Identify markers in unity

By using the canvas in Unity which is used for making the initial display on the main menu in the application, there are several buttons or buttons on the main

menu with their respective functions as shown in Figure 10. For the button to function as desired, a script is needed to run it.



Figure 10. Main menu view

After the creation of the bridge AR application is completed, the next step is the installation of the application on android which will be a device used to visualize the model by detecting the marker. Using the

device, users can interact with the bridge model that had been made into AR as can be seen in the picture in figure 11 (Figure 11).



Figure 11. Visualization on android

CONCLUSION

Following the discussion and results of this study, photos data are being taken from the air using drones and can be processed to produce a 3D model of the bridge. Furthermore, the bridge model and its surrounding environment also can be visualized with AR technology which is a new way that needs to be developed more in the future where users can see the visualization of the resulting model flexibly and easily. The visualization of bridge model and its surrounding area are also visualized clearly.

For further research, it is expected to further develop the visualization of the area around the 3D model by adding visualization of the model you want to build around the 3D model such as buildings, roads, drainage and others that can be used in development planning.

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