The application of unmanned aerial vehicle photogrammetry for building maintenance (case study: national education museum, universitas pendidikan indonesia)

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Abstract. The use of UAV photogrammetry for three-dimensional modeling continues to be developed to produce models with high accuracy which are then used for documentation, maintenance, and development of the object being modeled. In this research a three-dimensional modeling of the National Education Museum, Universitas Pendidikan Indonesia is one of the landmarks of the Indonesian Education University campus. At the acquisition stage, taking photographs with two flight paths, namely circular grid and vertical grid so as to produce photos with oblique orientation and upright parallel to the face of the building. At the processing stage, scaling is done using field dimension data inputted on the model to produce a model that has dimensions that resemble actual conditions. From the processing results, we get a three-dimensional model that has the shape and texture in accordance with the original conditions, but there is a large distortion in the glass object. In addition to the accuracy test analysis, there is an RMSe value of 0.278 meters in the comparison of the sizes in the model with the actual conditions.

1. Introduction

Utilization of Unmanned Aerial Vehicle (UAV) is no longer used for documentation purposes. With the development of computer vision technology, enabling UAVs to become vehicles that can be used to produce spatial information. [1]. By combining the principles of photogrammetry and computer vision and UAV vehicles, high resolution mapping can be produced with relatively fast time and has a fairly high level of security [2]. UAV Photogrammetry has been used by various researchers and practitioners to obtain geospatial data for various purposes such as area mapping[3], geomorphological mapping[4], flood analysis[5], Landslide mapping [6], for education [7] and other uses that require high-resolution spatial data. The development of UAV utilization then began to develop towards three-dimensional modeling.

In the last 1 decade, three-dimensional modeling has continued to increase, due to the technology that allows researchers to produce three-dimensional models of a building with a high degree of accuracy, one of which is using photogrammetric UAV methods [8]. The advantage of using UAV Photogrammetry for the purposes of three-dimensional models is the flexible reach so that it can reach the highest building locations, which cannot be achieved with ordinary surveying techniques such as Terrestrial Laser Scanners and Electronic Total Stations (Vacca, Furfaro, and Dessi 2018). Three-dimensional modeling using UAVs has been carried out to document historical buildings[9], Maintenance of ancient buildings [10], and construction of building information models for maintenance needs [11].
This research is focused on the use of UAV photogrammetry to produce a three-dimensional model of the UPI National Museum, Universitas Pendidikan Indonesia. This study uses two types of flight paths, namely circular grid and vertical grid, from the acquisition results will then be processed using the Surface from Motion method. Specifically, researchers do not use Ground Control Points to produce accurate three-dimensional models, but instead use a scaling approach (measurement of length in the field). Dimensions on several sides of the building will be measured and used as a reference in processing three-dimensional models. The results of the three-dimensional model are then analyzed using a comparative approach of objects that have been known to measure length in the field and compare them to the same object length in the model.

2. Method
The purpose of this study is to produce a three-dimensional model of two different flight paths, so as to produce photographs with nadir and oblique perpendicular orientation, to obtain these photos, UAV rides are equipped with cameras. The UAV used in this study was DJI Phantom 4 Pro. This UAV is equipped with a Sony Exmor camera of 12.4 Mega pixel resolution.

At the stage of field acquisition, two types of flyways are used, namely circular flight paths which will produce photos with an oblique orientation and vertical flight paths that will produce nadir perpendicular photos. The path illustration is shown in figure 1.

![Figure 1 UAV Fotogrametri Flight Grid](image)

The circular grid flight path is carried out at a height of 40 meters from and produces oblique photographs of objects. After acquiring photos with a circular grid, the researchers then made an acquisition with a vertical grid. The principle of the vertical grid is to take photographs with a vertical orientation or parallel to the facade of the building. Taking photos using overlapping 80% overlap from the base of the building to the roof of the building. The distance between vertical flight lanes is 11 meters to produce a 70% side lap. Illustration of vertical grid shown in Figure 2.
The photos obtained from the acquisition are then processed using Agisoft Photoscan software. At the rectification stage, the scaling model method is used. This method uses the dimensions of the object in the field and then inputted on the same object in the model, resulting in a model that has dimensions that resemble the actual object. After getting the three-dimensional model, an analysis is then performed by comparing the dimensions in the model and the field of the object that is not being referred to as scaling.

![Plan Flight Illustration](image)

**Figure 2** Vertical Grid Illustration

3. Result and Discussion
From the results of tie point processing, the orientation of the camera obtained from the data acquisition using two types of grids is obtained. Figure 3 shows the camera position at the time of data acquisition.

![Camera Position](image)

**Figure 3.** Camera Position
After processing the tie point, the researcher scales the model using the objects contained in the research object. There are four objects used as a reference scaling. Figure 4 shows an example of the dimensions of the object used in the scaling model.

![Figure 4 Scaling Bar Processing](image)

After scaling, a dense cloud and mesh is made, so that a 3-dimensional model of the National Museum of Indonesia's Education University building is produced. The Model resembles the actual condition of a building. The resulting three-dimensional model can also be measured in dimensions. Figure 5 presents the results of a three-dimensional modeling of the National Museum of Education, Universitas Pendidikan Indonesia.

Visually, there are some objects that have great distortion so that the shape of the model does not resemble the actual shape. One object that has a large distortion is a mirror object. The picture shows details of mirrored objects that are distorted. The occurrence of distortion in glass objects can occur due to the reflection of light which results in changes in the position of the object, this will have an impact on the accuracy and shape of the object [12].

![Figure 5 Three Dimension Model of National Education Museum](image)
In addition to doing 3-dimensional modeling, an analysis of the quality of the model is also done by comparing the dimensions of objects in the field and in the model. In this study used 4 objects representing 4 sides. Figure 6 displays the objects used to analyze the accuracy of the model.

![Figure 6 Distortion on Glass Object](image)

From the results of the comparison of the dimensions of the object then obtained an average RMSE value of 0.296 meters with a standard deviation of 0.278 meters. In table 1 shows the results of comparison of dimensions of objects in the accuracy test.

**Table 1 Comparison of field dimension and model dimensions**

| Object | Distance from Model | Real Word Distance | Differences (Real Word – Point Cloud) |
|--------|---------------------|--------------------|---------------------------------------|
| D1     | 2.703 m             | 2.75 m             | 0.047 m                               |
| D2     | 1.537 m             | 1.65 m             | 0.113 m                               |
| D3     | 2.58 m              | 2 m                | -0.58 m                               |
| D4     | 2.191 m             | 2.20 m             | 0.009 m                               |
From the results of the comparison it is necessary to develop the number of objects for scaling and the distribution of objects used for scaling, because in this study, the objects used are objects that are located at the bottom of the building.

4. Conclusion

Based on the results of three-dimensional modeling using UAV photogrammetry using two types of measurement grids, circular and vertical grid, three-dimensional models are obtained with accuracy and resolution close to the original condition, but there are large distortions in the mirror object. In the model accuracy test, the RMSe value obtained from the dimensions of the object in the field with the model is 0.296 meters. It can be concluded that by utilizing dual grid can produce a model with a high level of detail, but certain techniques are needed for objects that are able to reflect light, in addition it requires further studies on the use of scaling methods to produce three-dimensional models that have dimensions in accordance with the original conditions.

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