The Combination of Spherical Photogrammetry and UAV for 3D Modeling

T Ihsanudin¹ and A R Affriani²

¹Postgraduate student at Geomatic Engineering, Engineering Faculty, UGM
²Lecturer staff at Mapping Survey and Geographic Information (SPIG), Faculty of Social Science Education, UPI

taufiq.ihsanudin9@gmail.com

Abstract. The complete of 3D models required the object that was recorded from both side and top. If the object recorded from above, then the object from the side can not be covered, and if the objects recorded from the side, it can not be covered from the top. Recording of objects from the side using spherical photogrammetry method and from the top using UAV method. The merge of both models using a conform transformation, by bringing the spherical photogrammetry coordinates system to the UAV model. The object of this research is Ratu Boko temple, Sleman, Yogyakarta. The spherical photogrammetry recording was performed by rotating the camera in 360° angle on the entire area of the temple. The area consists of 12 stations. The UAV method uses a drone with flight attitude of 20 meters. The merge of the both models produced the completeness of the temple model from the top and side.

Keywords: Spherical Photogrammetry, UAV, 3D model

1. Introduction

The technology for the acquisition of earth surface objects using aerial photographs develops in close range photogrammetry. Close range photogrammetry is a spatial data acquisition technique on the surface of the earth using photogrammetric methods with the distance of the camera to the object is 10 meters up to 100 meters. The application of close range photogrammetry is spherical photogrammetry or panoramic imaging. Spherical photogrammetry is a photogrammetry method that used panoramic images as the basic information [1]. The excess of this photo has a 360 ° perspective in a horizontal direction, 180 ° in a vertical direction and can form a projection field of a spherical surface.

The complete three-dimensional (3D) model cannot be done using a single survey tool. It needs some tools which can fill the void of the measurement object that cannot be reached from one survey tools. This research aims to combine spherical photogrammetry photo with Unmanned Aerial Vehicle (UAV) model. Spherical photogrammetry model was recorded the object from the side. As a complement of data from the top view, it used the UAV method.
2. Method

2.1. Location
The object of this research is Ratu Boko temple, which located at Dawung, Bokoharjo village and Sumberwatu, Sambirejo village, Prambanan, Sleman, Yogyakarta.

2.2. Data
The temple cannot be captured by single view photo for detail 3D modeling purpose; it needs to be captured from terrestrial photo with spherical photogrammetry. This data acquisition method are panoramic and UAV.

Table 1. Acquisition of 3D modelling

| Type              | Equipment | Camera          | Average photo distance of Image |
|-------------------|-----------|-----------------|---------------------------------|
| Spherical Photogrammetry |          | Action camera Xiaomi YI | 7 m                 982           |
| UAV               |          | Action camera Xiaomi YI | 20 m                90           |

2.3. Spherical Photogrammetric Method
Photo data was taken by positioning the camera at one exposure point. This point was used as the camera's rotational axis when shooting at 360° viewing angle. Overlap panoramic camera was made be vertical to get stereo photo of the temple facade which will be made 3D model. Shooting configuration of spherical photogrammetry method can be seen in figure 1.

2.4. UAV Recording
UAV data collection using quadcopter with a flight attitude of 20 meters above the object. Yi's Xiaomi camera was mounted on the quadcopter body and set the exposure time every 1 second. The numbers of Ground Control Point (GCP) are 4 points and it measured using GPS rapid static method for 30 minutes observation. The GCP was used for reference binding during 3D UAV model processing.

3. Build 3D Model

3.1. Camera Calibration
The process of 3D modeling must have accurate position. The accurate position needs the internal parameters of a camera. So, it must be known. The internal parameters need to reconstruct the beam and to know the size of camera systematic error. Calibration was performed to obtain the focal length, the main position of the photo (Xp, Yp), radial distortion (K1, K2, K3), and tangential distortion (P1, P2).

3.2. Object Reconstruction
This research uses image-based modelling method. 3D modelling with IBM used to reconstructs the geometry object by identifying the same set of points from two or more photographs [2]. These points were connected with the same object or feature in each photo to produce the camera position and estimate the shape of the 3D model. The points from the same feature identification on several photographs resulted a very tight bounding point, it become a point cloud. The result of point clouds
using spherical photogrammetry can be seen in Figure 1. The result of point cloud using the UAV can be seen in Figure 2.

![Figure 1. Point cloud of Spherical photogrammetry](image1)

![Figure 2. Point cloud of UAV](image2)

3.3. Meshing and Texturing
Meshing and texturing becomes the final part of 3D modelling (Kwiatek, 2016). The surface of the object can be represented in mesh form. Mesh (in the computer graph community) was derived from integration of the point which connected with the same features into a triangular net, it known as Triangular Irregular Network (TIN) in photogrammetry. The TIN has not been able to display the objects in real and accurate position. The meshing process can be visualized by texturing. It was done by overlaid the photo on 3D surface. The internal and external orientation parameters of each photo were adjusted by photo coordinates for each vertex mesh, so the 3D surface will have a texture with realistic photographs [3].

The result of texturing process using spherical photogrammetry model can be seen in Figure 3. The result of texturing process using UAV model can be seen in Figure 4.

![Figure 3. Spherical photogrammetry 3D model](image3)

![Figure 4. UAV 3D model](image4)

3.4. Combination of 3D Model
The merge of both 3D model done by transformation conform between two 3D models. Merging is done by searching for a minimum of three Allied point between these two models. In the process of transformation, 3D roof model used as a reference, while the 3D facade models transformed to the roof model. This is because the 3D roof model was already on the ground coordinate system (georeferenced), while the 3D facade model was in the local coordinate system. The selection of ally point in both models generated a matrix transformation. It used to transform the 3D facade models to 3D roof models.
| No. | Method | Top View | Side View |
|-----|--------|----------|-----------|
| 1   | 3D model of Spherical Photogrammetry | ![Top View](image1) | ![Side View](image2) |
| 2   | 3D model of UAV                  | ![Top View](image3) | ![Side View](image4) |
| 3   | 3D Combine of Spherical Photogrammetry + UAV | ![Top View](image5) | ![Side View](image6) |

Each data processing produces its 3D model. UAV data produces a top-view 3D model, while spherical photogrammetry data produces a side 3D model (façade). Both models have their respective deficiencies the combination was done to get a complete three-dimensional modelling.

4. Conclusions
This research explains the combination of spherical photogrammetry and UAV. The advantage of combination 3D model result was fulfilled completeness side view (façade) of the temple. The previous UAV data only can model the visible part of a temple, then after the combination it can model the whole temple object. The disadvantage of the 3D model combination was can not unifying colour between the 3D roof model and 3D facade model. It happens because the difference time when shooting both object models. The difference time affects the brightness of the colours in both models.

References
[1] Fangi G 2015 Towards an Easier Orientation for Spherical Photogrammetry The International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences.
[2] Cohen A et al 2012 Discovering and Exploiting 3D Symmetries in Structure from Motion.
[3] Remondino F 2006 Image-Based 3D Modeling: A Review 21(September) pp 269–291.
[4] Huang F, R Klette, K Scheibe 2008 Panoramic Imaging Sensor-line Camera and laser Range-Finders (United Kingdom: John Wiley & Sons Ltd).
[5] Michail Bethel and McGlone 2001 Introduction to Modern Photogrammetry (New York: John Willey and Sons. INC).
[6] Lowe M B a D G 2003 Recognising Panoramas Nice, France, ICCV2003 pp 1218-1225.