Comparative Flight Direction Methods of Photogrammetry in Unmanned Aerial Vehicle (UAV) Technology
(Case study: Villa Isola Bandung, Indonesia)

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ABSTRACT

Indonesia is an archipelago country which has varieties of cultural heritage, both ancestral heritage and the remnants from the Dutch colonial period. Quantity, variations and locations scattered throughout Indonesia are the problem in making documentation. Photogrammetry is considered suitable for documenting cultural heritage buildings because it focuses on the methods and devices used as an important key to getting good data so that it can be processed. Villa Isola is one of the heritage buildings of the Dutch colonial government which was chosen as the research object because it has an irregular and dynamic shape. This paper studies the method of taking the visual data photogrammetry of a building as well as the landscape around it with 45 degree and 90 degree angle flight directions. The results of the study found that the comparison of the results of the processing of the two UAV flying methods above provided more important information. Furthermore, the picture of the number of clouds and meetings at a 45 degrees flying angle is more accurate than 90 degrees flying angle. Due to shorter duration data processing and lower memory consumption of devices of 45 degrees flying angle of devices.

Keywords: Documentation, Comparative, Heritage building, 3D modeling, Photogrammetry.

1. INTRODUCTION

Villa Isola building is located in the northern part of Bandung, designated by the Bandung City Government as a cultural heritage building because it has 4 criteria, such as: historical value, architectural value, scientific value and more than 50 years of age [1]. This building had been abandoned for several years but after independence it was slightly renovated [2]. Villa Isola has a distinctive character, a combination of modern architecture and traditional Javanese concepts [3]. Using the North-South cosmic axis which is strengthened by the arrangement of the garden landscape that follows the contours on the back and front of the building to broaden the view towards Mount Tangkuban Perahu (fig 1.a). The building adapts to the tropical climate and has a curved entrance concrete that is characteristic of C.P. Wolff Schoemaker's architectural style at that time [4]. The corners of the building curved in a quarter circle. The building is inspired by the curved and symmetrical shape of the temple.

From a photo taken in 1937 (fig 1.b), the character of Villa Isola is formed not only by the building but also by the arrangement of the garden around the building. On a cultural heritage site the thing that needs to be maintained is not only the building but also the supporting elements that strengthen the character. Therefore, the photogrammetry method is considered the right way for the documentation process of cultural heritage building. The photogrammetric method makes it possible to generate 3D measurement data and modeling documents and landscape areas more quickly and in accordance with the original conditions.

The purpose of this paper is to study the visual photogrammetry of the building and its supporting landscape using a UAV with the method of taking images in a horizontal direction at an angle of 45 and 90 degrees to the object. The character of the building is dominated by horizontal ornaments, cantilevers and the landscape around it that has been filled with tall trees. Therefore, the shooting settings were selected at an angle that would allow capturing the bottom of the

building and the bottom of the tree. The figure 01 (a and b) shows that the aspect of environmental systems in the form of landscapes around the cultural heritage building that strengthens the character of the cultural heritage building has not been a special concern. The Angle camera used to oblique 45 degrees of the vertical field is chosen with consideration in order to reach the bottom field of the tree and the cantilever object with an equal imaging length.
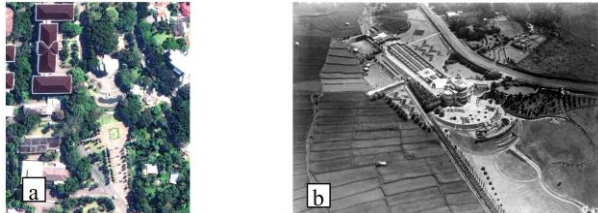

Figure 1 (a) Villa Isola Bandung at present time; (b) Aerial photo taken in 1937.

2. THEORY AND FORMULA

The photogrammetry method is used in many science disciplines and focuses on the methods with devices used as an important key to getting good data so that it can be processed. Photogrammetry is very useful at the design, construction, reconstruction, and stage of inventory of architectural objects [5]. Maintenance activities and integrating cultural heritage sites, using three-dimensional digital technology have an important role [6]. Requests for documenting and preserving digital heritage for the use phase such as visualization increases. In addition, to protect legacy sites and cultural and religious values or future generations [7]. Moreover, the photogrammetric data used and combined with historical knowledge of architectural objects makes it possible to reconstruct structural elements of even smaller architectural elements such as statues or memorials [8]. UAV-photogrammetry has attained a level of practical reliability and changed into a beneficial platform for spatial data result [9]. Furthermore, there has been rapid development in the documentation of Cultural Heritage due to the development of UAV along with high performance and user-friendly photogrammetric software [10]. In different contexts and with different purposes for large-scale documentation of Cultural Heritage many authors have successfully used UAV [11]. Furthermore, there has been rapid development in the documentation of Cultural Heritage due to the development of UAV along with high performance and user-friendly photogrammetric software [12].

3. EXPERIMENTAL SETUP

Data retrieval in this study in the form of aerial photos, using UAV type DJI Mavic 2 Pro, with the Drone deploy software application as a flight data

retrieval application. Image data. The catch is then processed using Agisoft Photoscan software. The conservation site will examine not only the Villa Isola building but also the landscape surrounding. As stated at the beginning, the landscape around the building has an essential role as a supporting factor to strengthen the character of a conservation site. The selected data retrieval method is flying horizontally to the flat plane to obtain data on the image of both. When the form of the building is non geometrical (curved) and the landscape around is the non-symmetrical period so that the direction of UAV flying degrees of building and site is significant. This study compares effective and efficient data retrieval methods with flying techniques between 45 degrees and 90 degrees. The height of flying is determined by: (a) local flight regulation, maximum fly zone at the height of 60 meters, (b) Obstacles around the area. The results of the altitude measurement of flying objects around the area with the highest tree height obtained 50 meters. UAV security factors with the distance of the reading of the UAV obstacle sensor is at a distance between 3-5 meters, and the contour of the northern land of the site increases, it is determined to be a safe height of UAVs flying in the 55m elevation.
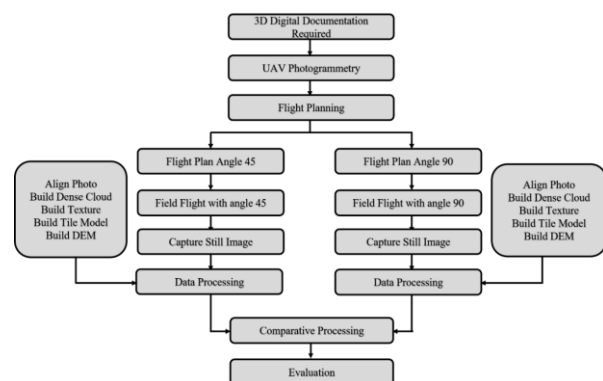

Figure 2 Diagram of comparative method of object data collection with UAVs media.

In order for the UAV image to catch data to produce 3D modeling buildings and areas around, needed two-way data images, X-axis and the Y-axis fly so that the UAV will fly with the Crosshatch method. Determination of the tilt angle of the camera of the vertical field is an essential factor, namely: (a) the character of a building is dominated by horizontal architectural elements, cantilever, and sun shading; (b) Landscape around the building object has a lot of high vegetation and trees that cause shadow areas under trees.

Fig 4 shows the differences in the camera's tilt angle in data collection of captured images with UAV. (a) Vertical camera angle or 90 degrees a flat field, this technique will produce better orthophotos and can be used instead of a map, but cannot reach the shadow area

at the bottom of the object because the image catch is taken perpendicular to the flat field. (b) The Angle Camera Low Oblique is a tilted air photo covering a larger area than the area covered by vertical air photos. Objects under high buildings can be seen at the corner of the Camera Low Oblique. (c) The corner of the camera of High Oblique, which is a very tilted aerial photo and the horizon line very clearly looks [13]. Image shooting techniques with low oblique camera angles, special corner 45 degrees, aim to get effective image captures and cover the bottom side of the building ornaments and the landscape surrounding.
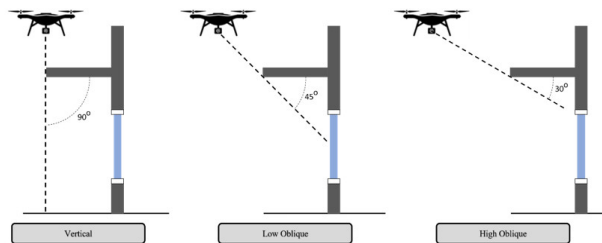

Figure 3 Horizontal architectural elements.

Figure 4 Type angle camera.

4. RESULTS AND DISCUSSION

Image captures taken with the photogrammetry method using flight plans with 45 degrees flight angles and 90 degrees will produce a variety of image quality, even though it uses the same camera parameters. Although the flying area planned with an area of 2 Ha produces a broader cloud point, it can be seen from the cloud point after the photo alignment is carried out by the Photoscan AgiSoft software. The number of UAV image catches with a 45 degree flying angle is 426

images while with a flight angle 90 degrees obtained 422 images, the difference in 4 catches from the two flying methods. Then the process (1) Align Photos; (2) Build Dense Cloud; (3) Build Tiled Mode; and (4) Build Dem, while for the Build Mesh process and Build Texture as part of the process to produce 3Dimensional modeling is not done because of the hardware limitations used to carry out the process. However, the results of the four processes can already provide an initial description of the determination of effective and efficient flying angles for taking photogrammetry data.

The entire catch of the UAV image was carried out by the photos align process, so the initial estimate of the Point Cloud was obtained. All catching catches from two flying methods can be done through the process of aligned cameras. UAV flight results in direction of 45 degrees produce more image captures and produce more point cloud but the duration of photo matching is shorter and the use of fewer devices memory. The duration of the photo alignment process is also shorter and the use of memory when photo alignment is fewer than the alignment process for 90 degree UAV image captures. Furthermore, UAV flights with a 90 degree flying angle, produce fewer image catches, less cloud points, but requires greater memory usage, which is 1.7 GB during the processing of the data, as well as longer processing time, namely the data processing process requires a time fewer, namely matching duration 16 minutes 17 seconds and alignment time 8 minutes 31 seconds.
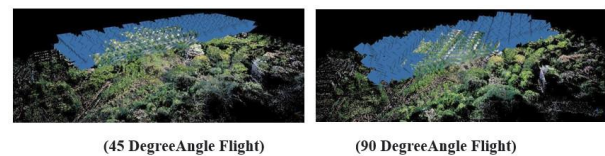

(45 DegreeAngle Flight)   (90 DegreeAngle Flight)

Figure 5 Align photo process generates point cloud.

The process of Align Photos UAV at a 45 degree flying angle produces 402.122 of 448,060 point cloud while for a flown angle 90 breeds produces 401.305 of 445.746 point cloud with medium accuracy parameters. More image captures will produce more point clouds.

Table 1. Dense point cloud process

Process	45 Flight Degree	90 Flight Degree
Angle	45 Degree	90 Degree
Count Image	426	422
Depth maps generation parameters		
Quality	Medium	Medium
Filtering mode	Mild	Mild
Max neighbors	40	40
Processing time	34 minutes 0 seconds	34 minutes 24 seconds
Memory usage	4.97 GB	4.54 GB
File size	931.19 MB	917.28 MB

Table 1. Cont.

Process	45 Flight Degree	90 Flight Degree
Dense Point Cloud		
Points	43,847,605	42,517,527
Point colors	3 bands, uint8	3 bands, uint8
Depth maps generation parameters		
Quality	Medium	Medium
Filtering mode	Mild	Mild
Max neighbors	40	40
Processing time	34 minutes 0 seconds	34 minutes 24 seconds
Memory usage	4.97 GB	4.54 GB
Dense cloud generation parameters		
Processing time	1 hours 13 minutes	1 hours 21 minutes
Memory usage	8.18 GB	7.81 GB
File size	579.78 MB	561.13 MB

The medium quality needed in data processing to facilitate the processing process and adjust the capabilities of data processing devices. Table 1 shows a significantly different process of processing data catching two flew angles 45 degrees and 90 degrees. There are two process parameters in the Dense Point Cloud process, namely Depth Maps Generation and Dense Cloud Generation. The flying angle is 45 degrees more tightly than a 90-degree. However, the depth map generation process for the 45 degrees will reduce 24 second of the process time. As well the duration of the Dense Cloud Generation process which is 12 minutes faster.
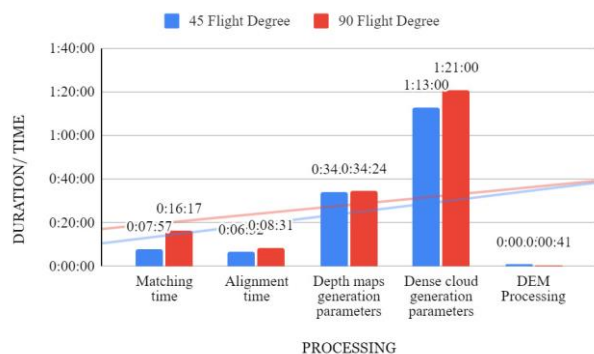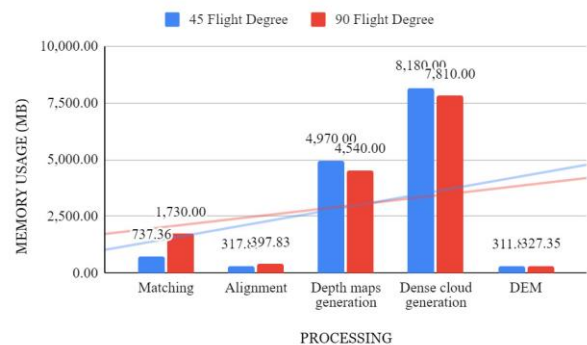

Figure 6 Processing and duration.

Figure 7 Processing and memory usage.

Fig. 6. Left shows a comparison of the time of each stage of the data processing process of 45 degrees and 90 degrees. Trend Duration of the UAV data process is 90 degrees higher than UAV 45 degrees. However, the graphical trend at the end of the process shows a meeting point with an insignificant duration. The use of memory on data processing devices is important to compare. The process of Dense Point Cloud, data image angle 45 degrees is greater than the use of the memory of 90 degrees. Furthermore, the graph in fig. 7 right shows a comparison of the consumption of the device's memory in processing UAV data angle 45 and 90 degrees. They conclude that the UAV fly method with a 90-degree angle at the beginning of data processing needs more data consumption of memory devices while at the end will consume less memory.

Table 2. Result processing

Result	45 Flight Degree	90 Flight Degree
Count Image	426	422
Flight Time	0:25:12	0:24:18
Accuracy	Medium	Medium
Total Processing Time	2:02:12	2:20:53
Dense Point Cloud	43,847,605	42,517,527
Average Memory Usage	2903.412	2961.036
RMS reprojection error	0.157864 (1.39124 pix)	0.170555 (1.51868 pix)

Based on table 02 illustrates the results of the UAV flight data at a 45-degree angle to produce more image catch data and a longer duration of flying. However, the duration of the data processing is shorter, and consumption of more mega bite average devices by generating the amount and level of density cloud more than 90 degrees angle.

5. CONCLUSION

The analysis results with some of the above parameters can provide an initial picture of the decision to the pilot to determine the effective and efficient horizontal flying method between 45 degrees or 90 degrees to the building and the area that will be retrieved. The decision of the following process: the duration of the data processing process and the consumption of the device's memory will affect effectiveness. As stated, the number of points cloud is generally sparse and will produce a low-quality 3D model with a shorter duration of the process. However, on the contrary, the dense number of point clouds produces high-quality 3D output with a longer duration of processes and greater memory consumption. Comparison of the results of the processing of two UAV flying methods above provide essential information and the picture of the number of points cloud and tight at the UAV 45 degree flying angle. However, with a duration of a shorter data processing process and the consumption of the device's memory is lower than the data retrieval with a Flying angle of 90 degrees.

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