Using Unmanned Aerial Vehicle in 3D Modelling of UniCITI Campus to Estimate Building Size

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Abstract. The drone mapping has a huge potential for numerous sectors including construction, agriculture, mining, infrastructure inspection and real estate. Drones are used as assisting tools in civil applications for large-scale aerial mapping of buildings, which is a difficult task for surveyors to do because of the unreachable access area, time consuming, and expensive due to limited resources and equipment. To address this issue, this paper introduces UAV-based mapping. Furthermore, when flying from a different flight plan, the UAV will capture and collect visual images. Then, the image from drone was process in Agisoft Metashape software to generate a 3D model of building. This process will go through several steps to analyze which method for capturing images can produce high-quality 3D mapping. The research results of this project are to determine which photogrammetry technique can generate a high quality of 3D mapping with accurate and fast.

Keywords: UAV Mapping, 3D Model, Agisoft Metashape.

1.0 Introduction

Unmanned aerial vehicles known as UAV are an aircraft that was designed to operate with no pilot on board. Recently, the unmanned aerial vehicle (UAV) has emerged as the most advanced technology developed, mapping, topographical surveys, remote sensing studies, and providing an ideal platform for aerial photography. [1-3]. Furthermore, UAV is used to determine the slope mapping, modelling of building or urban cities, forest-fire monitoring, road monitoring, vehicle detection, disaster management and mapping urban and suburban areas [4-6]. UAV photogrammetry is a new photogrammetric measuring tool that combines close-range photogrammetry, aerial mosaic imaging, and terrestrial photogrammetry [7-10]. Aerial photographs can be used to create planimetric and topographic maps with varying degrees of accuracy. On the other hand, it is a component of the geomatic programme used to calculate and chart the earth's surface. In addition, it introduced a real-time and automatic application and is a low-cost alternative compared to traditional manned aerial photogrammetry [11-16]. Thus, these papers focus to analyze the accuracy of measurements in 3D model building Agisoft Metashape software from UAV mapping from different flight paths.

2.0 Methodology

The pilot study’s workflow included the use of an unmanned aerial vehicle (UAV) called the DJI Mavic Pro to capture all aerial images. The area of study is located at UniCITI Alam campus, UniMAP Sungai Chuchuh, Padang Besar, Perlis. The selected building for this research is the 3 story shop lot known as Block S4 as mentioned in Figure 2.
2.1 UAV flight plan and image collection

The DJI Mavic Pro drone is equipped with high quality built-in camera with 12 Megapixels of resolution, GPS/IMU, stabilizing system, electronic compass and good battery life performance. Before flight, UAV should do the calibration process. Equipment such as UAVs, remote controllers, and computers must be tested to ensure proper operation in order to avoid crashes and system failure due to malfunction. The data collection by the UAV differs by the type of flight path. In this project, two flight plans were developed using Drone Harmony application that can be accessed from a smartphone or laptop. Following that, the mapping area is chosen, and a flight plan or waypoint is generated based on the size of the area. This project covers one acre, and the flight attitude is set at 98 feet (30 meters) above the ground. Other advanced settings include flight direction, flight speed during mapping, starting waypoint, obstacle avoidance, and front and side overlaps set to 80 percent and 70 percent, respectively. Figure 3 depicts two different flight plans.
Image processing and 3D model

The UAV collected raw images from two flight plans and the images were uploaded into Agisoft Metashape software to go through image processing part and generated in the 3D model. The first stage-loading photos to Metashape, followed by align photo, build dense point cloud, build mesh, build texture and build orthomosaic. Next, at align photo stage, the software refines the camera position for each photo and builds the point cloud model. The accuracy is set to the highest; the higher accuracy helps to obtain more accurate camera position estimates. After dense point cloud has been reconstructed, it is possible to generate a polygonal mesh model based on the dense cloud data. In mesh dialog, the surface type is selected to arbitrary, source data are from dense cloud, the polygon count is set to medium. To generate 3D model texture, the mapping mode in build texture dialog is set to generic, bending mode mosaic, texture count is set to 4096 x 1. Last stage is build orthomosaic. Orthomosaic export is normally used for generating of high imagery based on the source photos and reconstructed model as shown in Figure 4.

2.3 Measure Building

The building is measured using the scale bar, the measuring tool in software as shown in Figure 5. The experimental study results will determine the accuracy of measurement between 2 building from horizontal and vertical flight path thus can decide which flight path is suitable for mapping and produce a 3D model of building with accurate data measurement. The qualitative are done by
analysing the quality of the generated 3D model of building. Meanwhile, quantitative analysis is performed using error. The error is conducted using the equation shown in Equation 1.

$$\text{RMSE} = \pm \sqrt{\frac{\sum (n_1 - n_2)^2}{N-1}} \quad \ldots \ldots \quad (1)$$

where,

- $n_1$ = measured value
- $n_2$ = actual values
- $N$ = total number of data

Figure 5: Measuring building with tools in software.

3.0 Results and Discussion
In this study, the block S4-building measurements were taken according to the methodology explained. 3D models that have generated in the Agisoft Metashape software from horizontal and vertical path was measured to find the accuracy of measurements between the actual value and measured values. The results obtained from the UAV mapping were compared with the actual measurement from AutoCAD drawing plan, as shown in Figure 6 and Figure 7. The accuracy is analysed based on the calculation of the error between the two models of building.

Figure 6: 3D measurements from software (horizontal)
Table 1: Measurement of horizontal mapping data

| Building Parameter | Actual Value (m) | Measured Value (m) | Error |
|--------------------|------------------|--------------------|-------|
| Length             | 34.1             | 33.44              | 0.66  |
| Width              | 37.8             | 37.77              | 0.03  |
| Height             | 13               | 12.17              | 0.83  |
| Wall Length        | 33.6             | 33.45              | 0.15  |

The data in Table 1 and Table 2 show the positive differences from AutoCAD drawing plan measurements and UAV-mapping measurements. If the error value is smaller than one, the accuracy of measurements value using UAV mapping is acceptable meanwhile if the error value is bigger than one, the accuracy of measurements using UAV mapping is unacceptable.

![3D measurements from software (vertical)](image)

Figure 7: 3D measurements from software (vertical)

Table 2: Measurements from vertical mapping data

| Building Parameter | Actual Value (m) | Measured Value (m) | Error |
|--------------------|------------------|--------------------|-------|
| Length             | 34.1             | 29.66              | 4.44  |
| Width              | 37.8             | 33.81              | 3.99  |
| Height             | 13               | 10.82              | 2.18  |
| Wall Length        | 33.6             | 29.66              | 3.94  |

The differences calculated from the UAV imagery data show reasonably promising results, which demonstrated the potential and implementation of UAV based mapping in the urban development measure.

Conclusion

Finally, the flight plan was created in two paths using the Drone Harmony software. It was then uploaded to the UAV to design path mapping. Following that, all visual images captured by the UAV during flight from both the horizontal and vertical paths were collected. Then, all images were uploaded in the Agisoft Metashape software for image processing part. For generating 3D model, the images should go through the process of align, dense cloud, mesh and build texture/orthomosaic with parameters set up for every stage in image processing part. The accuracy of measurement is done for both building using scale bar.
tool in software and the actual measurement value is compared with the measured value in software. Subsequently, the horizontal path is suitable for mapping than vertical path using UAV as the accuracy of 3D measurement is accurate with smaller error value. For future work, this project can be applied for mapping road design, terrain and slope.

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