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Effect Unmanned Aerial Vehicle (UAV) for Topography Mapping at FKAAB

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Abstract: Recently, the user of UAV are increase in application of made topographical mapping. This approach can be the best way for a topographical survey to reduce time and cost. The Ground Sample Distance (GSD) still been questionable, mostly about the precision. These include several fundamental problems, for example, GSD accuracy, UAV output efficiency and UAV output terrain verification. the purpose of this study is to study the effect UAV for topography mapping at "Fakulti Kejuruteraan Awam dan Alam Bina" (FKAAB), UTHM with coordinate (Latitude: 1° 51' 6.59" N, Longitude: 103° 05' 6.60" E) will be obtained from Phantom 4 Pro observations and to evaluate the calculation accuracy of the Ground Sample Distance (GSD) using automated calculation compared to manual calculation methods. Using Phantom 4 Pro to take ortho images from 80 meters, 100 meters and 120 meters above sea level. Pix4D Software and the GSD calculator tool by Pix4D are applied to test the relationship with four altitudes through an automated flight plan. of the study found that automatic and manual calculations differ at distances of 80 meters, 100 meters and 120 meters height increased -0.02 cm / px, -0.03 cm / px and -0.04 cm / px. Thus, altitude adjustment, image overlap, time and production schedule are factors that impede GSD precision. DEM and 3D models received unreliable data due to extensive ortho-maps. Data accuracy loss is due to the higher the height the less the precision of GSD.

Keywords: Unmanned Aerial Vehicle (UAV), Ground Sample Distance (GSD), Topograhy Mapping, Ortho, Digital Elevation Model (DEM).

1. Introduction

For many businesses worldwide, the use of Unmanned Aerial Vehicles (UAV) to surveys is still mostly unknown. UAVs are often not first considered when suing for surveys [4]. In surveying, Topographic map is a detailed and accurate graphic,[1] the important in generation topographic maps are information contents, geometric accuracy and contour map. This process are involved the photogrammetry which making measurements using photographs [2] and Unmanned Aerial Vehicle (UAV) which are are defined as a space traversing vehicle that flies without a human crew on board, and that can be remotely controlled or can fly autonomously [3].To make sure the photogrammetry in correct direction, Orthophotography is photographs that have been corrected for distortions due to the

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tilting of the camera during the photographic survey, distortions from the camera lens, and relief distortions [5]. In other word, orthophoto is a satellite geometrically corrected image that is fixed (ortho corrected) to ensure that the image is consistent from one edge to another. In using drone or UAV to make a topography map, firstly is to consider the Ground Sample Distance (GSD) which is distance between two-pixel centers, as measured at ground level and Ground Control Point (GCP) which are used in the generation of the ortho-rectified imagery, for instance, acting as tie points in images that tie the images to a real-world coordinate frame (e.g., the surface of the earth) [6]. This paper are used Rectified Skew Orthomorphic Projection (RSO) which is an oblique Mercator projection that Hotine developed in 1947 [7] need to be convert into Cassini-Soldner Coordinate for projection map in World Geodetic System (WGS).

Today, demand for accuracy for each survey depends, however, on the final application and the use of cases. Instead of the average days or weeks before that, these little flying machines (UAVs) have only produced a matter for any area or object in a couple of minutes or hours. ' non-expecting' users can also access this mapping equipment as they can achieve survey accuracy on photogrammetric maps or 3D models using a simple drone like any model, such as DJI Phantom or DJI Mavic Pro. Hence, this paper purposely to analyse the flying altitude, Ground Sample Distance (GSD), Scale and to evaluate the calculation GSD in automated and manual.

2. Methods and Equipment

Focusing method in data acquisition which is have been detailed by systematic several phase. The acquisition data and data processing is critical path for this paper. The technique and procedure for acquiring photographic aerospace data, the planning of flights and the GCP monitoring facility. Besides, the calculation of the image resolution is explained based on equation.

2.1 Methods

Method generally are follow by phase shown in (a,b,c,d) where have told in first paragraph, Several methodological stages have been established, including data quality, software discovery, data processing, data collection and data analysis, for studying and achieving the objective. In this work, this approach will be applied.

a) Phase I – Research Plan and Literature Review
b) Phase II – Data Acquisition
c) Phase III – Data Processing
d) Phase IV – Result and Analysis

Data Acquisition started with flight planning which must use Pix4DCapture software, which have shown in Figure 1. Before the data collection process begins, it is important to be carefully and precisely planned. The purpose of this study was to design a UAV route, the scale of the project, end-lap, side-lap, height and sensor coordination system using Pix4DCapture for DJI devices. To getting a good stereo model for this project, end-lap will be set at 70%, while side-lap 70%. This section must avoid any UAV problem while on the flight. To ensure it is ready to fly with the coordinates pre-set in flight planning, the operator must calibrate the remote controller and the UAV internals GPS observation signal. For data processing are been divided by three process which is data input for Ground Control Point (GCP), Image processing and Image Calibration which must follow the procedure to avoiding software from error.

Figure 1: Interface for Pix4D Capture apps for flight planning

For Image processing the photography process was done using Pix4dmapper software (Figure 2) which the batch of images to Pix4dmapper was uploaded. The report of result has shown in PDF file format and the result, including quality report.

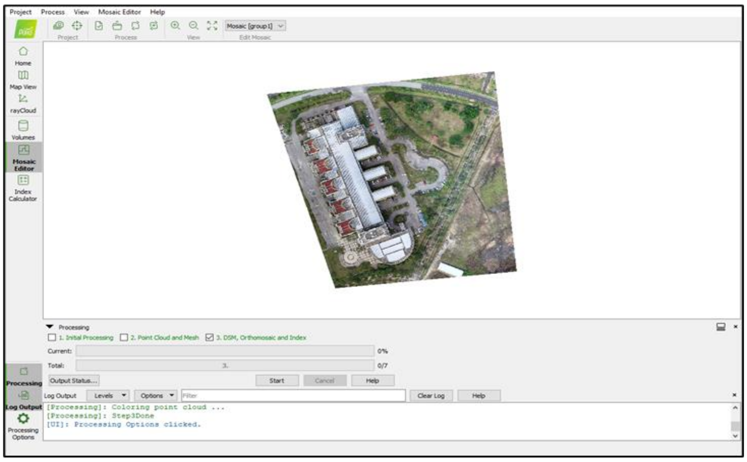

Figure 2: Interface for Pix4D image processing

During the initial processing stage of Pix4DMapper Software, the camera calibration process (Figure 3) is done automatically. Pix4Dmapper software uses the corresponding critical point of a picture with another picture in a project file for the camera calibration process. At least two images will produce a 3D position for each key point, which is matched. The extraction and regular calibration of critical points are automatically used.

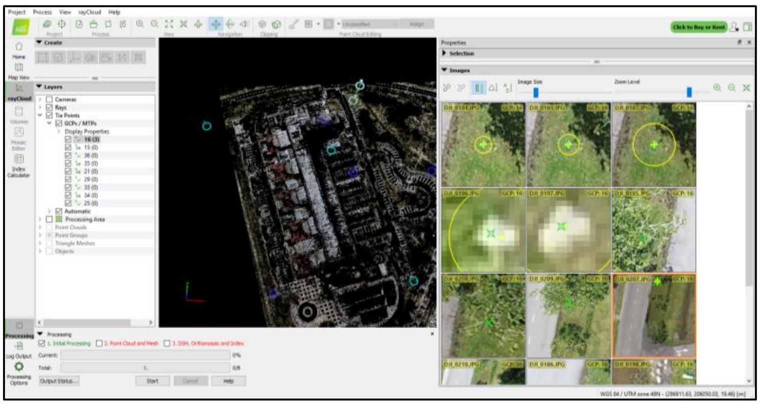

Figure 3: Calibration of the image with GCP in Pix4Dmapper software

2.2 Equipment

The equipment for data acquisition are shown below:

- DJI Phantom 4 Pro – This drone will capture the aerial photo. Table 1 show the specification aircraft and camera.

Table 1: Specification Aircraft, source from dji.com

Type of UAV	Multi-rotor UAV
Weight (Battery & Propellers included)	1388g
Diagonal Size (Propellers Excluded)	350 mm
Speed Vertical	72km/h
Camera	20 Megapixels (MP)
Mobile App	DJI GO 4
Max Services Ceiling Above Sea Level	19685 feet (6000m)
Satellite Positioning Systems	GPS/GLONASS
Hover Accuracy Range	Vertical:
	±0.1 m (with Vision Positioning)
	±0.5 m (with GPS Positioning)
	Horizontal:
	±0.3 m (with Vision Positioning)
	±1.5 m (with GPS Positioning)
Type of sensor	1" CMOS
Sensor Size	13.2 mm x 8 mm
The effective number of pixels	20.0 MP
Focal Length	8.8 mm
Maximal Opening	f/2.8 – f/11
ISO Sensitivity	100 – 12800
Shutter Speed	8 – 1/8000 s

- Pix4DCapture – Flight planning software developed specifically for DJI UAV. This software was functioning to do a flight planning for the related location to calculate a suitable flying height, a camera pixel and a time estimate for every flight.
- Laptop – Used to run the professional photogrammetry
- Pix4DMapper – Professional photogrammetry software.
- Autocad used to analyse GCP point data.
- RSO Converter to Cassini-Soldner Coordinate online.

2.3 Equations

Equations used to achieve certainty or estimate still within a range of values. Firsly, scale are needed to compute in manual calculation of GSD Eq. 1

$$Scale = \frac{Flying\ Height}{Focus\ Length} \quad \text{Eq. 1}$$

Change the size of the sensor unit to the micron Change the size of the sensor unit to the micron, 13.2 x 10^6 µm and 8 x 10^6 µm, Sensor size is 105.60 x 10^6 µm.Eq. 2

$$\sqrt{Pixel\ Size} \quad \text{Eq. 2}$$

Ground Sample Distance (GSD) calculated by times the value of scale with Pixel Size. Eq.3

$$GSD = Scale \times Pixel\ Size \quad \text{Eq. 3}$$

3. Results and Discussion

Comparing this results with another conventional standard survey procedure, given the accuracy of GSD measurement by means of difference altitude techniques that remain doubtful. The result is seen in the picture of report processing taken by the Phantom 4 pro gathered using Pix4D Capture flight planning and software Pix4D Mapper.

The results show that the ground resolution/ground sample distance (GSD) value is indicated for report processing. Table 2 shows the result of flying altitude difference with comparing manual and automatic GSD value which generated by formula and Pix4Dmapper software.

Table 2: Comparison between Manual and Automated GSD

Altitude/Height (m)	GSD Manual Calculation (cm/px)			GSD Automatic Calculation (cm/px)			Comparison (cm/px)
	Calculator	Avg	Formula	Apps Pix4D	Avg	Pix4Dmapper Calculation	
80	2.20	2.15	2.09	2.18	2.17	2.15	-0.02
100	2.76	2.69	2.61	2.73	2.66	2.59	-0.03
120	3.29	3.21	3.13	3.28	3.25	3.21	-0.04

The data findings have been analysed. The results have shown that the GSD 80 metres in altitude are more reliable than 100 metres and 120 metres because the camera has better resolution and good camera composure. In certain surveys, the site building height and requirement work must be considered. Based on the finding the accuracy are not to significantly based on limitation of UAV to take off in higher than 120 meter. In addition, by contrast, the automated and manual calculations for flight planning need to be considered to generate the best orthophotography. Camera composure is a crucial factor in obtaining accurate data. This is because high composure can produce a clear picture and be detected by the software. Table 3 shows the different of composure at a different altitude.

Table 3: Differential camera composure of Image-based on Altitude

80 Meter Altitude	100 Meter Altitude	120 Meter Altitude
		

The accuracy of data depends on UAV altitude from the table above shows that the altitude could zoom in more detail at the height of 80 metres. The inference is that the height is more desirable. It also makes it easy for applications to spot GCP with minor errors during in Calibration Images. From the result, a suitable area has been determined. The description has taken the safety of UAV and the precision as Factor of Suitability shows in Table 4.

Table 4: Detailing altitude for suitable area of work

Altitude (m)	Precision	Sharpness	Clearity	Description (Based on surveyor work only)
80	Yes	Yes	Yes	Suitable for earthwork survey/preliminary work which precision more preferred.
100	Yes	Yes	Yes	Suitable for site working area than not exceeds altitude height which precision preferred
120 or more	Yes	Yes	No	Suitable for site reconnaissance which precision not preferred

4. Conclusion

The analysis aims to analyse UAV altitude for GSD mapping through automatic tools and how it affects the UAV data accuracy. Before using automatic measurement, it can be summarised that it must be inspected by using a manual calculation. It also factors that UAV data inaccuracy can be applied if we do not verify the data. The concern is that a detailed orthophoto map, DEM or 3D model often looks the same as an imprecise one. When you have a specific height flight and good weather, in addition to a typical terrain with several characteristic points (which can be used for picture-compatibility), and accurate image overlap, the model should be authentic, but the only way to quantify an error study similar to the one above. The reasonable idea is to calculate multiple checkpoints on the track in addition to ground control points. The control points allow you to measure the model's accuracy using standard survey estimation methods.

The precaution needed to prevent the miscalculations of flight preparation that waste time and space. Where the weather is not always gorgeous, and there will be a complete memory room. The faulty option of flying high altitude often decreases UAV durability and is quickly exposed to damage. It also allows image data processing slower as extreme precision has to be processed. That would affect the working time. However, the ground control point (GCP) should be added to improve orthophoto accuracy, particularly for vertical precision. The ground control points significantly increase the orthophoto's global precision. The ground control points guarantees that the latitude and longitude of every location in the orthophoto match the real GPS coordinates exactly. The critical point where precision mapping and true accuracy of the global location is required. DJI Phantom 4 Pro, which is not survey equipment used for this analysis, was used for the UAV data. For the future, the UAV data testing method can overcome the mistaken flying altitude selection system during the flight planning phase. UAV precision, where the accuracy of a centimetre is appropriate for topographical mapping. However, this method can be a point for the future surveyor to restrict the specificity the specification requires.

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