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Evaluation of Orthophoto Image using UAV Photogrammetry in UTHM Parit Raja

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ABSTRACT

A map is highly vital to enable individuals to maneuver between places. It also provides a tool to estimate, characterize, or describe an area. Google Earth is the most recent technology used to help individuals navigate through places in this modern age. However, the displayed images in Google Earth become blurred when the image is enlarged to a lower height. The images of Universiti Tun Hussein Onn (UTHM) Parit Raja in Google Earth were mediocre resulting the image cannot be used or transform into other mapping product. Other than that, image displayed in Google Earth is not up to date as there were several changes that has occur on the infrastructure of the campus. This study aimed to produce high-quality orthophoto maps of UTHM Parit Raja with an area of 233 hectares to illustrate more complete details using UAV Photogrammetry techniques. The production of orthophoto maps was conducted through image capturing using DJI Phantom 4 Pro drone with Pix 4D Capture Software at an altitude of 100 m with 80% overlapping for the entire study area. The images were processed using Pix 4D Mapper software to produce orthophoto images and then perfected them to meet the characteristics of an orthophoto map. The orthophoto map was compared to the image of Google Earth in terms of image clarity when the image was enlarged to a lower height. The comparison of each map was analyzed on the ground site to confirm the reliability of the resulting orthophoto map. This study has produced higher resolution and clearer orthophoto maps with more precise detail display at low cost, less manpower, and produced in a shorter period.

Keywords: Orthophoto map, UAV photogrammetry, Unmanned Aerial Vehicle

1. INTRODUCTION

A map is a symbolic representation of selected characteristics of a place, usually drawn on a flat surface with components such as a scale, plane and elevation coordinate systems, a surface of reference in cartographic projection and its physic sizes [1]. Conventionally, the production with tacheometry method is the procedure by which horizontal distances and differences of elevation are determined using the optical properties of the telescope of the measuring instrument (transit, theodolite, level, or tacheometer [2]. This method is time-consuming and slow due to the large data collection; thus, it is not suitable for small areas as it is not economical [3]. An orthophoto is an aerial image that has been geometrically corrected that can perform measurements like the standard map. It is produced by using the aircraft of conventional photogrammetry [4].

Currently, orthophoto images with almost the same function are obtained from satellite images with Google Earth [5]. However, the constraints are that these images are blurry and not sharp when viewed at close range, and the current map is not updated [6-7]. Thus, the images displayed by Google Earth cannot be used or transform into other mapping product. This study aims to produce an orthophoto map of the whole area of Universiti Tun Hussein Onn Malaysia (UTHM),

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Parit Raja, Johor, using the UAV Photogrammetry technique. The image of the study location was captured using a DJI Phantom 4 Pro V2.0 followed by Pix4D Mapper software to produce an orthophoto image of UTHM Parit Raja. Lastly, Global Mapper software was used to insert cartographic elements to produce an orthophoto map of UTHM Parit Raja.

Unmanned aerial vehicles (UAV) have become a popular device for a broad option of emerging operations such as photogrammetry mapping, safe and rescue institutions, building monitoring, vegetation, import and export businesses, and film making industry [8]. The UAV business is estimated with a value of 100 billion USD. It is seen to be at a safe stake in the industry for another upcoming year [9]. The economic growth in this industry has pushed for more research and development to enhance the quality of the technology.

UAV is a light aircraft that fly without a pilot and uses aerodynamic power to fly, able to fly on its own based on preprogrammed flight plans or a complex dynamic automation system [10]. Nowadays, UAV has been getting much attention because it can be beneficial in various fields, not only military but other fields, such as vegetation, geomatic, field and soil analysis, and thermal studies [11]. The comeback has caused the number of studies and research on this issue to grow ever since.

The UAV Photogrammetry is a contemporary method of acquiring and receiving information at any point of interest, such as parameters, area, or any occurrence without any physical contact [12]. It is a method to create and build a map or plan from photographs [13]. This device will capture the images with 80% overlapping. These images will be processed and merged to produce an orthophoto map [14-15].

2. METHODOLOGY

The methods for this study were divided into three main parts: data gathering, image processing, and producing an orthophoto map.

2.1 Data Gathering

Anticipating fitting date was resolved to capture the image of the location of the study at an appropriate time when the weather is clear. All flights were conducted at the same time, which is only in the morning. In order to ensure that the flight can be conducted accordingly, the flights were planned by the coverage area and the battery life. Figure 1 shows the flight coverage areas for the study.

Figure 1. The flight coverage areas.

The flying started on 17th April 2021 and continued for another two days, on the 23rd of April 2021 and 24th April 2021. Twelve flights were carried out at a fast speed to capture the whole compound of UTHM Parit Raja, which is about 233 hectares. The flight was restricted to be conducted only in the morning to ensure uniformity in the image shadowing except for a few flights conducted in the afternoon because the weather on that particular day was gloomy and not sunny at all.

The image capture technique was carried out in the research area using the DJI Phantom 4 Pro V2.0, controlled by the Pix4D Capture application to set the camera at the desired angle, which was 90°. To produce good and comprehensible images for producing orthophoto images in a shorter time, the images were captured at the height of 100 m with 80% picture overlapping for the front and the back.

The total time taken to complete the image capturing process at the studied location was shorter than the expected time, about 3 hours, 34 minutes, and 37 seconds. The total number of images captured was 3969 images.

2.3 Image Processing

Two main parts built one complete orthophoto map. The first part was to process all the images taken from the flights into a part of orthophoto. The second part was to merge all orthophotos into a complete orthophoto of UTHM Parit Raja. In total, 12 complete cycles of flights captured all images of the UTHM Parit Raja areas. After the flights, all captured images were synchronized into a computer where Pix4D Mapper software was used to process each flight into an orthophoto project.

Three steps were needed to complete the processing of an orthophoto. The first step was the initial processing, which involved computing the true location and parameter of the original image using Pix4D advanced Automatic Aerial Triangulation (AAT) and Bundle Block Adjustment (BBA). The second step was the point cloud and mesh. This step was conducted to increase the density of 3D points. The third step was to generate the Digital Surface Model (DSM), Orthophoto and Index map

Figure 2 shows the first step to creating the orthophoto, which was the initial process for Orthophoto 1.0, and Figure 3 is the second step to creating the orthophoto map, which is the process of building a mesh.

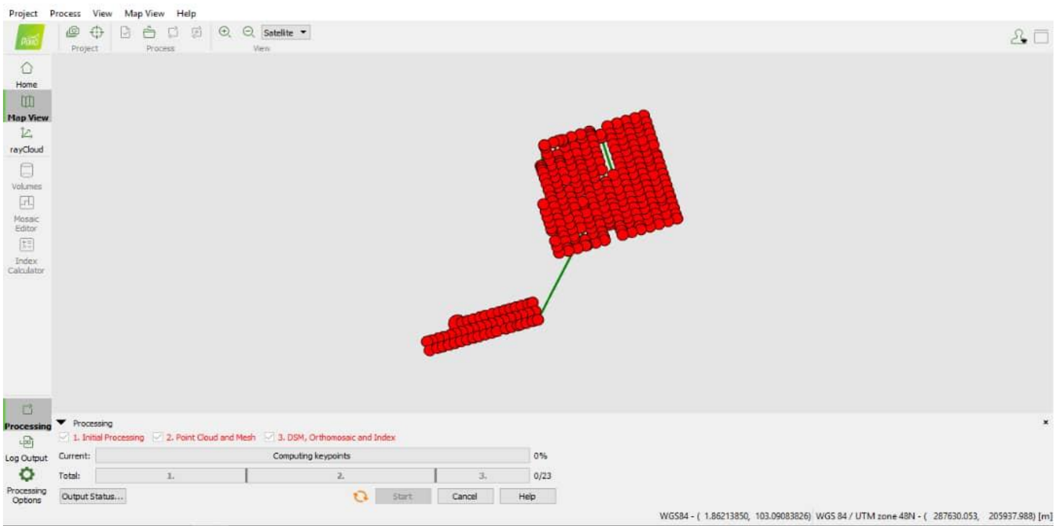


Figure 2. The initial process.

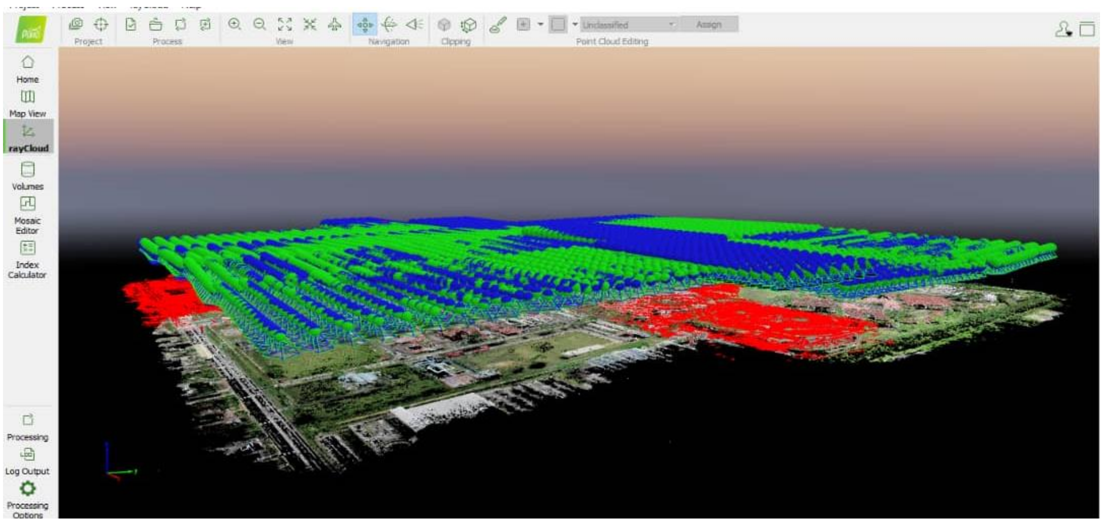


Figure 3. The process of building mesh.

Figure 4 shows the complete process of Orthophoto 1. All steps were repeated for another eleven orthophotos with an average of 300 images per orthophoto. The time taken to process 12 orthophotos was approximately 72 hours. This process was conducted due to the incapability of the computer used to process the high number of images as fast as the latest and more high-end computer model.

Figure 4. Orthophoto 1.

The second part of image processing was to merge all orthophotos into one big orthophoto map. In the base map, twelve orthophotos were divided into two separate orthophotos. The first 7 orthophotos were merged into the Orthophoto Part 1, and another 5 orthophotos were merged into the orthophoto Part 2. Therefore, in Level 1, the orthophoto Part 1 and orthophoto Part 2 were merged into the orthophoto map of the whole area of UTHM Parit Raja shown in Level 2, Figure 5.

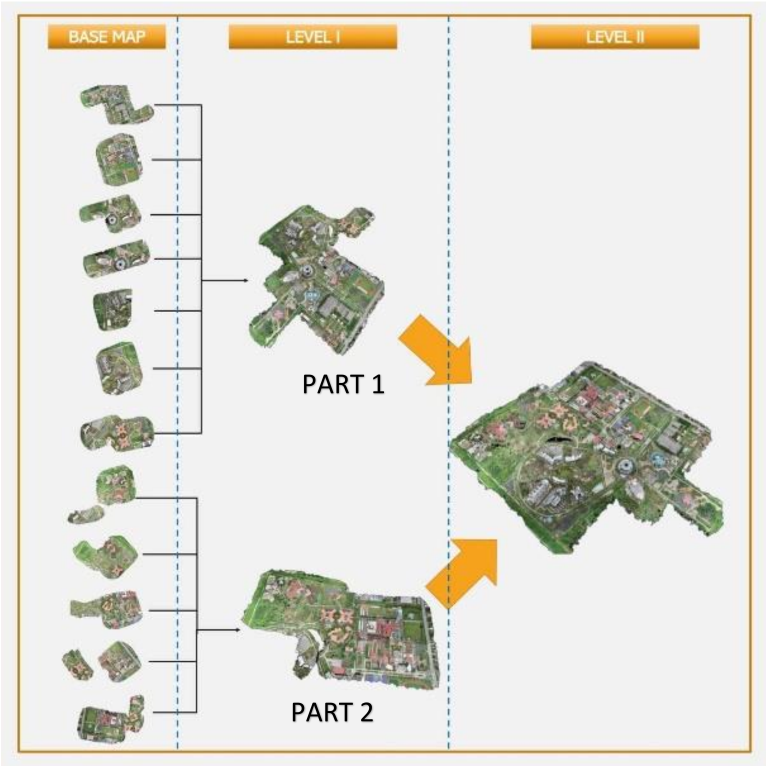


Figure 5. The merging process of orthophoto map

3. RESULTS AND DISCUSSION

3.1 Production of Orthophoto Map using Global Mapper

Generation of a complete orthophoto map using Global Mapper software involved three main steps. The first step was the labeling process which includes all the selected building areas modified using the custom description. Figure 6 shows the labeling result for all buildings within the orthophoto map of UTHM Parit Raja.

The second step was the selection of size for orthophoto map using map layout editor. The A0 size with a dimension of 84.1 cm × 118.9 cm was chosen for the orthophoto map. The orientation of the map was set as landscape, and bounds were included to make sure the map would fit into the margins.

The third step was to insert the coordinate, legend, image element, text element, scale, and north arrow onto the map. The grid frame option was selected, and the latitude/longitude grid was chosen as the grid type. Finally, 'Map Legend Element' was chosen and data from the label was loaded into the legend. The complete orthophoto map was then exported into the Geospatial PDF to preserve the map scale. Figure 7 shows the completed production of the orthophoto map using Global Mapper software.

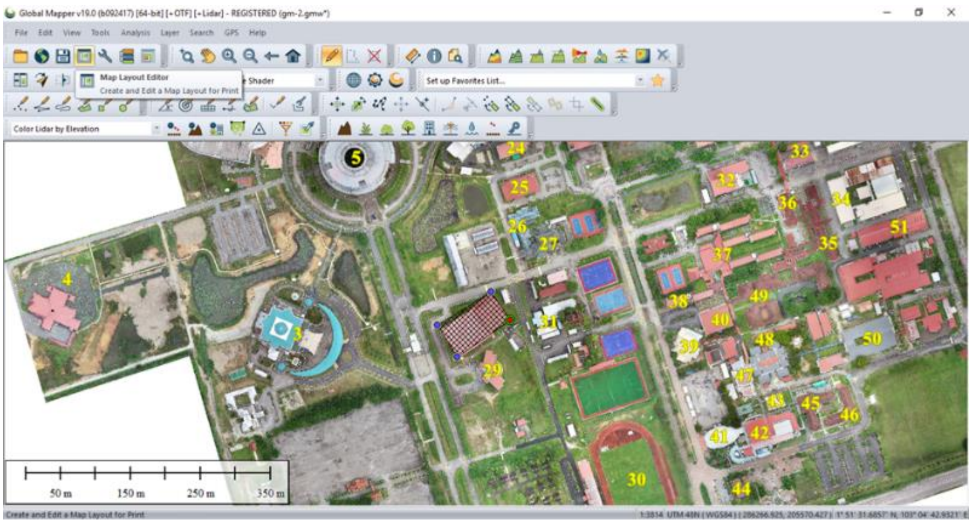


Figure 6. Labelling result for all buildings.

Figure 7 Generation of orthophoto map using global mapper.

3.2 Quality Analysis of Orthophoto Image and Google Earth Satellite View

This part clarifies the problem statement, where the image of UTHM Parit Raja in Google Earth becomes blurry when enlarged to a lower height. It compares the quality between the orthophoto map of UTHM Parit Raja and the image of UTHM Parit Raja from Google Earth. For better results, the map was zoomed in to a mutual spot and can easily be seen. The observation is on the height before the image becomes blurry.

Figure 8 shows the images from the same size and location: Sultan Ibrahim Mosque and Islamic Centre of UTHM Parit Raja but from different sources. Figure 8 (a) shows the image captured from the orthophoto map at the height of 17 m and Figure 8 (b) shows the image captured from Google Earth Satellite View at the height of 195 m—11 times higher than the image from the orthophoto map—to get a clearer image. Besides visual presentation in terms of color quality, the orthophoto map has better quality than the Image in Google Earth Satellite View. The image by orthophoto map is sharper than Google Earth. Table 1 shows the comparison between the orthophoto map and Google Earth view of UTHM Parit Raja.

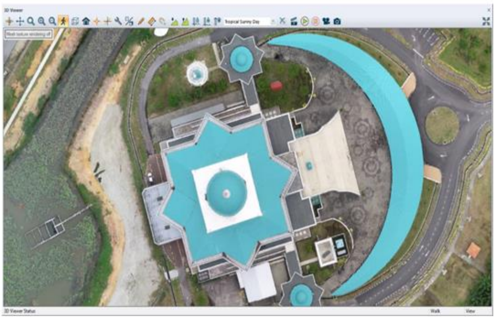
Figure	**Sultan Ibrahim Mosque and Islamic Centre**	
Source	a) Orthophoto map 	b) Google Earth Satellite View 
Height	17 meter	195 meter

Figure 8. Comparison of the image between the orthophoto map and Google Earth.

The image generated from the orthophoto map is a very high-quality image. Even when the image was enlarged to a lower height than 17 m, the image can still appear to be clear, precise, and sharp. Figure 9 shows the image of Sultan Ibrahim Mosque and Islamic Centre in orthophoto map when it was enlarged to a lower height, which is 4.8 m.

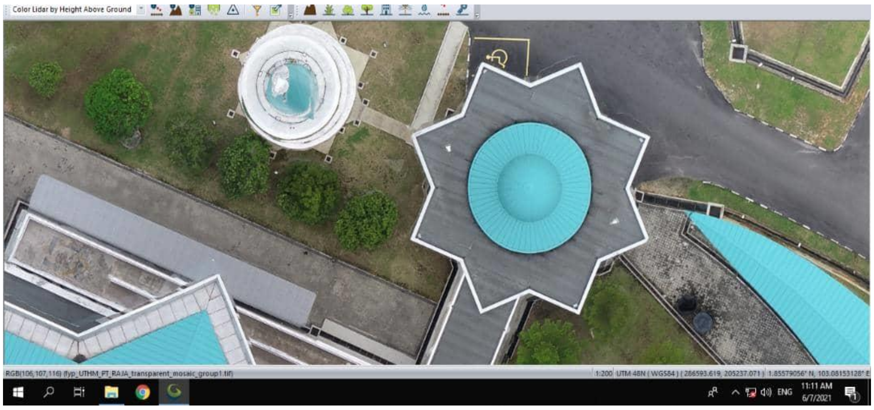


Figure 9. Sultan Ibrahim Mosque and Islamic Centre in orthophoto map at 4.8 m.

3.3 Verification Analysis of Orthophoto Map

Verification analysis was carried out to determine if the data and results obtained are the same as on the ground site to be considered valid. To obtain the verification value, the length of several areas or landmarks in the compound of UTHM Parit Raja was measured manually using the surveying tape. The data were compared with the length of measurement from the Global Mapper software.

The first validation point taken was at the basketball court in the compound of UTHM Parit Raja. Figure 10(a) shows that the length measured on the orthophoto map is 28.156 m while the length measured on site was 28.1m. Figure 10(b) shows how the verification length is manually measured at Point 1, located at the basketball court of UTHM Parit Raja. The manual measurement was done using a measuring tape that is usually used for surveying.

(a)

(b)

Figure 10. Verification analysis (a) Point 1 (Basketball Court) and (b) Manual measurement at Point 1 (basketball court).

The second landmark measured was the road in front of the Faculty of Electrical Engineering (FKEE) of the UTHM Parit Raja building. Figure 12 shows the measured road on the orthophoto map, about 6.288 m, while the length measured on site is 6.30 m.

Figure 12. Point 2 (the road in front of FKEE),

This validation helps in defense that the measurement and scale for this orthophoto map are accurate and can be used as a reference, especially for surveying and other mapping processes. Other than that, a comparison is made between these two maps to identify changes made in the infrastructure and building plan.

Table 1 shows several differences between the image from the Google Earth satellite view and the orthophoto from Global Mapper. Google Earth shows that the research center was still under construction. However, in Global Mapper, the construction of the research center has been completed. This outdated image from Google Earth is because the image from Google Earth was captured at a different time from the drone flying time. Even the road on Google Earth was not yet built, but there are already roads on the Global Mapper. It is shown that there were few changes on the facilities and the infrastructure in UTHM Parit Raja and the satellite view from Google Earth did not update the image.

Table 1 Comparison between Google Earth and Global Mapper

Type of Component	Google Earth Satellite View	Global Mapper Orthophoto
Research Centre		
Road		

4. CONCLUSION

In conclusion, this study succeeded in using DJI Phantom 4 Pro V2.0 to capture the image of the study area by using the photogrammetry technique in Pix4D Capture and producing the orthophoto map from these images with the help of Global Mapper software. The orthophoto images generated appeared to be clearer and sharper; therefore, the outcome of this study can be used as a referral for any research in the future. In terms of time, less than two weeks were taken to produce the orthophoto map of UTHM Parit Raja. The duration of producing an orthophoto map can be reduced if higher computer specification is used to process the images into orthophoto and merge the orthophoto. UAVs can be used to create an orthophoto map in a much more cost-effective, less labor force, and time-efficient manner. The product of this study can be used in an as-built survey that can be used for the university for any future town-planning [16]. The same technique can be applied in the industry to do mapping for the area that has high danger risk such as hillside area that could cause injuries to the labor workers [17]. Last but not least, the product of this study can be used for safety inspection [18]. The image for this study is very clear that we can check for any problem on buildings and ground so that actions can be taken to overcome the problem before it can cause damage especially to residents of the area.

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