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Production and Evaluation of Orthophoto Map using UAV Photogrammetry

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ABSTRACT

Maps are essential for individuals to be able to navigate between locations. They also include methods for estimating, categorizing, and describing a location. The mapping process has several methods, such as the conventional method, namely tacheometry, which uses the total station tool or theodilite. However, this method requires the expertise of experienced people, a large workforce and high cost. This study aims to produce an orthophoto map of UTHM Pagoh Residential College, covering an area of 12.75 hectares, with more detail utilizing the UAV photogrammetry method. The orthophoto map was conducted by capturing 549 images with a DJI Mavic 2 Pro drone and Pix4D Capture software at a height of 70m. The side overlap was 70%, and the front overlap was 80% across the full study area. Pix4D Mapper software was used to process the orthophoto images, which were subsequently improved to fulfil orthographic map features. The orthophoto map was compared to the existing layout plan of UTHM Pagoh Student Residential College. The comparison between the map and the layout plan can be seen from the quality and clearer view. In addition, the orthophoto map was examined on-site to ensure the accuracy of the generated orthophoto map. This study has produced better and higher resolution orthophoto maps with more accurate detail displays at a lower cost, with fewer labours, and in a shorter period of time.

1. Introduction

A map is a symbolic representation of the Earth or a specific area drawn on a flat surface [1]. Maps were used to be drawn on pieces of cloth or leather. A map is a flat depiction of the Earth's surface that has been reduced in size in accordance with a predetermined ratio. The contents of the map include the area and geographic data. Maps are created and used as navigational aids, as well as to locate and depict geographical places where information is few [2]. The individual who draws the map is known as a cartographer. The term "cartography" describes the art and science of

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mapping [3]. An orthophoto is a geometrically rectified aerial image that can be measured the same way a conventional map can. It is created using a standard photogrammetric plane [4].

In general, there are numerous approaches for carrying out the mapping process. Tacheometry is one of the methods for mapping. The total station has more detailed characteristics than theodolite because it requires high skills, and not everyone is able to master it because the technology available on the total station can produce good results when compared to the theodolite, which anyone can learn but not as easy as one hopes [5]. The number of stations required to be mapped takes time, but this tool is superior to theodolite [6].

Currently, orthophoto images have almost the same functionality as Google Earth satellite images [7,8]. However, the limitation is these images will get blurry and lack sharpness when viewed at close range, and the image displayed on Google Earth is not up to date and not the current image [9-11]. This study aims to produce an orthophoto map of the University Tun Hussein Onn Malaysia (UTHM) Pagoh Residential College by using the UAV Photogrammetry method. The images of the study area were captured using a DJI Mavic 2 Pro, categorized as a micro Unmanned Aerial Vehicle (UAV), and then the Pix4D Mapper software processed the images. Lastly, Global Mapper software was used to insert cartographic elements and produce an orthophoto map of UTHM Pagoh Residential College.

UAV or unmanned aerial vehicle refers to an aircraft that do not have a human pilot, crew, or passengers on board [12]. UAVs are part of an unmanned aircraft system, which also includes a ground-based controller and a communications system with the UAV [13,14]. The development of a smaller air drone known as a micro air vehicle in recent decades has raised the need for intelligence missions. UAVs that carry a range of sensing equipment are a new technical innovation that has begun to be employed for surveying surface structures [15,16].

Photogrammetry can be considered the best technique for image data processing, being able to deliver at any scale of application accurate, metric, and detailed 3D information with compatibility [17,18]. Photogrammetry is the science of obtaining reliable information about the properties of surfaces and objects without physical contact with them and measuring and clarifying the information [19,20].

UAV use has grown enormously in the commercial sector to propose alternatives for aerial imaging [21,22]. UAV photogrammetry is a modern method of obtaining and receiving information at any site of interest, such as parameters, regions, or events, without the need for human contact [23-25]. It is a method to create and construct a map or plan from images [13]. The images captured from UAVs are used to generate an orthophoto of the area [14].

This study aims to obtain a clear image of geographical conditions to produce an Orthophoto map of UTHM Pagoh Residential College using an Unmanned Aerial Vehicle (UAV). Therefore, the objective of this study is first to use UAV drones to acquire study location images; second, to use UAV photogrammetry to process the orthophoto image; and lastly, to produce an orthophoto map and evaluate its quality.

2. Methodology

The methodology for this study is divided into three main parts: data acquisition, image processing, and production of an orthophoto map.

2.1 Data Acquisition

The flight was planned to ensure battery capacity was adequate for the entire study area (Figure 1) to ensure that the process during flight time ran smoothly [26]. Safety aspects must be emphasized when flying and ensure that all systems are in working order and working simultaneously.

Fig. 1. Coverage the study area

The flying started on 21 March 2022 at 10.15 a.m. The flight was carried out speedily to capture the whole coverage area of UTHM Pagoh Student Residential College, about 12 hectares located at Pagoh, Johor. The flight was conducted only in the morning to avoid any shadow of the building that would affect the image quality.

The image capture technique was carried out in the study area using DJI Mavic 2 Pro equipped with the new 20MP 1-inch sensor from Hasselblad L1D-20c camera which is about 4 times larger than the first generation Mavic. Despite having a larger and more powerful sensor than its predecessor, the DJI Mavic 2 Pro is still compact and lightweight at only 907g. Measured 214mm x 91mm x 84mm when folded. Other enhancements include 10-bit colour log recording, 100Mbps video bitrate, 1080p Full HD recording at 120fps, up to 31 minutes flight time, 72km/h top speed, 8km 1080p live view range with lower latency, 1/8000th Sec shutter, and H.265 HEVC/MPEG-H video format recording.

The flight mission controlled by the Pix4D Capture application using Double Grid Mission and to set the camera angle at 70 degrees. In order to produce good images for producing an orthophoto image in a shorter time, the images were taken at a height of 70m with 70% picture side overlapping and 80% front overlapping. The total time to capture 549 images to complete the entire study area was about 34 minutes.

2.2 Images Processing

In order to create a complete orthophoto map, three main phases were needed: the initial processing, the point cloud and mesh, and DSM, Orthomosaic and Index process [27,28]. Figure 2 shows the process of Point Cloud and Mesh, and Figure 3 shows the completed process of orthophoto image, which is orthomosaic. The resolution of orthomosaic is 1 x GSD (2.52 [cm/pixel]). The bigger value of the image GSD, the lower the spatial resolution of the image and the less visible details. The

images processed by using device named Acer Predator Helios 300 that use Intel® Core™ i7-11800H @ 2.30GHz processor and NVDIA GeForce RTX3060 6GB GDDR6 graphic controller running on Windows 10. The screen resolution 1920 x 1080 and refresh rate 360Hz. The time taken to complete the process was about 9 hours, and depended on the computer hardware specification used in this process.

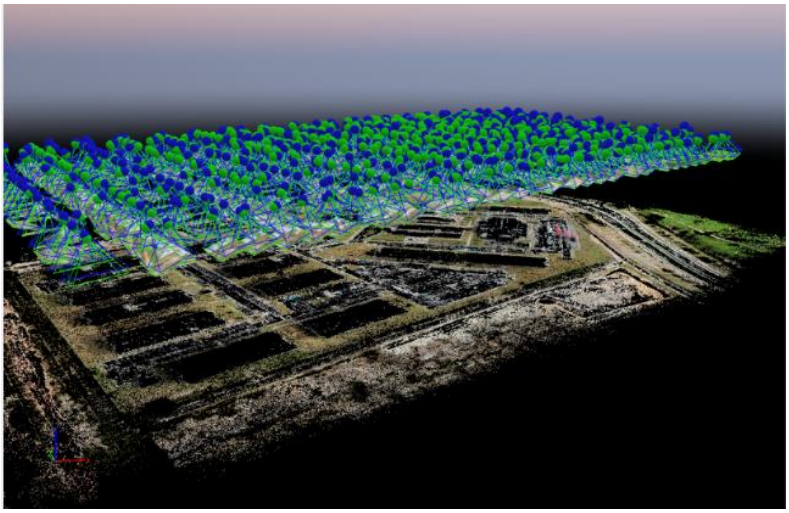


Fig. 2. Process of point cloud and mesh

Fig. 3. Complete orthophoto image

3. Results

3.1 Production of Orthophoto Map

In order to complete the generation orthophoto map, two software were used: Global Mapper and Adobe Photoshop.

Global Mapper was used to set the scale, insert the north arrow and scale bar, and to the latitude/longitude grid frame using the map layout editor. The A1 paper size with a dimension of 59.4 × 84.1 cm was chosen for the orthophoto map, and landscape orientation was set. Lastly, the map was exported into the PDF as a Mosaic. Figure 4 below shows the complete elements added to the orthophoto map using Global Mapper.

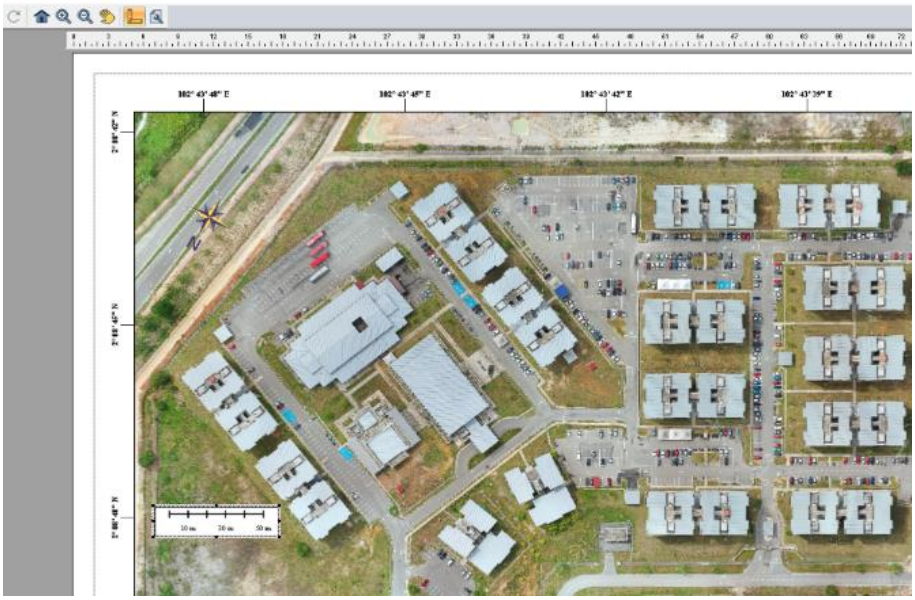


Fig. 4. Complete map elements added

Adobe Photoshop was used to label the building, insert the title and the UTHM logo, and create the map legend. This software involves two main steps before editing begins. In the first step, canvas size was chosen in pixels with dimension 9933 × 7016 px, which is the A1 paper size to preserve the map scale. In the second step, a PDF file from Global Mapper was imported into Adobe Photoshop. Figure 5 shows the labelling results of the orthophoto map. The complete orthophoto map was exported as a JPEG and PDF file. Figure 6 shows the complete orthophoto map.

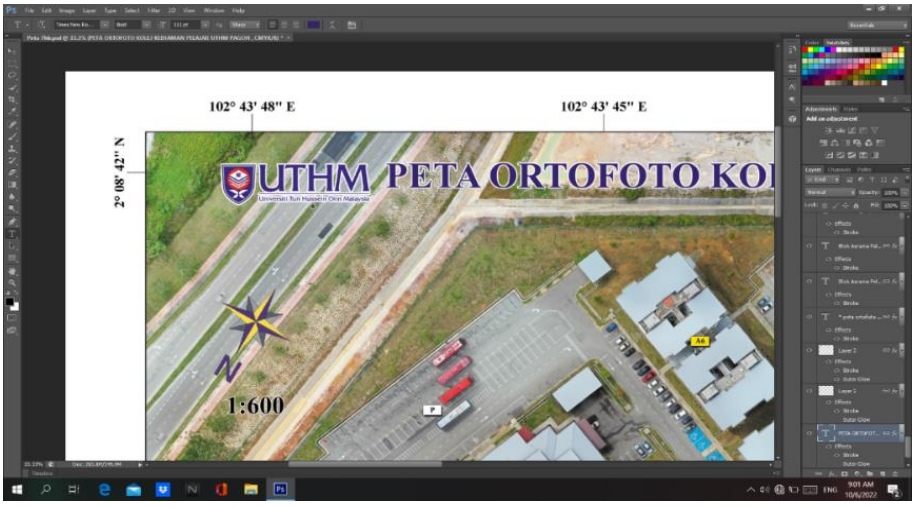


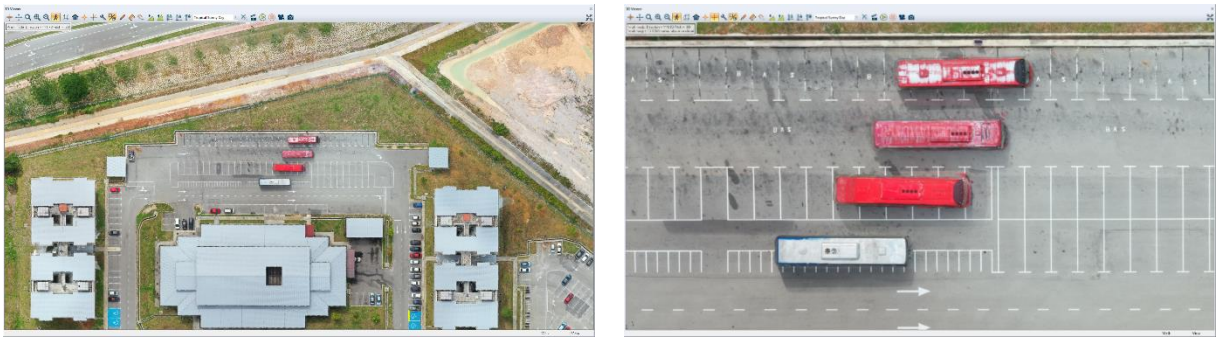
Fig. 5. Complete labelling of the orthophoto map

Fig. 6. Complete orthophoto map

3.2 Quality Analysis of Orthophoto Map

Verification analysis is performed to see if the retrieved data matches the on-site location where the results are considered valid. In this part, the lengths and areas of some landmarks in the UTHM Pagoh Residential College terrain were obtained from two sources: Global Mapper and field measurements. Disable car parks have been selected for the measuring. The measurement was measured manually using a measurement tape. Data were compared from length measurement in Global Mapper software. Figure 8(a) shows that the length measured on the orthophoto map is 3.442m while the length measured manually on site (refer to Figure 8(b)) is 3.485m.

This part analyses the magnified image of the UTHM Pagoh Residential College orthophoto map. This analysis compares these images in terms of the height of the captured image before the images are blurred or cracked when zooming. Figure 7 below shows the image captured before zooming (refer to Figure 7(a)) and after zooming at the bus parking area. The image can still be seen but becomes blurred after zooming in at 12m above sea level (refer to Figure 7(b)).

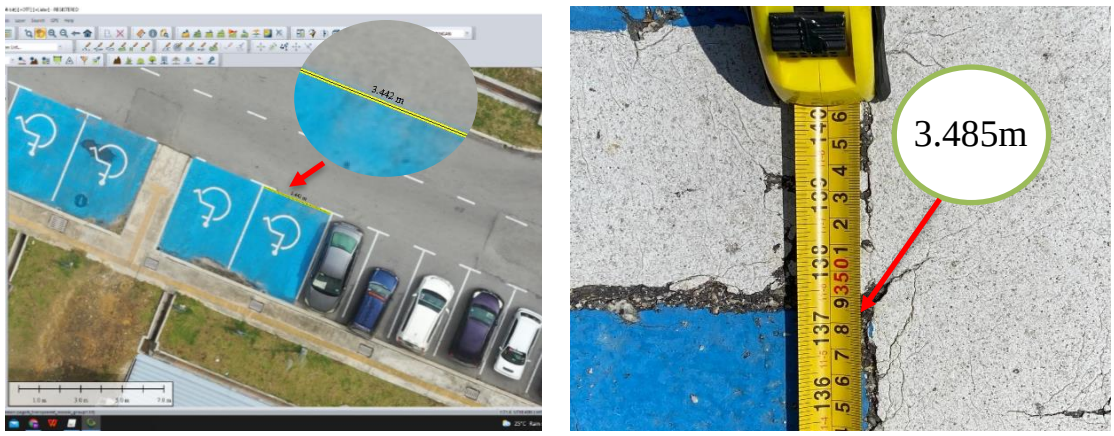


(a) (b)

Fig. 7. Images in the bus parking area

3.3 Verification Analysis of Orthophoto Map

Verification analysis is performed to see if the data retrieved matches the on-site location where the results are considered valid. In this stage, the lengths and the areas of some landmarks in the UTHM Pagoh Residential College terrain are obtained from two sources: Global Mapper and field measurements. Disable car parks have been selected as measuring places. The measurement was done manually using a measurement tape. The data were compared from length measurement in Global Mapper software. Figure 8(a) shows that the length measured on the orthophoto map is 3.442m while the length measured manually on site (refer to Figure 8(b)) is 3.485m.



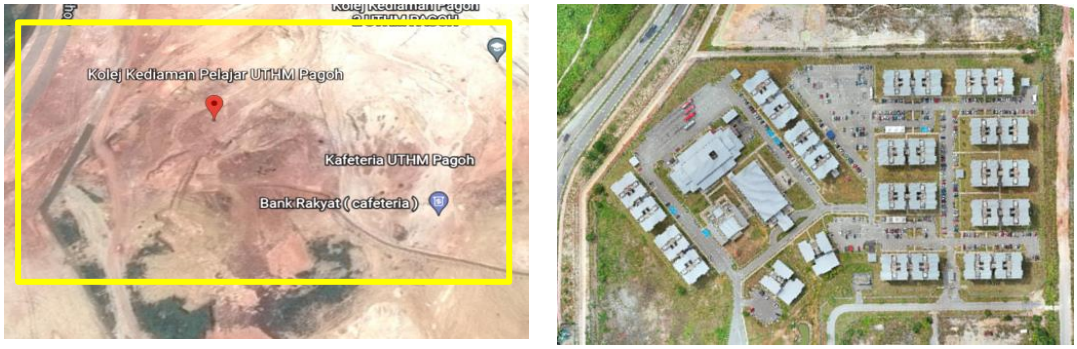
(a) (b)

Fig. 8. Verification analysis

This verification ensures that the measurements and scales of the orthographic maps are correct and may be used as a reference, particularly for surveys and other mapping procedures.

3.4 Newly Build Facilities and Infrastructure

Figure 9 shows several differences between the view from Google Earth (refer to Figure 9(a)) and the orthophoto map in Global Mapper (refer to Figure 9(b)). The latest image from Google Earth shows that the area around UTHM Pagoh Residential College is still under construction; hence, no buildings can be seen, but Global Mapper has completed buildings of the residential college. Furthermore, the roads in Google Earth have not been built, but the roads in Global Mapper are ready. It is shown that there were few changes to the facilities and infrastructure of UTHM Pagoh Residential College, and the images were not updated in the Google Earth satellite view.



(a) (b)

Fig. 9. Comparison between Google Earth view and orthophoto map in Global Mapper view

3.5 Practically of Orthophoto Map

The orthophoto map may be converted into a still image map that displays the position and orientation of the UTHM Pagoh Residential College at any place. The layout plan of UTHM Pagoh residential college, created by the architect and presented to the public, is shown in Figure 10. This layout design does not represent the actual image, which is evident with high-resolution imagery as seen in the orthophoto obtained by the UAV, which may provide users with incorrect information. The layout design also does not depict the colour of the buildings, which is less appealing. Therefore, the orthophoto map will present users with a more accurate and crisper perspective since visitors will be aware of their specific position.

Fig. 10. Layout plan of UTHM Pagoh Residential College

4. Conclusions

During the course of this project, it was discovered that an orthophoto map could be made much more quickly and cheaply by using a Micro Unmanned Aerial Vehicle (UAV). The whole process of the generation of this map took about 15 hours in total. This shows that the UAV photogrammetry method has more benefits than conventional methods in terms of time usage, manpower and costs. Since the orthophoto map of Pagoh Residential College was produced and made public, it is

concluded that this study has achieved its objective. Our project's objective is to create a map of the Pagoh Uthm Residential College, as the latest image was not displayed on Google Earth. The results of the UAV photography image may be utilized to produce an orthophoto map, which is one of the requirements and demands of the research. A total of 549 photos were obtained using a UAV camera vertically positioned at 70 degrees. This study also highlights the benefits of UAV Photogrammetry in gathering more accurate and practical local landscape data than satellite photography. The research's final product is a high-resolution orthophoto map made with a time and cost-effective UAV. With the help of this orthophoto map, viewers can get a bird's eye view of UTHM Pagoh Residential College. The product may offer several benefits, not just in appearance but also in future planning and development.

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