LOW-COST UAV FOR DETERMINATION OF HORIZONTAL AND VERTICAL COORDINATES CHANGES NEAR COASTAL AREA

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ABSTRACT: Coordinates are unique identification points on surfaces of two-dimensions or three-dimensions represented by numbers. Geographically, coordinates represent the longitude, latitude and elevation (x, y, z) of points on Earth's surface. Traditionally, the higher level of coordinate determination accuracy is achieved by geomatics technique such as land surveying, astronomical observation, manned photogrammetry, commercial remote sensing, and laser detection and ranging (LiDAR). With the advent of autonomous robots, a new survey technique has emerged based on Unmanned Aerial Systems (UAS) namely unmanned aerial vehicle (UAV) photogrammetry survey. The determination of horizontal and vertical are obtained through products of UAV in the form of orthophotographs (horizontal) and digital model (vertical) namely Digital Surface Model (DSM) and Digital Elevation Model (DEM). Orthophotographs (also known as orthophoto) is an aerial photograph that has gone through the process of georeferencing, geometric correction and geographic correction until it has the same properties of the map. The purpose of the study is to identify the changes in the horizontal and vertical formation at coastal area due to the coastal erosion and sea level rise. The data was captured by using low cost UAV namely Phanthon 4 with five control points. The findings have proven that a low-cost UAV is usable for the purpose as mentioned earlier with the acceptable accuracy at a sub-meter level for horizontal and vertical position.

KEYWORDS: UAV, Geospatial, Coastal changes, Geomatics, elevation

1. INTRODUCTION

The UAV system is becoming a common tool in the geoscience field nowadays (Arif, F., Maulud, K. N., & Rahman, A.A., 2018). They also mentioned it is also utilizable across different field due to its capability to determine coordinates at submeter-level accuracy over a large-scale area with minimal cost compared to the surveying techniques mentioned previously. With developments in the camera system, an inertial measurement unit (*IMU*) and GNSS chips; UAV is gaining momentum to be used for photogrammetric surveying and mapping. The system can be mounted in high-altitude or low-altitude platforms providing a different advantage for both platforms (Darwin, N., Ahmad, A., & Zainon, O., 2014).

The low-altitude system is advantageous in performing survey because it is not affected by cloud cover, able to capture a full image with high resolution from above and it can be used for frequent surveying of the same place at the specific time compared to remote-sensing technique. An example of this situation is shoreline changes at the coast as an effect of global warming and sea-level rise (De Falco, et al., 2018; Madihah et al., 2018). The shoreline is highly dynamic and highly vulnerable to erosion and flooding events that can spawn a negative impact on the wellbeing of humanity, environment and ecosystem altogether (Mohd, F. A. et al, 2018). Previously, the monitoring of shoreline changes is done by using various techniques either direct measurement or indirect measurement. High accuracy GNSS surveys are the most popular technique but it can be costly, timely and requires a lot of manpower towards completion. Hence, the usage of low-cost UAV to monitor shoreline changes is suggested.

The determination of horizontal and vertical are obtained through products of UAV in the form of orthophotographs (horizontal) and digital model (vertical) namely Digital Surface Model (DSM) and Digital Elevation Model (DEM). Orthophotographs (also known as orthophoto) is an aerial photograph that has gone through the process of georeferencing, geometric correction and geographic correction until it has the same properties of the map (Digital Orthophoto, 2016; Muji, A. L., & Tahar, K. N., 2017). This means that an orthophoto can be used to measure true distance on the real-world surface. On the other hand, the vertical coordinates are determined from a digital model namely DSM or DEM. Generally, these models are three-dimensional computer graphics representing the terrain of a surface used for visualization and analysis of the surface. DSM is a model representing the surface with above-ground objects such as trees, poles, building and any elevated feature above the surface from the mean sea level. On the other hand, DEM is a model representing the bare surface without the above-ground object (Muji, A. L., & Tahar, K. N., 2017).

The quality of the digital models is determined by its absolute accuracy and relative accuracy whereby; the absolute accuracy is a measure of how accurate the elevation is at each pixel and the relative accuracy is how accurate the geomorphology is presented (Höhle, J., 2012). In industrial application, the digital model serves as a guide for engineers, planners and architects; where they are particular on the elevation for certain points before a proper plan is designed to resolve a development.

2. MATERIALS AND METHODS

2.1 Materials

A low-cost factory-ready UAV namely DJI Phantom 3 Professional (*Phantom 3*) as shown in Figure 1 below. This UAV has integrated GNSS positioning module, camera stabilization system, an inertial measurement unit (IMU). It uses a camera affixed to the lower part of its body namely FC300X with Sony EXMOR camera sensor with a focal length of 2.8 mm and 94° field of view. The camera is capable of capturing 12 megapixels and capturing 4K resolution.

Table 1. DJI Phantom 3 Professional specifications

Specifications	Description
Weight (with battery and propellers)	1280 g
Diagonal size	350 mm
Maximum ascending speed	5 m s-1
Maximum descending speed	3 m s-1
Maximum speed	16 m s-1
GNSS system	GPS/GLONASS
Maximum flight time	Approximately 23 mins
Camera sensor	Sony EXMOR 1/2.3” Effective pixels: 12.4 Megapixels
Lens	FOV 94 degrees 20 mm f/2.8 focus at infinity
Photo format	JPEG, DNG
Stabilization	3-axis (roll, pitch, yaw)

Figure 1. DJI Phantom 3 Professional

2.2 Study Area

This research is conducted in coastal areas in Selangor of Malaysia at along Pantai Kelantan coast, which is located at the west coast of Peninsular Malaysia facing the Straits of Malacca. Pantai Kelanangis a low-lying area between the latitude of 3° 13’ 33.762” N and longitude of 101° 18’ 17.761” E. The study area covers a coastal where sand dunes is the majority material along the coast with several man-made structures. Pantai Kelanangis located as shown in Figure 2.

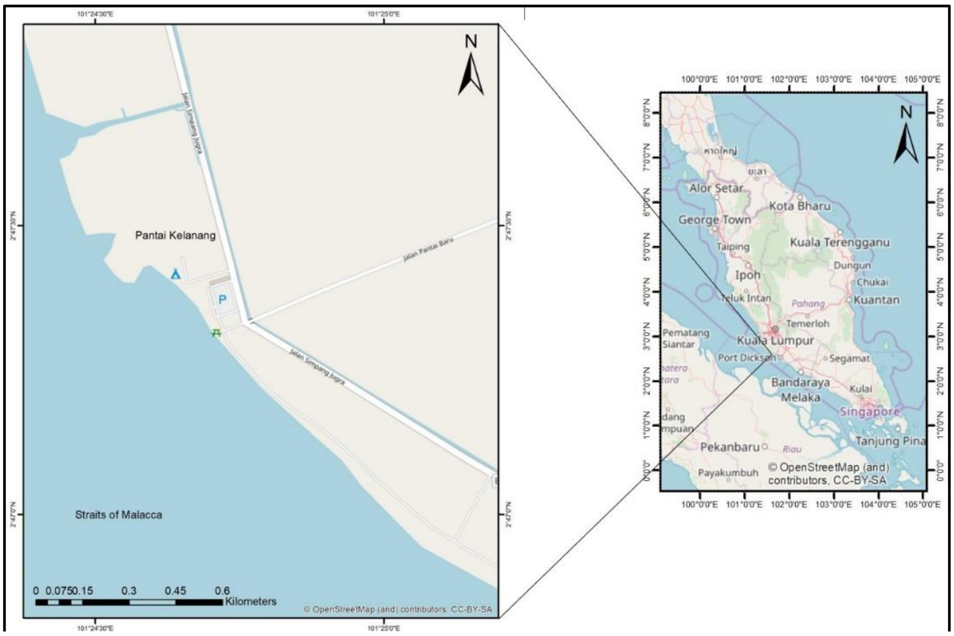

Figure 2. Location of Pantai Kelanang

2.3 Data Acquisition Process

Prior to the flight, mission planning apps namely MapPilot as shown in Figure 3 is used to draft a flight plan covering the intended beach area. The plan consisted of 60% end lap and 60% side lap which is sufficient to map and build the area. Aerial images perpendicular to the ground were taken with it and flew alongshore at above ground level (*AGL*) of 70 m to obtain data at the highest resolution possible while avoiding an obstacle on the ground. Ground control points (*GCP*) for aero triangulation of the images is observed at five different positions near to the beaches by using RTK-GPS of Topcon GRS-1.

Figure 3. Flight planning through MapPilot application

2.4 Data Processing & Analysis

From the series of aerial photos obtained, we can import it into an image processing software named AgisoftPhotoScan (Figure 4) which stitches images via Multi-View Stereo (*MVS*) concept and Structure from Motion (*SfM*) algorithm to produce point cloud, dense cloud, mesh and texture. The processing goes through relative orientation, interior orientation and absolute orientation. The spatial resolution of these photos will be produced later in the results. The aero triangulation via GCP allows the usage of the orthophoto for quantitative and qualitative analysis. Subsequently, orthophotos of the coastal area of Pantai Kelanangis produced as shown in Figure 4.

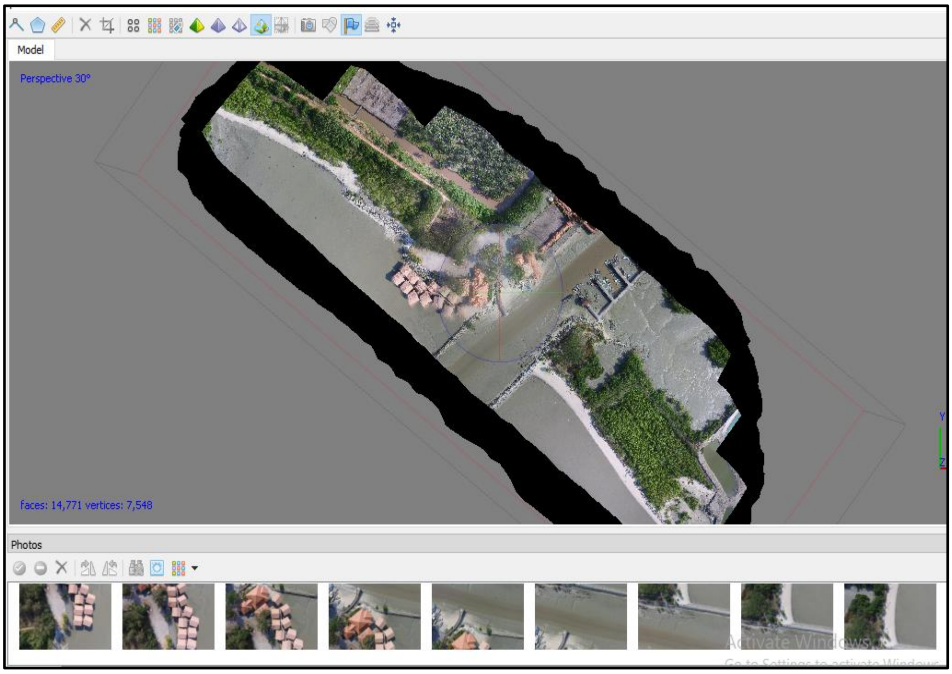

Figure 4. Overview of Agisoft Photoscan

3. RESULTS AND DISCUSSION

Based on the UAV images processed, the orthophoto and DSM of the coastal area are obtained. From the orthophoto, the horizontal coordinates are able to be determined at high resolution achieving ground resolution of approximately 2.6 cm per pixel which can be considered finely detailed for coastal mapping. The images obtained were projected with a coordinate system of *WGS84* as shown in Figure 5.

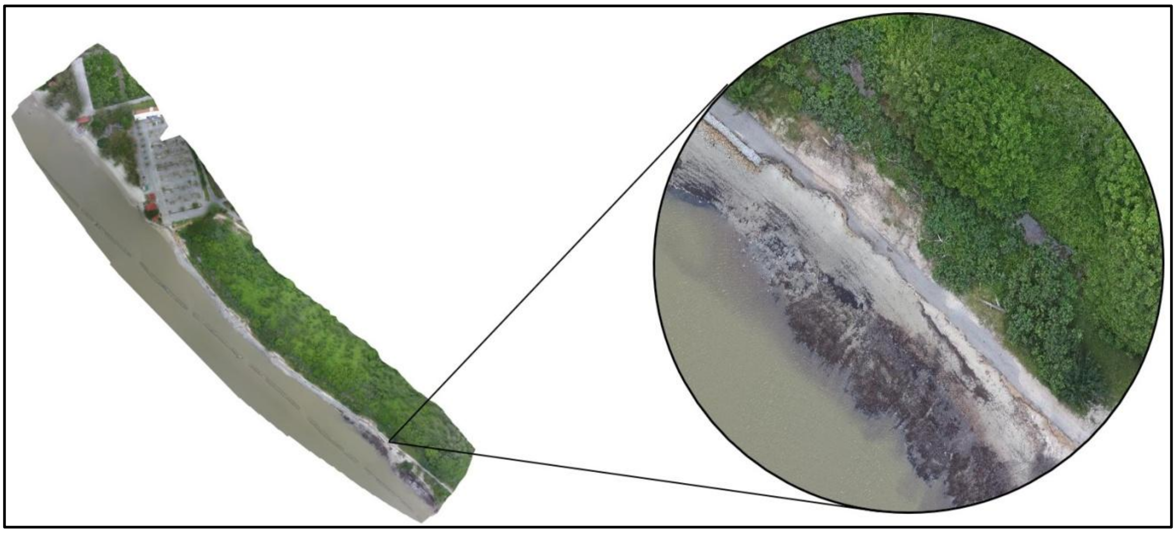

Figure 5. Orthophoto of Pantai Kelanang in September 2017

From the DSM obtained, the vertical coordinates on the coastal areas can be roughly obtained. However, it is only suitable for rough estimation or planning. This is because DSM includes the terrain and man-made features in it such as trees, buildings and electric poles. Figure 6 shows the DSM of Pantai Kelanang.

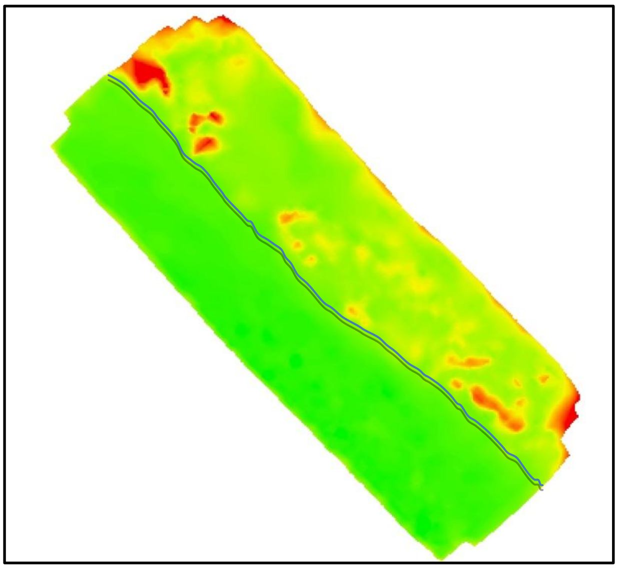

Figure 6. DSM of Pantai Kelanang in September 2017, the blue line indicates the shoreline

4. CONCLUSION

In this study, low-cost *UAV* was utilised for determination of horizontal and vertical coordinates through photogrammetry survey. The results have proven that a low-cost UAV is usable for the abovementioned purpose with the limitation of accuracy at sub-meter level for horizontal coordinates. However, the vertical coordinates are only suitable for rough planning and landscape modeling. This shows that the UAV is advantageous in a survey which requires a low budget, fast result and fair accuracy.

5. ACKNOWLEDGEMENT

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