The Shoreline Bathymetry Assessment Using Unmanned Aerial Vehicle (UAV) Photogrammetry

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Abstract. The shoreline is the boundary between land and sea. The shoreline has an irregular nature and change due to tidal conditions. Shoreline changes occur due to human activity and natural environment that results in eradication of erosion and sediment in the shoreline. UAV as a tool used to identify the shoreline change. However, the measurement of large-size reclaimed land using terrestrial survey methods, such as total station and GPS requires a huge number of efforts in terms of time and labour spending. Although, the current method is good in airborne sampling, however it is quite expensive and more complicated to handle. The objectives of this study is to identify the shoreline change from the image taken by using Unmanned Aerial Vehicle (UAV) and to analyse the data using pix4Dmapper and Global Mapper. Planning flight plans for UAV is necessary in this study. The shoreline changes are visibly clear during low tide from July to October 2018. Total length of erosion for three months from July to October 2018 is 8.428 m. Since the aim of this study was successfully achieved, using UAV photogrammetry could be applied in many fields and in determining and identifying the shoreline change.

Keywords: UAV, Shoreline change, erosion

1. Introduction
The shoreline and coastline is the area of the boundary between land and sea and has an irregular to changes due to coastal process and tidal condition such as move of the sand by the wave currents and wind by the supply of sand [1]. Shoreline movement is manipulated by the changes of short-term and long-term relative sea-level. The changing of ocean level with respect to the land and the expansion and decline in sand movement to the coast that reason the shoreline withdraw or growth over a period around 50 years or more [2]. The long-term may rise in relative sea level along the upper. Relative sea-level rise has additionally constrained sand supply to the coast by drowning ancient river valleys and forming the coastal bays. Shoreline change that occurs over a decades or less and that may be in the opposite directions of the long-term trend is difficult to understand and predict. These short-term shoreline changes can also be quite variable alongshore. One element of the coast might also be experiencing shrink back while just a few kilometers away stable or advancing conditions may prevail. However, it is important for coastal residents to recognize that even though a particular beach may have been advancing or stable over the last several years, then retreat will eventually continue if it has been retreating for the previous decades [3].
Tides are rising and decreasing level due to Earth’s rotational and gravitational attraction of the Moon. These tides occur in the coastal estuary area, typically two times raising and two times decreasing per day. The prevailing tide causes a shoreline change. The evaluated shows that 60% of the world population are dwelling in the coastal erosion problems [4]. Despite the fact that the coastal front condition can hold some level of normal character, expanded human alteration reduce the “instinctive nature” [5]. The area of the shoreline and changing position of this limit through time are of natural significance to the seaside scientist, managers and engineers [6].

The increasing of wave from 1.5m to 2.5m causing the occurrence of various tide and tendency to increase [7]. There is 5 factor that makes shoreline mapping is difficult to analyse because of constantly changing conditions. The 5 factors are sea level change, sediment supply, wave and current process, human activities and coastal geology and morphology [8]. There are several methods to determine the shoreline change. Ground survey technique and aerial photo is conventional method to monitoring shoreline which were expensive and time-consuming [9]. Unmanned Aerial Vehicle (UAV) classified aircraft that fly without a pilot. The unmanned aerial system is easy to use, can be cheap, on-demand technology for gathering remote sensing data [10] [11]. The current methods are good in airborne sampling but more complicated to use and more expensive compared to UAV Dji Phantom [11]. Hence, the UAV Dji Phantom is a great advantage with low operational costs in determining shoreline changes and conduct modelling three-dimensional (3D). Other than that, Unmanned Aerial Vehicle (UAV) is also widely used to monitor the small area and also provide results faster and usually higher spatial resolution [11] [12].

2. Literature review

The geographic interface of the shoreline, the limit amongst land and ocean, alongside different land utilizes, and different impacts of topographical and hydrodynamic phenomena and their belongings have made shoreline changes a standout amongst the most widely common process in coastal areas [13]. Malaysia is located between latitudes 1° and 7° north and longitudes 107° and 119° east. It comprises two regions, Peninsular Malaysia and the state of Sabah and Sarawak (collectively referred to as East Malaysia) on the northern part of the Borneo Island, which is separated by 640 km of South China Sea. The total land area is 330,400 km² while the shoreline totals approximately 4,809 km² [7] [14].

Almost, all the coastal state faces with the issue of the coastal erosion. Coastal erosion and accumulation have dependably existed and added to the forming of the present coastline [15]. Coastal erosion is a process whereby a coastal area loses its subaerial land part (dunes, bluffs, beaches or cliffs) resulting in a net sediment imbalance and subsequent retreat. This process consists of an extensive range of processes such as wind, water currents, wind-induced waves, amongst others that are acting at different temporal and spatial scales, and that are usually self-related [15]. The coastal sediments, besides those arising from upcountry erosion and transported seaward by rivers, are decentralized on the coast, providing material for dunes, beaches, marshes and reefs [4]. Erosion could also be amplified throughout the monsoon period when high water levels, related to this season, lead to waves breaking directly against the scarp, inflicting loss of material. Although some of this material could come back to the shore by swells once the monsoon, the number came back is often abundant less; hence the net result’s erosion [16].

Coastline changes may give impact to the environment such as flora and fauna and also will effect to human social life. The impact of coastline changes can be categorized into two part which is the impact to socioeconomic and the impact on the natural environment [17]. Shore or a shoreline is the fringe of land at the edge of a large body of water, such as lake, sea and ocean. In physical oceanography, a shore is the wider fringe that is geologically modified by the action of the body of water past and present, while the beach is at the edge of the shore, representing the intertidal zone where there is one. An idealized definition of shoreline is that it coincides with the physical interface of ocean and land [18]. The stability of shorelines is ceaselessly beneath threat due to changes to the natural environment caused by the wind, waves, tides, currents, and also because of human intervention that ends up in changes in the dynamic equilibrium prevalent at a given coastal stretch. It is documented that anthropogenic structures amendment the natural flow of currents and
sediments inflicting alterations within the local sediment budget and hence in the patterns of current sediment or erosion [19].

The drawback of the ground-based surveying techniques in the growth of interest in aerial photogrammetric surveying using UAV which can easily reliable spatial information for tremendously large scale measurement [20]. Most of the popular UAV that has been used is multicopters UAV. Multicopter UAV is easy to handle and their use is restricted to easy-to-access environment [11]. UAV is will potentially improve option for mapping, surveying and monitoring coastal zone [21]. The latest developments in new generation image matching algorithms including sensor detectors, and better battery technology have resulted in the use of Unmanned Aerial Vehicle (UAVs) in the various field [22]. UAV has been used in coastal areas to map the river channels [23]. UAVs have turned out to be more affordable and simpler to work and provide coastal research specialists with an apparatus that beats a significant number of the restrictions of conventional data collection method; specifically, cost and spatial and temporal resolutions [24].

3. Methodology

Figure 1 shows the flowchart of this study to be carried out to obtain the result. While Figure 2 shows the study location part of coastal area at Pantai Punggur, Batu Pahat, Johor.

Figure 1: Flowchart of study

Figure 2: View of Pantai Punggur (the 600m is marked with red line)
3.1 Flight plans
The flight of UAV have were planned carefully to avoid rainy weather to get the best result. The data were taken during low tide because shoreline can be seen during low tide. Tide data obtained from Department of irrigation and Drainage (DID) was used in this study in order to plan proper timing for UAV flight during low tide. Table 1 shows the flight plan from July to October 2018.

Table 1: The flight plans from July to October 2018

| Title | Date          | Tides                                |
|-------|---------------|--------------------------------------|
| Fly 1 | 27/7/2018 (Friday) | 0.61m (low tide) – 4.54PM | 2.77m (high tide) – 10.04PM |
| Fly 2 | 12/9/2018 (Wednesday) | 0.12m (low tide) – 6.13PM | 2.80m (high tide) – 11.28AM |
| Fly 3 | 25/10/2018 (Thursday) | 0.21m (low tide) – 5.03PM | 2.98m (high tide) – 10.13AM |

3.2 Image Capturing
Dji Phantom 4 Pro is used to captured the image from the atmosphere region. The image data were taken three times in July, September and October to identifying the shoreline change. Photogrammetry was used to replace the measurement such as levelling, theodolite, measuring tape and others. Photogrammetry is describes from three words, that is photo-light, gram-something drawn, and metry-measurement [25]. The concept used by photogrammetry is triangulation. At least two different locations are used to capture the image “lines of sight” can be created the points on the object. Figure 3 shows the process of photogrammetry and elevation modelling. While Figure 4 shows the drone capture the image on each point in map by using Pix4d capture application to created grid for 2D maps.

Figure 3: Photogrammetry and elevation modelling
Figure 4: The drone captures the image

3.3 Image Data Processing by Pix4Dmapper and Global mapper
The UAV has recorded total 365 of images and processed by Pix4Dmapper to create the orthophoto or one big 3D image. The duration to process the image was two days based on the number of the image taken. After complete the process in Pix4Dmapper, it will be transferred into the Global Mapper. By using the Global Mapper, all of the image were overlayed to drawn the line of shoreline to identify the shoreline changes. Figure 5 shows the interface of Pix4Dmapper and Global Mapper software.

Figure 5: Processing image in (a) Pix4Dmapper (b) Global Mapper

4. Results and Discussions
Figure 6 shows the overlayed image for three months of data to identify the shoreline changes. Figure 6(a) shows the left side of Pantai Punggur while Figure 6(b) shows the right side of Pantai Punggur. This shoreline change is visible seen eroded from July to October. The right side of the coastal site not detected any changes of shoreline because the revetments built along the beach. However, shoreline changes were clearly seen on the left side of Pantai Punggur. Based on data analysis the coastal area indicates a significant change in the environment that can affect in the future.

The blue line in Figure 6 represents the shoreline in July. The red line represents the shoreline in September and the yellow line represents the shoreline in October. The blue line used as a reference to identify the shoreline changes that occur.
4.1 The tidal effect to coastal area
Table 2 shows the tidal effect to the coastal area from July until October 2018. The tree on the image is used as a reference to marking a point for measuring the length from the line of shoreline to the tree.

Table 2: The tidal effect to the coastal area

| Fly | Date     | Description                                                                                                                                 |
|-----|----------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | 27/7/2018| The red line represents of shoreline. The blue line represents of coastline. The yellow circle is the area of the tree and used as reference point. The black line represents the length of erosion from the reference point to shoreline. Length from tree to shoreline is 8.938 m |
| 2   | 12/9/2018| The seconds fly shows the length of erosion from reference point to the shoreline is 4.58 m                                                   |
In this study, it clearly shows the occurrence of erosion at Pantai Punggur. Total length of erosion that occurs in three months is 8.428 m. This erosion has been identified through the analysis using Global Mapper.

### 4.2 Erosion at Pantai Punggur

The erosion occurs at Pantai Punggur area where it can be seen from the observation by the naked eye and compared with the image from drone. Table 3 shows the effect of the erosion that causes the shoreline changes.

#### Table 3: Erosion effect at Pantai Punggur

| Date   | Image Taken Using Drone | Image Taken Using Mobile Phone |
|--------|-------------------------|-------------------------------|
| Fly 1  | 27.7.18                 |                               |
| Fly 3  | (25/10/18)              |                               |

The 3rd fly shows the erosion has increased and the length from reference point to shoreline is decreased to 0.51 m.
The difference image taken by drone and image taken using mobile phone in three months from July to October 2018. To differentiate the situation for three months data, the first flight data shows that a tree is used as a reference to identify the erosion. The second fly data shows that the tree is falling due to erosion while the third fly data shows that the tree is completely eroded. Figure 7, Figure 8 and Figure 9 shows the erosion that occurred along the left side of the coastal area.

Figure 7: Erosion effect at coordinate 1;41;152200, 103;5;44.929999
Figure 8: Erosion effect at coordinate 1;41;13.886499, 103;5;46.335399

Figure 9: Erosion effect at coordinate 1;41;10.059000, 103;5;50.598500

Figure 7, Figure 8 and Figure 9 were taken during the last flight of data. Many factor that cause of erosion. The tidal is one of the factor that cause of erosion. Other than that, the factor of revetments built along the right side of coastal site can reduce and control the erosion for continuously happen. In fact, these changes are coming up fast without warning.

5. Conclusions
This study is introduced the use of UAV as a tools to gathered information and identifying the shoreline changes. Besides, this method also can be used to identify coastal erosion in different area. This study on shoreline change is very important and helps to plan ahead to control the erosion form continuing happen. The shoreline changes visible clear happen as it eroded between July to October 2018. The shoreline change in Pantai Punggur is critical and may affect the other coastal area in future. This method can be widely use in future research as a tool for monitoring and identifying the shoreline change, coastal erosion, inspection of building and others. By using this method its successfully achieved the objective of this study. This method can be done and implemented for future research and UAV is the great tools to determine the shoreline change and other coastal problem.

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