

Geohazard reconnaissance mapping for potential rock boulder fall using low altitude UAV photogrammetry

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Abstract. This paper discusses potential applications of unmanned aerial vehicles (UAVs) for evaluation of risk immediately with photos and 3-dimensional digital element. Aerial photography using UAV ready to give a powerful technique for potential rock boulder fall recognition. High-resolution outputs from this method give the chance to evaluate the site for potential rock boulder falls spatially. The utilization of UAV to capture the aerial photos is a quick, reliable, and cost-effective technique contrasted with terrestrial laser scanning method. Reconnaissance of potential rock boulder susceptible to fall is very crucial during the geotechnical investigation. This process is essential in the view of the rock fall hazards nearby site before the beginning of any preliminary work. Photogrammetric applications have empowered the automated way to deal with identification of rock boulder susceptible to fall by recognizing the location, size, and position. A developing examination of the utilization of digital photogrammetry gives numerous many benefits for civil engineering application. These advancements have made important contributions to our capabilities to create the geohazard map on potential rock boulder fall.

1. Introduction

Recently, the utilization of unmanned UAVs in the civilian and commercial term are ending up progressively normal, as well as for the use of concerning anthropic and natural disasters. The use of UAVs can be considered as a quick and low-cost effort to reach the zone which is frequently troublesome to investigate in safe conditions. Without a doubt, UAVs can be utilized to acquire information on the unstable region, by taking incalculable of photos and recordings from several points and distinctive edges of view [1] [2][3].

UAV's these days an essential wellspring of information for inspection, reconnaissance, mapping, and 3D modeling demonstrating issues. New applications in the short range proximity territory are presented, being the UAVs a low-cost option to the traditional manned aerial photogrammetry. UAVs, equipped for producing the photogrammetric data acquisition with mounted digital cameras. It can take off in manual, semi-automated and autonomous modes. With the photogrammetry output such as 3D results like DSM/DTM, contour lines, textured 3D models, vector data, and so on can be created, in a sensible automated manner [4][5][6].



UAVs is proven development in the field of mapping and research. Reconnaissance and monitoring should be possible with straightforward, cheaper, and precise than using different platform, for example satellites and light aircraft. The UAV capabilities are awesome and have a great deal of points of interest for the civilian purpose for monitoring, precision agribusiness, and urban development. The high-quality images can give the extraordinary outcome for different applications which can do visual translation in view of the pictures. This image is reasonable for mapping reason since it is cover little region and can deliver the updated map, for example update the Google Earth images with overlay the layer with UAV image and the user can recognize the changes on that territory [7] [8][9].

As of late, the flight of UAVs works with high degrees of autonomy by the global position system and onboard digital camera and computer. Capabilities of UAVs output to produce high accuracy topographic map by means of the image of quad-rotors UAV and ground control points (GCPs). UAV basically comes to quick riddles; little includes the high precision topographic mapping tasks. As engineers and planners, we have to see whether UAV-based photogrammetry would be sufficiently precise to map high accuracy topographic to replace current GPS and total station [2][10].

2.Site description

The study area is located at Bandar Baharu, Kedah. The study area is the new site for the development of motocross track. Fig 1 (a) and (b) shows the condition of the study area with rock boulder and its position on the small hills.



Figure 1. Overview of site with rock boulders location on (a) front and (b) side views

3.Methodology

The study took place on 17 July 2017, utilizing DJI Phantom 4 Pro quadcopter. Its objective was to distinguish the potential rock boulder fall at the examination range. The territory that was measured is shown in figure 2 with all the ground control point marked. The flight plan was plotted using DJI Ground Pro Station mission planner application in which flying altitude, zone and flight direction was loaded. The flight took off 75 meters from the ground and total of 89 photos were gathered for the desired GSD of 3.5 cm.



Figure 2. The site with all the location of marked GCP.

Measurements of ground control point were taken utilizing RTK method with receivers Trimble R6 and 5800 GNSS. Ground control points reading was taken using maximum number of satellites and taking into consideration all the ground obstacles in the encompassing region. In the survey, 150cm x 150cm plastic marking sheets were utilized. The drone able took off autonomously in autopilot mode due to the on-load up the control system. The information obtained was processed with the aid of photogrammetry software Agisoft Photoscan, which is proficient in creating a geo-referenced 2D orthomosaic and 3D point-cloud from the imagery obtain during the flights. The software has three stages as shown in (Figure 3)

- Initial processing, where it is conceivable to choose a region of orthomosaic with cloud points and include a ground control points, accordingly performing areal-triangulation.
- Point Cloud Densification is to create a 3D point cloud.
- DSM and orthomosaic generation to create the model of the ground and orthomosaic.

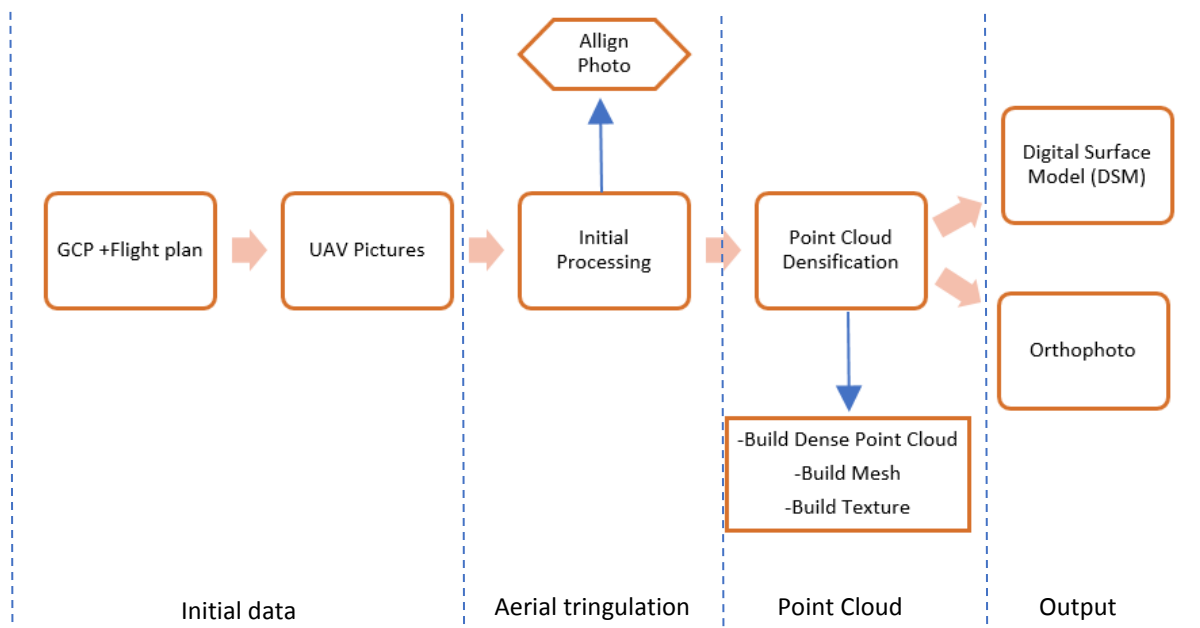


Figure 3. Example of the Agisoft Photoscan workflow for UAV photogrammetry process.

4. Results and discussion

The result of this research is Digital Surface Model (DSM), digital orthophoto, digital orthophoto as geohazard map. The Agisoft Photoscan software was used to process the images. For analysis processing, Global Mapper was used to create the 3D model. Analysis can be performed based on the final product and software capability.

4.1. Orthophoto

The Agisoft Photoscan software was also used to produce the orthoimages. For this process, the fundamental prerequisites are the digital image, the interior and exterior orientation parameters of each image and the DSM of the study area. The orthoimages were produced utilizing image resolution equal to one GSD which 3 cm/pixel. Figure 4 indicates one of the generated orthoimages.



Figure 4. Generated orthoimage for the whole region.

4.2. Digital Surface Model

The triangulated Digital Surface Model (DSM) of the block region was obtained by photogrammetric technique utilizing digital correlation of pixels in the Agisoft Photoscan software. The method to choose only ground points to create the DSM was done based on the stereoscopic view and manual methodology. The number ground points chose to produce the DSM was almost to 44 380 and around 1 point for each square meter. The DSM region has the minimal elevation near 55 m and 103 m for the most elevated esteem. Based on height values of the 5 surveyed control points, the precision for the DSM was approximately to 0.9 m. Figure 5 shows the 3D representation of DSM region.

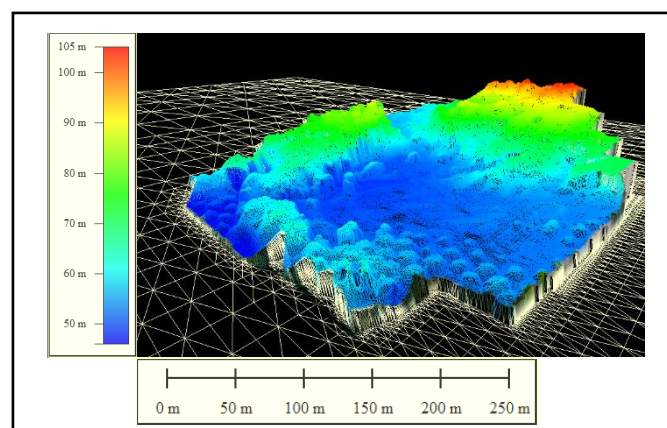


Figure 5. Show the 3D representation of the generated DTM

4.3. Geohazard Map

The digital orthophoto was used to mark the potential rock boulder which may fall based on three categories. Their categories are overhanging, positioned on loosely ground and size more than 3m rock boulder. The boulder was classified based on these 3 categories with the aid of Digital Elevation model and 3D model. Figure 6 below is the geohazard map of potential rock boulder fall.

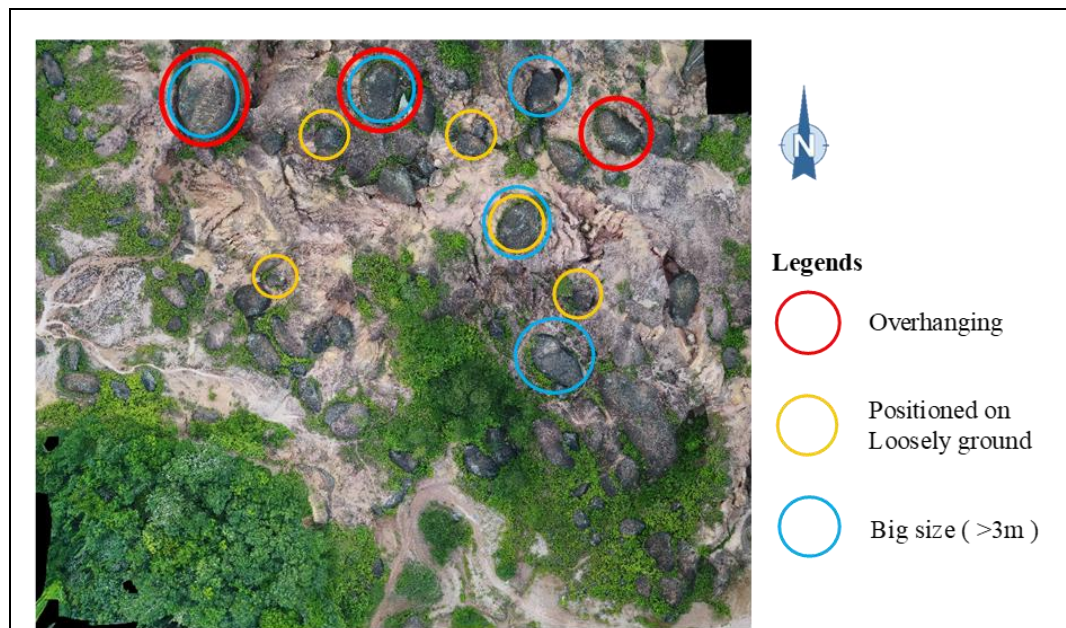


Figure 6. Geohazard map on potential rock boulder fall.

4.4. Risk and hazard of rock boulder fall

For this section, the analysis was carried out to identify the possible zone where the rock fall may occur. Few lines were drawn in the global mapper software to identify the possible direction where it may topple based on the elevation line. Figure 7 shows the example of rock boulder chosen to carry out the analysis to identify the section elevation and rockfall zone. Based on the elevation, the slope angle of the drawn section can be identified, and the critical zone is identified through the possibility of rock fall through slope angle (table 1).

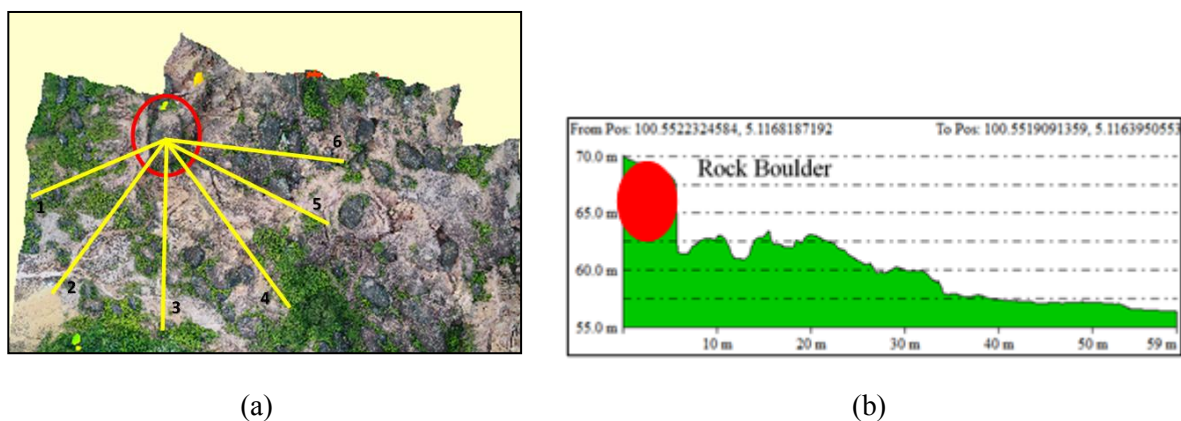


Figure 7. (a) Marked section to identify the elevation and (b) Cross section of Line 1 elevation.

Table 1. Shows the angle of the slope and the possible hazard of rock fall.

Line	Angle of rock slope (°)	Possibility of hazard through rock fall
1	30	Yes, because the angle of the slope is steeper and the distance for it to roll is longer.
2	40	Yes, because the angle of the slope is steeper and the distance for it to roll is longer.
3	20	Yes, because the angle of the slope is steeper.
4	10	No, because the distance for it to roll is shorter.
5	5	No, because the distance for it to roll is shorter.
6	5	No, because the distance for it to roll is shorter.

5. Conclusion

In this study, we have demonstrated the outcome obtained by utilizing UAVs to survey areas on potential rock boulders fall as one of the preliminary studies. The results were used to produce geohazard map on the rock boulder before the start of any work at the proposed development of motocross track. The products outlined have been considered to help the decision making to manage the potential risk of rock boulder fall. The presented study evidenced that both qualitative and quantitative evaluations of potential rock boulder fall can be conducted with the aid of UAVs, where the survey results are accessible in a fast and straightforward manner.

Acknowledgments

The author would like to express their appreciation to Universiti Sains Malaysia Research University(RU) Grant (1001/PAWAM/814192) for the financial support to carry out this research.

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