ISSN 2278-3091
Volume 9, No.1.1, 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse9091.12020.pdf
https://doi.org/10.30534/ijatcse/2020/9091.12020

Slope Inspections with Unmanned Aerial Vehicle (UAV)

M Kaamin[1]*, N B Hamid[1], M E Daud[2], N Ngadiman[1],S Sahat[1], M E Sanik[1], M A A.Zahari[2]
[1]Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Kampus Pagoh, 84000 Muar, Johor, Malaysia.
[2]Department of Infrastructure and Geomatic, Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia.
*masiri@uthm.edu.my

ABSTRACT

In Malaysia, there are plenty of natural slopes trimmed for the construction of public transport infrastructure. This causes the slope structure becomes unstable and can cause an avalanche. Constant monitoring of the slope surface structure is made to obtain an early warning before collapse. The slope monitoring activities that often practiced are extremely high risk. Usually, maintenance personnel will climb up to the top of the slope to take pictures for the purpose of monitoring reports. Therefore, this research aims to examine the extent the usage of micro UAV aircraft that could help in monitoring the slope. This study was carried out on the slope category A (High) near the exit Plaza Tol Ayer Itam, North-South Expressway. The process involved in this study is, planning and preparation before the flight, data retrieval using UAV for the flight at an altitude of 50 meters to be used as a model slope 3D using software Agisoft PhotoScan and flying height of 2 meter for identifying structural damage slopes and effectiveness appropriate height to capture the image for the identify the damage. The results of this study, a total of 4 locations of damage to the structure of the slopes have been identified and the maximum flight distance capture for detecting damage of the crack is 9 meter height, while for damage vegetation cover types were as high as 50 meters from the slope surface structure.

Key words : micro UAV aircraft, monitoring slope, Agisoft PhotoScan, collapse; structural damage.

1. INTRODUCTION

The increase in geography disaster cases is associated with the development of infrastructure is rapidly increasing and urgent to spread to terrain-terrain hills [1]. This is because the hills had to be cut and produce artificial slopes unstable and disturbed by construction activities in hilly areas [2]. It will be solved if there is a monitoring system that can help the maintenance process. Monitoring will be undertaken to provide preliminary information on the situation and the stability of a slope. Maintenance activities can be regarded as the work required to restore and preserve the construction structure [3]. Maintenance is divided into two major categories of planned maintenance and unplanned maintenance [4].

Therefore, this study is about slope monitoring maintenance using a micro UAV aircraft.. UAV is widely used in public use for mapping purposes as clearer images obtained from satellite [5]. This paper focuses on the use of high-resolution digital camera combined with a very light platform known as unmanned aerial vehicles UAVs [6]. By using of UAV can help monitoring the slopes in obtaining a visual representation of the surface structure of the slopes in the study area. Monitoring activities conducted in the study area can cause multiple hazards where officers monitor the slope need to climb up to the top of the slope structure that can cause slipping and attacked venomous animals [7, 8].

Therefore, this study is about the use of micro UAV aircraft for monitoring slope in visual. UAV is a tool that can provide information to create a visual record in the form of images and video more clearly. By using an UAV can help monitoring the slopes in obtaining a visual representation of the surface structure of the slopes in the study area. Monitoring activities conducted in the study area can inviting multiple hazards where officers in charged to monitor the area of research need to climb up to the top of the slope structure that can cause slipping and attacked by venomous animals.

This study was conducted to determine the extent of the use an UAV helps in monitoring the implementation of the slope surface. There are several objectives to be achieved. These include:

a) To investigate the methods of monitoring conducted on the surface of the slope.
b) Record and analyse information visually to help the work of monitoring the slope structure using micro UAV aircraft.

The scope of this study involves the monitoring of the surface structure of the slope near the exit Plaza Tol Ayer Itam, North-South Expressway. It is as a new alternative to facilitate the work of inspection structure slopes in the study area are maintained by the OPUS Network Maintenance Management. The study area was chosen because one of the slopes that are categorized as type A (high) situated at the exit toll plaza, North-South Expressway [9].

2. LITERATURE REVIEW

The slope is an exposed surface which forms an angle to the horizontal plane. The slope is divided into two types, natural slopes and man-made slopes [10, 11]. Natural slope failure accelerated by human activities such as deforestation and soil excavation [12]. Normally slope failure associated with steep slope conditions but this is not true because there are many cases of slope failure occurred on a gentle slope [13]. Some factors that contribute to the occurrence of slope instability factors such as geological, physical, human activities, and the weathering process [14-16].

Monitoring is a procedure for analysing the work to be done for the next level [13, 17]. This monitoring work is very important because after monitored work, the captured data will be analysed to determine the damage done to the structure of a slope. The results of the analysis performed, then the maintenance work can be identified and the next steps will be taken. According to the maintenance manual OPUS, slopes along the PLUS highway are classified into four categories, namely slope type AA (very high), A (high), B (medium) and C (low) to provide guidelines for periodically monitoring [7, 8, 9].

The micro UAV aircraft is a small light aircraft, which is 1/3 or 1/5 of the size of the actual aircraft guided [18]. UAVs are also equipped with a camera that offers the possibility to mapping an area more quickly and high flexibility [19]. UAVs are also becoming popular for use in large scale mapping of a low budget [20]. Now, the use of UAVs has expanded in the field of civil engineering. In this study, UAV types DJI Phantom 3 Advance used to retrieve information and visual data for slopes. UAV uses a camera sensor 1 / 2.3-inch made by Sony with image capture resolution of 12 megapixels and maximum flight duration of the flight is 24 minutes [21].

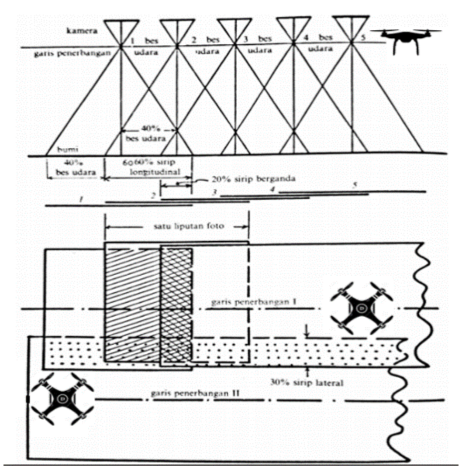


Figure 1: Taking of Aerial Photography at 60% Front Fins and 30% Side Fin

Photogrammetry in definition is to obtain reliable measurements and 3D models by means of photograph., whether images are taken from the air or from the surface of the earth itself [22]. In photogrammetric UAV, it is used for mapping a low budget. Additionally, the advantages of images taken by UAV can also be used for mapping the high resolution textures that can be realized in the form of a DSM (Digital Surface Model) and 3D model. The method of taking aerial photography is important where every image taken must be at least 60% front fins and 30% side fin to ensuring that all the images cover the whole study area as shown in Figure 1.

3. METHODOLOGY

Research methodology of this study is to ensure that the data collection methods used to be achieved the objectives. Figure 2 describes briefly the overview of the process and workflow involved in this study.

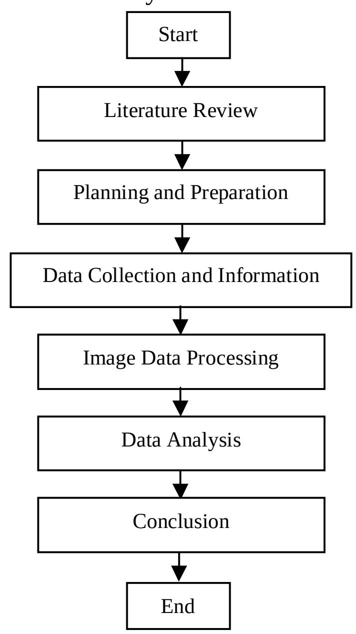
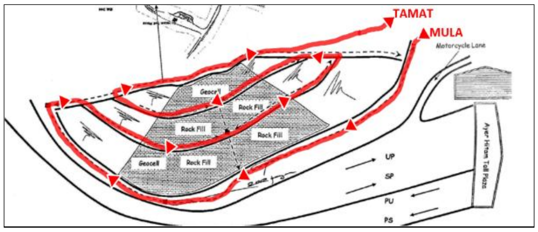


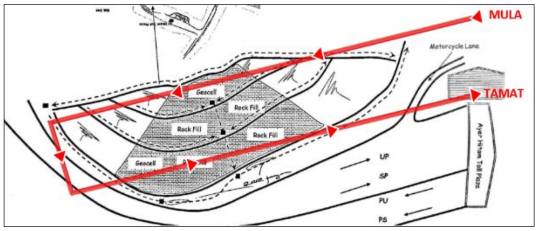
Figure 2: Workflow process

There are two methods of data collection in this study. The first method is a video recording of the distance of 2 meters from the slope surface using horizontal flight patterns to identify the image damage to the structure of the slope and video recording for a distance of 50 meters from the down slope to produce slope structure in the 3D model using software Agisoft PhotoScan as shown in Figure 3.

Both the video footage will be snapshot as an image using the software VLC Media Player. The results of analysis of images taken 2 meters of surface slope, slope damage to the structures identified and connected to the slopes of the 3D model. For the second method of data collection, the image taking of each meter height to determine the maximum height of the image to determine the slope damage. All of the data analysis for this study is based on images taken from video footage using UAV.



(a)



(b)

Figure 3: Flight track of Video footage at height of **(a)** 2 meters and **(b)** 50 meters from the surface of the slope.

4. RESULTS AND DISCUSSIONS

4.1 Data Analysis for 3D Structure Slope Model and Labelling Slope Location

Data were collected through video footage within 50 meters from the down slopes with video recording for 1 minute 31 seconds has been snapshot to 32 pieces of image using the software VLC Media Player. After completion of the snapshot, image brightness was edited using Microsoft Office Professional. There are 32 pieces of images are combined to generated a 3D model using software Agisoft PhotoScan as shown in Figure 4.

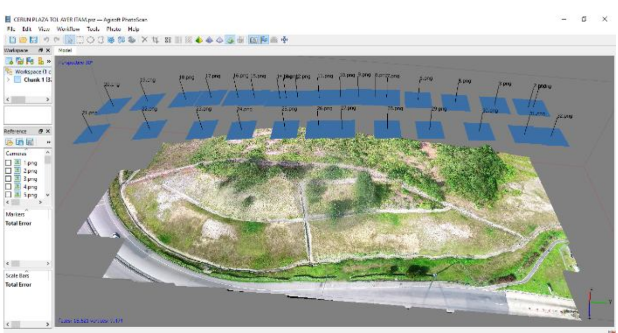


Figure 4: Combination of 32 Pieces Pictures using Software Agisoft PhotoScan

Figure 5: Structure 3D Model Slope at Research Area

Figure 5 shows a 3D model of the entire slope area of study. Next, the marking of 8 coordinates on the 3D model of slopes to be linked into the Google Earth Pro software to identify the position of the slope as shown in Figure 6. Figure 7 shows 8 coordinate values marked on the slopes of the 3D model.

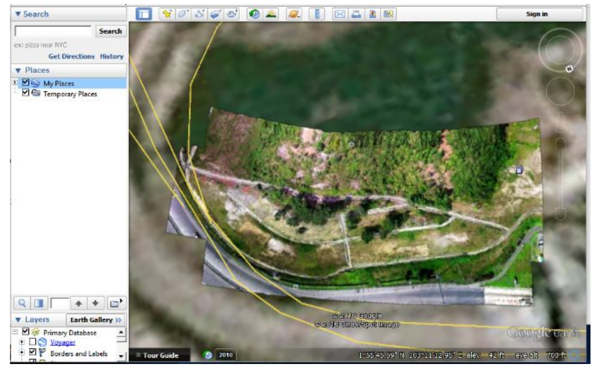


Figure 6: Location in the Study Area In Google Earth Pro

Markers	Longitude	Latitude	Altitude
point 1	103.186100	1.929480	7.000000
point 2	103.186330	1.929700	13.000000
point 3	103.186500	1.929530	19.000000
point 4	103.186850	1.929450	21.000000
point 5	103.187350	1.929150	14.000000
point 6	103.187500	1.928970	8.000000
point 7	103.187270	1.929650	7.000000
point 8	103.186930	1.929730	5.000000

Figure 7: The Coordinates for Longitude, Latitude and Altitude entered at Each Point for Marking Coordinates

4.2 Data Analysis for Determining Damage Structure Slope Images

Data obtained in the form of video footage for 7 minutes 25 seconds with distance 2 meters of the slopes have been replayed and analysed to identify structural damage of the slope. Several structural damage to the slope in the video have been identified and the snapshot to convert the video into images using software VLC Media Player before entering the software AgiSoft PhotoScan combined to produce a 3D model. After investigation, there are two types of damage that occur on the slopes of the cracks and vegetation coverage on slopes drain. A total of 3 points of cracks, and only one vegetation coverage on the slope drain structure identified. All the damage was combined and produces a 3D model where each is shown in Figure 8, Figure 9, Figure 10 and Figure 11.

Figure 8: Damage Analysis of 3D models Vegetation Coverage

Figure 9: Damage Analysis of 3D models Crack No 1

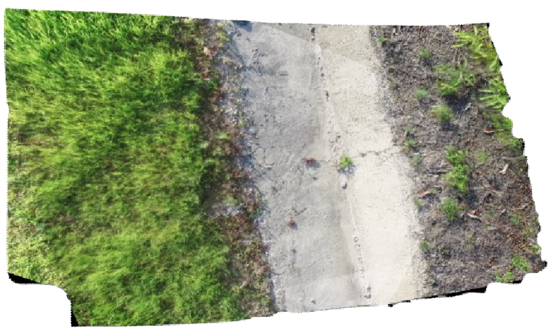


Figure10: Damage Analysis of 3D models Crack No 2

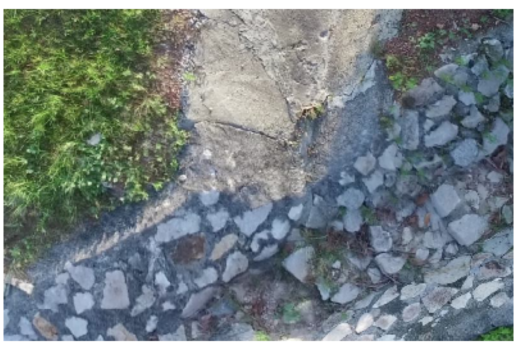


Figure 11: Damage Analysis of 3D models Crack No 3

The entire 3D damaged model is linked to the overall structure of a 3D model of the slope using Google Earth Pro software, as shown in Figure 12. Finally, the coordinates of the damage can be identified from Google earth pro, as shown in Table 1.

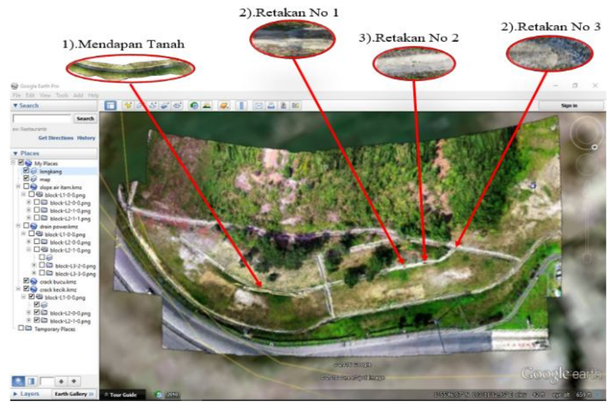


Figure12: Damage position at The Slope Structure in Google Earth Pro

Table 1: Damage Coordinates of the Structure of Slope Obtained from Google

Damaged No.	Latitude	Longitude
1	1°55'46.00"N	103°11'14.17"E
2	1°55'46.56"N	103°11'12.36"E
3	1°55'46.66"N	103°11'12.04"E
4	1°55'46.67"N	103°11'11.64"E

4.3 Data Analysis for the Appropriate Height to Determine the Image of Structural Damage.

This data analysis is to examine the extent to which the maximum height of the UAV in the air to take pictures in the work of monitoring the slope structure. Based on the analysis of data that previously, there are only two types of damage that occur on the slopes of the study area vegetation coverage and cracked. Micro UAV has been flown over the damaged area. At the height of each meter, the existing cameras on UAV will capture the image starting from a distance of 1 meter until 50 meters on the damaged area. The results of observation, there is a difference where image clarity with altitudes shooting depends on the type of damage. Damage caused by vegetation coverage can still be identified even at height of 50 meters as shown in Figure 13, but for the damage of cracks at height of 10 meters is starting to blur and at an altitude of 12 meters of cracks image is not clear. Therefore, the maximum image height of the damage type of crack is only 9 meters as shown in Figure 14 and for the damage of plant coverage is as high as 50 meters from the slope surface structure.

Figure 13: Zoom Image for Vegetation Coverage at Height 50 Meters

Figure 14: Zoom Image for Crack at Height 9 Meters

5. CONCLUSION

As a conclusion, the usage of micro UAV aircraft as one of the new alternatives to capture and identify the damage for the purpose of monitoring the slope of the surface structure. This method can also facilitate the work of inspection slopes in addition to saving time and energy as well as to reduce the risk of harm. Therefore, the usage of UAV in assisting the work of slope monitoring should be introduced to increase the frequency of monitoring, especially in high risk slopes that are abundant along the PLUS highway. This study has been proven by using UAV in visual recording provide information for the inspection of the slope. Besides that, image processing and analysis will be shown in details the defect that occurs and the location by providing the 3D model of the slope.

ACKNOWLEDGEMENT

Authors would like to appreciate to all participants who helped directly and indirectly in this study. The authors also thank the Research Management Centre (RMC), UTHM, Johor for their financial support.

REFERENCES

[1] Tajul Anuar Jamaluddin, Ibrahim Komoo & Mohd For, M. A. (2003). Geohazards in Tropical Mountainous Terrain – The Malaysian Experiences. In: Hood, S., Ibrahim.

[2] Abu Bakar R. S., (2008, Disember 10). Impak Alam “Jangan Ganggu Hukum Alam” – Harian Metro

[3] Mukminin, Ahmad, Tasrif Kartawijaya, Yudi Herdiana, and Irfan Yulianto. (2009). "Laporan Monitoring."

[4] Leong, K.C.(2004). The essence of good facility management - A guide for maximization of facility assets' economic life asset optimisation for reliable services and user satisfaction. Buletin Ingenieur, 24, pp. 7-19.

[5] Ibrahim, i.,(2009), pengunaan UAV Bagi Aplikasi Awam. URL: http://gisondemand.blogspot.com/2009_08_01_archive.html

[6] Ahmad, A., & Samad, A. (2010). Ariel Mapping using High Resolution Digital Camera and Unmanned Ariel Vehicle for Geographical Information System. International Colloquium on Signal Processing & its Application. Pp. 1-6. https://doi.org/10.1109/CSPA.2010.5545303

[7] …kaedah pemantauan struktur cerun di sekitar Lebuhraya Utara-Selatan, Yong Peng. (Rumin, M. E., komunikasi peribadi, November 22, 2015).

[8] Fahmy Ahmad, (2016, Januari 11). Pengalaman PLUS Hampir Tiga Dekad Urus Lebuh Raya Untuk Keselamatan Pengguna – Utusan.

[9] ESMaS. Expressway Slope Maintenance Management System. Pengurusan Lantas Berhad : inspection manual. 2000.

[10] Chowdhury R.N., (1978). “Slope analysis”. Developments in geotechnical engineering (Vol 22) : Elsevier Scientific Pub. Co., 1978. Pp. 237.

[11] Cernica, J. N. (1982). Geotechnical engineering. 6th ed. New York: Holt, Rinehart and Winston.

[12] Ahmed A.M.,(2013). Faktor-Faktor Yang Mempengaruhi Kegagalan Cerun. Retrievedon August 10, 2013, from http://pagarmuseh.blogspot.my/2013/08/faktor-faktor-yang-mempengaruhi.html

[13] Dunn, Downes, C.M., and C.M. Francis. (2000). Canadian Landbird Monitoring Strategy: monitoring needs and priorities into the new millennium. Canada, Ottawa: Partners in Flight; Pp .64

[14] Towonsing, A. (2015). Fenomena Tanah Runtuh: Jenis, Punca, Kawalan Serta Impak Terhadap Sosial Dan Ekonomi. Retrieved on March 18, 2015 from http://www.malaysian-ghost-research.org/fenomena-tanah-runtuh-jenis-punca kawalan-serta-impak-terhadap-sosial-dan-ekonomi/.

[15] Craig, W .H. (1974). Model studies of the stability of clay slopes. PhD thesis, University of Manchester.

[16] Bromhead, E. N. (1992). “The Stability of Slopes (Second Edition)”.Great Britain: Blackie Academic & Professional. Pp. 103.

[17] Candra. A. (2013). Monitoring. Retrieved on Disember 8, 2013, from http://andreancandra.blogspot.my/2013/12/monitoring.html

[18] Lin, Z. (2008), UAV for Mapping - Low Altitude Photogrammetric Survey. The International Archived of

the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII Part B1. Beijing pp. 1183.

[19] J. Unger, M. Reich & C. Heipke (2014). UAV Based Photogrammetry : Monitoring Of A Building Zone, XL (June), 23-25. Doi : 10.5194/isprsarchives-XL-5-601-2014.

[20] Darwin, N., Ahmad, A., & Zainon, O. (2014). The Potential of Unmanned Airial Vehicle for Large Scale Mapping Of Coastal Area. Doi ; 10.1088/1755-1315/18/1/012031.

[21] DJI Technology Co. (2015). Phantom 3 Advanced User Manual v1.2 en

[22] M Kaamin, S N M Razali, N F A Ahmad, S M Bukari , N Ngadiman, A A.Kadir, N B Hamid. (2017). The Application of Micro UAV in Construction Project. AIP Conf. Proc. 1891, 020070-1–020070-6; https://doi.org/10.1063/1.5005403.