PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 19 ISSUE 5 (2021), Page 160 – 168

LANDSLIDE MONITORING USING CLOSE RANGE PHOTOGRAMMETRY

Munirah Radin Mohd Mokhtar[1], Suriani Ngah Abdul Wahab[2], Mohd Najib Bin Husain[3], Haslina Hashim[4], Asmma' Che Kasim[5]

[1,3,4] *Department of Science & Geomatics,*
[2] *Department of Building Survey,*
[5] *Department of Estate Management,*
Faculty of Architecture, Planning and Surveying,
Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus

Abstract

This paper presents the preliminary results of a simulation study on the production of low cost Digital Elevation Model (DEM) for a landslide study area in Seri Iskandar, Perak. The important objective of this paper is to present the potentiality of Close Range Photogrammetry (CRP) as a data acquisition tool in producing a Digital Elevation Model (DEM) by using data from surface measurement. This method was applied using stereopair photographs captured data from ground level detection, or known as close range photogrammetry with the use of a digital camera mounted on a tripod as a tool for data collection. Close Range Photogrammetry (CRP) applications is useful for mapping of areas that are difficult and risky to point manpower on terrain that consist of steep and dangerous slopes. Conventional methods require measurement using Electronic Distance Measuring (EDM), but this method is very costly and requires a survey team placed on the land site area. The research data were carried out with two different epoch data. The outcome proves that CRP can produce DEM with less cost compared to other methods.

***Keywords**:* Digital Elevation Model (DEM); Close Range Photogrammetry (CRP); stereopairs; digital camera; Electronic Distance Measuring (EDM)

[1] Corresponding Author Email: munirah@uitm.edu.my

INTRODUCTION

The hill slope monitoring performing that had been antecedently applied by some researchers will be discussed. However, the methods used before had some constraints that limited the monitoring work in terms of how to access the area and the time required to effectively complete the work. Thus, the UAV and CRP method present in this research study will help the country to figure out the problem of not accessing dangerous slopes of the hills and the method will significantly improve the monitoring of landslides.

The CRP technique is used because constant monitoring of the slope in our country is very crucial to detect the movement of soil structure that can change to the occurrence of landslides. The monitoring of landslides should be done more often in nearby regions of continual human activity like the slopes around highways, in residential areas and so on. The constant monitoring can reduce the occurrent of landslides by providing early warning to the authorities about the weakness on the slopes so that proper action can be taken.

Choosing the monitoring method and equipment suitable for the study of ground movement in certain areas depends exclusively on the kind of slopes that is being studied. This is because the in-situ monitoring work affects the slope stability analysis. However, the proposed UAV and CRP method offers a novel remote monitoring method to conduct slope stability analysis. This part will be thoroughly discussed further in this chapter as a new approach to monitor landslides

Photogrammetry has been defined by (American Society for Photogrammetry and Remote Sensing) ASPRS as the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena (Wolf, 2000).

In general, close-range photogrammetry (CRP) is a technique of representing and measuring 3D objects using data stored on 2D photographs, which are the basis for rectification. In order to obtain 3D information, two photographs of the same objects are necessary. CRP is a part of terrestrial photogrammetry but has dissimilarity in camera to object distance. In CRP, the limit of camera to object distance is less than 100m (Meneses, 2005). CRP is mostly used for deformation measurement of structures, architectural mapping, modeling buildings, documentation of artifacts, reverse engineering purposes, or remodeling traffic accidents and crime investigation. Architectural and archaeological photogrammetry are examples of CRP applications that have widely been used since the 1960s (John, 1999).

The technique is implemented through stereo aerial photogrammetry and continuously developed parallel with the advancement of computer and digital technology (Ellen,2007). Images on close-range photogrammetry can be captured using three types of camera: metric camera, semi-metric camera and non-metric camera (Sunhui, 2005). Measurements by using these digital cameras offer a low cost imaging process, an attractive alternative to mapping data collection tools.

The accuracy of photogrammetric depends on camera resolution, quality of camera calibration, geometry of the camera position and the precision of marking location on the images (Q. Zhang, 2010). Most of the photogrammetry works need accuracy in the project. High accuracy work requires a well calibrated camera. Landslides on sloped areas can be well detected by calculation of Digital Elevation Model (DEM) from at least two different epoch data, or by profiling of longitudinal section or cross section over the DEM observed slope area.

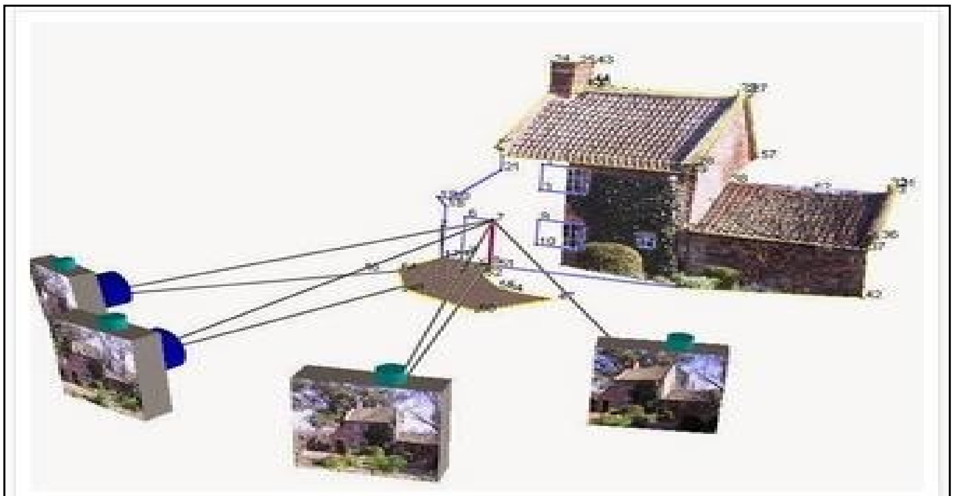

Figure 1: Terrestrial and close range Photogrammetry concept
(Source: http://fotomito.blogspot.com/2014_10_01_archive.html)

LANDSLIDE CLASSIFICATION

Landslides can be defined as the steeply downwards motion of sliding rock, debris or materials on the surface of the earth under high pressure. Most of the landslide occurrences are favored by steep slopes. The steeper the slope condition the greater the potential for landslides. Among the reasons for the occurrence of landslides are natural factors like an earthquake, volcanic eruption activity, heavy rain, and changes in the level of underground water as an agent that can weaken the rock or soil naturally. Look on the type of movement of the hill slopes, landslides are classified into fall (shaped debris), flow (earthflow) and slides (Z. Othman, 2011).

In Malaysia, landslides are one of the most dangerous natural disasters after floods. Malaysia has high total annual rainfall (tropical) which is one of the main factors contributing to the occurrence of landslides that can cause loss of life and property damage (H. Lateh, 2011). According to H. Lateh (2011), the Malaysian average annual rainfall is between 2000 and 2500mm. From 1970 to 2008, referring to a statistical report issued by PDW more than 300 landslides occurred throughout Malaysia. Soil failure usually occurs in the form of flow (mudflows) which are associated with the water content in the soil.

In fact, (H. Lateh, 2011) found in his research that most of the landslides in Malaysia are shallow landslides triggered by heavy rains that increase the water pressure in the slopes and its eventual collapse. The follow-up of statistical reports propose the need to take urgent action to create knowing to the public about the importance of studies about landslide monitoring on the slope of hills (Husin, M. Z., M. S. Usman, I., & Suratman, R. (2021) The studies are in particular important to the professionals connected with the work of monitoring the slope of hills in Malaysia.

Different from other natural disasters, the incidence of landslides in Malaysia is usually controlled by factors like earthquakes and floods caused by heavy rainfall in certain areas during the monsoon (November to February). The meteorological department is responsible for raising awareness so that people can take precautionary measures and prepare themselves in case of any natural event since they are all concerned about their own safety and properties as well (Suliman, S., Samsudin, S., & Ahmad, M. H. (2021). Landslide occurrences are often fast and without warning especially on slopes of areas undergoing development projects without good planning and not in accordance with the authority standards. This happens because activities like highway construction, mining, etc., accelerate the instability of the slopes.(.H. Lateh,2011).

MATERIALS AND METHOD

For respective years, there have been early in technology that can effectively help researchers to improve remote data collection, whether from a satellite, aerial photo platform (balloon, kite) or manned aircraft. The next paragraphs discuss the application of the CRP method for monitoring landslides by previous researchers.

CRP can be used to observe landslides on the slope of a hill. His research focused on unstable slopes in a former sand mining area at Taman Bandar University, Seri Iskandar, Perak, Malaysia. Two DEMs of the same area were produced using CRP data collected. Results were obtained by comparing the quality of DEM data with data obtained using a reflectorless total station.

Stereo images of the front view of the hill slopes were captured from a baseline distance of 8 meters and the distance from camera to object (slopes) of 50-65 meters for both epoch1 and 2.

The study used a common selection method for the variety of the control point to generate a 3D DEM. Long cross sections of the DEM were used to calculate the amount of translation in the slope of the hill.

This study was conducted in Parit, Seri Iskandar, which is located approximately at 4°23'04.03"N in latitude and 100°56'34.89"E in longitude. There are two different study sites to be used in this research. The aim of this research is to demonstrate the capability and effectiveness of CRP as a data acquisition tool in generating DEM and inaccessible landslide monitoring

The most important step to be carried out in this preliminary work is establishing a control point at the study site located in Seri Iskandar, Perak. It is needed to rectify images and produce 3D models. At least three or four control points are needed in the rectifying process and six control points in producing 3D. The list of equipment used in establishing control points include one total station (Laser Reflectorless GTS -750 series), two tripods, prism and measuring tape.

Data are observations developed from monitoring the real world. Data are collected as facts or evidence that may be processed to give them meaning andthen transferred into information. The data for this research were generated from field investigations at the study site.

DIGITAL ELEVATION MODEL (DEM)

Digital Elevation Model (DEM) is a three-dimensional creation of digital data of an object (towards the east, north and height) that is produced using data from a variety of data collection techniques. Among these methods is a close range photogrammetry (CRP) that uses two-dimensional (2D) photographs as input to obtain geometric information of three-dimensional (3D) objects by extracting the stereo model (R. Scholar, 2012).

In addition, other techniques are used to generate a Digital Elevation Model (DEM) using data from sources like topographic survey, Global Positioning System (GPS), digitised topographic maps, aerial and terrestrial photogrammetry, and laser scanning. Figure 2 illustrates the main framework process for producing and analyzing DEM in several applications.

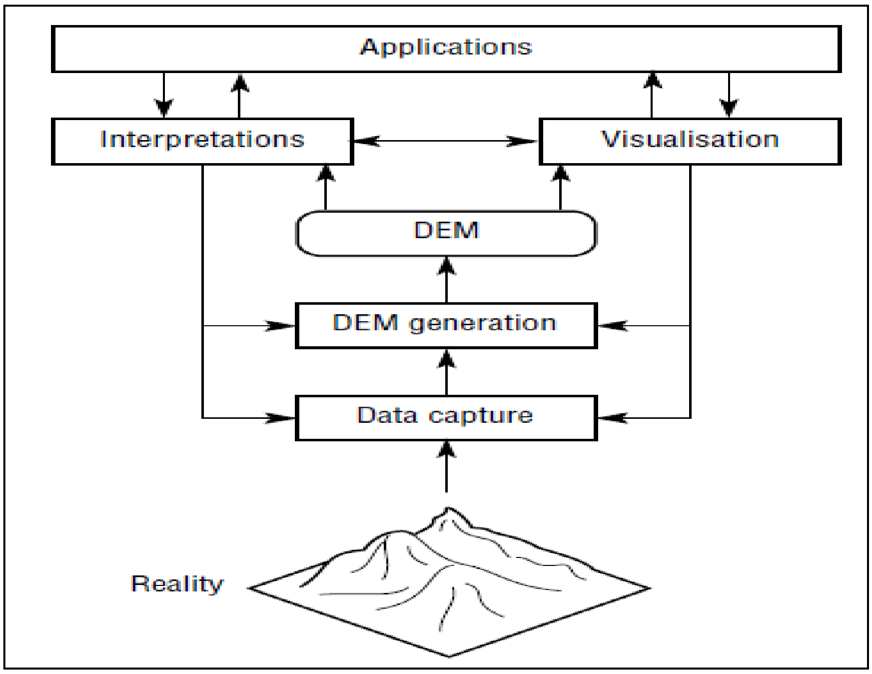

Figure 2: Framework for DEM application. _(Source: M. F. Hutchinson,1996)_

Furthermore, DEM is an elevation data model representing the actual state of the real terrain that helps to monitor the movement of slopes in a related study. Thus, the DEM generated from Photogrammetry sources is an important model for predicting changes in terrain (P. D. Savvaidis,2003).

Finally, DEM is a origin for mapping the relevant characteristics of a terrain such as topography slopes and the quality of DEM representing surface topography is essential in determining the characteristics of the existing topography on the map.

As a further indication, according to S. Suganthi (2010), DEM has the advantage of providing information about the height of the real terrain. In addition, DEM is a representation of a three-dimensional grid based on the height of the real terrain and it is an important aspect of GIS datasets and GIS-based analysis. As mentioned previously, various data reference (mainly contours or data points) can be used to generate a DEM. DEM data is also a valuable source of data for many applications, especially those related to the movement of surface slopes. Therefore, the accuracy of the DEM will be represented by the height and spatial resolution data [40].

FIELD WORK OBSERVATION RESULTS

The results of processing data from the study site consists of three-dimensional points that have coordinate values for each of the Cartesian axes (X, Y, and Z). A 3D model is a set of connected 3D points, edges, curves, and cylinders or shapes representing an object. The results represent the result of a 3D image generated from the collected data from the field site. A DEM represents a regular array of elevation points. The quality of a DEM can influence the accuracy of terrain measurements including slope and aspect (Kang,2008). Slope and aspect play a regular role in hydrologic modeling, snow cover evaluation, soil mapping, landslide delineation, soil erosion and predictive mapping of vegetation communities (Kang, 2008).

The 3D Analyst extension allows 3D GIS data management and creation of layers with 3D viewing properties. Terrain mapping and analysis can use raster data, vector data, or both as inputs. Contouring is the most common method for terrain mapping. Contour lines connect points of equal elevation, the contour interval represents the vertical distance between contour lines, and the base contour is the contour from which contouring starts (Kang,2008).

Imagine a DEM has elevation readings ranging from 44.883 to 62.628 meters. The conception of 3D modeling description of the shape of an object consist of determination of its main frame of reference and if required, creation of the textural database for the selected surfaces of structure. The arrangement and pattern of contour lines reflect topography. For example, contour lines are closely spaced in steep terrain and are curved in the upstream. Each commercial software has different advantages in processing the data. No measurement technology can be perfect, and all measurements involve performing approximations. ArcGIS 9.0 is no different. Not all the 3D coordinate results can be of the same quality.

The slope measures the rate of change of elevation at the surface location. Slope may be expressed as percent slope or degree slope. For this paper, the result of slope is shown in degrees. Aspect Model is the directional measure of slope. Aspect starts with 0 degree at the north moving clockwise and ends with 360 degree also at the north. Slope and aspect were derived extremity from the contour map.

Table 1: Typical elevation accuracy from different data source used to compare DEM Accuracy (Source: T. Hengl, 2003)

Collection Method	**Main Characteristics**	**Examples systems used**	**DEM Accurac y**

Ground survey	Highest accuracy; Small sampling; High costs	DGPS systems, Tacheometry (total station), levelling systems	≤ 1m; 1mm- 1m; ≈ 1mm
Stereoscopic imagery	High sampling density; Can be semi- or fully automated; vegetation is a constraint;	Aerial photography, Satellite imagery (SPOT, ASTER)	0.1-1m;10m (20m)
Laser scanning	Placed in the airplane navigated with GPS; The raw data require filtering and resampling before it can be used	Airborne laser scanning (LIDAR)	≈ 0.2-1.0m

There are various methods that had been implemented by many researchers in the previous studies regarding to the monitoring of landslides. At present, it is possible to predict the location of potential landslide occurrence. However, there limitations and constraints in methods that are being implemented and consequently better methods are necessary to improve the monitoring of landslides. Most of the methods discussed cannot be implemented in areas that are inaccessible and dangerous taking as example steep slopes nearby a highway. In addition, monitoring of slopes using existing methods require extensive manpower in the study area, the period of time to obtain complete information is quite long and the total budget is high. Therefore, in order to effectively address the concerns mentioned above, this research study proposes a novel method of monitoring landslides by Close Range Photogrammetry as a platform for collecting data especially in areas that are not accessible. Finally, the slope profile depicting soil displacement and physical changes is extracted and analyzed using the DEM covering the potential landslide area.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the support from Universiti Teknologi MARA. In addition to that, the authors would like to thank Universiti Teknologi PETRONAS for their assistance and consultation during this project.

REFERENCES

Suliman, S., Samsudin, S., & Ahmad, M. H. (2021). DECISION MAKING PRINCIPLES IN LAND DEVELOPMENT APPROVAL. *PLANNING MALAYSIA*, *19*(18). https://doi.org/10.21837/pm.v19i18.1038

Husin, M. Z., M. S. Usman, I., & Suratman, R. (2021). DENSITY CHALLENGES OF HIGH-RISE RESIDENTIAL DEVELOPMENT IN MALAYSIA. *PLANNING MALAYSIA*, *19*(18). https://doi.org/10.21837/pm.v19i18.1036

Ellen Banzhaf, (2007)," Monitoring the Development of Urban Gradients and Inner Urban Structure".

John Boland, Eastman Kodak panel Chair (1999).ASP Camera Calibration Panel Report

Kang –Tsung Chang, (2008), Introduction *to Geographic Information Systems*, Mc Graw Hil, Singapore.

H. Lateh and J. Ahmad, (2011) "Landslide issues in Penang, Malaysia Students 'environmental knowledge, attitude and practice," vol. 4, no. 4, pp. 65–72.

M. F. Hutchinson and J. C. Gallant. (1996) "Representation of terrain," no. 1991.

Meneses, A.S., Chasco, F.R., Garcia, B., Caberas, J., Audican, M.G. (2005). Quality Control in Digital Terrain Models, Journal of Surveying Engineering ASCE, Vol.131, p.118-124.

P. D. Savvaidis. (2003) "Existing Landslide Monitoring Systems and Techniques," pp. 242–258.

Scholar and T. Nadu. (2012). "DEM ASSESSMENT DERIVED FROM CLOSE RANGE PHOTOGRAMMETRY: A CASE STUDY FROM KADAVUR AREA, KARUR DISTRICT, TAMIL NADU, INDIA ABSTRACT:" vol. XXXIX, no. September, pp. 405–410.

Suganthi and K. Srinivasan. (2010) "Digital Elevation Model Generation and Its Application in Landslide Studies Using Cartosat 1," vol. 1, no. 1, pp. 41–50.

Sunhui Sim Department of Geography. (2005). University of California, Santa Barbara, *"A proposed method for disaggregating census data Using object-oriented image classification and GIS".*

Wolf, P.R., Dewitt, B.A(2000)., *Element of Photogrammetry with Application in GIS*, (, Mc Graw Hill, Singapore.

Z. Othman, I. Campus, R. Estate, W. Maju, and R. (2011). Area, "2. Monitoring Land Displacements Monitoring landslide activity is of paramount importance for landslide studies. Land displacement monitoring in a certain landslide prone area in principle is the monitoring of changes in distances, height differences,"

Received: 19th August 2021. Accepted: 2nd December 2021