INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 12, Issue 10, (2022) E-ISSN: 2222-6990

Advanced Landslide Prediction Utilising Unmanned Aerial Vehicle (UAV)

Muhamad Danish Zabidi, Basharudin Abdul Hadi
Centre for Civil Engineering Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500, Pulau Pinang Malaysia

Adnan Derahman
Centre for Civil Engineering Studies, Universiti Teknologi MARA, Shah Alam, 40450, Selangor Malaysia

Nor Aminin Khalid
Department of Business Management Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500, Pulau Pinang Malaysia

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v12-i10/15460 DOI:10.6007/IJARBSS/v12-i10/15460

Published Date: *20* October 2022

Abstract

Slope stability involves developing a terrain slope profile and determining the geometry of the failure surface to compute the slope factor of safety. Terrain capture and reconstruction traditionally has been expensive, time consuming and manpower intensive. This innovative method utilizing unmanned aerial system technology alongside the advancement in graphics processing can be proven as more effective and cost efficient. This research aims to develop a method to forecast the occurrence of landslide by utilizing drone technology. The objectives are to obtain data on terrain slope, create 3D model of the land, then perform analysis on the slope stability. Drone technology equipped with high accuracy GPS system captures high resolution aerial images of a land area for mapping. The data obtained is uploaded into computer software to generate the 3D model of the land. Then, the critical details such as contours or the elevations can be extracted. This information is transferred into an alternative software such as GeoStudio to analyze the stability of slope. Thus, the results can be used to predict the level of safety of the terrain slope and taken for further safety measures involving the particular area.

Keywords: Drone, Slope, Analysis, Prediction, Landslide

Introduction

A common approach on slope area survey is to use the Total Station method. Although this reliable method have been used for years by surveyors, the key problem is laborious. It requires various equipment at survey field and manpower in handling the equipment as well as manually recording the data. This poses a further problem when carrying out the slope survey which involve the safety of worker at site.

Recent development of advanced technologies and power systems have played an important role in the use for Unmanned Aerial Vehicle (UAV) known as drones. Drone technology can be applied to solve these problems. Some drones are equipped with Topographical Light Detection Ranging (LiDAR) system make us of light to create maps with various environmental elements. According to Sawant et al (2021); Mahajan (2021), drones have been applied in civil engineering, especially in the construction industry. These drones are commonly used for monitoring building structures, surveying tunnels for railway tracks or roads, and exploration of quarries and minerals (Sanson, 2019). The aerial photographs provided using drone survey in construction projects can assist surveyors, engineers, architects and project management team when compare to the BIM model (Kumar et al., 2020). According to Tezza (2019), drone technology can also be useful in assisting authorities to find and rescue casualties for landslide disaster. However, to avoid such casualties from occurring, the method of landslide prediction using drone has not been recognized and therefore is needed.

This aim of this study is to develop a method on predicting the occurrence of landslide by utilizing drone technology. This study will focus at natural slopes near residential areas. Data collection is done using drone. The data is processed and a 3D model of the terrain slope is created using computer software. Analysis of the slope stability will be done in another software to compute its factor of safety and evaluate its safety. The main advantage of utilizing drone technology when compared to conventional method is efficiency (Li et al., 2019). Nonami (2016) mentioned the favorable aspect of using drone for its autonomous flying and real-time data. It is quick and has high accuracy in data collection, thus results from analysis are more precise (Burgett et al., 2021).

Objectives

I. To collect data on terrain slope using drone technology
II. To produce 3D model of the land using computer software
III. To analyze slope stability of the area and evaluate its safety

Methodology

The method involves in this research can be categorized into three stages which are data collection, 3D modelling, and slope stability analysis. The three stages are represented in the diagram below.

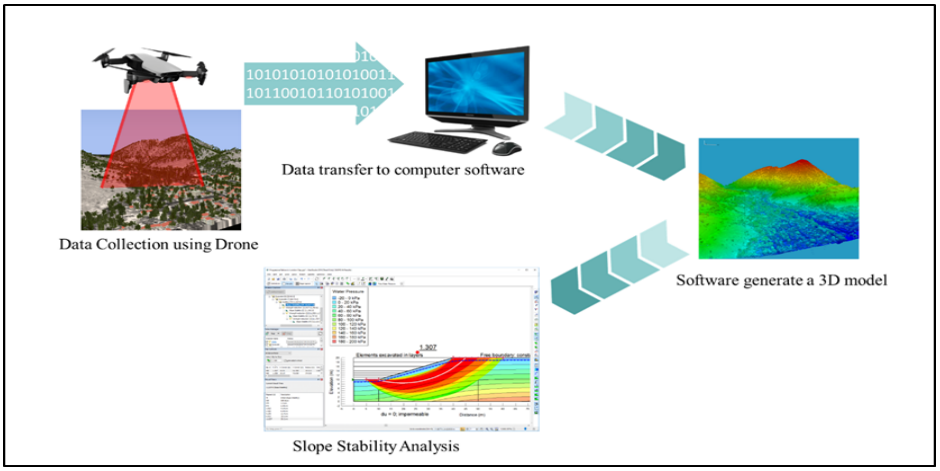

Figure 1. Stages of Landslide Prediction

Data Collection using Drone Automated Mapping

Drone will be used to obtain the data on the terrain slope. The drone will be connected to Department of Survey and Mapping Malaysia (JUPEM) server through internet connection. The drone will receive and record data of real-time position from the Global Navigation Satellite System (GNSS) from the server connected. A flying course is set by placing control points around the mapping area. Once set, the drone will fly autonomously at the designated flying course. The drone will take aerial photographs throughout the flying course. An example of drone and the flying course for mapping area is given below.

Figure 2. Drone and Flying Course for Mapping Area

3D Modelling of Digital Surface Model

The data obtained throughout the mapping area will be uploaded into a computer software. A mapping software will process images from drone and generates a 3D spatial data model of terrain slope. Figure below shows an example of the 3D model.

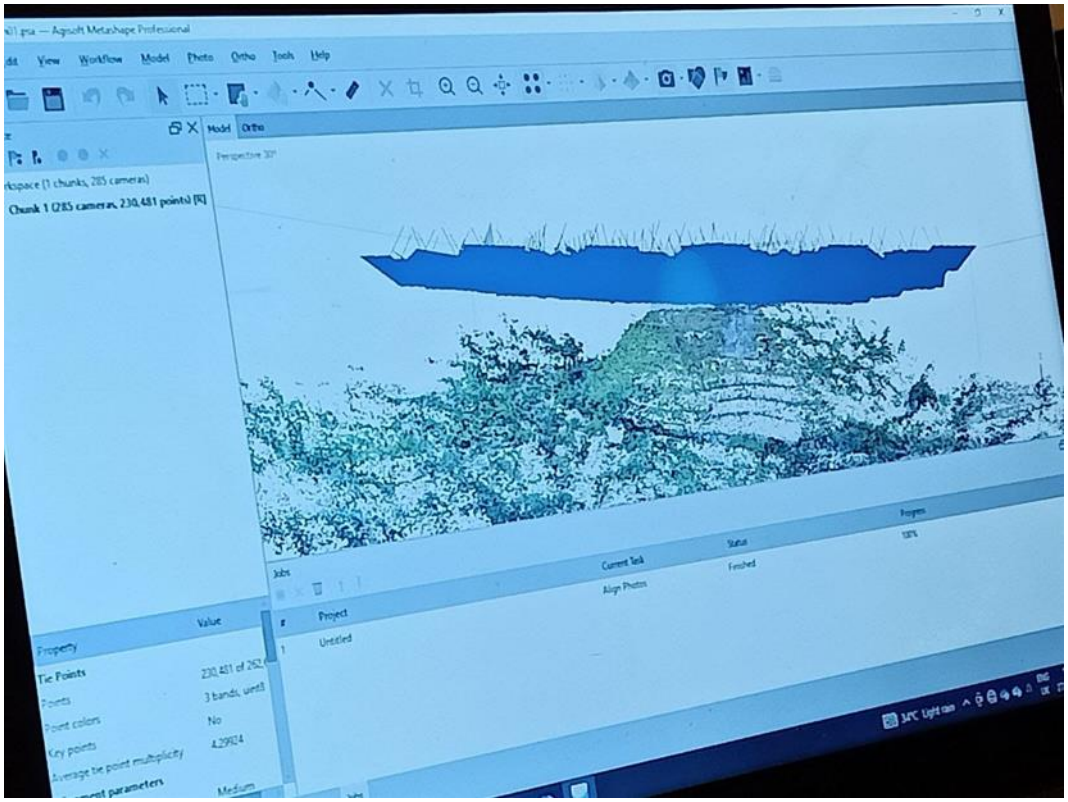

Figure 3. Data Processing of the Terrain Slope using Mapping Software

Slope Stability Analysis

The data from mapping software is then transferred into another software for computing the slope stability. This software will run analysis after input information based on previous software. The results from this analysis then can be assessed for the slope safety.

Results

Figure 4 and 5 show the model obtained by processing data from drone in a mapping software. 3D model of the terrain can be seen using the orthoimage and digital surface model (DSM). Using the same software, the cross-section of the terrain is obtained as shown in Figure 6.

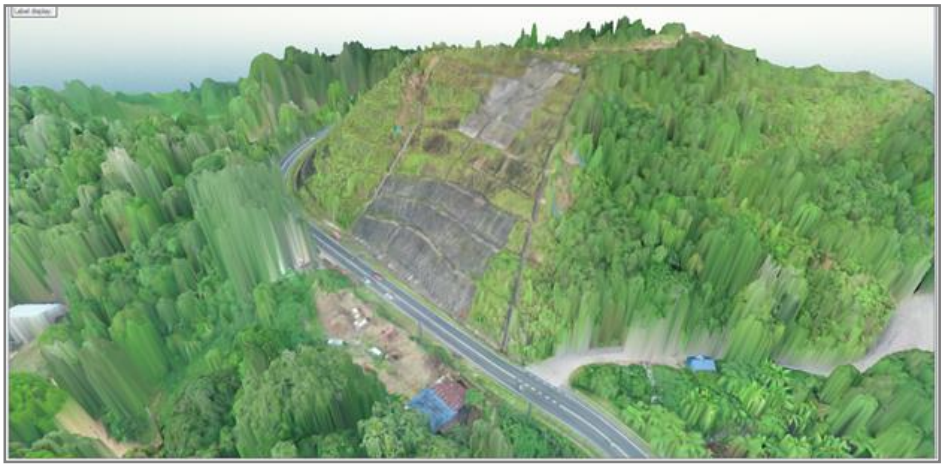
Figure 4. 3D View of the Terrain Model

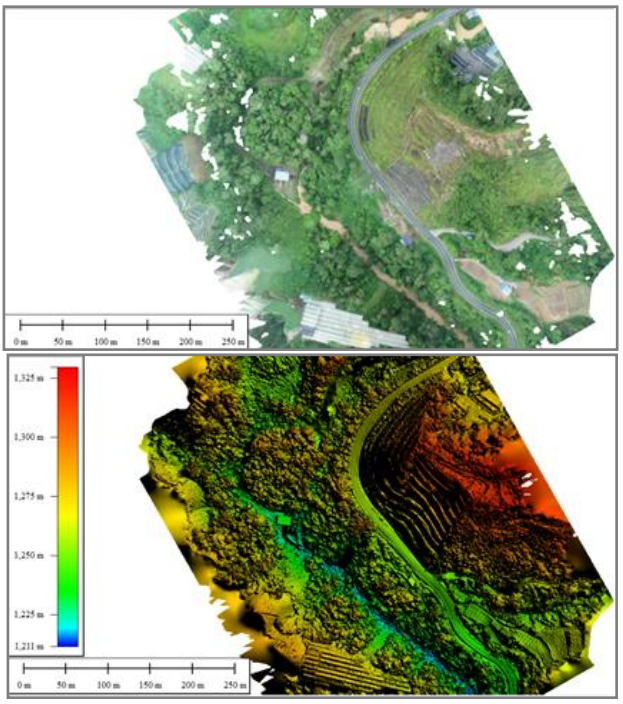

Figure 5. Orthoimage (left) and Digital Surface Model, DSM (right) based on Drone Mapping

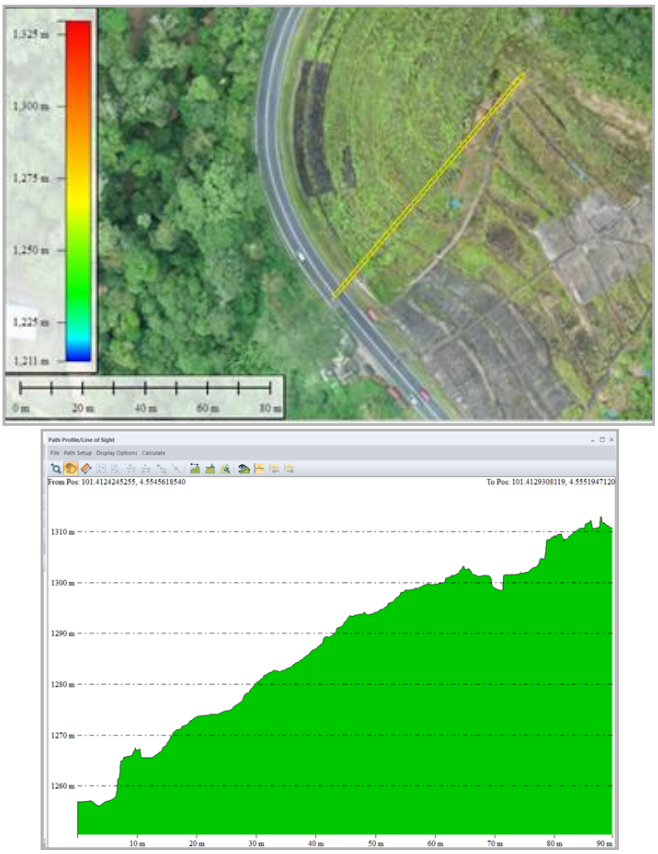

Figure 6. Cross-Section of Terrain Slope

The information obtained from the modelling software is transferred into slope stability analysis software to compute its factor of safety (FOS). The critical slip surface and the FOS is shown in Figure 7. The factor of safety for the above slope cross-section computed is 1.617.

While the minimum requirement provided by Department of Works Malaysia (JKR) is 1.3, this slope is thus safe.

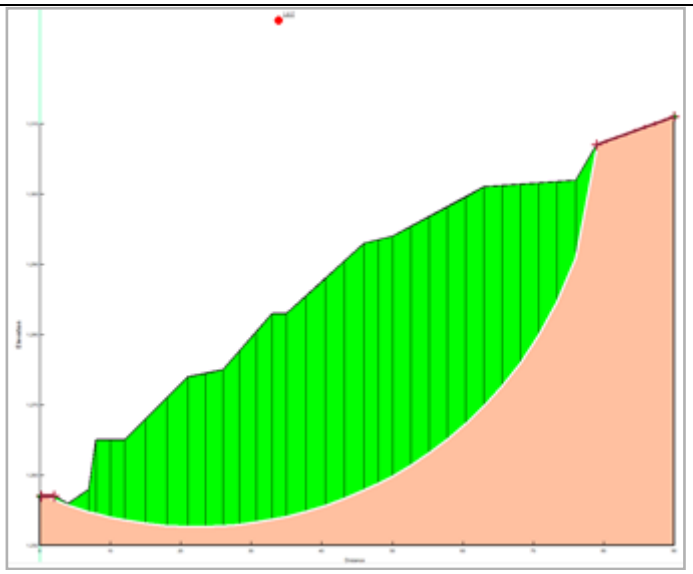

Figure 7. Slope Stability based on chosen Terrain Slope Cross-Section

Analysis

The method of predicting landslide using drone technology will produce 3D terrain model of the selected area. As the drone is connected to the JUPEM server, real-time data can be acquired, resulting in digital surface model (DSM) and aerial image that is geometrically correct known as orthoimage. Thus, high accuracy data is produced when using drone in survey mapping.

The processed drone data in form of orthoimage as well as DSM can be utilized by surveyors and engineers in order to locate potential landslide risk slopes without risking workers at site through autonomous mapping. Among the many functions, the cross-section function provides data on slope elevation, location and it's coordinate. Various cross-sections data can be extracted based on engineering judgement on slope, thus the 3D model can also be used by engineers to analyse more landslide prone areas. The slope stability analysis can be further enhanced when using drone as it proved to be quick in collecting data.

Novelty

Although the use of drone technology in civil engineering is becoming more common nowadays, its application in predicting landslide has yet been made full use of. By incorporating drone technology and slope stability software, the real-time high accuracy data can be obtained quickly, thus proper safety measures can be taken by authority before landslide incident occurred.

Conclusion

The application of UAV can optimize tedious works in slope surveying. This paper provides an innovative method on predicting landslide using drone technology. The data on land terrain can be obtained utilizing drone automated mapping. The data is then transferred into a software for processing and the outcome can be used to analyze the slope condition.

The results from this analysis can predict landslide based on the slope factor of safety obtained. Traditional approaches that requires many equipment and manpower at field can be minimise by using the drone technology. It is also safer and time efficient method. High accuracy data can be obtained then transferred for slope stability analysis can produce an accurate result to be used for predicting landslides.

Acknowledgement
The author express appreciativeness to the Ministry of Higher Education Malaysia (MOHE) for support financially in this research through Fundamental Research Grant Scheme (FRGS) (Ref: FRGS/1/2018/TK08/UITM/02/03) which make this essential research feasible.

Corresponding Author
Basharudin Abdul Hadi
Centre for Civil Engineering Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500, Pulau Pinang, Malaysia
Email: basharudin@uitm.edu.my

References

Burgett, J., Lytle, B., Bausman, D., Shaffer, S., & Stuckey, E. (2021). Accuracy of Drone-Based Surveys: Structured Evaluation of a UAS-Based Land Survey. *Journal of Infrastructure Systems, 27(2)*, 05021005.

Kumar, D. N., Ahamed, A. A., & Sundar, M. G. (2020). Surveying Using Drones And Providing Results By Using Photogrammmetry Software.

Li, Y., & Liu, C. (2019). Applications of multirotor drone technologies in construction management. *International Journal of Construction Management, 19(5)*, 401-412.

Mahajan, G. (2021). Applications of Drone Technology in Construction Industry: A Study 2012-2021. *International Journal of Engineering and Advanced Technology, 11*(1), 224-239.

Nonami, K. (2016). Drone technology, cutting-edge drone business, and future prospects. *Journal of Robotics and Mechatronics, 28*(3), 262-272.

Sanson, J. (2019, February). Drone Use in the Construction Industry Leads to Integration into the Current Civil and Construction Engineering Technology Curriculum. *Paper presented at 2019 CIEC*, New Orleans, LA. https://peer.asee.org/31517

Sawant, R. S., Ravikar, A., Bagdiya, N., & Bellary, V. (2021). Drone Technology in Construction Industry: State Of Art. *Vidyabharati International Interdisciplinary Research Journal*, 643-648.

Tezza, D., & Andujar, M. (2019). The state-of-the-art of human–drone interaction: A survey. *IEEE Access, 7,* 167438-167454.