Proceedings of the Seventeenth (2007) International Offshore and Polar Engineering Conference
Lisbon, Portugal, July 1-6, 2007

ISBN 978-1-880653-68-5; ISBN 1-880653-68-0(Set); ISSN 1098-6189 (Set)

The Variation Measurement of a Slope by Photogrammetry

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ABSTRACT.

Slope failures and landslides associated with earthquakes and typhoons are major natural hazards in Taiwan's mountain highways. This paper attempts to apply photogrammetry technique to carry out speedy in-situ survey. We firstly create the three-dimensional (3D) model of a brick wall and validate that the average error is 0.28 mm in the measured distance. Afterward, the same measurement procedures are applied in an in-situ mudstone slope. The average error in the estimated distance is 0.41cm. Therefore, the investigating result guarantees the accuracy of applying Photogrammetry to investigate the geometry of in-situ failed slope.

KEY WORDS: Highway; slope failure; photogrammetry.

INTRODUCTION

In Taiwan's mountain areas, slope failures and landslides associated with earthquakes and typhoons are major natural hazards. The in-situ investigation must be proceeded to clarify a complicated combination of factors of slope failures caused by seismic force and rainfall (Oka, 1997). Methods for measuring the volume variation of the slope includes measuring object coordinates of targets, which is placed in danger location, using GPS observation networks, measurement with observation networks of high precision total station, and using 3D laser scanner to get the surface condition of a slope (Miura, Hattori, Akimoto and Nishiyama, 2004; Mikos, Vidmar and Brilly, 2005). However, these methods have not been widely used owing to their long measurement time or high cost.

Photogrammetry is a visual metrology, and has been successfully applied in medical investigations, facial image identification, underwater surveying, and slope deformation monitoring (Mitchell, 1995; Green, Matthews and Turanli, 2002; Lynnerup, Adersen and Lauritsen, 2003; Miura, Hattori, Akimoto and Nishiyama, 2004). This paper uses Photogrammetry accompanying to a computer program, the Eos Systems program, PhotoModeler Pro 5, for speedy investigation and measuring the variation of a slope. The Nikon D100 digital camera with six million pixels is used. A laboratory experiment is conducted to a brick wall to insure the investigation procedures workable before an in-situ test. This study not only creates the 3D model of the slope, but also estimates the volume variation of the slope at two time epochs. In addition, we also evaluate the accuracy of measurements by comparing the data estimated by photogrammetry with the ones through the in-situ survey.

PHOTOMODELER

The Eos Systems program PhotoModeler Pro 5 is the main surveying technique used in this study. The technique involves an essential photo-triangulation program, which uses a calibrated camera to measure the ray paths from the principle point of the camera through the photographic image, to various points on the site. With multiple views of the same targeted points, the geometries of the camera and lens are known, and we can then calculate the angles between the camera and various points on the object. Therefore, the complete geometry of the object can be resolved from different shooting locations. Green, Matthews and Turanli (2002) proposed that the target points need to be well defined, and some controls are required to provide scale for the data.

A digital camera with high resolution is essential to achieve high accuracy because the resolution of photos strongly affects the accuracy of coordinate measurements. Hence, this study uses a digital camera with six million pixels, Nikon D100. Because the focus is the same in the whole photos, and moving the slope is impossible to take a larger vision, a wide angle lens must be used to broaden the angle of view and increase the depth of view. The enough depth of view can make that objects near and far are in focus and clear enough to be identified in the same photograph. Therefore, a wide angle lens, Nikon 24mm f/2.8D AF Nikkor, is chosen and is calibrated by the camera calibration procedure in the PhotoModeler program. The calibration needs the photos taken from four different positions and two photos at each position (as illustrated in Figs. 1 and 2). The calibration result is shown in Fig. 3.

LABORATORY EXPERIMENT

This study performs a laboratory experiment for insuring the investigation procedures workable to measure an in-situ slope. The object used in the laboratory should be movable and constructed