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Study on the accuracy of geometric parameters of rock mass discontinuities based on photogrammetry

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ABSTRACT. *A large amount of geometric data of a remote target can be obtained in a short time by collecting photographs based on photogrammetry. photogrammetry has become an important method to extract the geometric parameters of rock mass discontinuities. The purpose of this paper is to quantitatively analyze the accuracy of the geometric parameters of the three-dimensional model obtained by photogrammetry through a physical model test, and thus to obtain the inspiration of the photogrammetric accuracy of the rock mass discontinuities. The results of the physical model test shows that the measured error of the geometric parameters is very small, and the measured values can satisfy engineering requirement.*

KEYWORDS: *photogrammetry, accuracy of geometric parameters, rock mass discontinuities, physical model test*

1. Introduction

A discontinuity refers to a boundary plane with a certain range in rock mass formed in geological process. The discontinuities usually cut the rock mass into multiple blocks, but the strength of discontinuities is much lower than that of rocks. Therefore, the discontinuities control the mechanical properties and failure modes of the rock mass [1]. It can be seen that extracting geometric information of discontinuities is still the basic work in the geological engineering.

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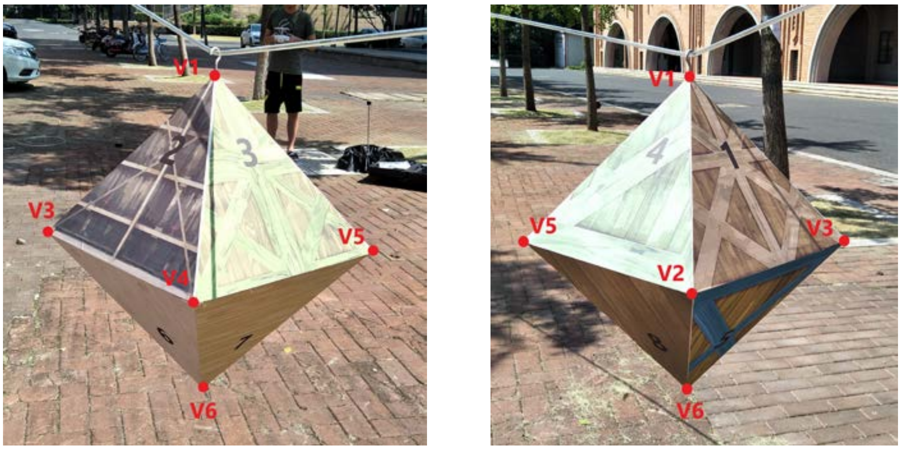
The traditional method of collecting information of rock mass discontinuities is manually measurement by a compass and a steel tape. Photogrammetry, As a technology that can measure over a long distance and a wide range, has been widely used in the measurement of geometric parameters of rock mass discontinuities [2-4]. To be specific, photogrammetry is to reconstruct the three-dimensional (3-D) model by taking a series of photos that meet a certain degree of overlap of the target, and to obtain the geometric information of the study area. The measurement accuracy of photogrammetry will directly affect the effectiveness of numerical simulation and rock mass stability analysis. Therefore, it is very important to evaluate the accuracy of the photogrammetric products, and a large number of researches that focus on the accuracy have been conducted based on the physical experiments and the field tests [5-7].

In this paper, a physical model test is designed to study the accuracy of the geometric parameters of discontinuities obtained by photogrammetry based on a civil unmanned aerial vehicle (UAV).

2. Methodology

2.1 Physical model

To simulate the measurement process of the geometry parameters of rock mass discontinuities based on photogrammetry, an regular octahedron model with edge lengths of 0.5 m is produced by 3-D printing. To recognize the local features of the model easier by photogrammetry software, different texture images were posted on the all planes of the model. As shown in Figure. 1, the vertices of the octahedral model are marked as *Vi* (*i* = 1 to 6) and the planes are numbered from 1 to 8.



(a) Front view *(b) Rear view*

Figure. 1 Physical model

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2.2 Scheme of field test

In order to satisfy the safe flying height of the UAV, the regular octahedron model is first suspended vertically to a certain height. In the shooting process, the UAV Phantom 4 RTK was used to collect photos around the octahedron model at a distance of 5 m (see Figure. 2). A total of 30 photos were obtained and the included angle between adjacent camera positions is 12°.

The Phantom 4 RTK can attach geographic location references to the photographs through on-board real-time kinematic system. Therefore, the photogrammetric model can be georeferenced directly on the basis of the geotagging of each photographs. After the field photos are obtained, the 3-D reconstruction process of photogrammetry is carried out by software ContextCapture.

Figure. 2 Shooting process of physical model test

3. Results and discussion

In the field test, the dip direction of each plane and the coordinates of each vertex of the model are not easy to be measured accurately, but the dip angles (= 54.73°) and edge lengths (= 0.5 m) are accurately known. Therefore, the dip angle and edge length are selected as important indexes to evaluate the accuracy of the physical model test.

The errors between the measured value and the real value of the dip angles and lengths are plotted in Figure. 3 and Figure. 4. The results show that (a) in Figure. 3, with respect to eight planes of the physical model, the errors of the dip angles range from 0.47° to 1.06°; (b) in Figure. 4, the maximum relative error of edge lengths is 2.68%, and the minimum error is 0.53%; and (c) thus it can be seen that the accuracy of dip angles and lengths obtained by photogrammetry is very high, which can fully meet the engineering requirements.

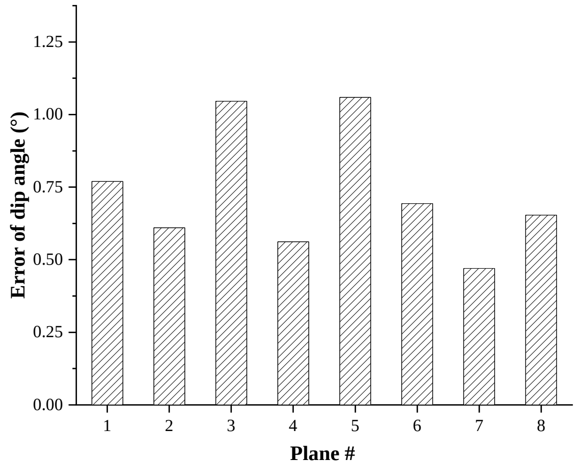

Figure. 3 Error of dip angles of the physical test

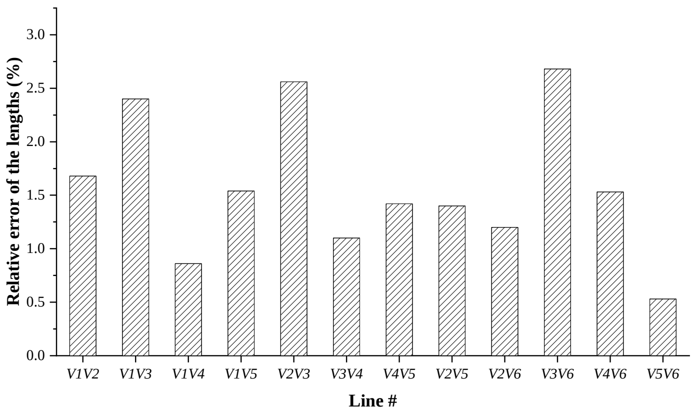

Figure. 4 Error of lengths of the physical test

4. Conclusion

As a hot measurement technology in the field of extracting the geometric information of rock mass discontinuities, photogrammetry can reconstruct 3-D models with high accuracy. To access the measurement accuracy of the geometric parameters of rock mass discontinuities, a physical model test is conducted in this paper. The drawn results show that the errors of the dip angles of eight planes and the lengths of twelve edges of the regular octahedron model reconstructed by photogrammetry are very small. Therefore, photogrammetry is valid for the measurement of the geometric parameters of rock mass discontinuities and the results can satisfy the requirement of practical engineering.

Acknowledgments

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