Structural Geology in Automized Fracture Measurement System

Glenn Jason Coderis[1] · SangGi Hwang[1)*] · TrungThanh Dang[1]

1. Introduction

Field measurements on the excavated rock surface are tedious and sometimes very risky, especially if working in unstable slopes. During slope stability studies, detailed measurements are required for a better and more accurate analyses but the problem comes if the slope is very wide and very high. In order to solve these limitations, GIS Laboratory of PaiChai University developed Surface Mapper 1.0 for measuring geologic orientation remotely, using the photogrammetry concept. Measurement routines are coded in Visual Basic and GIS components and appropriated equipments are built for taking stereo photos.

Today, Photogrammetry is being used in engineering works for getting a much faster and more accurate results, and the active application fields include detecting rock mass discontinuity (Hwang, 2001 ; Nguyen, 2004 Antony and Dove, 2006), characterizing rock mass (Kemeny et. al, 2002), estimating roughness or rock surface (Lee and Ahn, 2004), and mapping high walls (Soole and Poropat, 2002). This paper will introduce the Surface Mapper system and the measured examples as well as the problems that can be encountered.

2. Surface Mapper

Surface Mapper is a device that can measure orientations of structural geologic features like faults and joints remotely and automatically and analyzes slope stability, as well. The system uses Nikon D70 digital camera with customized mount (Figure 1), and the stereo photos from the system are analyzed by built in software, which performs measuring orientation of planes, generation of 3D models, combination of photos, and drawing of cross sections.

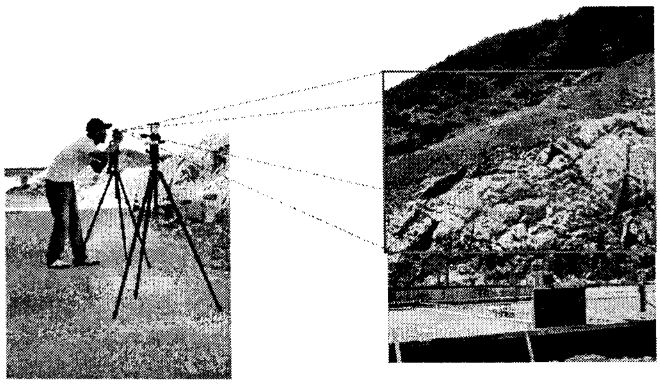

Figure 1. *Shows how Surface Mapper equipments are set-up and how stereo photos are acquired*

Keywords : Fracture measurement system, Surface Mapper, Photogrammetry

1) Department of Civil, Environmental and Railroad Engineering, PaiChai University, Daejeon, South Korea (* *sghmap@pcu.ac.kr*)

Processing of photos are divided into two parts, first is the measurement of dip and dip direction and the second one is the slope stability analysis. Before starting to measure fracture orientation and analyze for slope stability, stereo photos has to be taken first with at least 60% overlap using the equipments for maximum measurements. The pictures will be processed and RGB of each pixel in a picture will be converted to Intensity value. The intensity values will be used to match points between two photographs.

All the photos are combined using the photo combination algorithm of the software. A point in the left image and its corresponding matching point on the right image are located. The locations of each photo are recorded in the database. After this process, all the photos are plotted in AutoCAD and fracture network of the excavation surface is drawn for structural geological analyses. Measurements are conducted to the selected fractures of the network. Combined slope pictures are also used for further processing which includes measurement plotting, fracture delineation, and cross-section drawing.

To measure a plane, at least three matching points must be selected. These points should be well distributed so as to represent the best plane orientation. When done measuring, measurements can be saved in a file and that can be opened and edited if needed again and this file will be used for plotting measurements in AutoCAD.

To analyze slope stability, measurements are plotted first onto the photos. During the plotting process, the database information such as the name of the model, the orientation and coordinates of the measurements, the slope orientation, and the mode of failure are transferred to the AutoCAD line for further analyses. Once plotted, data can be read from the AutoCAD drawing and can be analyzed by built in stereonet function. The stereonet functions not only analyze the failure criteria of graphically selected fracture sets but also performs grouping algorithm based on eigenvalues and eigenvectors. Lines with internal properties are also grouped accordingly by changing its colors in AutoCAD drawings for better visualization of fracture distribution.

3. Discussion and Conclusion

In terms of accuracy, Surface Mapper has been used and tested for some slopes in Korea. 25 planar data are selected and measured in one of the slopes using both surface mapper and conventional compass. Results show that error range in strike is 5.25 $\pm$ 4.53 and 3.18 $\pm$3.17 in dip angles, when 2 standard deviations were considered, which also coincided within 10-degree range difference with compass measurements. However, despite its accuracy, errors are still inevitable. Some of the possible causes of error are listed below.

1. *When the points are not matching.* Due to depth differences, disparity values can change drastically, leading to unmatched points if unnoticed.

2. *When the measuring plane is in a shadow area.* Due to similarities in intensity values, planes in shadow area are prone to mismatching points.
3. *When the measurement using compass is done near the equipment.* Compasses' needles are very sensitive to metallic objects. If a measurement is done near a metallic object, the resulting orientations are deflected, thus giving a wrong camera orientation

When dealing with structural geologic features such as faults and joints, we always get the general plane orientation which can be a representative of the whole feature. However, it is known that these features never occur as a single straight line with one single orientation or direction; instead they occur as non−continuous, sometimes curvy lines of varying orientations. Furthermore, fractures occur as a set and their concentration density varies from area to area. Therefore, analyses of the fracture networks based on structural geology could often be more critical than mass measurement process. Figure 2 shows different fracture network systems on the excavated rock surfaces.

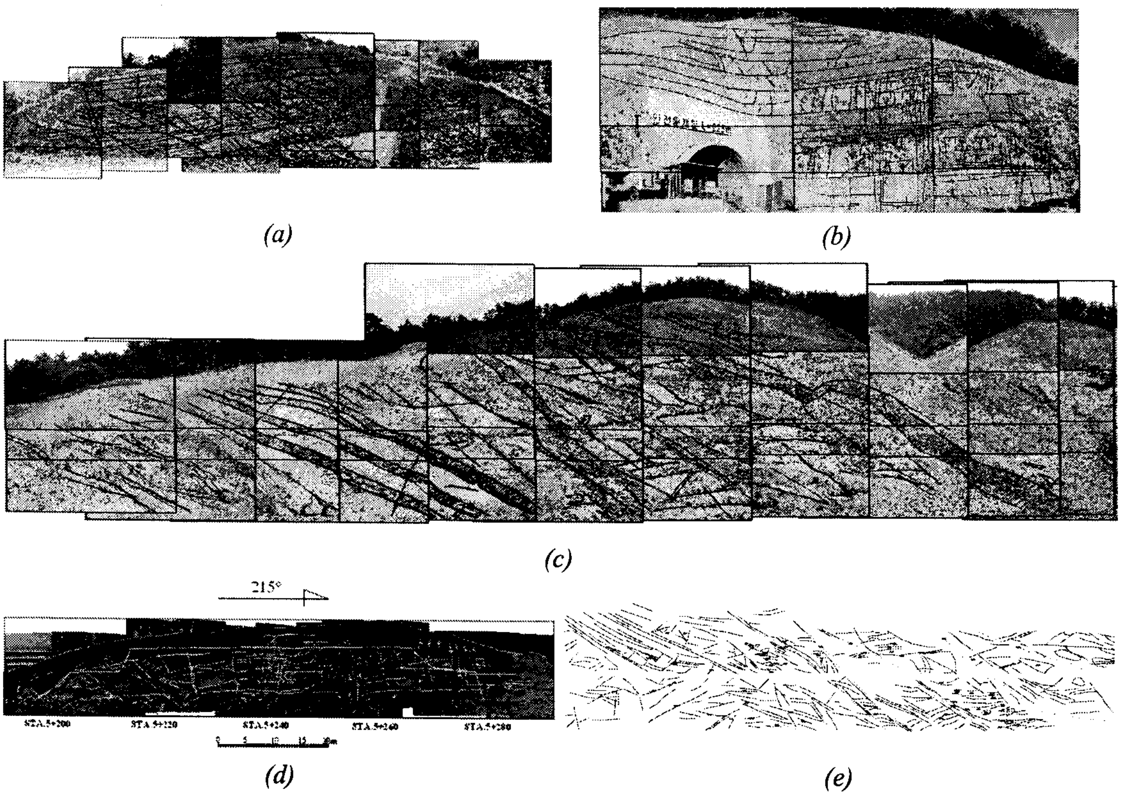

Figure 2. *Fracture types that are normally encountered.*

(a) Classified fracture groups are well demonstrated but structural patterns are not well justified.

(b) Sedimentary rock units which show strong bedding anisotropy and discontinuous crossing joint between the layers.

(c) Foliated gneiss unit with unique dykes and fracture orientations.

(d) Normal fault geometry which shows toppling instability.

(e) Shear zones and related secondary fracture sets.

4. References

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