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Application of Image Processing Techniques for Geometrical Simulation in Rock Slopes

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ABSTRACT

This paper is attempted to present the artificial intelligence based on algorithm which is used the image processing techniques for computer-based simulate of jointed rock slopes in three dimensional condition. For this purpose, the applying the digital image processing has been used for identifying of geometric structures in rock slope and preparing rock mass information. This information is used as a database for generating three dimensional models which is implemented in MATLAB software. The algorithm is utilized for processing input image; generate a main dataset and providing the 3D model of slope, based on geometrical properties and joint set's network in rock slope. In this regard, several steps processing are conducted on input image that is concluded as pre-processing, main processing, feature extraction, database generation and model preparation. As results, the algorithm is able to generate simplified dataset for preparing the 3D view of the rock slope geometrical conditions.

1. Introduction

Geotechnical investigations were involved the slope mass, the geometrical properties of the rock body that is play a key role in structural stability which are used for proportions of mine design (Alejano et al., 2007), blasting patterns (Hamdi and du Mouza, 2005), open-pit excavations (Yarahmadi et al., 2015; Azarafza et al., 2017), rock blocks volume (Palmstrom, 2005), dimension stone (Saliu and Idowu, 2014), and so on (Nikoobakht et al., 2016). Goodman (1989) is stated that all rock mass on earth surface associate with discontinuities (such as joints, faults, bedding, folding, etc.) were affected rock structures characteristics. For example, it can be illustrated as reduced compressive and tensile strength that made nonlinear behaviors, extended anisotropy in rock mass, etc. These changes make rock body's weak and caused instability and structural failure (especially rock slopes). Hudson and Harrison (1997) found that by increasing the discontinuities density in rock masses, the engineering dimension decreased and has made environment to get unstable. Thus, the knowledge of the rock geometrical properties and discontinuities networks help to overcoming the problem of rock slope mass instability. The first step in rock mass geometrical investigations is obtained the location of discontinuities network in rock mass and preparing the joint's datasets (Azarafza et al., 2017; 2018). For this purpose, several experimental, computational, remote-sensing and geophysical procedures have been developed (Porsani et al., 2006; Prost, 2013; Bozzini et al., 2014; Cacciari and Futai, 2016). In the meantime, computational and computer-based approaches like digital image processing and machine vision are quickly and significantly grow and possessed many attention of experts and professionals.

Image processing (in computer science) is the application of digital computer-based algorithm to process digital images which are used for effective extract and useful data form images. The digital image processing methodology had been developed in 1960s based on artificial intelligence specialists works in

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Massachusetts Institute of Technology (MIT), University of Maryland, Bell Laboratories and Jet Propulsion Laboratory that is utilized for satellite imagery, medical imaging, photograph enhancements, wire-photos and videophones. Although, the primary purpose of early image processing was to quality improvement of the input image, but today it is used for many engineering fields (Gonzalez and Woods, 2017).

In the rock mechanic and engineering geology, image processing is applied for identifying of discrete structures like joint sets, discontinuities, faults and folding, etc; that is responsible for creation of rock blocks in rock slope masses. Recognitions of rock blocks in slope body is the best way to stability assessments. In image processing the aim is extracting the geometrical properties which is used for generate the discontinuity network in rock slope mass were related to rock block emplacements (rock blocks created based on discontinuities intersections, and their geometry depends on the discontinuities emplacement in the rock mass). So, if you have discontinuity network data and joint set emplacement, you can estimate the rock block location in rock mass body which is removable rock blocks affected the entire rock slope stabilities.

2. Image processing and feature extractions

In digital image processing for extraction of useful properties, usually used the several assessment procedures which is classified as pre-processing, main processing and post-processing. In each steps some progress are conducted to modify the input image conditions. But before that, it is required to prepare input image as well as possible to analysis stepsthat they are not accompanied by errors; so, there is no need to perform various pre-processing. In this regard, the input image must be high-resolute and taken directly from slope surface without any vegetation or external effects. Input image should be free of any shadows, associated with appropriate dimensions (scale) and same lighting or sun's radiation angle to preparing the suitable input image (Azarafza et al., 2018). It should be noted that the light or sun radiation angle variations can improve or disprove the image analysis results (Gonzalez and Woods, 2017).

After preparing the input image, the image processing procedures are conducted on image concluded pre-processing, main processing and post-processing steps. In pre-processing photograph filtered and stabilized to providing the basic image for main calculations and extraction of features. Removing the image background, preparation of basic progress histograms, reduce noise, increase image sharpness are several concept of pre-processing. In image properties discrete structures detections, several filtration functions are successfully used where can categorized as grey-scale, adaptive noise-removal, laplacian, laplacian of gaussian, gradient and gradient orientation, pad-array and solbel filtrations (Gonzalez and Woods, 2017). The presented study is used these filtration functions to modified the input image condition and prepare the basic image for main process applications were implemented in MATLAB software (Gonzalez et al., 2010; MathWorks, 2014).

In main processing stage, the modified image is used for edge detection and extracts the joint sets and discontinuity network information. Edge detection includes mathematical methods that conducted for identifying points in basic image which the image brightness changes sharply or formally has discontinuities were typically organized into curved sets of line segments termed edges. These lines are represented the joint network in rock bodied were used to indentified the rock block emplacement in rock slope mass. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties which is count as advantage for 3D modeling of rock mass geometry. It is should be noted, the edges extracted from non-trivial images are often hampered by fragmentation which meaning that the edge curves are not connected and missing edge segments as well as false edges not corresponding to interesting phenomena in the basic image. Thus complicating is the subsequent task of interpreting the image data (Gonzalez and Woods, 2017). In these cases, the post-processing must be conducted to provide improved results. The Fig. 1 is presented the digital image processing procedures for prepare the results and extract information form images.

Figure 1. Digital image processing steps for feature extraction

3. Material and Methods

This study used the image processing techniques for investigating rock slope geometry and identifying the discontinuity network emplacement in rock slopes. To this end, the three step digital image processing contained pre-processing, main processing and post-processing stages are used for identification and extraction of joints characteristics. The MATLAB software is used for applying the procedure and preparing the database of joint sets in rock mass. For this purpose, an input image is taken from the slope surface and used for feature extraction. After extract the discontinuity network data, this dataset is used as main framework for generate the rock blocks in rock mass and simulate the three dimensional rock slope geometrical modeling. The process flowchart of the study is presented in Fig. 2.

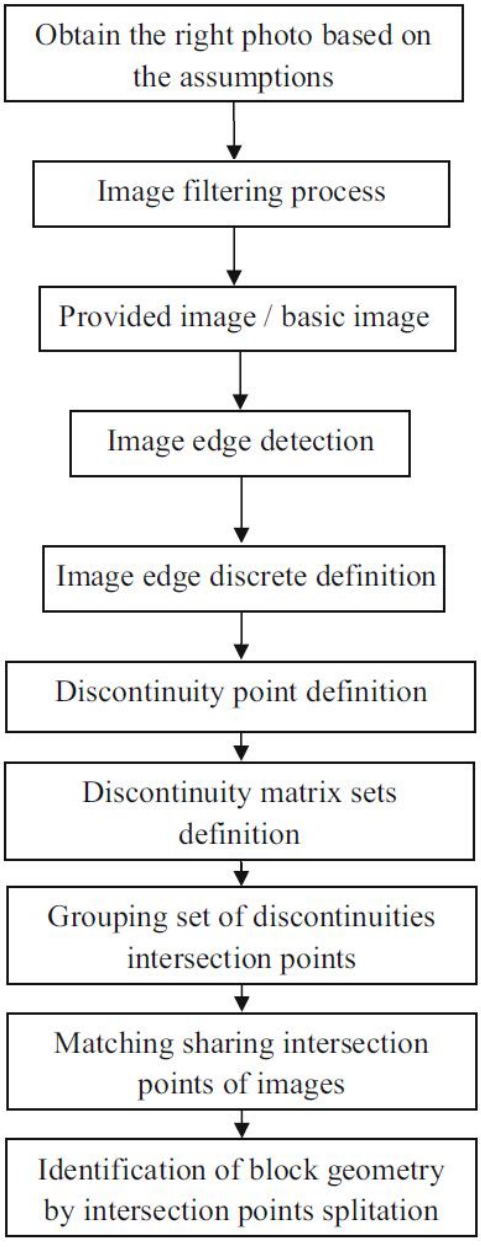

Figure 2. The flowchart of dimensional algorithm process

4. Results and discussions

Figure 3 is presented the studied slope view which is utilized for rock slope geometrical simulation for extracting the discontinuity network in rock body. The studied slope is after preparation, used for feature extraction and prepares the joint sets data-set creations. The figures 4 and 5 are illustrated the digital image processing application on studied image. After the extraction of rock slope characteristics form the basic image, the discontinuity dataset used for generate the rock bocks geometry. To this end, Heliot algorithm is used (Heliot, 1988). The figure 6 is presented the three dimensional status in rock mass. Referring to the methodology of the study, after generating the discontinuity network is attempted to identification of rock blocks in rock slope. The results of the simulation are presented in Figs 7 and 8.

Figure 3. A view of the studied slope

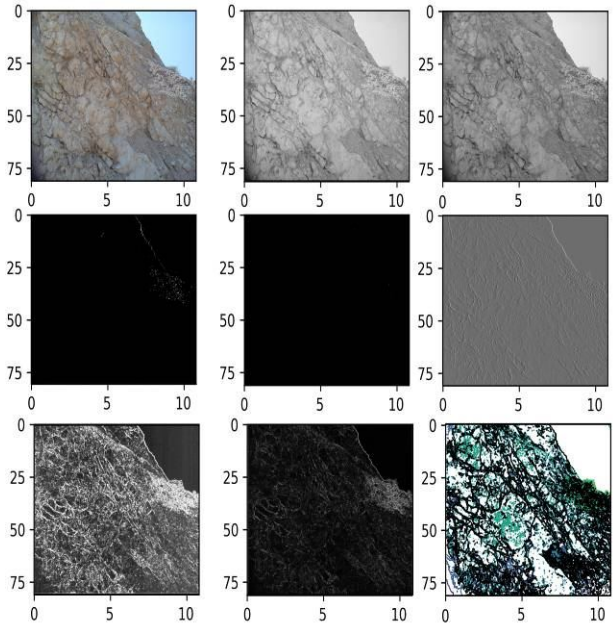

Figure 4. Application of several pre-processing filters in image processing evaluations (dimension is m)

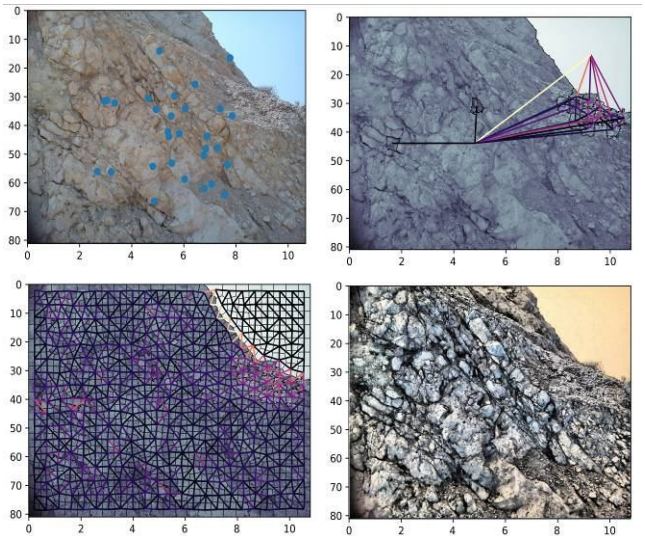

Figure 5. Application of several main-processing and edge detection in image processing evaluations (dimension is m)

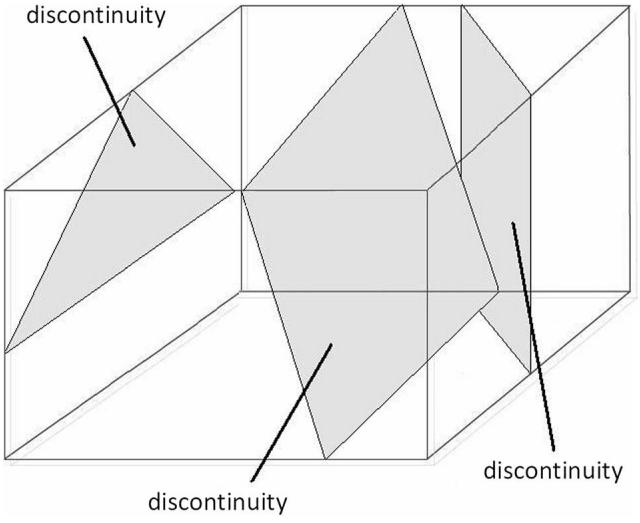

Figure 6. Discontinuity network in rock mass (Azarafza et al., 2017)

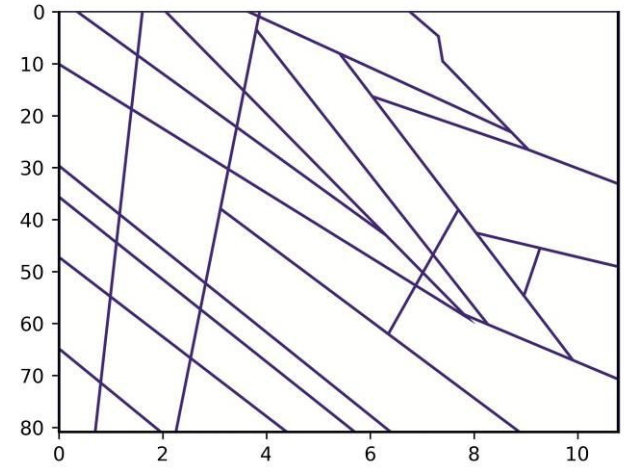

Figure 7. Rock blocks identification in two dimensional spaces (dimension is m)

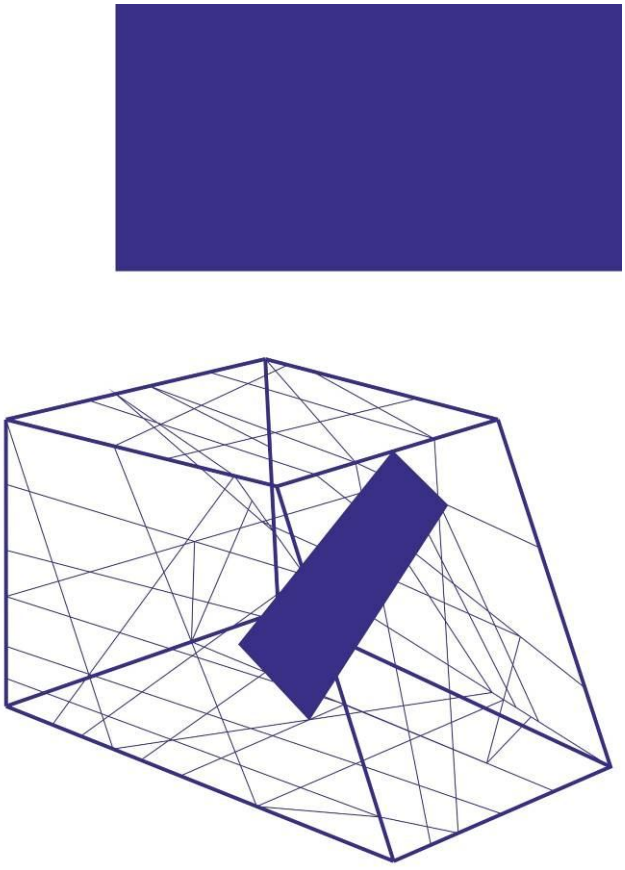

Figure 8. Rock blocks identification in three dimensional spaces

The main objective of the presented paper is to detect the discontinuity network and generate the rock block geometrical emplacement on rock slopes based on the digital images processing techniques as key factor in rock slopes stability assessments. To this end, it has been pointed out that artificial intelligence-based techniques and image processing are applied successfully. According to the results of the simulations, the algorithm is able to generate simplified dataset for preparing the 3D view of the rock slope geometrical conditions.

5. Conclusion

The structural rock slops stability is one of the impotent concepts in the geo-engineering which is controlled by rock mass geometrical properties. In rock mechanics the geo-mechanical investigation of rock geometry is divided into several experimental, computational, remote-sensing and geophysical procedures. In the meantime, computational and computer-based approache like digital image processing and machine vision are quickly and significantly grow and possessed many attention of experts and professionals. In this study used the image processing techniques for investigate the rock slope geometry and identified the discontinuity network emplacement in rock slopes. To this end, the three step digital image processing contained pre-processing, main processing and post-processing stages are used for identification and extraction of joints characteristics. The MATLAB software is used for applying the procedure and

preparing the database of joint sets in rock mass. For this purpose, an input image is taken from the slope surface and used for feature extraction. According to the results of the simulations, the algorithm is able to generate simplified dataset for preparing the 3D view of the rock slope geometrical conditions.

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