Abstract

Digital image processing of rocks either for size distribution analysis, or for textural analysis, is an important aspect of modem rock mechanics. The knowledge gained in such approach can be made available on-line, thereby leading to rapid decision-making as needed, and also automation of many rock handling processes.

The study taken up examines the issues of fragment size distribution and texture analysis of rocks. Literature review is conducted in terms of capturing images, digitization, analytical techniques for fragmentation determination, evaluation of texture feature, correlation of the features with rock properties, and rock classification based on texture features.

Photographs taken from miniature rock piles created with known size distribution are used in the prediction of fragmentation distribution. Various pre-processing adjustments are studied to determine their impact on image quality. Select images are digitized using CCD cameras and edge tracing is performed based on conventional (Sobel) method, mathematical morphological technique and a new a-priori knowledge based method. In the new method, the edge tracing is conducted interactively with the operator's intervention, using certain features of the individual fragments, like the area, length, orientation etc.

The predicted size distribution when compared with actual size distribution revealed that maximum apparent length is a good indicator to simulated size distribution. It is also noticed that out of the three methods, the results based on the a-priori knowledge technique are much closer to the actual values.

Texture analysis has been conducted on six rock types using SEM and thin-section images. SEM images numbering 72 have been captured from the 3-D relief surfaces of fractured rock cores.

About 150 thin-section images were prepared from rock cores at varying orientations. Gray-level digital images from the thin-sections were analysed for all rocks. Additionally, colour images were analysed for sandstone.

The fractal features of SEM images are analysed based on fractal dimensions using three magnifications (100x, 900x and 1760x). Consistency of results is better at 900x. Quartz has lowest FD value (2.0 - 2.1), and limestone grade II has highest FD value (2.5 - 2.6). Intra rock consistency is better with prism method, whereas better distribution for FD value is obtained in differential box counting method. FD values exhibited good correlation with cohesion, friction angle, and punch shear of rocks.

Texture analysis on thin-section images is conducted based on the features of geometric texture index, gray level co-occurrence matrices, run length, texture spectrum, and a new method based on quadratic orthogonal polynomial framework.

Analysis relating to orientation of thin-section images, or the colour of the image has not led to any significant conclusions. The ability of the texture features to classify rock (core-wise intra-rock classification for sandstone, and inter-rock classification among all rocks) is investigated using linear and quadratic discriminant analyses. Overall classification accuracy of a good number of texture features based on piece-wise linear discriminant function is quite high with 12 feature values giving classification accuracy in excess of 80%. The new texture feature of "average weighted mean" based on quadratic orthogonal polynomials gave the best classification accuracy (93%). The most effective features have been AWM of QP, GTI, run percentage and degree of direction of TS.

The correlation of texture features with rock properties is quite good. As many as 13 correlations are observed with coefficient of determination above 0.9.

The applicability of neural networks for rock classification is investigated. From the thin-section images, 120 images of size 100 x 100 pixels are selected to train the networks and an equal number of images are used for testing the classification. The two algorithms examined are radial basis function networks and back propagation ensembles network. The latter is a modified version incorporating a GA based optimization technique. Rock property prediction using the neural networks gave errors in the range of 5 - 10%, with RBFN appearing to be marginally better than BPN.

Two new texture feature schemes investigated as a part of the study include geostatistical transforms and anisotropic wavelet transforms. The semivariogram and square root pair difference measures of geostatistical transforms are examined as texture feature, whereas the AWT coefficient is examined in the latter category. The results suggested that minute texture details can be successfully captured with AWT coefficient, and texture quantification in terms of both scale and direction can be successfully accomplished with the proposed texture schemes.