# Rock Image Segmentation

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## Abstract

A hybrid approach to rock image segmentation based on thresholding and rock structure knowledge has been developed. This technique furnishes a new rock digital photoanalysis tool for obtaining statistical data of rock fragmentation size effectively. In the proposed approach, a rock image is processed in two major phases. In the first phase, it is presegmented by means of a thresholding method, in which the rock blocks are extracted and the image is transferred into binary one with missed weak boundaries. In the second phase, the missed boundaries are reconstructed approximately based on a set of assumptions on rock structure and the mode matching techniques. The algorithms have been implemented and tested using a set of real rock images. They yield encouraging results.

**KEYWORDS:** Hybrid Approach, Thresholding, Presegmentation, Structure knowledge, Vertex Modes, Boundary Reconstruction.

## 1 Introduction

In rock engineering, in order to monitor blasting quality, optimize blast design, and reduce costs and environmental impact, it is important to efficiently measure the size distribution of fragmentation produced by blasting. For years rock engineers have tried to deal with the challenge. Among them are Franklin and Maerz [1], whose "digital photoanalysis" approach which combines image processing and photoanalysis provides a promising technique for measuring the size distribution of rock fragments.

In digital photoanalysis, image segmentation plays an important role because it is at this stage that the individual rock blocks are extracted from an image for subsequent analysis and calculations. During the last two decades, many image segmentation techniques have been developed. They are generally based on one of the two basic properties of gray-level values: *discontinuity* and *similarity*. These belonging to the first category are based on edge detection while those in the second category are based on thresholding and region-oriented methods [2].

For high contrast and noise free pictures, edge segments can be detected using gradient operators. They are then joined to form close boundaries using an edge-linking algorithm. However, this process usually fails when applied to noisy images with fuzzy boundaries or to images containing texture regions. The major difficulties are nonuniformity in the brightness level of objects (high frequency noise) and the loss of contrast (low frequency noise). Though a number of more sophisticated edge techniques have been proposed, they are not effective enough to handle the segmentation problems of complicated pictures. Thus early efforts to segment rock images by edge detection have not been encouraging [3].

Thresholding is a simple and direct method for extracting objects [4]. This approach is based on the assumption that different classes of segments of an image are represented by distinct "modes" in the distribution of suitably chosen features extracted from the image. The technique fails if this assumption were not true. Compared to the edge detection techniques thresholding techniques are less affected by noise. They usually give close boundaries.

The region-oriented approaches include region growing and split-merge methods [5, 6]. The main advantages of these methods are that at any step in the algorithm, it is always possible to obtain closed regions and noise can be effectively suppressed. However, it is not always possible to find a suitable region predicate to complexed images (like the rock images). Basically, all of these region extraction techniques use local information heavily, and are usually computation and memory intensive.

Because of rock images' complexity, i.e. noise, fuzzy boundaries and irregular texture, no single conventional segmentation method is considered adequate. Rock images are currently segmented by manually tracing the edges of rock blocks in an image, which is indeed a slow and tedious procedure.

This paper proposes a hybrid rock image segmentation approach based on thresholding and rock structure knowledge. With this method, a rock image, at first, has a pre-segmentation in which the rock blocks are extracted roughly by using thresholding (Section 2). In this stage, a rock image is transferred into binary one with missed weak boundaries. In the second phase (Section 3), the missed