International Journal of Mining Science and Technology 24 (2014) 191–194

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

Development of 2D computer program to determine geometry of rock mass blocks

Yarahmadi Reza [a,*], Bagherpour Raheb [a], Kakaie Reza [b], Mirzaie N. Hossein [b], Yari Mojtaba [a]

[a] Department of Mining Engineering, Isfahan University of Technology, Isfahan, Iran
[b] Faculty of Mining Engineering, Geophysics and Petroleum, Shahrood University of Technology, Shahrood, Iran

ARTICLE INFO

Article history:
Received 28 July 2013
Received in revised form 18 August 2013
Accepted 20 September 2013
Available online 12 February 2014

Keywords:
Block detection
Computer programming
Rock mass
Algorithm

ABSTRACT

Due to various geological processes such as tectonic activities fractures might be created in rock mass body which causes creation of blocks with different shapes and sizes in the rock body. Exact understanding of these blocks geometry is an essential issue concerned in different domains of rock engineering such as support system of underground spaces built in jointed rock masses, design of blasting pattern, optimization of fragmentation, determination of cube blocks in quarry mines, blocks stability, etc. The aim of this paper is to develop a computer program to determine geometry of rock mass blocks in two dimensional spaces. In this article, the geometry of jointed rock mass is programmed in MATLAB™.

1. Introduction

There are two general approaches for determination of blocks geometry in rock mass but in two and three dimensional spaces. In the first approach, length and direction of discontinuities are assumed to be infinite and parallel respectively. In the methods that are based on this approach, geometry of rock blocks is determined by geometrical parameter of rock mass such as joint spacing, RQD and so on.

In the second approach length of discontinuities is assumed finite and their directions assumed in the real direction. Many researchers have developed different algorithms for characterization of blocks in rock body; Table 1 summarizes the researchers conducted by different people on this issue.

Sharma et al. presented equations to determine rock mass blocks volume in his book. Based on geometrical parameters of rock mass, Warburton developed an algorithm and computer program to determine rock mass blocks geometry [1,2,22]. In this algorithm joints are supposed to be parallel and infinite. Lu and Latham, Starzec and Tsang and Smith also studied block-ability upon geometrical parameters [11,13,14].

In second attitude discontinuities supposes is real and with limited length. In this method the main goal is determining blocks created by contact of posed lines and planes. For determining blocks in two and three dimension diverse algorithms have been presented. Ferreira et al. claim essential time and volume for data processing is an algorithm based on graphs theory [12]. According to this algorithm, first of all points of lines contact in two dimensions should be calculated and then a graph generates using these points and lines and creates several polygons as two dimensional blocks.

Heliot in 1988 presented an algorithm based on numerical methods in three dimensions for modeling discontinuities and specifying geometrical features of blocks [5]. In 1985 Goodman and Shi, offered an algorithm considering vector methods in two and three dimensions [3]. Shi (1988) has paid attention to detecting created blocks due to Curved and straight discontinuities contact in two dimensions [6]. SIMBLOCK software has been designed by Maerz and Germain (1996) for defining blocks in underground spaces [10]. Jing and Stephenson (1994–2007) have played a main role in development of these algorithms according to numerical methods in two and three dimensions [7–9]. In their last research mechanical properties and fluid flow in discontinuities has been supposed too. Presented algorithm by Lu et al. determines blocks using vector methods in three dimensions [15]. In this method planes are supposed limited and contact points of interface lines, planes are dealt as vectors and these vectors in next stage generate blocks. Ulker and Turanboy in 2009 implemented genetic algorithm to determine blocks in three dimensions based on the tree structure [17].

* Corresponding author. Tel.: +98 03113915118.
E-mail address: r.yarahmadi@mi.iut.ac.ir (R. Yarahmadi).

http://dx.doi.org/10.1016/j.ijmst.2014.01.008
2095-2686/

Table 1
Survey of researches in block detection.

Researcher	Date	Method basis	Dim
Warburton [1,2]	1983–1985	Geometrical parameter	2 and 3
Goodman et al. [3]	1985	Vector method	2 and 3
Line et al. [4]	1987	Topological techniques	3
Heliot [5]	1988	Numerical systems	3
Shi [6]	1988	Directed graphs	2
Jing et al. [7–9]	1994–2007	Numerical techniques	2 and 3
Maerz et al. [10]	1996	Geometrical parameter	3
Lu et al. [11]	1999	Geometrical parameter	2 and 3
Ferreira et al. [12]	2000	Graph theory	2
Starzec et al. [13]	2002	Geometrical parameter	2 and 3
Smith [14]	2004	Geometrical parameter	2 and 3
Lu et al. [15]	2002	Vector methods	3
Palmström [16]	2005	Geometrical parameter	2 and 3
Ulker et al. [17]	2009	Genetic algorithm	3
Zhang et al. [18]	2010	Finite element modeling	3
Jafari et al. [19]	2011	Square matrices	3
Khishvand et al. [20]	2011	Square matrices	2
Zhang et al. [21]	2012	Mesh gridding technique	3

Jafari et al. offered a novel algorithm according to operation on basic matrix to detect three dimension blocks and Khishvand et al. developed this algorithm for two dimensions problems [19].

As shown in Table 1, other researches were developed algorithms based on second approach to characterize blocks geometry in rock mass. As presented, all algorithms are in two classes in both two and three dimensions. Being unspecified features of discontinuities like length, shape and direction and three dimensions modeling of rock mass uncertainty, it has been preferred to use two dimension analysis. As mentioned, two dimension models presented up to now have these disadvantages:

- These algorithms are very complicated in terms of understanding and implementing the model.
- These algorithms have enormous calculation volume.

In this research an algorithm based on modification of Khishvand algorithm has been designed that solves the mentioned problems.

2. Selection of suitable algorithm

To characterize blocks in 2D, basic polygons from a set of arbitrary line segments should be identified. Different algorithms are presented for block detection in 2D, four algorithms to solve this problem will be compared in this paper, and these algorithms will be introduced and discussed as follows:

2.1. Ferreira's algorithm

This algorithm is based on graph theory and has four main steps to detect polygon from set of lines.

(1) Find line segment intersections;
(2) Create a graph induced by the drawing;
(3) Find the minimum cycle basis (MCB) of the graph induced in previous step;
(4) Construct a set of polygons based on cycles in the previously found MCB.

Because this algorithm combines several algorithms to detect basic polygons from a set of arbitrary line segments, understanding of this approach is complex and it is difficult to develop computer program by this algorithm.

2.2. Jing's and Stephansson's algorithm

This algorithm is based on numerical techniques and the technique presented in this approach uses combinatorial topology theory and 2D boundary operators, together with the extended Euler-Poincare formula for polyhedral. Block detected in five steps in this method as follows:

(1) Fracture intersection and edge set formation;
(2) Edge regularization;
(3) Boundary operators of 2D complexes;
(4) Block tracing in 2D;
(5) Representation of flow path and mechanical contacts of blocks.

In this method flow path and mechanical contacts of blocks are also investigated. The boundary operators made this algorithm complex and it is not easy to develop computer program through this algorithm.

2.3. Shi's algorithm

The principle and algorithms for block system construction are presented by Shi (1988). Block detection in his algorithm is done in five steps:

(1) Determination of intersection points.
(2) Connectivity between intersection points.
(3) Tree cutting.
(4) Tracing all blocks.
(5) Tracing real blocks.

Firstly in this algorithm, all possible blocks are distinguished and then real blocks or minimum polygons are separated from other blocks. Shi's algorithm also introduces concepts of "Edge Direction" and "Loop Direction" for block tracing. This concept leads to consideration of each edge twice, in positive and negative direction, while tracing the blocks. Shi (1988) has mentioned that curved and straight lines can both be considered; however, no detail example is presented.

2.4. Khishvand's algorithm

Khishvand developed a new method for block detection which is based on the concept of using matrices to increase speed and accuracy of calculations. Edges and vertices with no potential of block formation are eliminated in the algorithm. Therefore matrix dimensions are considerably reduced which in turn results in faster calculations. This algorithm is progressive in five steps:

(1) Define geometry of model.
(2) Fracture intersection and edge tracing.
(3) Edge regularization.
(4) Formation necessary matrices.
(5) Block tracing.

Amongst the stated algorithms for 2D block detection and delineation, in this research Khishvand's algorithm has been developed and modified for block detection considering the following reasons:

- Less computing time for data processing.
- simplicity of realization and implementation.