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Postprint: Application of Improved Region Growing Algorithm for Rock Mass Discontinuity Identification

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Abstract

Natural rock mass discontinuities possess unique mechanical properties that can define weak zones within rock masses, playing a decisive role in the structure, strength, and stability of various rock engineering projects such as tunnel support, surrounding rock classification, and slope reinforcement. Therefore, the identification of individual discontinuity planes and well-developed dominant sets is of paramount importance. This method divides the automatic identification of dominant discontinuity sets into three components: 1. normal vector calculation based on a robust randomized Hough transform; 2. an improved region growing algorithm proposed to segment individual discontinuity planes, which incorporates curvature, planarity, and roughness in seed point selection and region growing criteria while adding dynamic outlier detection. Furthermore, the relationship between thresholds and discontinuity quantity is utilized to qualitatively assess extreme segmentation cases and simultaneously screen for optimal threshold ranges; 3. finally, an S-K-means clustering algorithm is proposed to achieve dominant set clustering. The algorithm' s identification accuracy was validated using a rock slope, with results demonstrating that dip direction and dip angle errors ranged between 0.7° and 2.5°, with mean errors of 1.8° and 1.7°, respectively. This method transforms the conventional approach of directly clustering point clouds to identify dominant sets into first segmenting individual discontinuities before clustering, thereby refining the procedure for dominant discontinuity set identification, enhancing computational speed and robustness of discontinuity clustering, and being applicable to various discontinuity data, thus providing a more accurate and efficient approach for intelligent identification of rock mass discontinuities.

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Full Text

Application of Improved Regional Growth Algorithm to Identification of Rock Mass Discontinuities

基于改进区域生长算法对岩体结构面识别

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Abstract

Natural rock mass discontinuities possess unique mechanical properties that define weak zones within rock masses, playing a decisive role in the structure, strength, and stability of various rock engineering projects such as tunnel support, surrounding rock classification, and slope reinforcement. Therefore, identifying individual discontinuity planes and well-developed dominant sets is crucial.

This method divides the automatic identification of dominant discontinuity sets into three steps: point cloud normal vector calculation, individual discontinuity plane segmentation, and dominant set clustering. First, normal vectors are calculated using a robust random Hough transform method. Second, an improved region growing algorithm segments individual discontinuity planes, incorporating curvature, planarity, and roughness in seed point selection and region growing criteria, along with dynamic outlier detection. Additionally, the relationship between thresholds and discontinuity plane count is used to qualitatively identify extreme segmentation cases and screen for optimal threshold ranges. Third, an S-K-means clustering algorithm achieves dominant set clustering.

The algorithm' s accuracy was validated using a rock slope case study, with results showing dip direction and dip angle errors ranging from 0.7° to 2.5°, and mean errors of 1.8° and 1.7°, respectively. This approach transforms the conventional method of directly clustering dominant sets from point clouds by first segmenting individual discontinuity planes before clustering, refining the identification process, improving computational speed and robustness of discontinuity set clustering, and demonstrating applicability to various discontinuity data types, thereby providing a more accurate and efficient method for intelligent identification of rock mass discontinuities.

Keywords: Individual discontinuity plane; Dominant discontinuity set; Improved region growing algorithm; S-K-means clustering; Intelligent identification

Note: Figure translations are in progress. See original paper for figures.

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