Rock slope discontinuity extraction and stability analysis from LiDAR point clouds

case study of an urban rock slope

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State of the art

- Classical approach: fieldwork and compass. Decisions including conscious and sub-conscious opinions based on experience.

- Split-FX (Slob et al 2005). Maps discrete fractures from 2.5D data (TIN).

- COLTOP 3D (Jaboyedoff et al 2007). Calculates the normal vector for each point and assigns a unique color per orientation and inclination.

- DiAna (Gigli and Casagli 2011). Searches voxels of space and determines local planarity.

- Planedetect (Lato and Vögue 2012).
The Method

A new approach for semi-automatic rock mass joints recognition from 3D point clouds, Riquelme et al (under review)

Objectives

Using the 3D point cloud obtained with LiDAR, the aim is to find the discontinuity orientations and how are clustered in the space. The method uses the real 3D information of the point cloud.
The GUI

1. Load data
   - Create artefact
   - Load puntos.txt
     - Load
     - hexahedron
     - Scatter3D

2. Setup planes
   - knn 30
   - tolerance 0.2

3. Statistical analysis
   - N° bins hist: 64
   - Angle min v ppol: 20
   - Max number ppol: 4

4. Ppol poles assignment

Discontinuity Locator Software (DLS) v_beta_01. Adrián Riquelme, edriquelme@gmail.com

Status: Waiting orders...

Poles Density Plot

Panel

Poles Density Plot, Principal Poles. Isolines each 1.25%

Riquelme, Abellán, Tomás and Jaboyedoff
Vertical Geology 2014, Lausanne (Switzerland)
The Method

Part A  Local curvature calculation

1. Nearest Neighbour Searching (*knnsearch*)
2. Coplanarity test (*PCA*)
3. Plane adjustment and calculation of the normal vector

Part B  Statistic analysis of the plane poles

1. Density estimation (*KDE*)
2. Semi automatic discontinuity set identification

Part C  Cluster analysis

1. Clustering (*DBSCAN*)
2. Plane generation (*PCA*)
3. Error fitting check (tolerance)
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Part A: Local curvature calculation

- Search the knn nearest neighbours around each point.
- Calculate the coplanarity of the set.
- If OK, calculate the normal vector of the set.

**Figure:** Subsets and normal vector orientation
Part B: Local Statistic analysis

- Plot each normal vector in a stereoplot
- Calculate the poles’ density using *KDE*
- Locate the relative maximums using certain conditions

**Figure:** Statistic analysis of the poles

Riquelme, Abellán, Tomás and Jaboyedoff Vertical Geology 2014, Lausanne (Switzerland)
Part B: Local Statistic analysis

Figure: Principal orientation assignment
Part C: Cluster analysis

Figure: Clustering of an icosahedron
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Site Description

Figure: Photo of the site in San Blas, Alicante, SPAIN
Site Description

Figure: Point cloud alignment
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Analysis parameters

\(k_{nn}\) Number of neighbours: 30
\(\eta_{max}\) Maximum deviation: 20
\(\gamma_1\) Minimum angle between discontinuities: 30
\(\gamma_2\) Maximum angle between assigned pole to a discontinuity: 20
\(ppc\) Minimum number of points per cluster: 500
Data Analysis. Large dataset analysis

Figure: Poles’ density 3D of a large dataset

Figure: Poles’ density of a large dataset
Data Analysis. Reduced dataset analysis

Figure: Poles’ density 3D of the reduced dataset

Figure: Poles’ density of reduced dataset
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Figure: discontinuity sets
Results

Figure: Clustering results
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Conclusions

- Discontinuity sets were identified using the 3D point cloud
- TIN was not used to find the orientations
- Separate analysis areas in order to avoid density interferences
- Each cluster is identified with its equation
- Further researches?
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