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. Decissions including concious 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

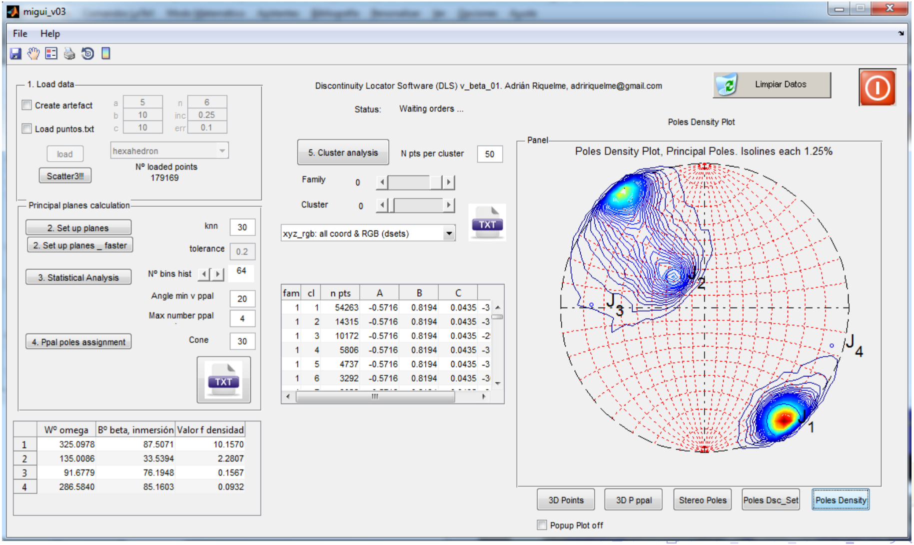
The Method

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


migui_v03
File Help
1. Load data
Create artefact
Load puntos.txt
a 5 b 10 c 10
n 6 inc 0.25 err 0.1
load
hexahedron
Scatter3!!!
Nº loaded points
179169
Principal planes calculation
2. Set up planes
2. Set up planes _ faster
knn 30
tolerance 0.2
3. Statistical Analysis
Nº bins hist 64
Angle min v ppal 20
Max number ppal 4
4. Ppal poles assignment
Cone 30
TXT
Wº omega | Bº beta, inmersión | Valor f densidad
1 325.0978 87.5071 10.1570
2 135.0086 33.5394 2.2807
3 91.6779 76.1948 0.1567
4 286.5840 85.1603 0.0932
Discontinuity Locator Software (DLS) v_beta_01. Adrián Riquelme, adririquelme@gmail.com
Limpiar Datos
Status: Waiting orders ...
Poles Density Plot
5. Cluster analysis
N pts per cluster 50
Family 0
Cluster 0
xyz_rgb: all coord & RGB (dsets)
fam cl n pts A B C
1 1 54263 -0.5716 0.8194 0.0435 -3
1 2 14315 -0.5716 0.8194 0.0435 -3
1 3 10172 -0.5716 0.8194 0.0435 -2
1 4 5806 -0.5716 0.8194 0.0435 -3
1 5 4737 -0.5716 0.8194 0.0435 -3
1 6 3292 -0.5716 0.8194 0.0435 -3
Panel
Poles Density Plot, Principal Poles. Isolines each 1.25%
J1
J2
J3
J4
3D Points
3D P ppal
Stereo Poles
Poles Dsc_Set
Poles Density
Popup Plot off

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.

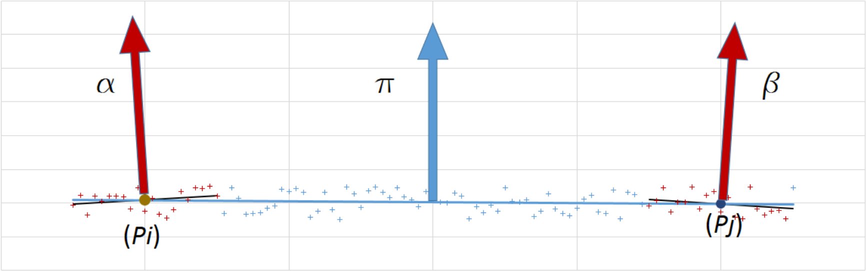

Figure: Subsets and normal vector orientation

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

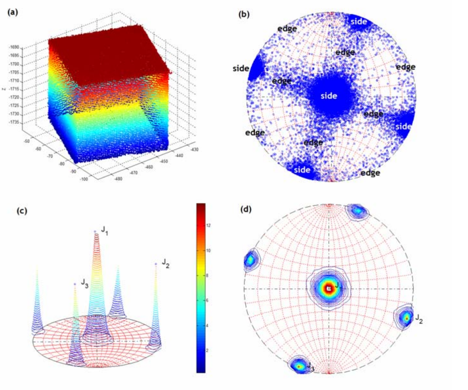

Figure: Statistic analysis of the poles

Part B: Local Statistic analysis

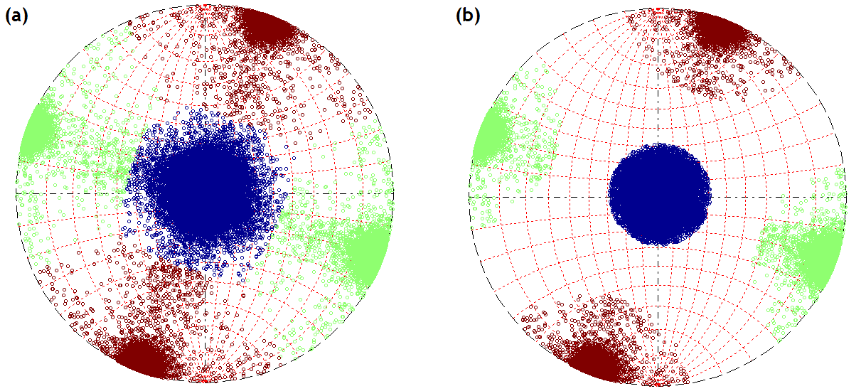

Figure: Principal orientation assignment

Part C: Cluster analysis

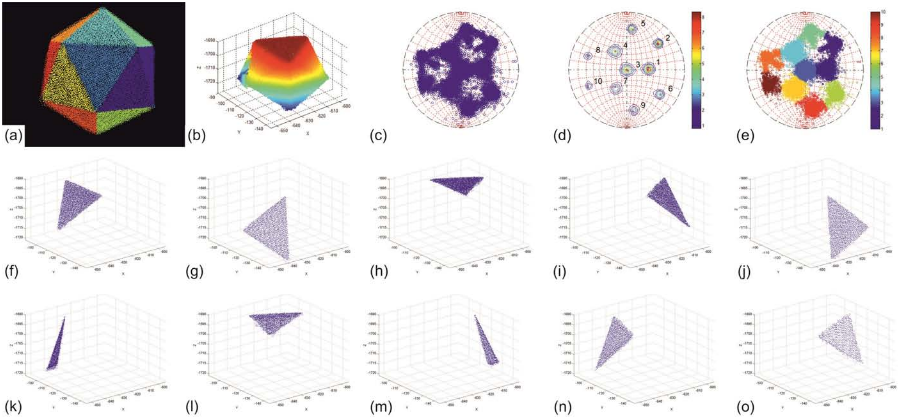

Figure: Clustering of an icosahedron

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Site Description

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

Site Description

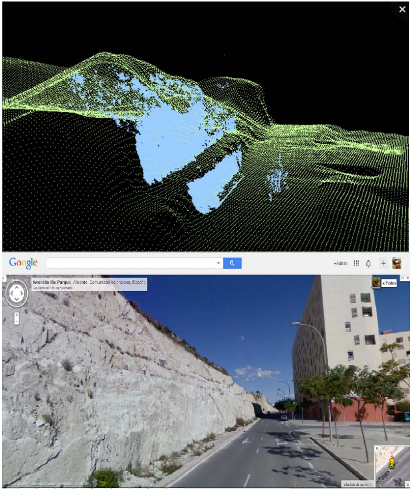

Figure: Point cloud alignement

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Analysis parameters

- knn: Number of neighbours: 30
- η_{max}: Maximum deviation: 20
- γ_1: Minimum angle between discontinuities: 30
- γ_2: Maximum angle between assigned pole to a discontinuity: 20
- ppc: Minimum number of points per cluster: 500

Data Analysis. Large dataset analysis

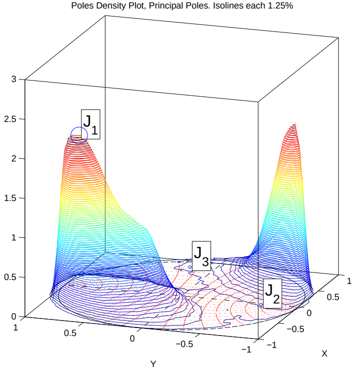

Figure: Poles' density 3D of a large dataset

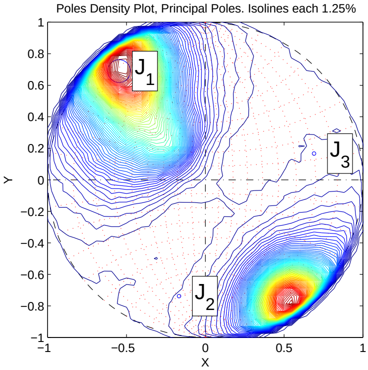

Figure: Poles' density of a large dataset

Data Analysis. Reduced dataset analysis

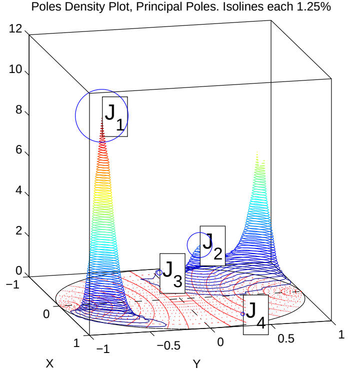

Figure: Poles' density 3D of the reduced dataset

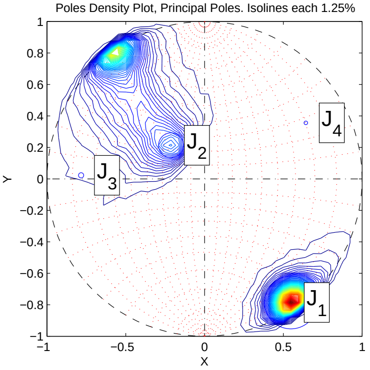

Figure: Poles' density of reduced dataset

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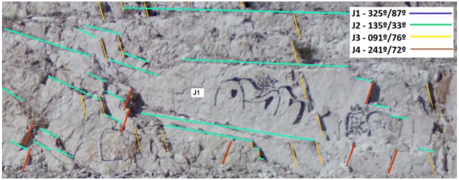
Results



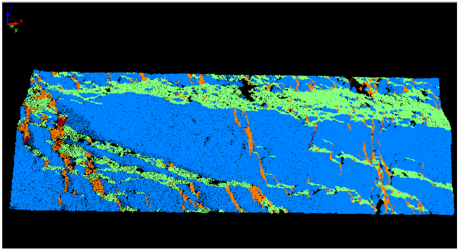


Figure: discontinuity sets

Results

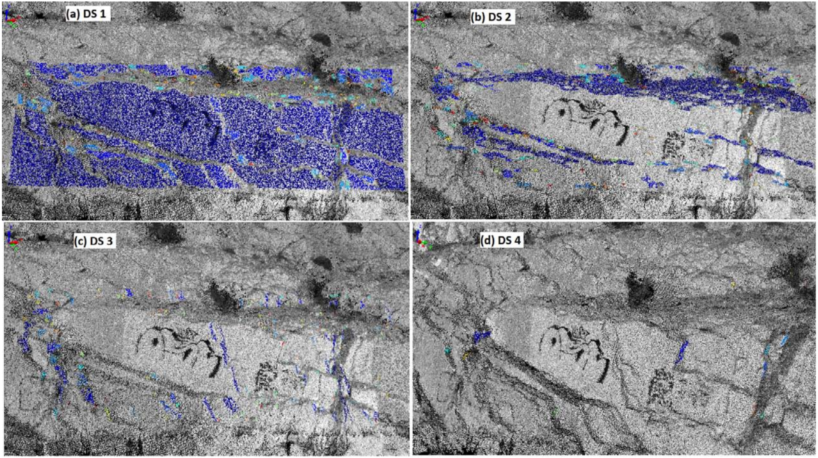


Figure: Clustering results

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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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