3D point cloud semantic segmentation

FOSS4G-be

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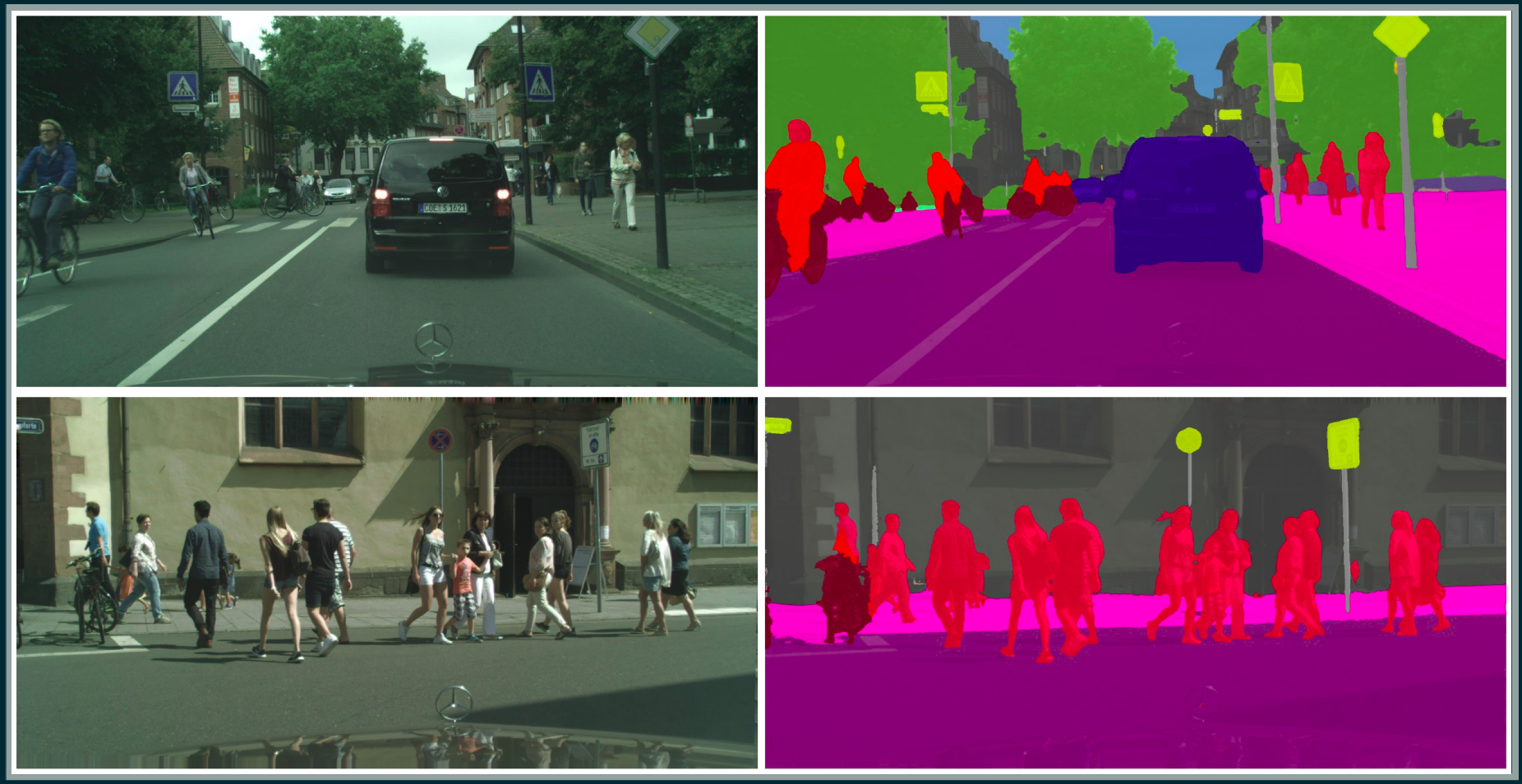
About us

- Damien Garaud, Raphaël Delhome
- Programmers & Data Scientists
- Oslandia: SIG, Data, 3D, simulation

  Open Source, Remote, Agile method, Open Data, Machine Learning, PostgreSQL, PostGIS, QGIS, Python, C++, JavaScript, OpenStreetMap, OpenLayers, ...

Semantic segmentation?

Automatically infer the class of objects in a scene



In 3D scenes, that's even harder

- One dimension further...
- Labelled dataset scarcity
- Indoor *vs* Outdoor, urban context *vs* natural context

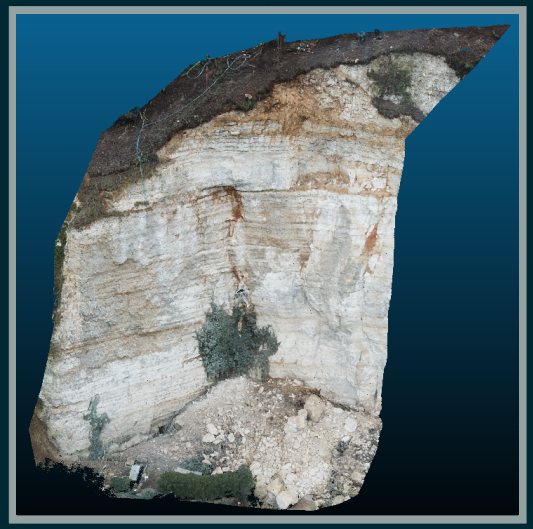
The project

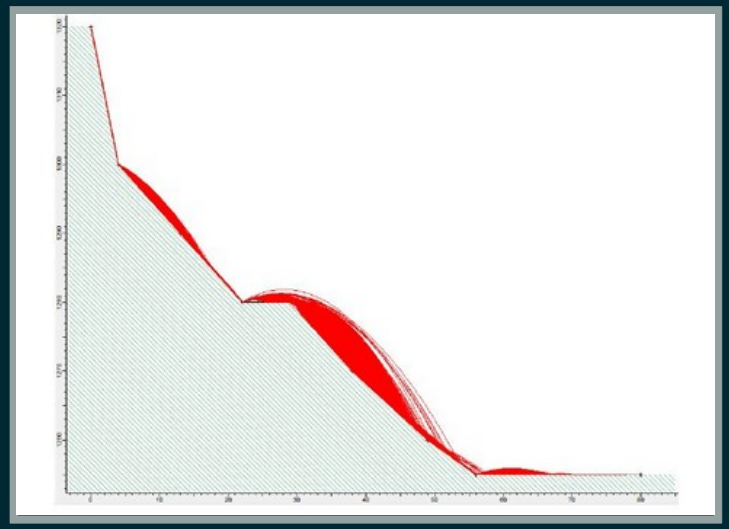
Project context

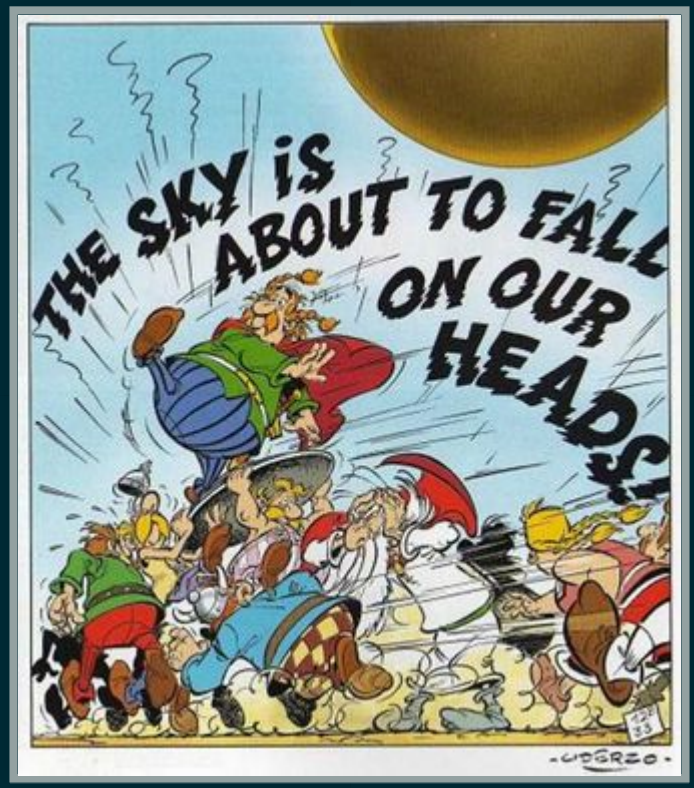
Public funding for a joint R&D project (2018)

Geolithe business

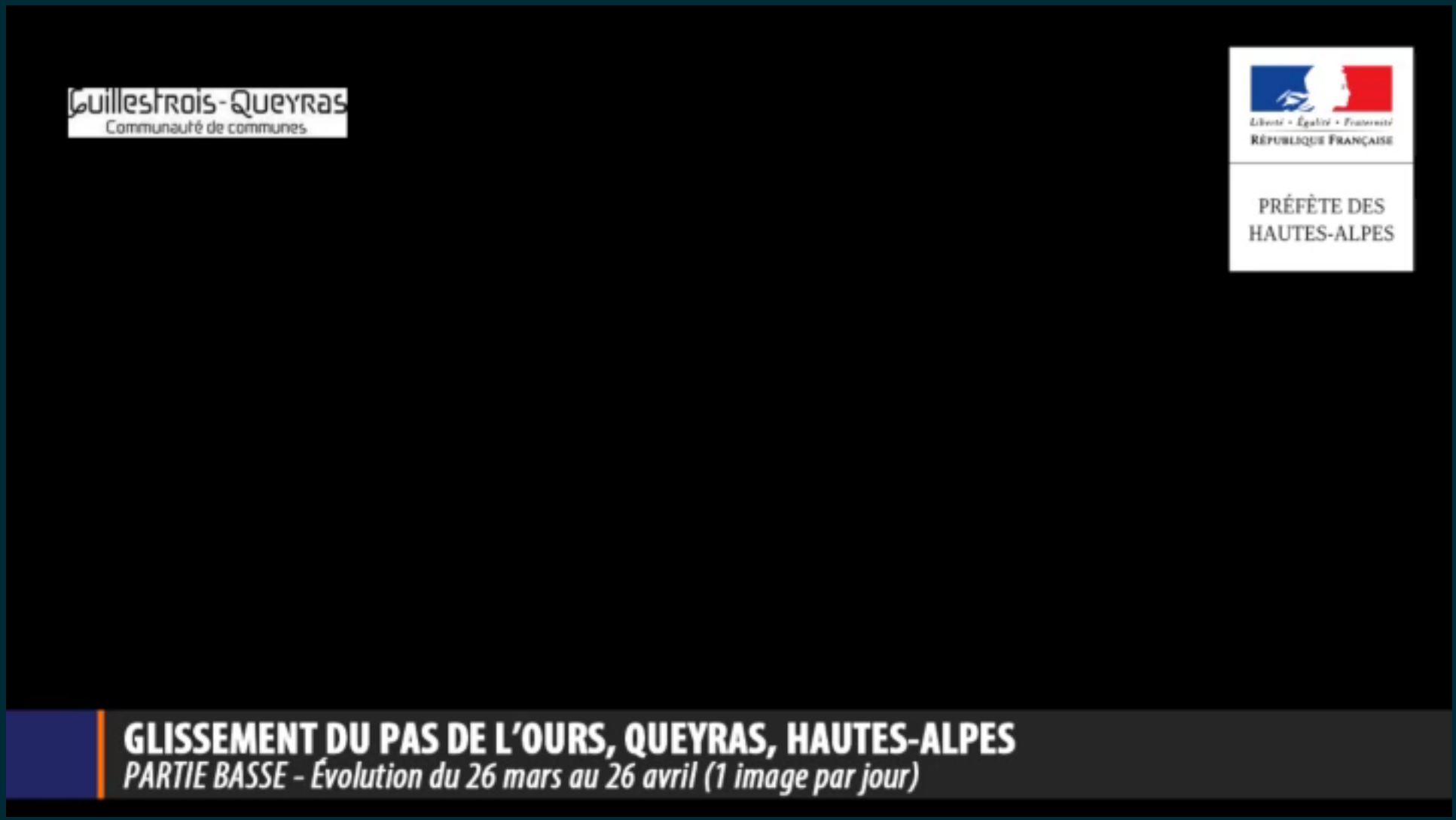
- Risk analysis in mountainous environments (crumbling, mudslides, ...)
- Field measurements: 2D (imagery), 3D (photogrammetry), trajectory studies






THE SKY IS
ABOUT TO FALL
ON OUR
HEADS!
-UDERZO-

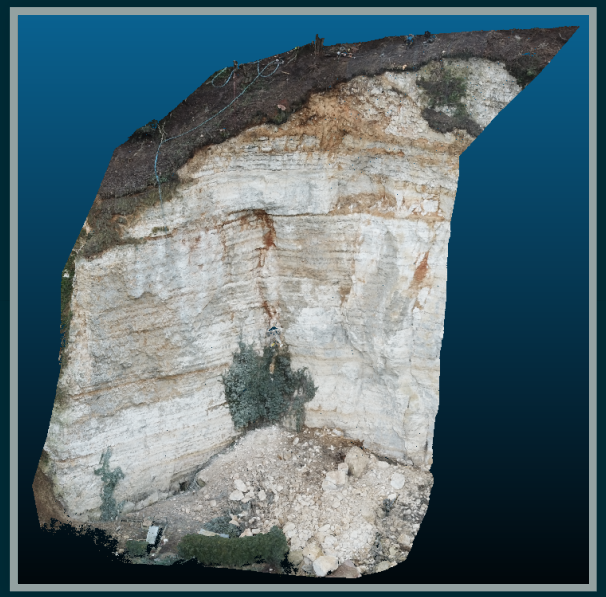
Pas de l'Ours (april 2018)



Problematic

Detect material nature to qualify the crumbling risk

- scree
- vegetation
- rock
- sand
- ...



Problem solving outline

1. How we **can't** do Deep Learning
2. 3D geometric feature extraction
3. Unsupervised learning
4. Towards (weak) supervision

At the project beginning...

Actually, no

O. "To run deep learning algorithms, we need plenty of labelled data."

G. "We have only a few (unlabelled) point clouds. Is that enough?"

O. "Well, not sure. You can label them?"

G. "How much does it cost?"

Doing with what we have

- point location: XYZ
- color information: RGB, reflectance, ...

(...and that's all!)

By being smart, we can extract more info

Consider local point neighborhoods (PCA! ... Maths!)

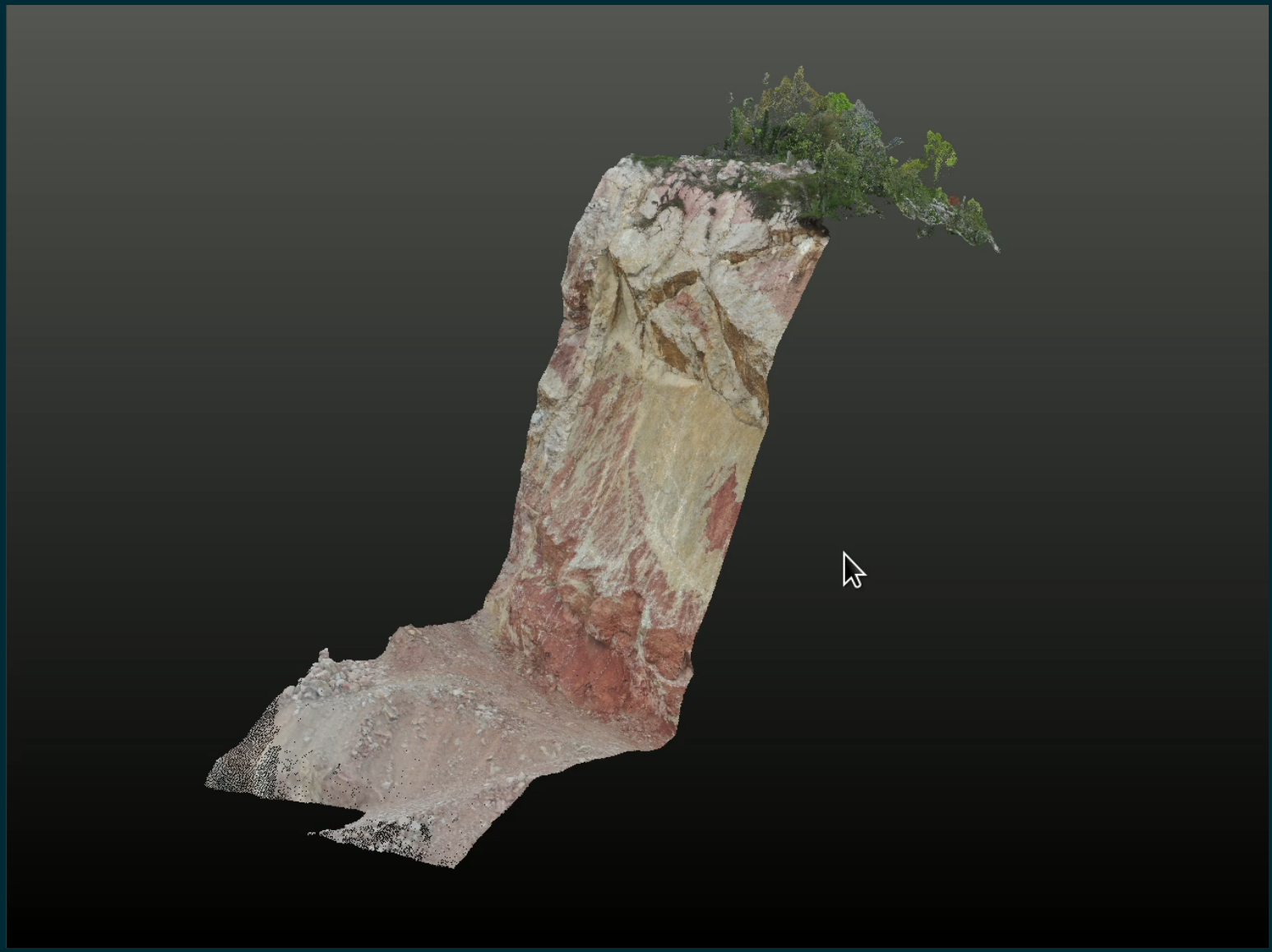
- infer local geometric structures
- 2D or 3D projections
- neighborhood sizes (10 neighbors? 100? 1000?)

https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.PCA.html

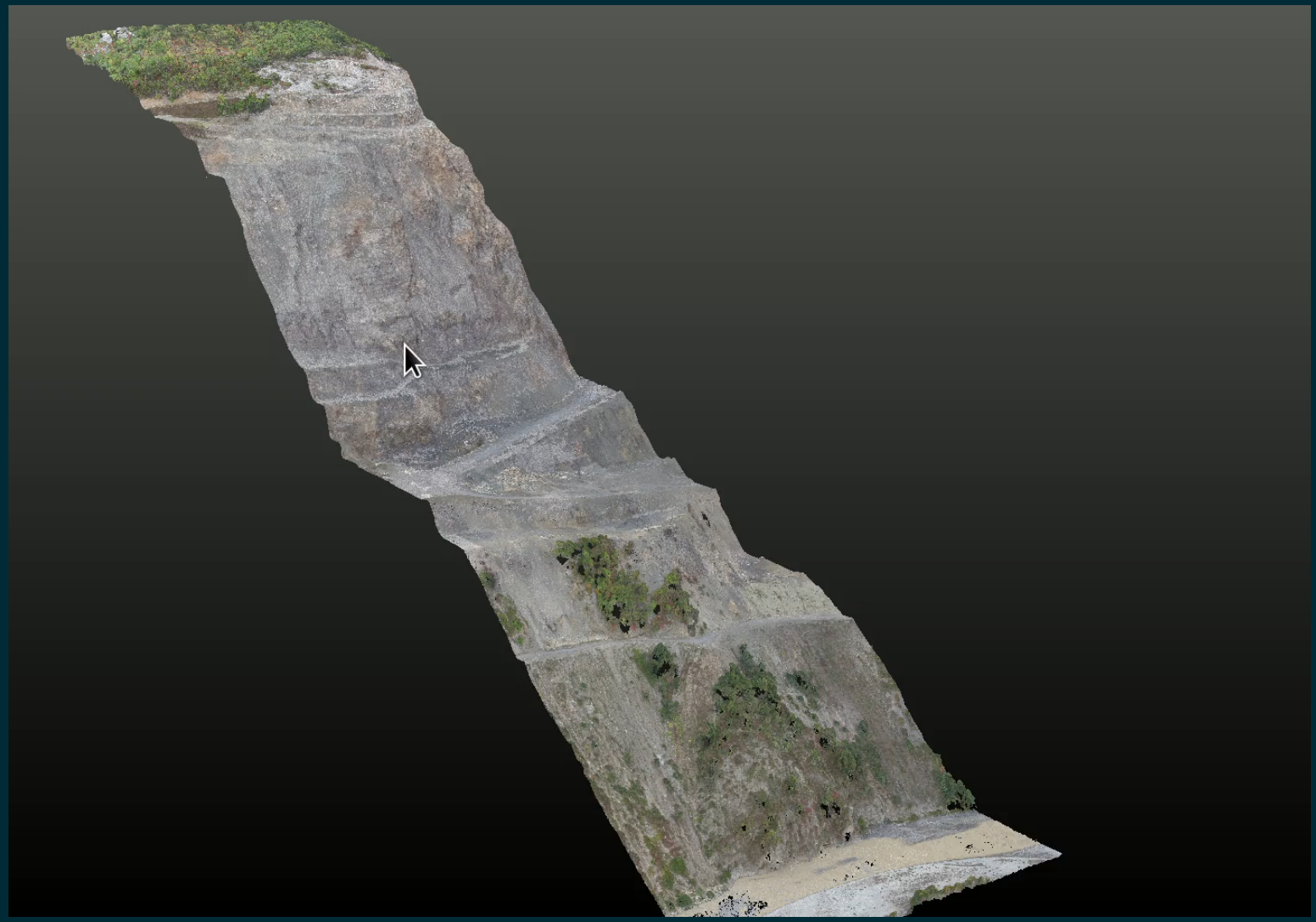
Unsupervised learning

Exploit all these features in k-means clustering: classify points with respect to their geometric properties

Yeah, it works! (almost)

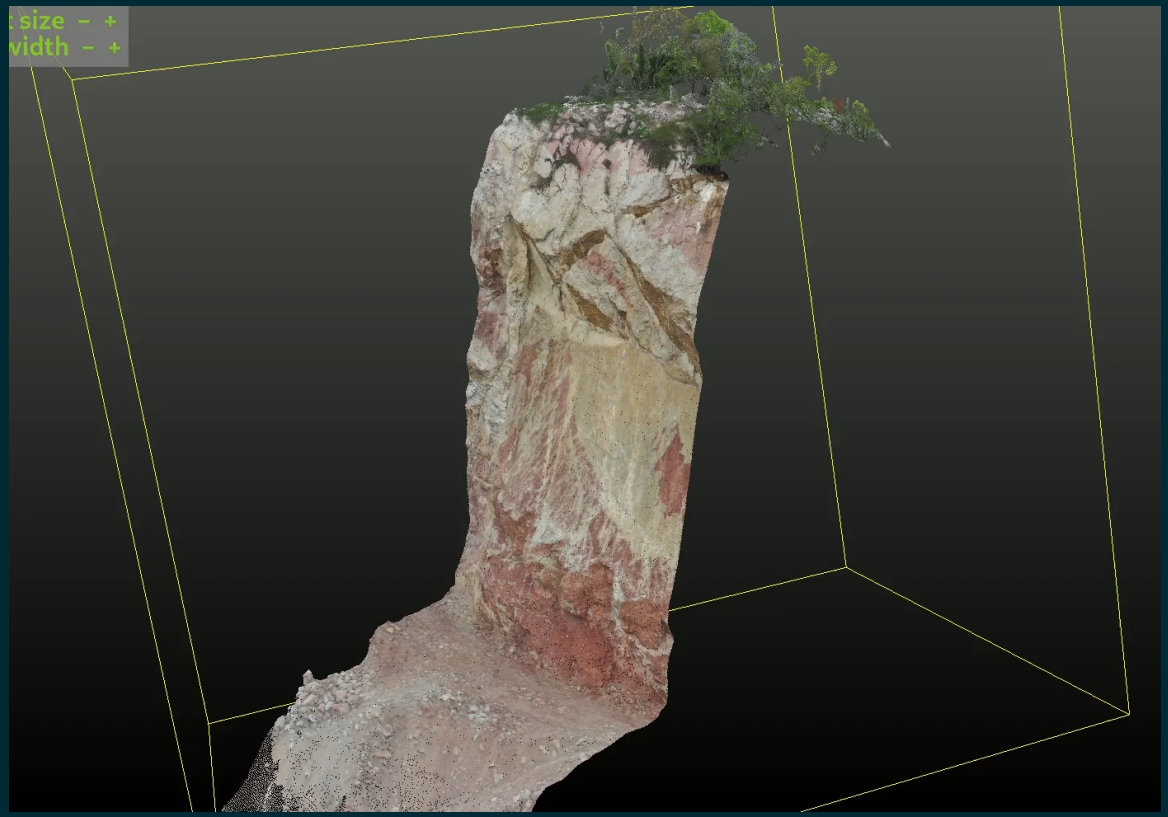


(**spoiler:** sometimes, it fails…)



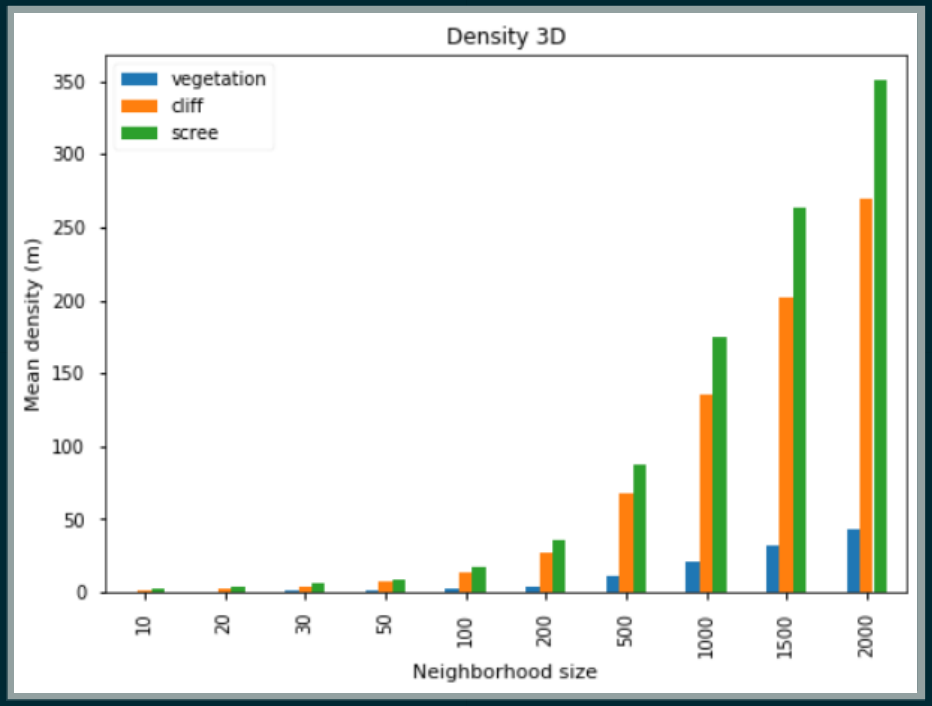
Extract local point cloud samples

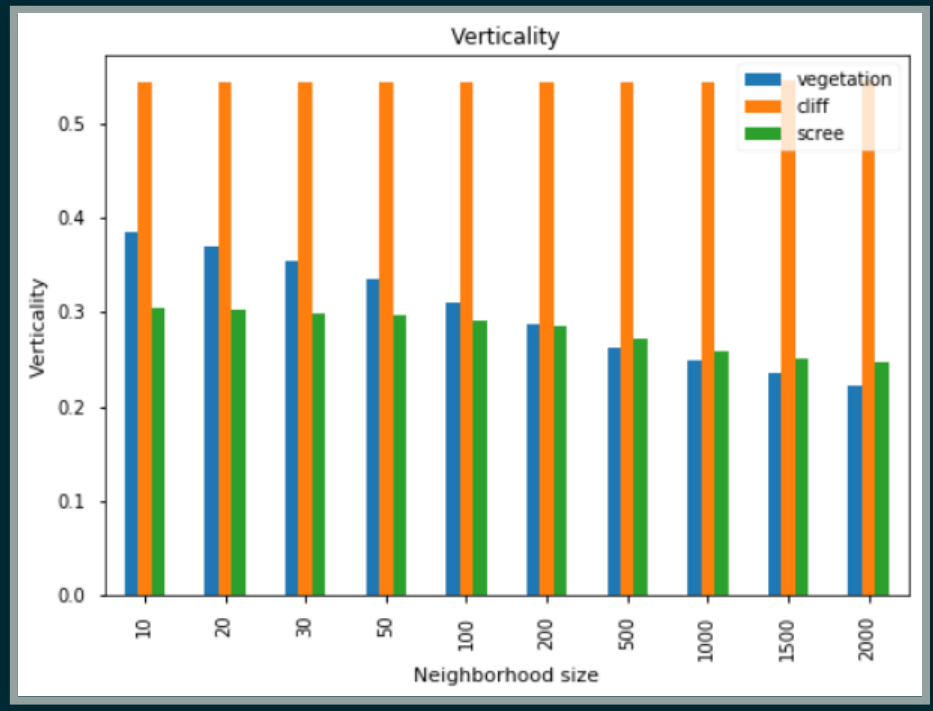
One can "cut" local samples of known class:



Geometric feature advanced study

- Elementary statistics on each features
- Feature ~ neighborhood size * label sample





Supervised learning

Logistic Regression!!

1. Consider a sample for each label
2. Extract the whole set of geometric features
3. Concatenate all the sample features
4. Here comes the labelled dataset (+50k points)

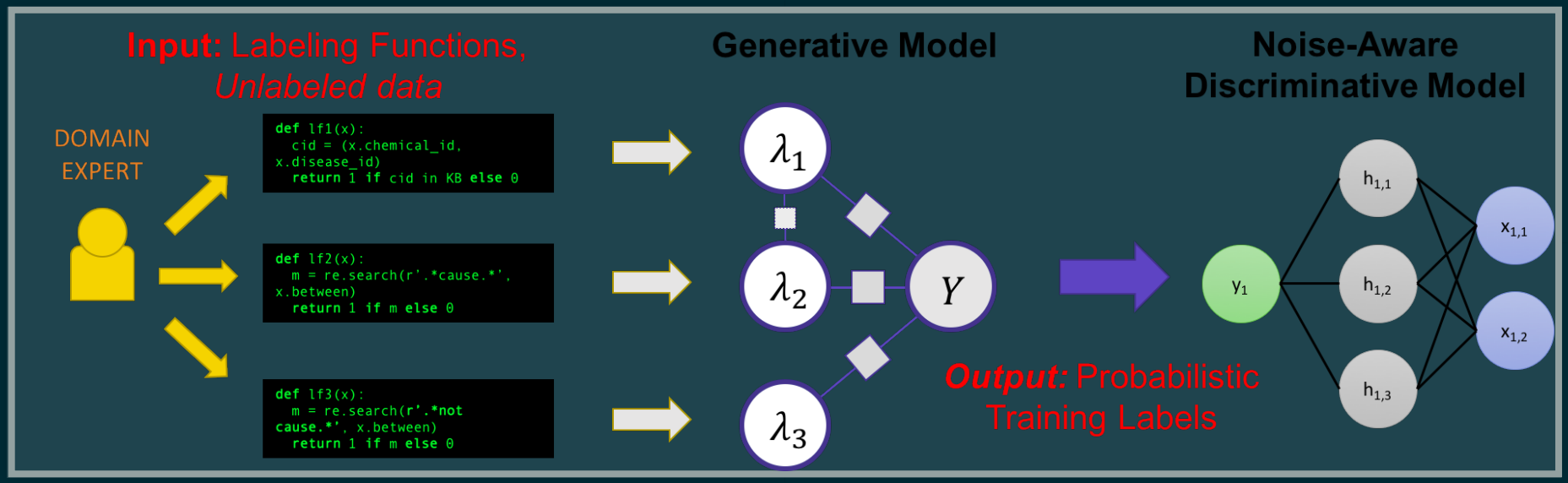
A few more results

- >99% accuracy even after cross-validation
- However, overfitting!
- Multi-colinearity
- Training data representativeness

What if we do not have any labels?

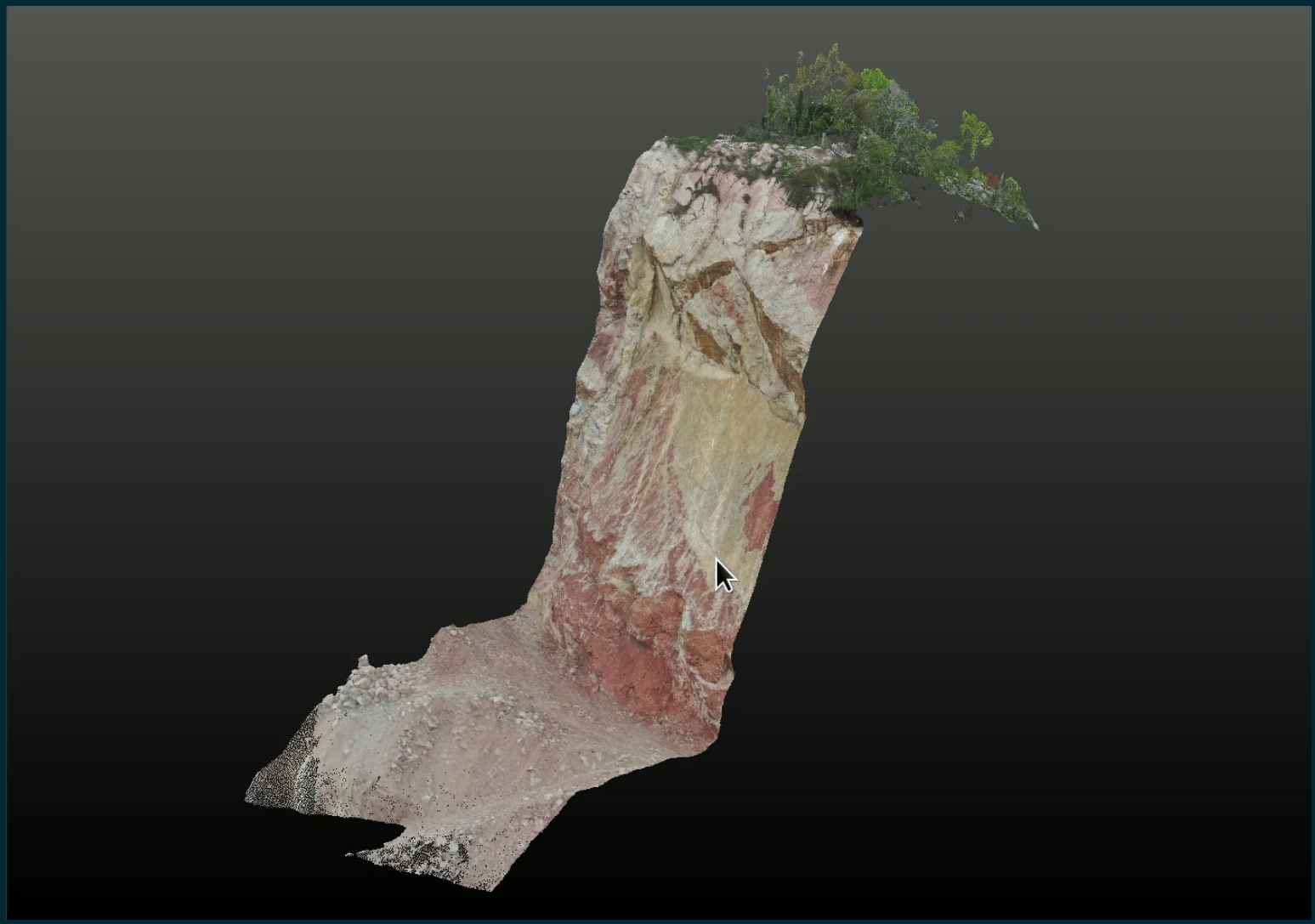
Weak Supervision!!

- Label the point cloud massively, automatically, by exploiting expert knowledge



- Snorkel: https://www.snorkel.org/ (Stanford)

A on-going work...



O. "Finally we did some deep learning stuffs... :)"

Conclusions

- We developed 3D skills, (re)discovered hard maths, and did a lot of parallel programming! :)
- A bunch of really promising results
- Test of a new exciting machine learning technique: *weak supervision*

Thanks for your attention!

Questions?

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See more on Oslandia's blog and on
github.com/Oslandia/geo3dfeatures (released soon)

References

- Nicolas Brodu, Dimitri Lague, 2011. 3D Terrestrial lidar data classification of complex natural scenes using a multi-scale dimensionality criterion: applications in geomorphology. arXiv:1107.0550.
- Martin Weinmann, Boris Jutzi, Stefan Hinz, Clément Mallet, 2015. Semantic point cloud interpretation based on optimal neighborhoods, relevant features and efficient classifiers. ISPRS Journal of Photogrammetry and Remote Sensing, vol 105, pp 286-304.