Click here to hide/show the code

A tour of point cloud processing

Mathieu Carette

Notebook available at https://github.com/rockestate/point-cloud-processing (https://github.com/rockestate/point-cloud-processing)

Slides available at https://www.rockestate.be/point-cloud-processing/presentation/ (https://www.rockestate.be/point-cloud-processing/presentation/)

(previous versions here (https://github.com/rockestate/point-cloud-processing/releases))

About me

- PhD in Mathematics (ULB, 2009)
- Postdocs (UIUC, UCLouvain, McGill)
- Data Scientist (KBC, Forespell)
- Now working on

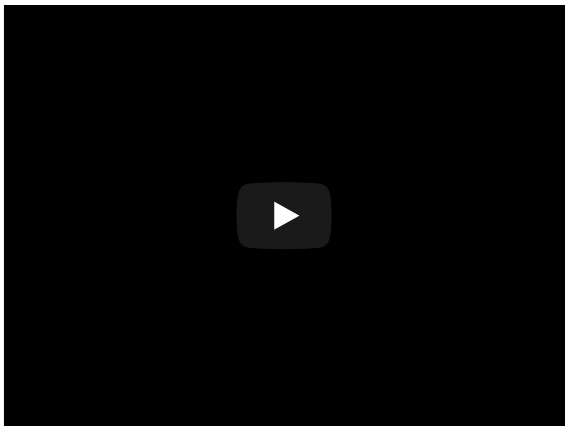
ROCKESTATE

(https://www.rockestate.be)

Favorite software stack:

Where do 3D point clouds come from?

Out[2]:



Open LiDAR data for Brussels and Flanders : https://remotesensing.agiv.be/opendata/lidar/ (https://remotesensing.agiv.be/opendata/lidar/)

File formats and software

- LAS (https://www.asprs.org/committee-general/laser-las-file-format-exchange-activities.html) standard file format
- LAZ (https://www.laszip.org/) compressed file format

- PCL (http://pointclouds.org/) **P**oint **C**loud **L**ibrary
  - Open source: https://github.com/PointCloudLibrary/pcl (https://github.com/PointCloudLibrary/pcl)
  - C++
  - Powerful general purpose algorithms

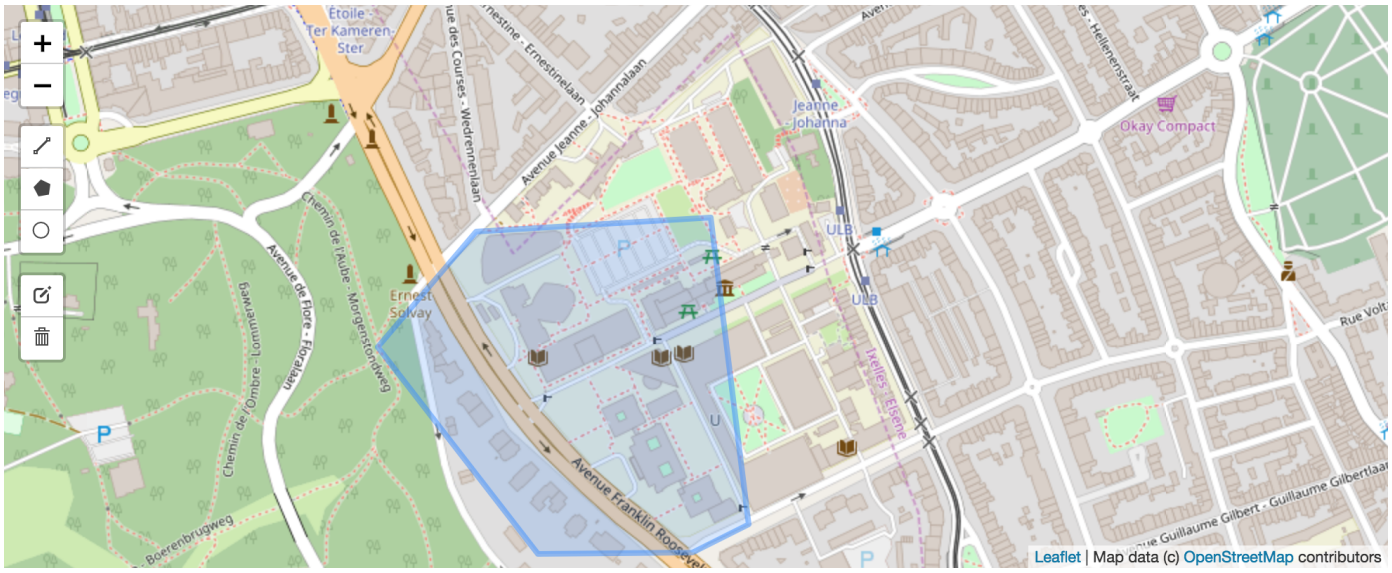
- CGAL (https://www.cgal.org/) **C**omputational **G**eometry **A**lgorithms **L**ibrary
  - Open source: https://github.com/CGAL/cgal (https://github.com/CGAL/cgal)
  - C++
  - State of the art 2D and 3D geometry algorithms

- PDAL (https://www.pdal.io) **P**oint **D**ata **A**bstraction **L**ibrary
  - Open source: https://github.com/PDAL/PDAL (https://github.com/PDAL/PDAL)
  - C++, command-line, python
  - Wraps some PCL functionality
  - For windows users: part of the OSGeo4W (https://trac.osgeo.org/osgeo4w/) distribution

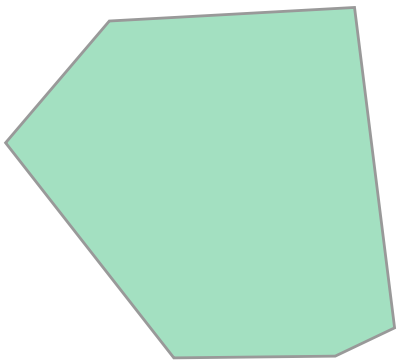
- LAStools (https://rapidlasso.com/lastools/) from RapidLasso
  - Proprietary, preferred pricing for academic use
  - Windows only, runs on wine
  - command-line, GUI
  - Open source laszip (https://www.laszip.org) compression/decompression: https://github.com/LASzip/LASzip (https://github.com/LASzip/LASzip)

Let's process some point clouds

Selecting street portion with a polygon

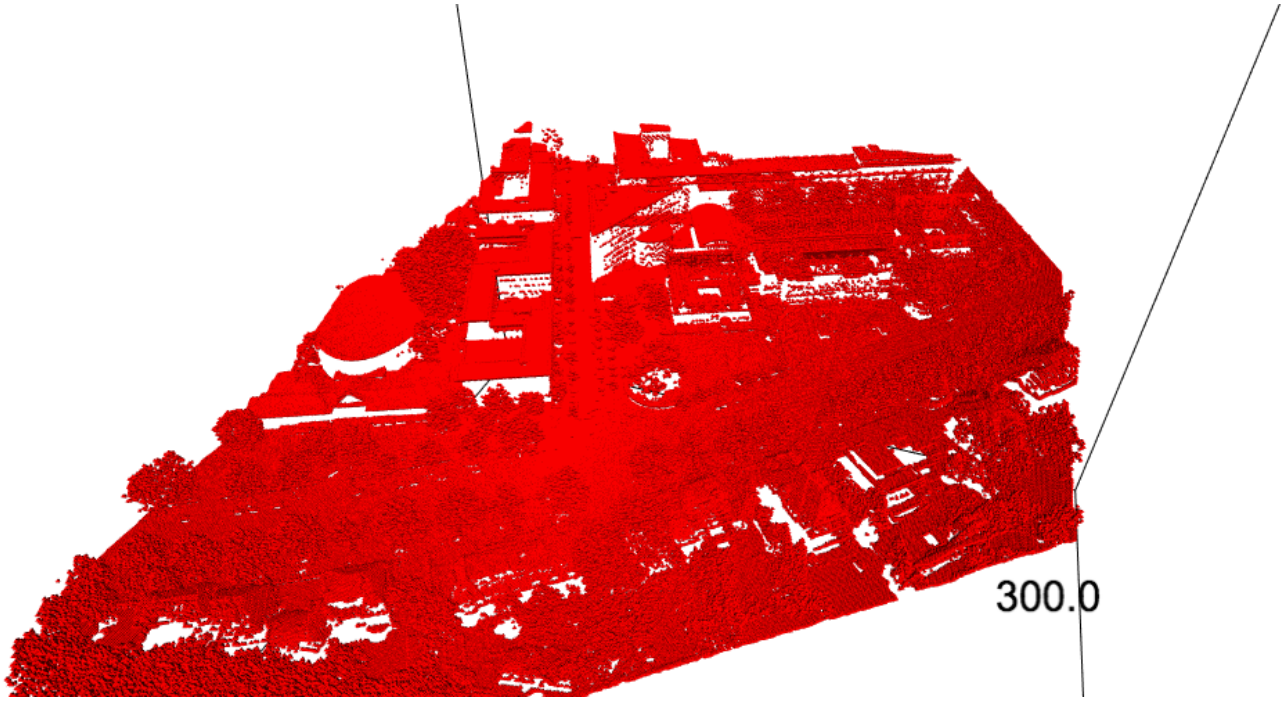



```
POLYGON ((150687.8518289287 167058.3858805448, 150939.3740217351 167072.33228858, 150980.4548986266 16674
3.7380920332, 150919.5663185167 166714.6929215267, 150754.0807228128 166712.885090881, 150581.449810213 1
66933.4497666787, 150687.8518289287 167058.3858805448))
```

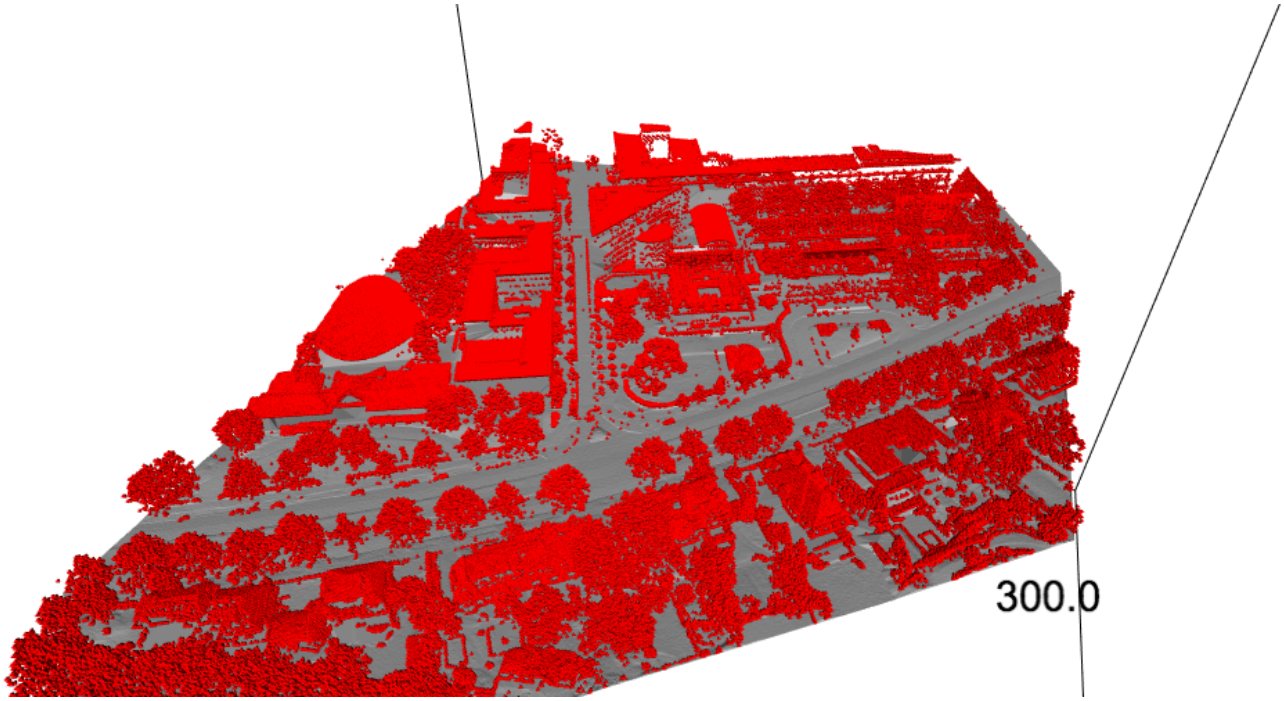


```
CPU times: user 15.9 s, sys: 318 ms, total: 16.2 s
Wall time: 16.3 s
Pipeline selected 473184 points (4.4 pts/m2)
```

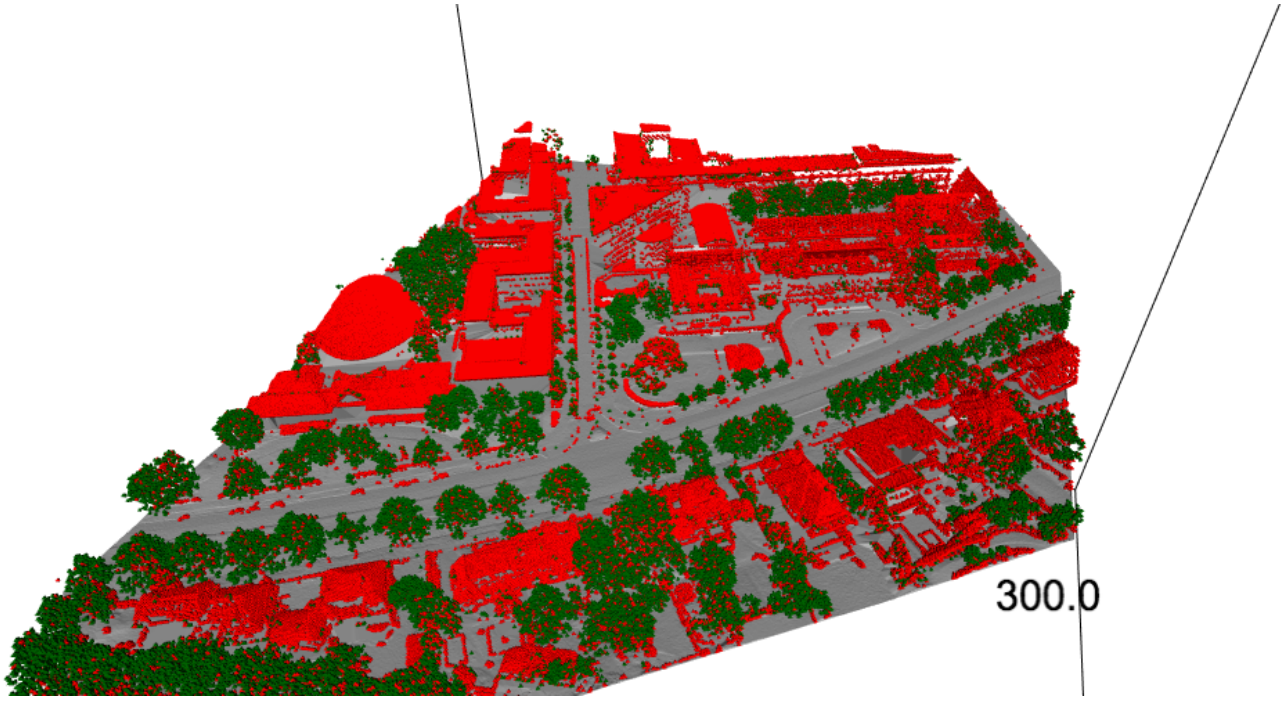
Original data



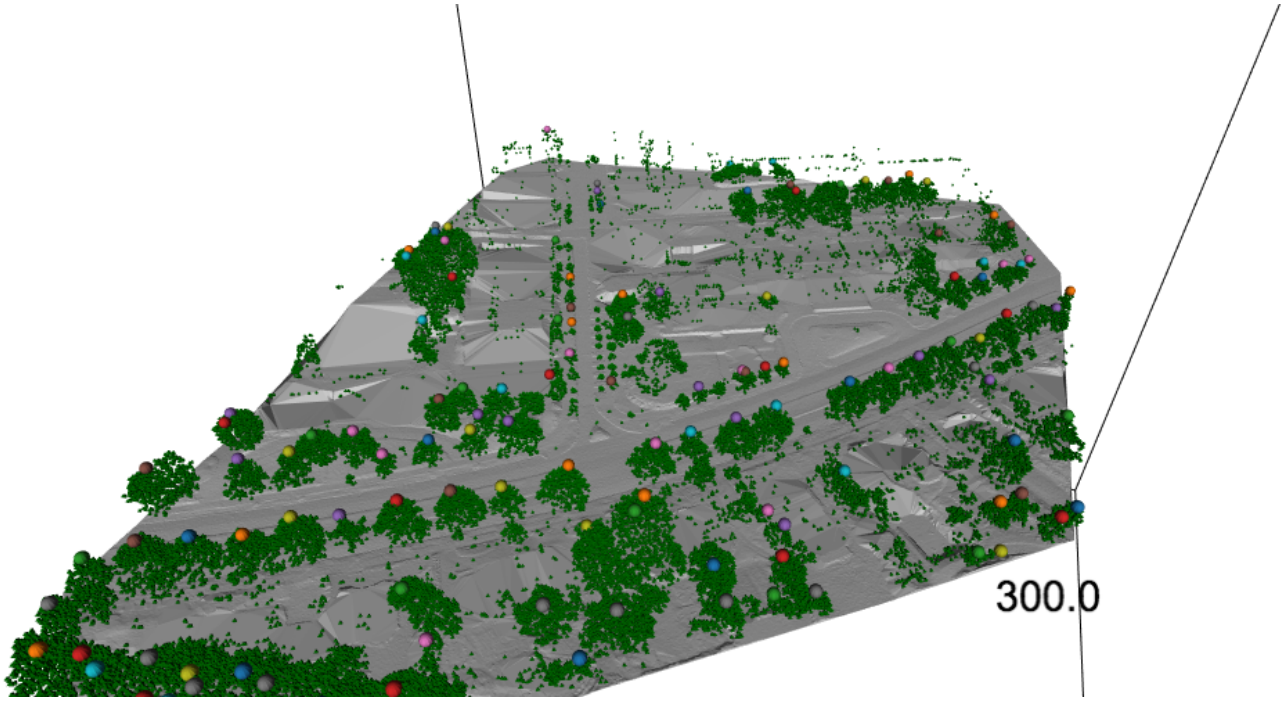
Use gound / non-ground classification



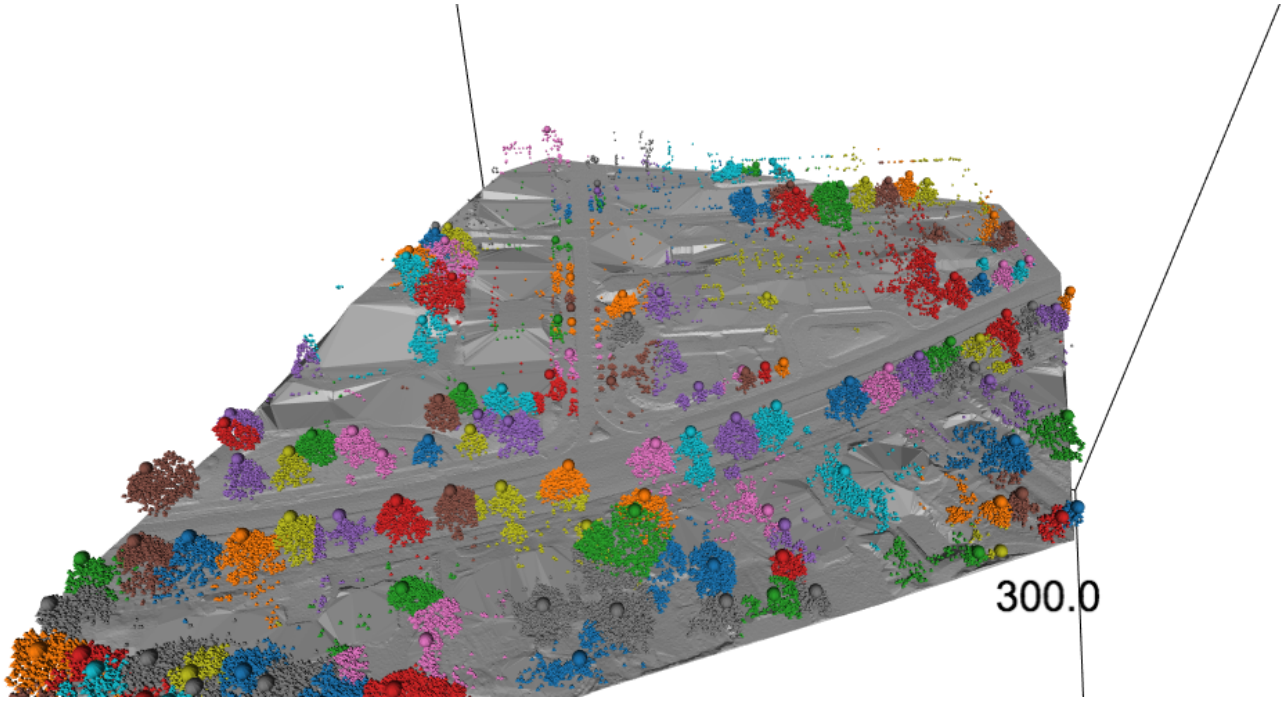
Use point flatness to separate trees from the rest



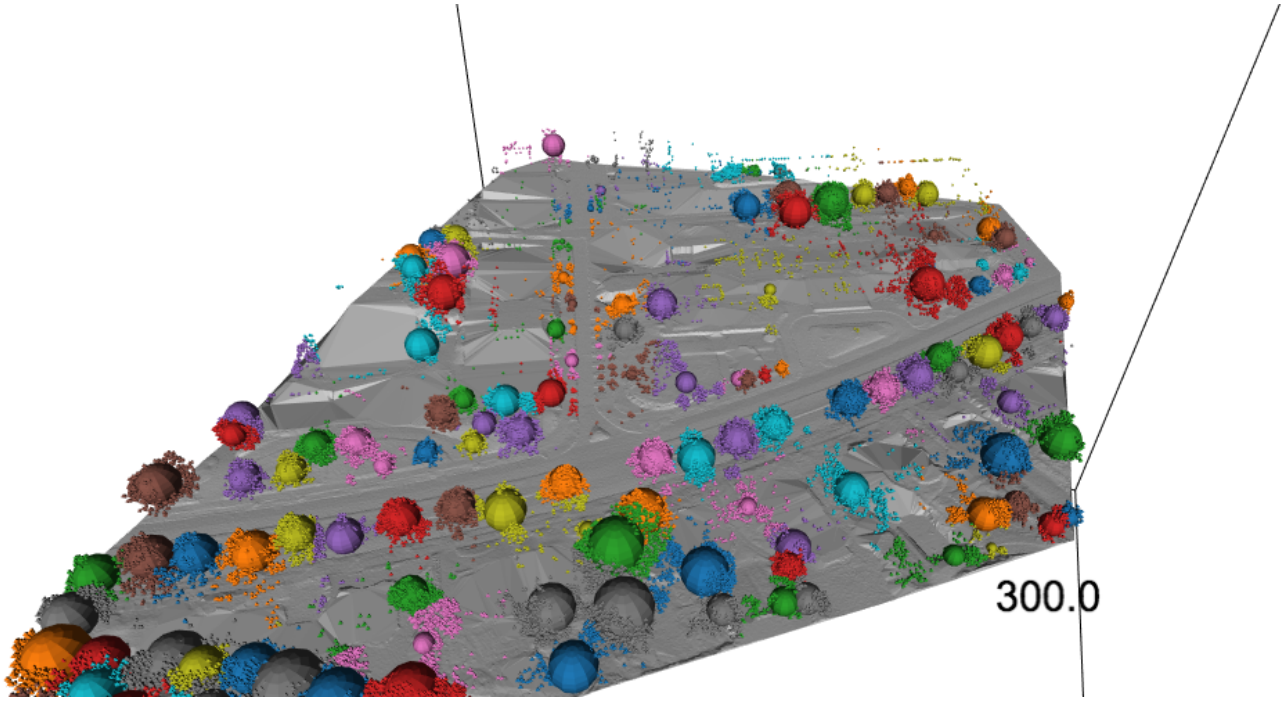
Find treetops as local maxima



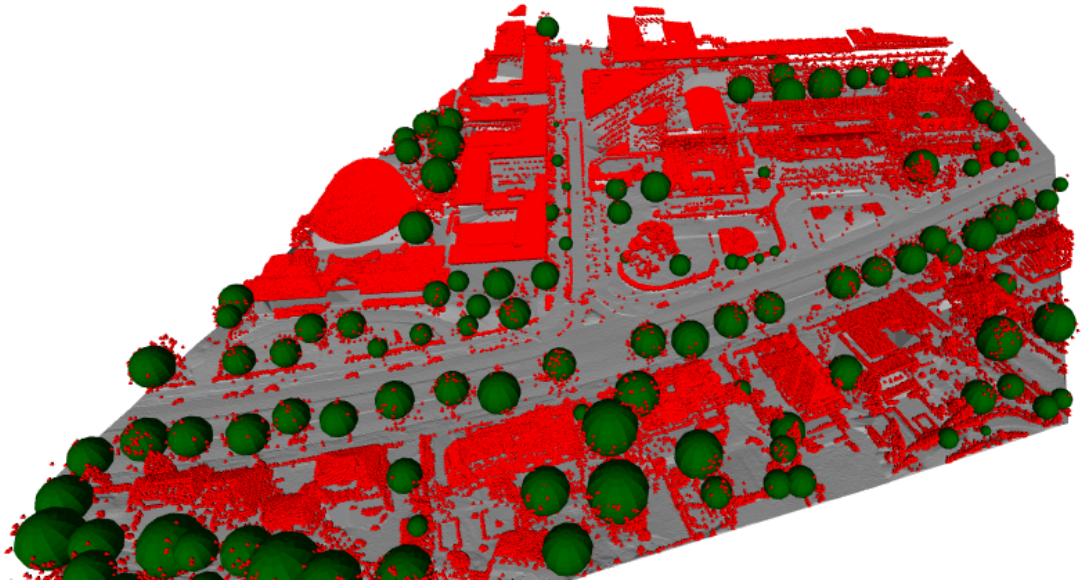
Separate trees using closest treetop



Model each tree individually



Final street model



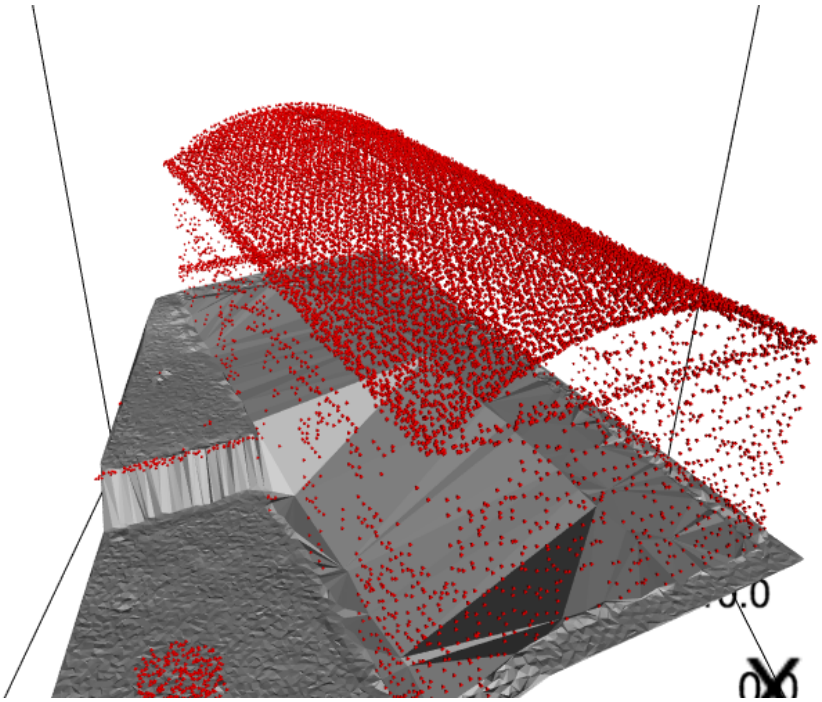
Building Modeling

Selecting building with a polygon

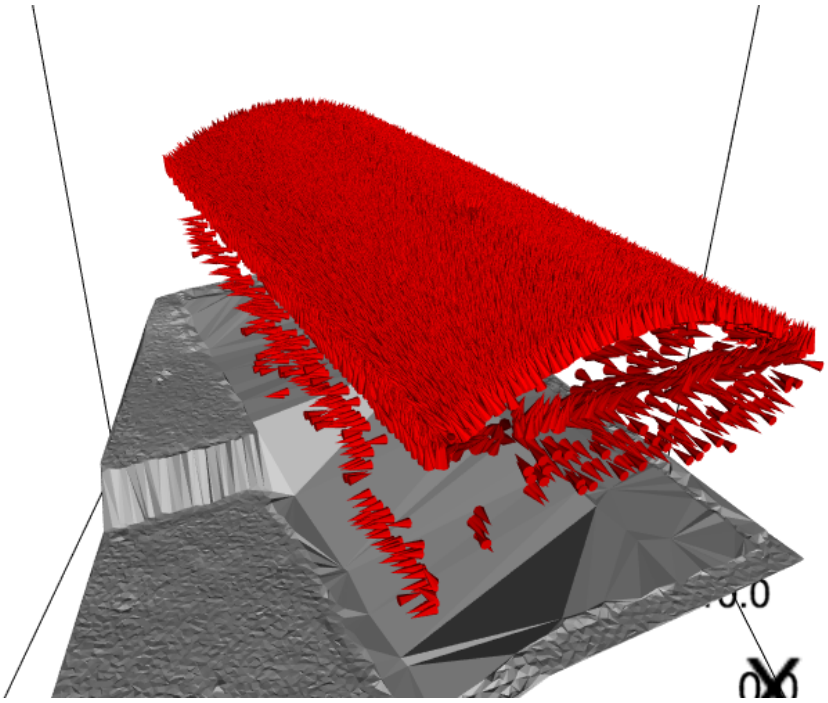

```
POLYGON ((150876.6899425487 166855.1808815384, 150913.4053620266 166873.7645316971, 150904.3812825281 166
890.1151175071, 150861.390885691 166886.3253158694, 150876.6899425487 166855.1808815384))
```

```
CPU times: user 5.39 s, sys: 880 ms, total: 6.27 s
Wall time: 6.5 s
Pipeline selected 31223 points (28.8 pts/m2)
```

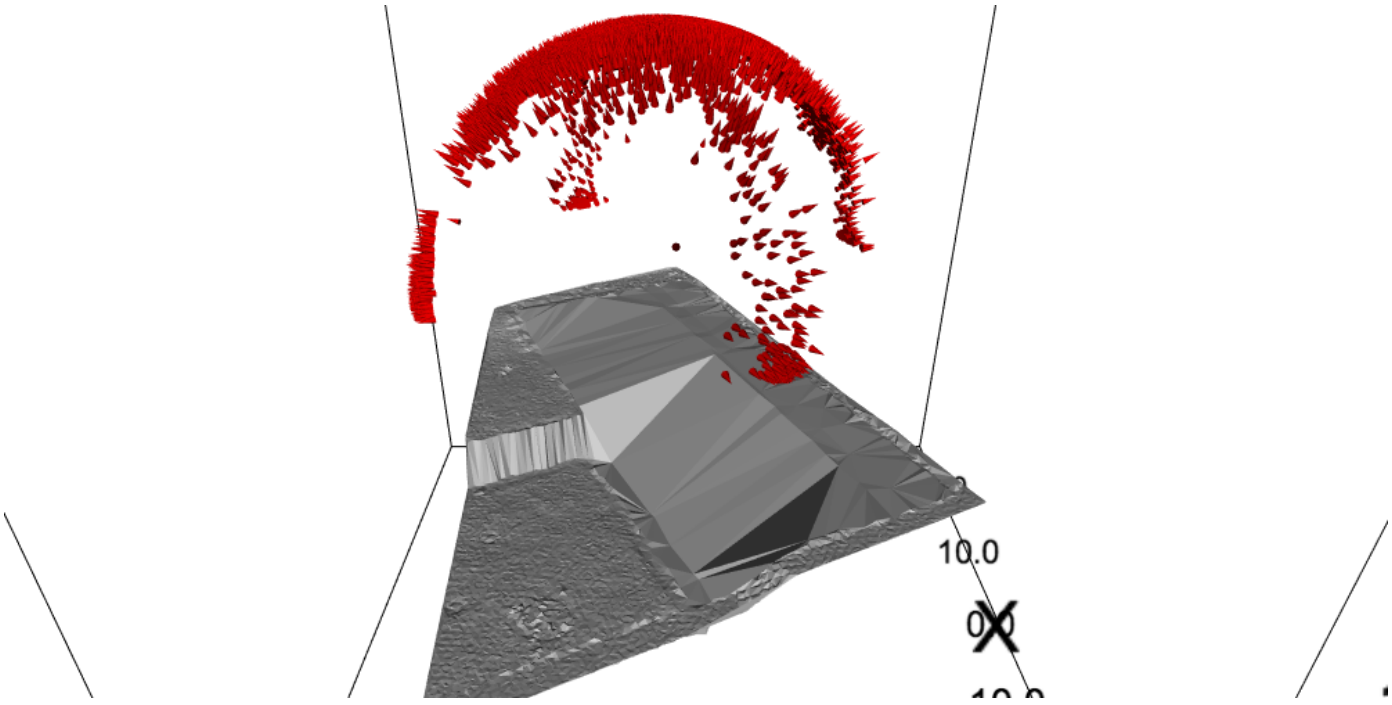
Original data



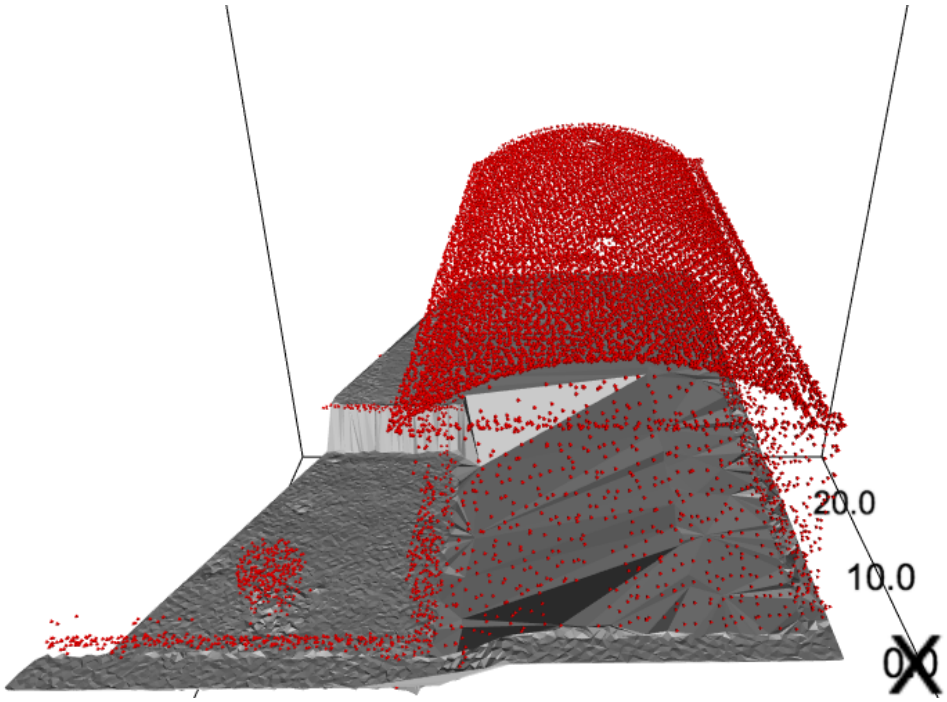
Visualize normals



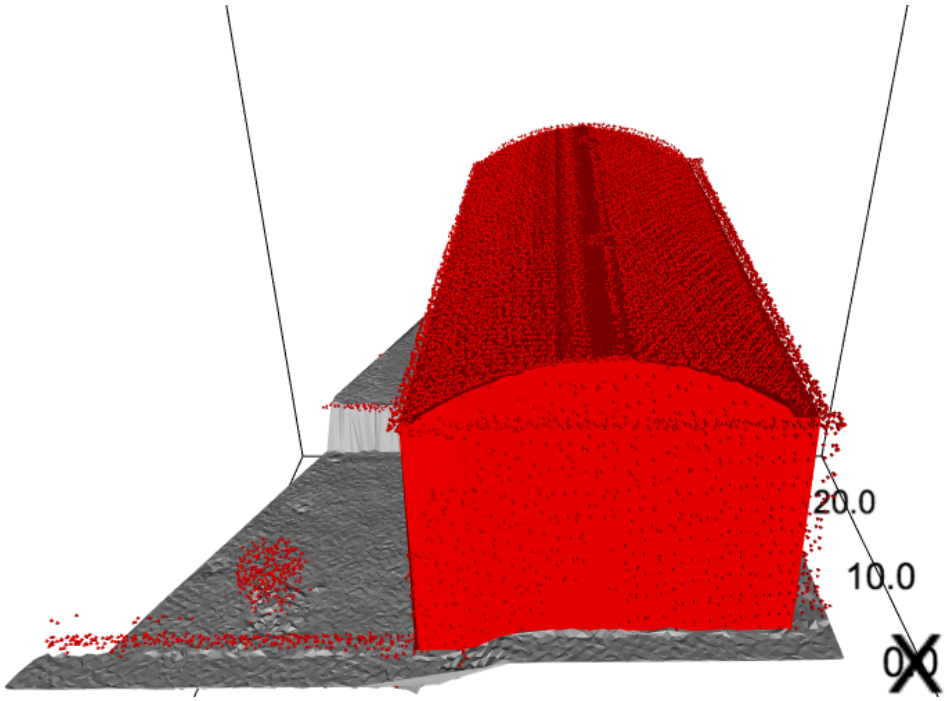
Infer building orientation using normals



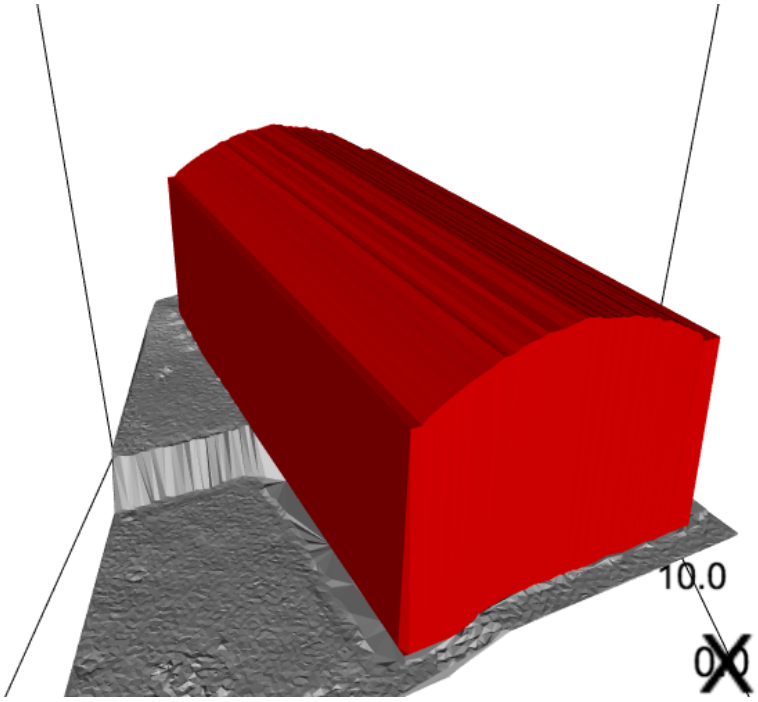
Align building orientation along X-Y axes



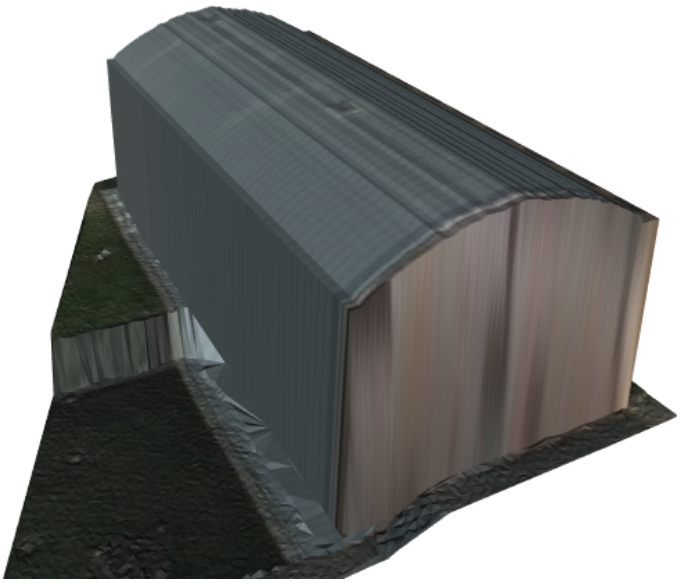
Model the building using axis-aligned view



Rotate back to original coordinate system



Add texture from aerial imagery



Things to look out for

pdal

- Fast point-in-polygon algorithm implemented
- Apache arrow support
- Conda packaging

jupyter

- C++ jupyter kernels
- Jupyterlab

Thank you!