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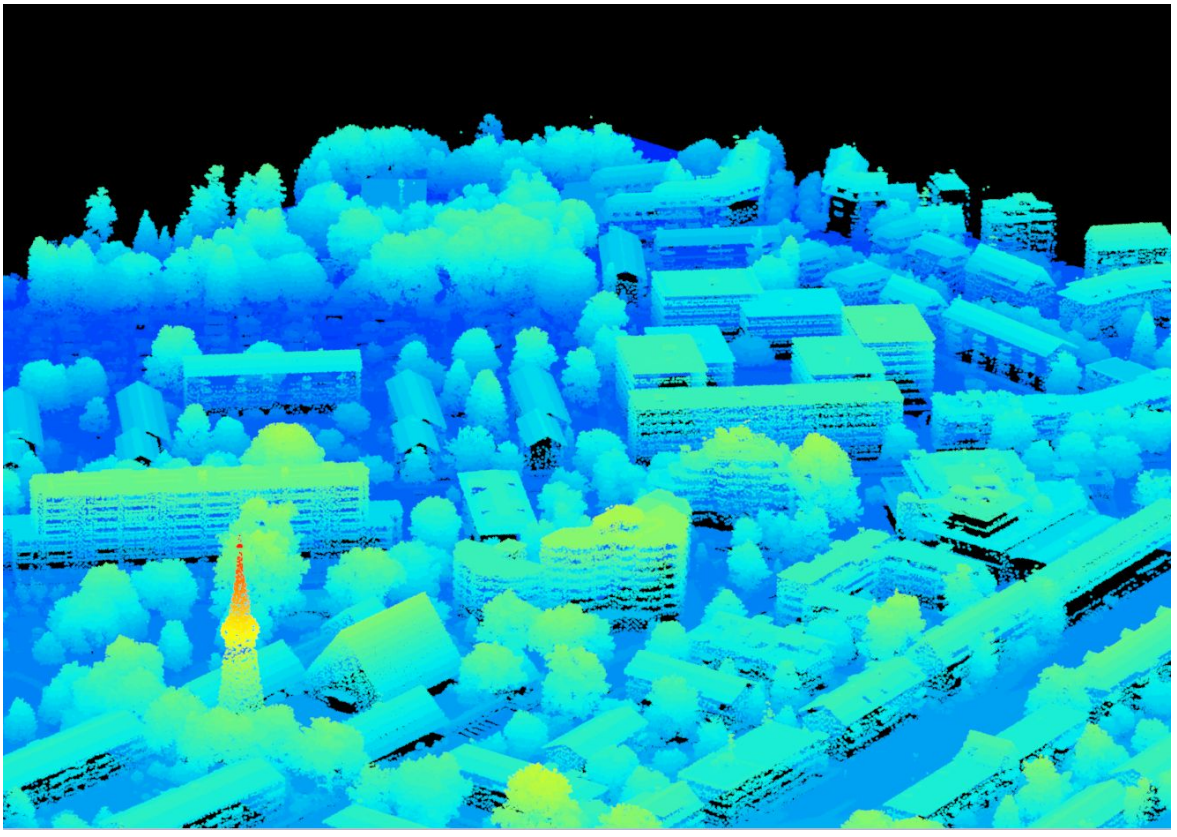

Challenge

> Challenge description: Extracting individual trees from LIDAR

The city of Zürich maintains a tree database, where all trees planted by the municipal gardeners (Grün Stadt Zürich) are recorded. But cities do not only green because of the work of the municipality: garden and balcony owners also contribute to the greening of the city.

By using LIDAR data, green areas can be analyzed in a more precise and comparable way. Thus, this dataset offers an interesting alternative to measure the greening of municipalities. Carrying out this calculation with LIDAR data is, however, not trivial - especially since the datasets are huge. Finding a methodology that allows for fast and precise analysis of this dataset is therefore very rewarding.

Possible topics for analysis are the extraction of individual trees as points or as tree outlines. Moreover, additional information could be attributed to each extracted tree, such as tree height and crown area. The tree database of the city of Zürich can serve as a validation dataset, as properties like tree position, tree height and tree species are recorded in this dataset.

Both the LIDAR data and the tree data are available as Open Data. The LIDAR data has been obtained in spring 2014. In addition to the X,Y and Z coordinates, other variables such as the pulse return magnitude and the standard set of ASPRS classification are available.

> Ideas for attributes that could be calculated for each tree

- tree position (X, Y)
- tree height (Z)
- tree diameter
- tree species or tree classification (e.g. coniferous vs deciduous)
- district name (Quartiername)
- location (garden, balcony, street, park etc.)
- …

> Proposed Study Area: Sihlfeld

> Additional possible LIDAR data challenges

- calculate the volume of each building
- find paths in the forest
- describe the shore ground cover of the lake Zurich
- find artificial water bodies (Swimming pools, ponds)
- … You are very welcome to bring your own ideas! :)

Available Datasets

> LIDAR

- data
  - USB: .../LIDAR/Data/LIDAR
  - online: https://maps.zh.ch/download/hoehen/2014/lidar/
    => the tile IDs are visualized here:
    https://maps.zh.ch?topic=LidarZH&scale=9317&x=2680630.08&y=1247805.22&srid=2056&offlayers=dom2014hillshade&over=HoehenlOverlayZH%2CUpBackgroundZH

- metadata
  - general : https://www.geolion.zh.ch/geodatensatz/2618
  - LAS Specification Version 1.2:
    http://www.asprs.org/a/society/committees/standards/asprs_las_format_v12.pdf
  - additional information:
    - Factsheet Abgabe der Daten «Luftaufnahmen42»:
      https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiyhvamjY3eAhWNjqQKHSmxDlYQFjAAegQIABAC&url=http%3A%2F%2Fkapozh.ch%2Fdam%2Fbaudirektion%2Fare%2Fgeoinformationen%2Fvermessung%2Fluftaufnahmen%2Fluftaufnahmen42%2FFactsheet_Luftaufnahmen42%2520Abgabe%2520der%2520Daten_Aug2016.pdf.spooler.download.1471503780004.pdf%2FFactsheet_Luftaufnahmen42%2BAbgabe%2Bder%2BDaten_Aug2016.pdf&usg=AOvVaw30LW2j3nYXq6F69CS8PFef
    - Projekt «Luftaufnahmen42» Technische Spezifikationen:
      https://www.geolion.zh.ch/geodatensatz/2618/downloadPDF
    - Classification:

ID	Name	Description
0	Created, never classified	We are using both 0 and 1 as Unclassified to maintain compatibility with current popular classification software such as TerraScan. We extend the idea of classification value 1 to include cases in which data have been subjected to a classification algorithm but emerged in an undefined state. For example, data with class 0 is sent through an algorithm to detect man-made structures – points that emerge without having been assigned as belonging to structures could be remapped from class 0 to class 1.
1	Unclassified	We are using both 0 and 1 as Unclassified to maintain compatibility with current popular classification software such as TerraScan. We extend the idea of classification value 1 to include cases in which data have been subjected to a classification algorithm but emerged in an undefined state. For example, data with class 0 is sent through an algorithm to detect man-made structures – points that emerge without having been assigned as belonging to structures could be remapped from class 0 to class 1.
2	Ground	

3	Low Vegetation	< 30 cm
4	Medium Vegetation	< 3m
5	High Vegetation	> 3m
6	Building	
7	Low Point (noise)	Outliers and erroneous measurements
8	Model Key-Point (mass point)	Class 8 “model key points” is actually a subset of class 2 and so is created as a separate product. Bare earth points have classification value #2 and there is also a Mass Point class that is a reduced set of points that is classification #8. This points are considered to be model key-points and thus generally should not be withheld in a thinning alogarithm. => Model Key-Points represent a subset of the Ground points that have been filtered to identify those points that are required to build a surface capable of producing two foot contours. You’ll lose some detail for sure by weeding out these points, but the contours created are “statistically” valid at the 95% confidence level.
9	Water	Water is not classified in this dataset.
10	Reserved for ASPR Definition	Reserved for own classification
11	Reserved for ASPR Definition	Reserved for own classification
12	Overlap Points	Overlap Points are those points that were immediately culled during the merging of overlapping flight lines. In general, the Withheld bit should be set since these points are not subsequently classified.
13-31	Reserved for ASPR Definition	Reserved for own classification
15	contact lines, masts, antennas	contact lines, masts, antennas
17	Rest	For example vehicles

> Vegetation height

- data
    - USB: .../LIDAR/Data/Vegetationshoehe
- metadata: https://www.geolion.zh.ch/geodatensatz/3148

> Orthophoto

summer RGB 2014/15

- data:
  - USB: .../LIDAR/Data/Orthophoto/
  - online: https://maps.zh.ch/download/orthofoto/sommer/2014/rgb/jpeg/
    => the tile IDs are visualized here:
    https://maps.zh.ch?topic=OrthoZH&scale=320000&x=2692500&y=1252500&srid=2056&offlayers=ortho_fcir%2Cortho_sp%2Cortho_sp_fcir%2Clk500%2Clk200%2Clk100%2Clk50%2Clk25%2Cup8%2Cup24%2Ckachelung_sp
- metadata: https://www.geolion.zh.ch/geodatensatz/2831

summer Infrared 2014/15

- data:
  - USB: .../LIDAR/Data/Orthophoto
  - online: https://maps.zh.ch/download/orthofoto/sommer/2014/fcir/jpeg/
    => the tile IDs are visualized here:
    https://maps.zh.ch?topic=OrthoZH&scale=320000&x=2692500&y=1252500&srid=2056&offlayers=ortho_fcir%2Cortho_sp%2Cortho_sp_fcir%2Clk500%2Clk200%2Clk100%2Clk50%2Clk25%2Cup8%2Cup24%2Ckachelung_sp
- metadata: https://www.geolion.zh.ch/geodatensatz/3029

spring RGB 2015/16

- data:
  - USB: .../LIDAR/Data/Orthophoto
  - online: https://maps.zh.ch/download/orthofoto/fruehjahr/2015/rgb/jpeg/
    => the tile IDs are visualized here:
    https://maps.zh.ch?topic=OrthoZH&scale=320000&x=2692500&y=1252500&srid=2056&offlayers=ortho_fcir%2Cortho_sp%2Cortho_sp_fcir%2Clk500%2Clk200%2Clk100%2Clk50%2Clk25%2Cup8%2Cup24%2Ckachelung_sp
- metadata: https://www.geolion.zh.ch/geodatensatz/3033

spring Infrared 2015/16

- data:
  - USB: .../LIDAR/Data/Orthophoto
  - online: https://maps.zh.ch/download/orthofoto/fruehjahr/2015/fcir/jpeg/
    => the tile IDs are visualized here:
    https://maps.zh.ch?topic=OrthoZH&scale=320000&x=2692500&y=1252500&srid=2056&offlayers=ortho_fcir%2Cortho_sp%2Cortho_sp_fcir%2Clk500%2Clk200%2Clk100%2Clk50%2Clk25%2Cup8%2Cup24%2Ckachelung_sp
- metadata: https://www.geolion.zh.ch/geodatensatz/3031

> Tree data of the city of Zürich

- data:
  - USB: .../LIDAR/Data/Baumkataster
  - online: https://data.stadt-zuerich.ch/dataset/baumkataster
- metadata: https://data.stadt-zuerich.ch/dataset/baumkataster
- map: https://www.maps.stadt-zuerich.ch/zueriplan3/Stadtplan.aspx?#route_visible=true&basemap=Stadtplan&map=&scale=64000&xkoord=2682885.4779529376&ykoord=1247492.2378006037&lang=&layer=Stadtbaum&window=&selectedObject=&selectedLayer=&toggleScreen=&legacyUrlState=&drawings=

> Official survey

Ground cover

- data:
  - USB: .../LIDAR/Data/AV_Bodenbedeckung
- metadata: https://www.geolion.zh.ch/geodatensatz/3133

Building address

- data**:**
  - USB: .../LIDAR/Data/Gebäudeadressen
  - online: https://data.stadt-zuerich.ch/dataset/adressen
- metadata:https://data.stadt-zuerich.ch/dataset/adressen

Borders

- data:
  - USB: .../LIDAR/Data/AV_Grenzen
- metadata: https://www.geolion.zh.ch/geodatensatz/3141

> Stream and lakes

- data:
  - USB: .../LIDAR/Data/Offentliche_Oberflachengewasser
- metadata: https://www.geolion.zh.ch/geodatensatz/743

Tools to analyse LIDAR data

> R packages

- lidR:
  https://www.rdocumentation.org/packages/lidR/versions/1.6.1
  USB: .../LIDAR/LidR.Rmd
- rLIDAR:
  https://www.rdocumentation.org/packages/rLiDAR/versions/0.1.1
- rLiDAR and FUSION:
  http://quantitativeecology.org/using-rlidar-and-fusion-to-delineate-individual-trees-through-canopy-height-model-segmentation/

> Web Applications: Note that the Laz file loading is only available in Chrome

- http://plas.io/

> Python packages

- laspy:
  https://pypi.org/project/laspy/
  https://laspy.readthedocs.io/en/latest/index.html
- ForestTools:
  https://cran.r-project.org/web/packages/ForestTools/vignettes/treetopAnalysis.html
- Pyfor:
  https://github.com/brycefrank/pyfor
- Stackexchange - What Lidar processing tools are available in Python?:
  https://gis.stackexchange.com/questions/88322/what-lidar-processing-tools-are-available-in-python
- Tutorial - Calculate Vegetation Biomass from LiDAR Data in Python
  https://www.neonscience.org/calc-biomass-py
- Earth Lab University of California:
  https://www.earthdatascience.org/courses/earth-analytics-python/lidar-raster-data/

> QGIS:

- https://gis.stackexchange.com/questions/19338/viewing-lidar-data-las-in-qgis
- https://gis.stackexchange.com/questions/273300/installing-lastools-in-qgis-3-0
- USB: .../LIDAR/LIDAR.qgz

> LASTOOLS

- http://www.cs.unc.edu/~isenburg/lastools/-
- ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/LAS_File_Processing_Using_LASTOOLS.pdf

How LIDAR works

Before you start to work on the challenge it might be useful to get a basic understanding of how LIDAR works. This video offers a good explanation:
https://www.youtube.com/watch?v=EYbhNSUnIdU