University of Oregon - GEOG 485/585 – Remote Sensing 1 – Fall 2021

Lab Assignment #6: Canopy height measurement using LiDAR

Objectives: In this lab, you will make a canopy height model in QGIS using LiDAR data.

Logistics:

Date assigned:	Week 6
Date due:	Before the beginning of Week 7 labs
Points:	100 points
Deliverables:	Post a PDF document on Canvas with all answers and necessary graphics using the answer sheet given to you. Your responses are expected to be in complete, grammatically correct sentences based on knowledge gained from lecture, reading, and lab exercises. Remember that many of the questions have multiple parts so make sure you answer all parts of the questions.

Preface:

The lab instructions will be available on Canvas (canvas.uoregon.edu) and the class network drive (details below). Data used in labs are not posted on canvas and should be accessed through the SSIL network (you can also remotely connect to this network from off campus, following these instructions).

The class data is available at the following path:

`R:\GEOG485_12740_05\Class_Data\Lab6\`

You should store your work in a separate folder for each lab on your local computer. **Note:** I recommend anything you save on your local computer should also be backed up to a USB stick or Google Drive account at the end of each session. Your folder should have the following path (except has your own SSIL username):

`R:\GEOG485_12740_05\Student_Data\Your_Username`

For this lab, create a "`Lab6`" folder in which to store your work inside your user folder. Your lab write-up and any additional materials should be turned in online to the course website on canvas.uoregon.edu. Lab questions are due by the end of the lab, but it is suggested you do these questions first thing.

Lab overview

Forest inventories are the backbone of forest management around the world. In most forestry administrations, they are performed every couple of years in order to assure that logging activities are sustainable. The process involves trained foresters who visit each stand (i.e. an area where the forest is similar in terms of age structure and tree species) and perform surveys of tree height using a tape measure and inclinometer. However, the development of airborne LiDAR has made forest inventories much less time consuming. Airborne LiDAR can survey large areas from which canopy heights can be extracted using relatively simple GIS techniques.

In this lab, we will first work through an example of producing a canopy height model using some sample date. You will then download some more LiDAR data and produce your own canopy height model for a region of your choice. Note that this region has to be Eugene because the last question involves collecting your own in situ observations of canopy height for comparison.

1. Install some plugins

We will first install the QuickMapServices plugin which provides some basemaps for locating our LiDAR data.

- **Plugins** → **Manage and Install Plugins**
- Search for " *QuickMapServices*" and **Install Plugin**

When the plugin is installed, we will display the OpenStreetMap (OSM) basemap in our QGIS workspace. OSM is a free editable geographic database of the world.

- **Web** → **QuickMapServices** → **OSM** → **OSM Standard**

Now we will install some software for working with LiDAR data.

- Again go to **Plugins** → **Manage and Install Plugins**
- But this time search for "*LAStools*" and **Install Plugin**

- Once that plugin is installed navigate to https://rapidlasso.com/lastools/ on a web browser
- Click **DOWNLOAD**
- Unzip folder by right-clicking on the file in Explorer, left-clicking **Extract All** and **Extract**
- Right-click on the newly extracted **LAStools** folder and left-click **Properties**
- Highlight and copy or make a note of the folder's **location** (e.g. *C:\Users\jryan4\Downloads\LAStools*)
- Note: you could also save the LAStools folder to your student folder in R: drive

- Go back to QGIS and select **Settings** → **Options** from the top menu
- Select **Processing** from left menu and **Providers** → **LAStools**
- In **LAStools folder** enter the location of your LAStools folder

- Click **OK**

Note: If you log-off and log back in again, you may have to repeat the last step (e.g. point the LAStools plugin to the LAStools folder).

2. Examine the data

We will now have a look at some example LiDAR data. The data is in LAZ format which is an open-source compressed pointcloud format, supported (is readable) by most open-source and free software. The uncompressed version of this format is LAS.

- Open the toolbox panel by selecting **Processing** → **Toolbox** from the top menu
- Find **LAStools** → **file – checking quality** → double-click **lasinfo**
- For **input LAS/LAS file** select `drawno.laz` which is located in the `R:\GEOG485_12740_05\Class_Data\Lab5\data\`
- Scroll down to the bottom and click the three dots next to **Output ASCII file** and **Save to File**. Save in your student folder with a sensible name (e.g. drawo_info.txt)
- Click **Run**
- Have a look at the new text file in your student folder

Some more information about *lasinfo* can be found here:
https://www.cs.unc.edu/~isenburg/lastools/download/lasinfo_README.txt

Now we will view the data.

- Go to **LAStools** in the **Processing Toolbox** again and select **file – checking quality** → **lasview**
- Select `drawno.laz` as **input LAS/LAS file** and click **Run**

A new window should appear showing the point cloud data. The brown points are points classified as *ground* and the gray ones are *unclassified*. Some tips for navigating:

- Hold down left-click while moving mouse to pan across the point cloud.
- Click spacebar to change to translate, zoom, or tilt
- Click the letter **g** to visualize only the ground points or the letter **u** to see only the unclassified points.
- Click the letter **a** to see all the points again.

Some more information about *lasview* can be found here:
https://www.cs.unc.edu/~isenburg/lastools/download/lasview_README.txt
As you can see, we only have points labeled as “ground” or “not classified”. In this case, we only need to know where the ground points, the rest of the points can be assumed to be vegetation.

- Close **lasview**

3. Produce a digital surface model

We need to convert the pointcloud to a raster for analysis.

- **LAStools → file – raster derivatives→ las2dem**
- Select `drawno.laz` as **input LAS/LAS file**
- Set **step size / pixel size** to 0.3333
- Click the three dots next to **Output raster file** and save as `drawno_dsm.tif` in your student folder (remember to add the `.tif` extension)
- Add new layer to QGIS project, right-click on the layer and left-click **Zoom to layer**

We should see a small 100 x 100 m raster on our screen and, if we zoom out a bit, we find that this LiDAR data was collected over a forest near Drawno, Poland.

- In **Symbology**, change the **Render type** of this layer to “*Singleband Pseudocolor”* and set the **Color ramp** to “*Viridis*”

Some more information about *las2dem* can be found here:
https://www.cs.unc.edu/~isenburg/lastools/download/las2dem_README.txt

This is great but not very useful since it is not clear which values represent the ground and which values represent the canopy in this digital surface model. It also contains lots of “salt-and-pepper” effects where the laser returns have partially penetrated the canopy. These noisy values will hamper subsequent analysis of single tree detection, height, and crown diameter computation.

4. Produce a canopy height model

Since the the ground returns are already labeled, we can compute the height of trees in this 100 x 100 m plot very easily by producing a canopy height model. All we need to do is “height-normalize” the LiDAR data using **lasheight**. This tool computes the height of each canopy point above the ground. The tool first triangulates the ground points into a triangulated irregular network (TIN) then calculates the elevation of each point with respect to this TIN.

- **LAStools → file – processing points→ lasheight**
- Select `drawno.laz` as **input LAS/LAS file**
- Click **replace_z** and **drop_above** enter *30* since there are no trees higher than 30 meters in this plot
- Click the three dots next to **Output LAS/LAZ file** and save as `drawno_normalized.laz` in your student folder (remember to add the `.laz` extension)

The 'replace_z' parameter means that afterwards all ground points will have an elevation of zero and all other points will have an elevation that equals their relative height above (or below) the ground TIN at their x and y location. In a sense this will "normalize" the elevations of points in respect to their surrounding ground truth.

Some more information about *lasheight* can be found here:

https://www.cs.unc.edu/~isenburg/lastools/download/lasheight_README.txt

4.2. Visualize canopy height model

Let's have a look at what **lasheight** did by gridding the pointcloud again using **lasgrid**.

- **LAStools → file – raster derivatives→ lasgrid**
- Select `drawno_normalized.laz` as **input LAS/LAS file**
- Set **step size / pixel size** to *0.3333*
- Set **Method** to *highest*
- Click the three dots next to **Output raster file** and save as `drawno_chm_v1.tif` in your student folder
- Click **Run**
- Add new layer to QGIS workspace

We choose a **step size** of 0.3333 because that is the average pulse spacing of our sample data. The '*highest*' option means that each pixel of our grid will contain the highest z coordinate for all LiDAR returns falling into the corresponding 0.3333 by 0.3333 meter area.

This looks good, the new raster is scaled to between around 0 and 28 m and it is more obvious where the trees are compared the digital surface model. But the raster is full of empty pixels (termed "pits") that will hamper our analysis.

Some more information about *lasgrid* can be found here:
https://www.cs.unc.edu/~isenburg/lastools/download/lasgrid_README.txt

4.3. Produce a better canopy height model

Part of the problem with the previous method is that we assumed each laser return was a single point when laser returns actually have a small ground footprint (largely dependent on the distance between the aircraft and surface). A simple improvement can be obtained by specifying the ground footprint of each return. In our case, this is about 10 cm radius (or 20 cm diameter).

We can also improve our approach by interpolating all **first** returns (as well as all the ground returns which was achieved with *lasheight*) with a TIN. To do this we will (1) keep only one highest return per grid cell using *lasthin* (2) interpolate all these highest returns using *las2dem*.

- **LAStools → file – processing points→ lasthin**
- Select `drawno_normalized.laz` as **input LAS/LAS file**
- Set **size of grid used for thinning** to *0.3333*
- Set **keep particular point per cell** to *highest*
- In the **additional command line parameter(s)** box, enter -*subcircle 0.1*
- Click the three dots next to **Output LAS/LAZ file** and save as `drawno_thin.laz` in your student folder

- **LAStools → file – raster derivatives→ las2dem**
- Select `drawno_thin.laz` as **input LAS/LAS file**
- Set **step size / pixel size** to *0.3333*
- Click the three dots next to **Output raster file** and save as `drawno_chm_v2.tif` in your student folder

This is looking much better. Now change the color ramp to something more interesting. For visualization purposes, we will also add a hillshade layer.

- **Raster → Analysis → Hillshade**
- Use the default settings and save as `drawno_chm_v2_hill.tif`

Change the **Symbology** of the hillshade layer by setting **Global Opacity** to *20%*. Overlay the hillshade layer on top of the canopy height model layer.

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Question 1 (20 points): Copy and paste your canopy height model with hillshade layer on top.
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5. Estimate canopy height in your neighborhood using LiDAR

LiDAR data is often made publicly available. In Oregon, a large quantity of LiDAR data has been collected by the Oregon Department of Geology and Mineral Industries (DOGAMI). It is available for download from OpenTopography. To complete this lab, you will download some LiDAR data from somewhere in Eugene and make a canopy height model.

- Go to https://portal.opentopography.org/lidarDataset?opentopoID=OTLAS.022011.2994.1
- Click **Select a Region** in the top left of the map and draw a small box around somewhere in Eugene
- Scroll down and make sure your region contains less than 1 million points
- Untick **3a DEM generation (TIN)** because we will do that ourselves
- Everything else can be kept the same
- Fill out **Job title, Job description** and **Email address** and click **SUBMIT**

Now use the instructions in Sections 2 and 4 to produce your own canopy height model for this study area.

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Question 2 (60 points):
a) Provide a short description of your study area, including where it is and why you chose it
b) Make a canopy height model for your study area and paste it with your answers
c) Identify the heights of some of the trees in your study region
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6. In situ observations

Once you have identified some of the trees and their heights in your study area, make your own observations of their height using the following as a guide: https://bigtrees.forestry.ubc.ca/measuring-trees/height-measurements/. Compute the height of between two and six trees.

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Question 3 (20 points): Write a short paragraph about your comparisons between LiDAR-derived tree heights versus manually-derived tree heights. What was the difference between the two datasets? If there were significant differences, can you think of reasons why? Which source of observations do you think are more accurate and why? Include an annoated figure to show which trees you compared.

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This concludes Lab 6! Remember to type up all answers on your word document, convert file to PDF and upload it to Canvas by the deadline.