**Lab 9**
ESRM430
Instructor: Dr. L. Monika Moskal

Lab Objective:

- LiDAR Measurements

Tools:

- FUSION Software version 3.42
- Clip of Olympia WA digital LiDAR data

**What you will hand in:**

- **Upload the tree measurement *.csv file to the Lab9 dropbox. The file should include at least 5 tree measurements.**

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**Task 1:**

- Download the Lab 9 LiDAR data from course website.
- Set up a directory on the computer to work from. I suggest using …ESRM430/Lab9.
- Do not work from your flash drive, but do back up the lab folder you have been working with to the flash drive at the end of the lab.

**Task 2:**

- Open the FUSION.exe software.

**Task 3:**
In this lab you will be working with LiDAR data only, no imagery will be used in the lab. However, an intensity image created from the LiDAR will be provided to ease in the visualization of the tree crown that you will measure.

- Click on the "Image…" button in the FUSION task pane to add the intensity image. It can be found in Lab 9 folder ../Lab9/data/clip/intensity/intensity.bmp.

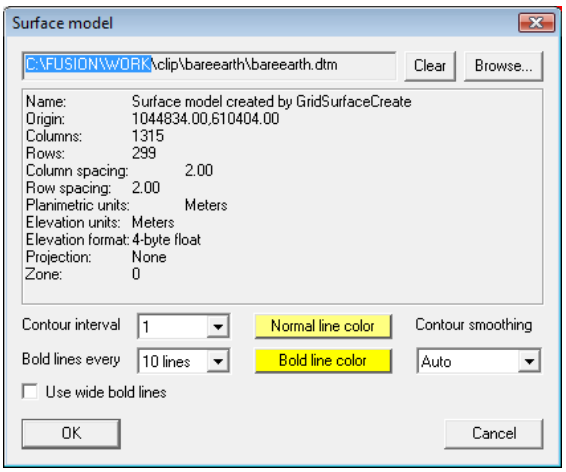
You can read more about how this image was created and why parts of it appear red in the FUSION Manual located in the software folder. As with many of the functions in FUSION the image was created using a command line utility driven interface. The command used is called 'IntensityImage' and it's derived from the intensity values attributed to the LiDAR point cloud.

- Click on the "Raw data…" button to add the LiDAR data. It can be found in the Lab 9 folder ../Lab9/data/clip/lidar/lidarclip.lda.

The data you are using in this lab is a subset of data used in previous labs, the clipping can be achieved using the command line 'ClipData'.

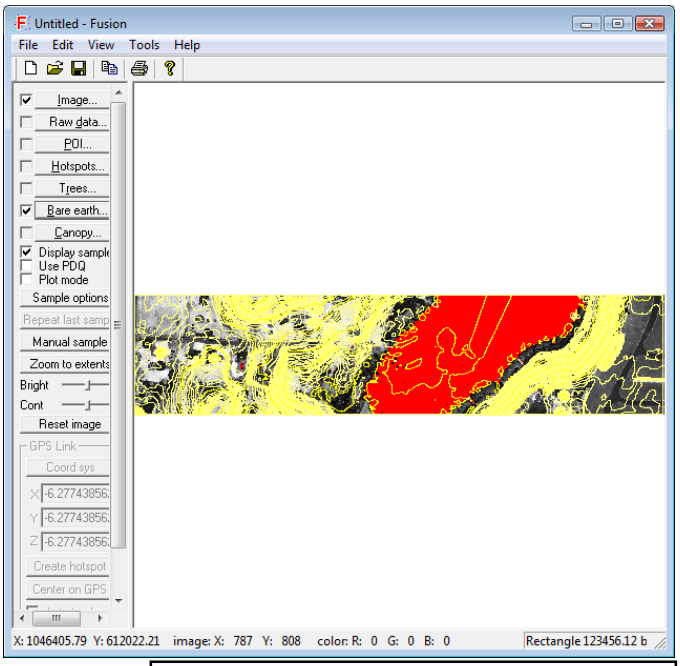
- To open the bare earth model data click on the "Bare earth…" button. It can be found in the Lab 9 folder ../Lab9/data/clip/bareearth/bareearth.dtm.

- Set the Contour Interval to 1 and Bold lines every 10 lines. Set both colors to yellow.




The bare earth model is a digital terrain model (dtm) created using the LiDAR point cloud from which points not representative of the ground (vegetation and buildings) have been removed. This is a multistep process in the FUSION command line and it involves creating a point cloud that is representative of only ground points (a ground model). You can view this point cloud by opening the groundmodel.lda file located in the groundmodel folder in **PDQ**. The 'GroundFilter' command is used first to extract the ground points. A good description of the methodology

behind this process including the papers on which this process is based on in FUSION as well as the thresholds necessary to perform it is given in the FUSION manual. Once the ground filter is evaluated and acceptable (most points are ground points) a dtm is created out of it using the 'GridSurfaceCreate' command, this surface can be smoothed and filtered for outliers, the full process is described in the FUSION manual.




This is what your FUSION screen should look like once you import all the data sets.

**Task 4:**

- Select a stroked box sample that includes trees.
- Type Alt+U to display the bare earth model and Alt+I to display the intensity image on the surface model (or access these options from the right-click menu).
- Right-click in the LDV window to activate the pop-up menu and select **Measurement marker**. The display will change to an overhead view and show the measurement cylinder. Enter Alt + C to show points outside the measurement cylinder.
- Move the cylinder using the keys shown in the box to the right of this text; play around with these options till you feel comfortable navigating in the measurement marker view.
- Type h to automatically move the cylinder to the highest LiDAR point in the view. The value of the measurement marker location is displayed in LDV's window.
- To measure the ground elevation of this location, type g to automatically move the cylinder to LiDAR points corresponding to the ground surface.
- Close the LDV

**Measurement Marker Movement**

- Shift + Arrow keys: **moves the cylinder**
- Ctrl + Shift + Right clck drag right: **increases cylinder size**
- Ctrl + Shift + Right click drag left: **decreases cylinder size**

**h** : moves the measurement marker to the top return in the cylinder
**g**: move the measurement marker to the lowest return in the cylinder (disabled if Subtracting ground elevations automatically)

- You can calculate tree heights by simply subtracting the ground elevation from the tree-top elevation.

**Press Enter**: this records (in memory) the current X,Y,Z of the measurement marker

**Task 5:**
FUSION can automatically subtract the ground elevations from the tree tops to automate the acquisition of heights.

- Back in the FUSION window click the Sample Options button.
- Enable the Subtract ground elevations from each return on the Options section and click OK to close the window.
- Click the Repeat last sample button. Notice that the sample area is "flat" (no changes in topography) in LDV and the elevation bar to the left is providing height above ground.
- Right-click in the LDV window to activate the pop-up menu and select Image plate (Alt+P) to turn the intensity image on below the LiDAR data; the two data sets are slightly off-set in vertical alignment which is not an issue when viewed straight from above.
- Right-click in the LDV window to activate the pop-up menu and select Measurement marker.
- Move and resize the cylinder as you did before to highlight a single tree.

- Click and drag the data cloud with the left mouse button to view the cylinder from the side.

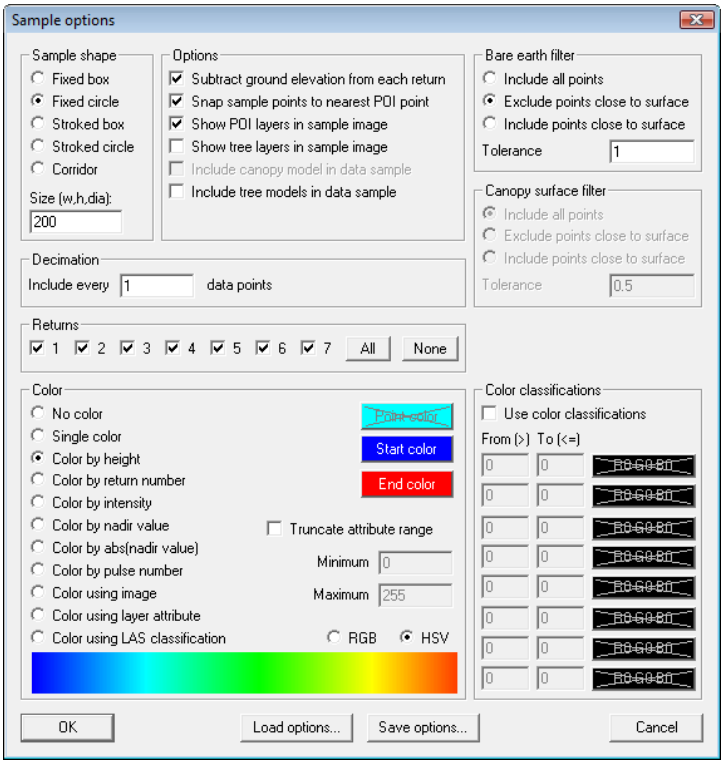
- Now, when you type h, the measurement marker moves to the tree top and gives you the height of the tree (there is no need to type g — in fact, that function is inactive).

Note: If you wish to take multiple measurements, you can record them to a CSV file (readable in Excel) moving the measurement cylinder around using Shift + arrow keys and navigate to a tree. Then resizing the cylinder to properly isolate a tree within the measurement cylinder and using the h and g keys to get the height and ground measurements (if you used the Subtract ground elevation when you set up your sample option the g measurement is not necessary). Press enter after each h and g measurement. Repeat for multiple trees. Once you measure all the trees you are interested in right-click to activate the LDV popup menu and select Save measurement line. This will allow you to save the measurements you recorded in a XYZ comma separated (.csv) file. You can open the .csv file in Excel.

**Task 6:**

FUSION enables you to measure individual tree metrics in defined areas (plots), the final task in lab 9 will be to select an area that contains at least 5 trees and to measure all of the tree characteristics using the LiDAR point cloud.

- In the FUSION main window click the **Sample options** button and select the following options:
  - Sample shape: **Fixed circle**
  - Sample Size: **200** (diameter)
  - Options: **Subtract ground elevation from each return**
  - Options: **Snap sample points to nearest POI point**
  - Options: **Show POI layers in sample image**
  - Bare earth filter: **Exclude points close to the surface**
  - Bare earth filter: Tolerance **1**
  - Leave all other options as default and click OK.

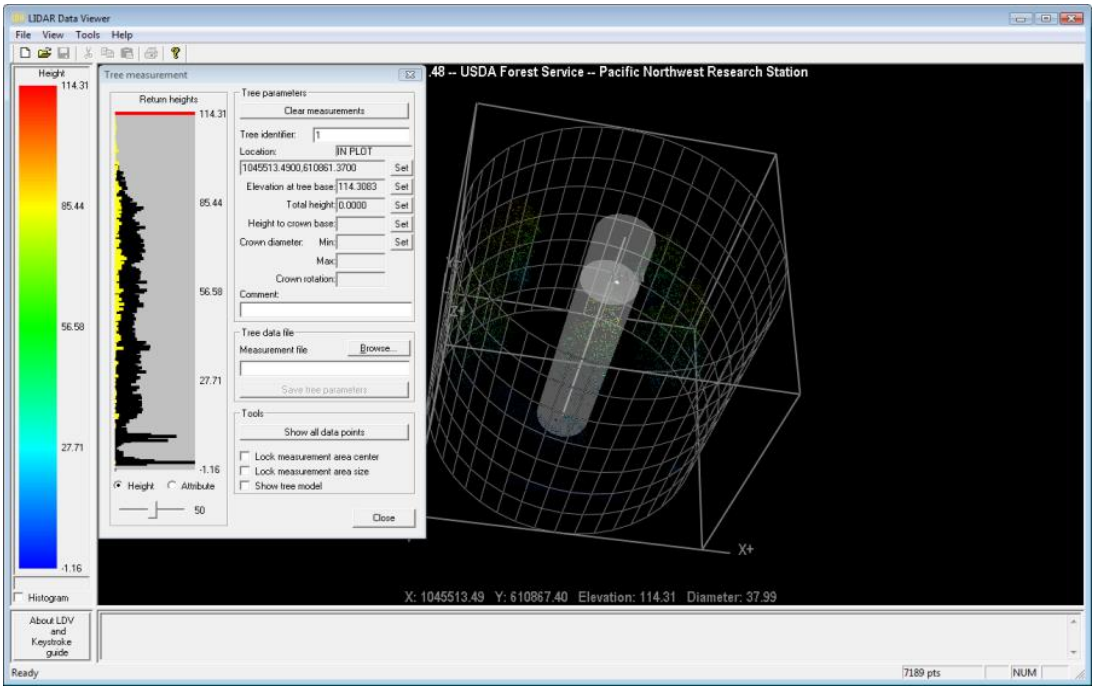



- In the FUSION main window Toggle the check mark for **Plot mode** and **Display sample** on.

- Click on the location of the plot from which tree information will be extracted (click somewhere in the image where there are trees, the denser the trees the more difficult the measurement will be; avoid water areas). The subset of data will pop up in the LDV window.

- Once the plot is displayed in the LDV window **hit the F9 function key**. This brings up the Tree Measurement window. Now you can make measurements on all of the individual trees in your plot. You can use the same movement and measurement keys as in Task 5 and 6 to display and move your measurement marker. Your view should look similar to the one below.

**Note:** The yellow histogram represents the LiDAR points within the measurement cylinder; the black histogram represents all of the LiDAR points within the plot.




**Task 7:**
You will measure at least 5 trees within your plot, if your plot does not have 5 trees select an area with 5 trees and repeat Task 6.

- Center the cylinder over a tree you would like to begin measuring within the plot. You may find it easier without the plot boundary displayed, which you can toggle in the menu by right clicking in LDV. Once you have the cylinder centered over a tree click the **Lock measurement area center** checkbox on (remember to unlock it when you want to move the cylinder to another tree).

- In the Tree measurement box add an entry for a **Tree identifier** (these are your tree ID numbers: 1, 2, 3, 4, and 5).

- Set the location of the cylinder center by clicking the Location **Set** button on the right of the "Tree measurement" window.

- For **Elevation at tree base**: type "l" (lower-case L) to drop the "measurement disk" to the lowest point in the cylinder (don't type upper-case L or you'll move the cylinder) and adjust the measurement disk (horizontal red line) up/down to the tree base by holding Shift+right click (check that this is set to zero or a number slightly above zero else tree models that you will soon create won't display) and click the adjacent **Set** button.

- For **Total height:** type "h" to raise the marker to the highest point in the cylinder, manually adjust the Measurement marker to the top of the tree and click the adjacent **Set** button.

**Tree Measurement Tool Tips**

- The diameter can be changed by shift-ctrl-right mouse
- The shape or aspect ratio can be changed from circle to ellipse by using ctrl and up or down arrows
- The orientation of the ellipse is modified with ctrl + left and right arrows
- Using these key and mouse combinations is not immediately intuitive (to put it mildly). However, it is important to fit the 3D measurement cylinder as closely as possible to the 3D shape of the tree.
- As you change the position, shape, and size of the cylinder, note how the histogram changes in the Tree Measurement window.
- Try moving the measurement disk to the base of a crown (up/down), then make sure the cylinder is larger than the crown and press the "F" key. This fits the cylinder to the crown points.

- For **Height to crown base**: scroll the measurement disk down to the crown base and click the adjacent **Set** button.

- For **Crown diameter**: min, max and crown rotation: These three values are extracted from the cylinder diameter measurements when you click the adjacent **Set** button (Note: if min and max are the same value, you've used a simple circular tree crown model (not an ellipse). If the crown rotation angle is zero, you've not rotated the ellipse). To get full credit you must rotate and stretch the measurement disk to capture the diameter of the crown. Even if this appears unnecessary to accurately fit the tree, you still must make a tiny adjustment.

- Leave the **Comment:** blank.

- **Create** a new .csv file or **Select** an existing .csv file to save the measurements to by clicking on the **Browse…** button.

- Click **Save tree parameters**. Note: After the parameters are saved, the points belonging to the tree you've just measured disappear from the screen (they can be brought back by hitting the show all data points but they cannot be turned off again). The tree identifier increments automatically.

- Uncheck the **Lock measurement area center** checkbox and move the cylinder to the next repeat measurements and save data for at least 5 trees.

- Open the .csv file in Excel to assure that you have 5 trees measures.

**Task 8**: Submit a .csv file with your last name and lab number to the lab 9 drop box with at least 5 tress measured.

Keystroke Guide

Mouse

| | |
|---|---|
| Left & motion | rotate data cloud |
| **Ctrl-left & motion** | **zoom in/out** |
| Wheel | raise/lower image plate |
| | raise/lower measurement disk |
| Shift-Wheel | fine adjustment |
| Wheel press | save measurement point |
| Right | menu |
| **Shift-right** | **raise/lower measurement disk** |
| **Ctrl-right** | **move measurement cylinder** |
| **Shift-Ctrl-right** | **change measurement cylinder diameter. Must drag mouse to make change** |

Keyboard

| | |
|---|---|
| I/i | raise/lower image plate |
| X/x | move YZ clipping plane |
| Y/y | move XZ clipping plane |
| Z/z | move XY clipping plane |
| | |
| ctrl-+ | increase symbol size |
| ctrl-- | decrease symbol size |
| + | increase image plate/surface opacity |
| - | decrease image plate/surface opacity |
| | |
| Esc | stop wiggle/scan…reset measurement line |
| Back | remove last measurement point |
| **Enter** | **save measurement point** |
| | |
| Space | activate popup menu |
| | |
| S | move measurement marker to marked point |
| **G** | **set measurement marker on ground surface** |
| **H** | **set measurement marker elevation to highest data point within measurement area** |
| shift-H | move measurement marker to highest data point within measurement area |
| L | set measurement marker elevation to lowest data point within measurement area |
| shift-L | move measurement marker to lowest data point within measurement area |
| C | set elevation of measurement marker to closest data point within measurement area |
| shift-C | set elevation and move marker to closest data point within measurement area |
| | |
| R | deactivate (don't display) datapoints within measurement area |
| B | activate (display) datapoints within measurement area and lower than marker |
| A | activate (display) datapoints within measurement area and higher than marker |
| shift-A | activate (display) all datapoints |
| T | toggle active status for datapoints within measurement area |
| | |
| **shift-arrows** | **moves measurement marker** |
| ctrl-up/down | change aspect ratio of measurement marker (shift-ctrl for coarse adjustment) |
| ctrl-left/right | rotate measurement marker (shift-ctrl for coarse adjustment) |
| O | reset aspect ratio and rotation of measurement marker to 1.0 |