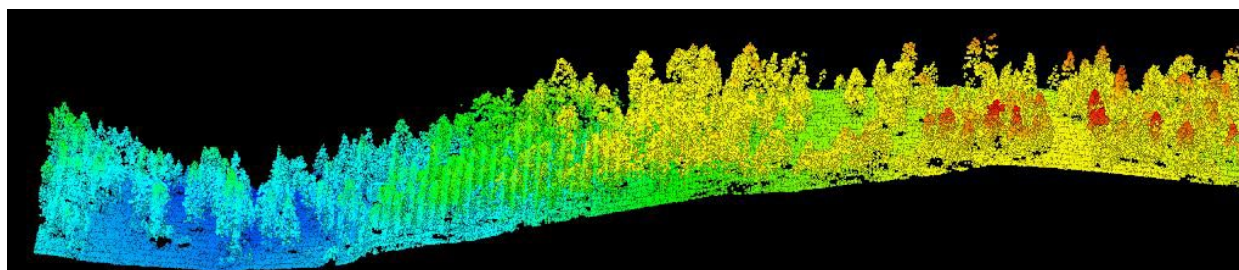


EXERCISE 3

Review FUSION Tools and Perform Quality Assessment of Lidar Data



Introduction

When beginning a project, the Catalog utility is very useful for performing some basic quality control. The Catalog utility in FUSION generates detailed information pertaining to data coverage, LAS classifications, return densities, and the intensity images. This information can be used to identify any errors in the LAS data and evaluate the pulse density (first return density) of the lidar data. When data is delivered by a vendor, analysts typically use the Catalog utility to ensure that the vendor met customer-defined acquisition specifications.

Objectives

- The objective of this exercise is to review the Setup batch file and assess the overall data quality of the lidar point data using the Catalog utility in FUSION.

Prerequisites

- Completion of Lidar Point Cloud Processing Exercises 1-2.



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Part 1: Create a text file containing a list of LAS files

Creating a text file listing all the LAS files and their paths will make the workflow more efficient by enabling FUSION to read them in when necessary. This also helps to prevent common human errors in a processing run. Let's create that file now and copy it into the products folder.

A. Create a .las file list

1. Navigate to the directory containing the raw LAS files by typing in the following command:

```
cd \project_home\point\las\all_points
```

***Tip:** The easiest way to change the current directory is to navigate to the folder in question in Windows Explorer. Clicking the path at the top of the window will highlight the path and enable you to copy and paste it into the command prompt. To paste in a command prompt, simply right click.*

2. We can now automate the creation of the text file by typing in the following syntax into the command prompt: **dir /b /s *.las>filelist.txt** then press **Enter**.
3. In windows explorer navigate to **\project_home\point\las\all_points** and confirm that **filelist.txt** was created.
4. Copy **filelist.txt** and paste it into the processing home directory: **\Project_Home\Products\QAQC**. We should now be set to move forward with some processing.

Part 2: Review the Catalog utility in FUSION

The Catalog utility in FUSION produces a set of reports describing several important characteristics of lidar datasets. It also lets you create a return density raster layer, which is important in large lidar acquisition processing. This return density layer can be produced more efficiently using the *ReturnDensity* tool in Fusion, but Catalog allows you to generate a quality report of your data as well. Let's take a moment to review the Catalog syntax.

A. Review Catalog Utility

1. Open a Command Prompt.
2. Type **catalog** and press **Enter**. You will now see a description of the catalog utility and its syntax (You can do this for any of the FUSION command line utilities). Please take a moment and familiarize yourself with the syntax and available switches. It is also recommended that you reference the FUSION manual for a better understanding of the catalog command.

```

C:\Windows\System32>catalog
Catalog v2.30 <FUSION v3.60> <Built on Oct 6 2016 08:48:37> DEBUG
--Robert J. McGaughey--USDA Forest Service--Pacific Northwest Research Station
Prepares a report describing a LIDAR dataset and optionally indexes all data
file for use in FUSION

Syntax: Catalog [switches] DataFile [CatalogFile]
DataFile      LIDAR data file template or name of a text file containing a list
               of file names <must have .txt extension>
CatalogFile   Base name for the output catalog file <extensions will be added>

Switches:
Switches are preceded by a "/". If a switch has multiple parameters after
the "=", they should be separated by a single comma with no spaces before
or after the comma.
  
```

B. Set Up a Catalog Command

1. Open notepad or your preferred text editor.
2. In notepad, set up a catalog command. Remember the syntax is: `Catalog [switches] [input] [output]`. The switches you will want to use to create the appropriate layers are:
 - i. `/rawcounts` outputs the number of returns
 - ii. `/coverage` creates an image showing the coverage of your data
 - iii. `/intensity:100,0,255` will create an intensity image with a pixel area of 100 units m², and values between 0 and 255
 - iv. `/firstdensity:100,8,20` will create a first return pulse density image with a pixel area of 100 m² (10 meter cell size) and quality breaks of 8 and 20 units.
 - (a) First return density is used as a proxy for pulse density.
 - (b) If you are working with QL2 data, you should set the first quality break to 2, not 8.

Note: We generally use a cell size of 100 (area of 10,000 m²) for the first density raster, but since we are working with four tiles in these exercises, we chose a higher resolution of 10. If you set the area to 10,000 for these four tiles, the first density map output will be very difficult to see. Note that changing the first density cell size will affect the percentage of data that meet the different first return density thresholds.

- v. `/density:10000,4,20` will create an all return density image with an area of 10,000 m² (100 meter cell size) and quality breaks of 4 and 20 units.

Note: the density switch creates a `return_count.dtm`, which is an important input to the Area Processor. Setting the density area to 10,000 m² (100 m cell size) provides a sufficiently detailed representation of the returns throughout the study area while maintaining a cell size that doesn't slow down the Catalog utility too much.

The intensity data, however, is not an integral part of this workflow, and it can be set to a much lower resolution or not created at all.

Finally, if your data has horizontal units in feet, refer to page 37 of the FUSION manual to see what thresholds you should use that are equivalent to the quality breaks in meters.

3. Once you've added the switches, you'll need to point to the input data (filelist.txt) and designate an output (QAQC.csv).
4. The final command you should have written into notepad is: `Catalog /rawcounts /coverage /intensity:100,0,255 /firstdensity:100,8,20 /density:10000,4,20 filelist.txt QAQC.csv` where

filelist.txt refers to the file list you created in part 1 and copied into the QAQC folder, and QAQC.csv is the output report.

Note: Insert a space before the forward slash (/) for every switch. This is one of the most common syntax errors you will encounter when working with FUSION utilities.

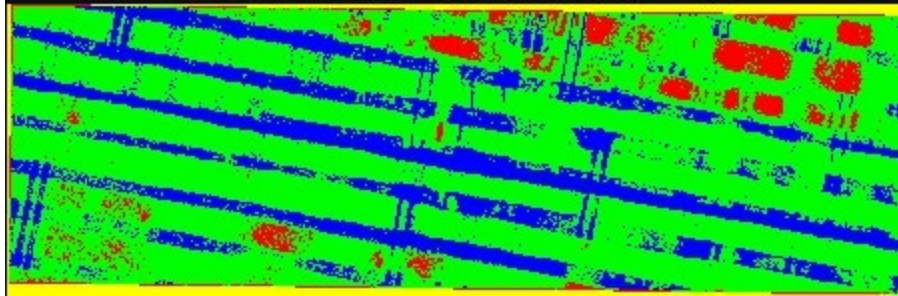
5. Save the file in your QAQC folder (C:\Project_Home\Products\QAQC) as: **QAQC.bat**. You must save the file with the **.bat** extension, otherwise the file will save as a text file and windows will not recognize the catalog command you just typed.
6. Open a command prompt window.
7. Change your current directory to the QAQC folder where you copied the filelist.txt file in part 1 of this exercise by typing: **cd C:\Project_Home\Products\QAQC**.
 - i. Since you changed the directory (cd) to the location of you input and output files, you don't need the full paths for those files, just the names and extensions.
8. Enter the name of the batch file, **QAQC**, into the command prompt and hit enter. This could take a few minutes to run.

Part 3: Inspect Catalog Results

The primary output from the Catalog utility is an HTML file that contains the descriptive outputs you specified with the various switches.

A. Viewing QAQC Report

1. Open Windows Explorer and navigate to **\Project_Home\products\QAQC**
2. After the Catalog command has finished running, a number of files will be available in the QAQC folder. These include a csv file, html file, return_count.dtm files, and all the requested image files.
3. Double-click on **QAQC.html** to open it. Take a few moments to go through the summary report. Below we have reiterated some information from the summary report.
 - i. In the File Summary section you should note that the Total Returns for the tiles range from ~22 million to 26 million. Why do you think the Total Returns have this range? How can the vertical structure of the forest cause tiles to have different return numbers despite the data being collected at the same pulse density?
 - ii. Notice the different return density sections: Return Density and First Return (Pulse) Density. Why do you think we use the First Return Density information as a surrogate for pulses per square meter?
 - iii. In the **First Return (Pulse) Density** section, you should notice that 70.15% of the area with data has between 8 and 20 pulses per square meter or greater, while 23.30% of the area has more than 20 pulses per square meter. That means over 93% of the total study area has met our desired quality assessment specifications, and only 6.55% of the area averaged below 8 pulses per square meter. Note that 4.92% of the total area has no points (first returns), meaning that those areas are simply outside of the actual tiles that contain the point cloud.



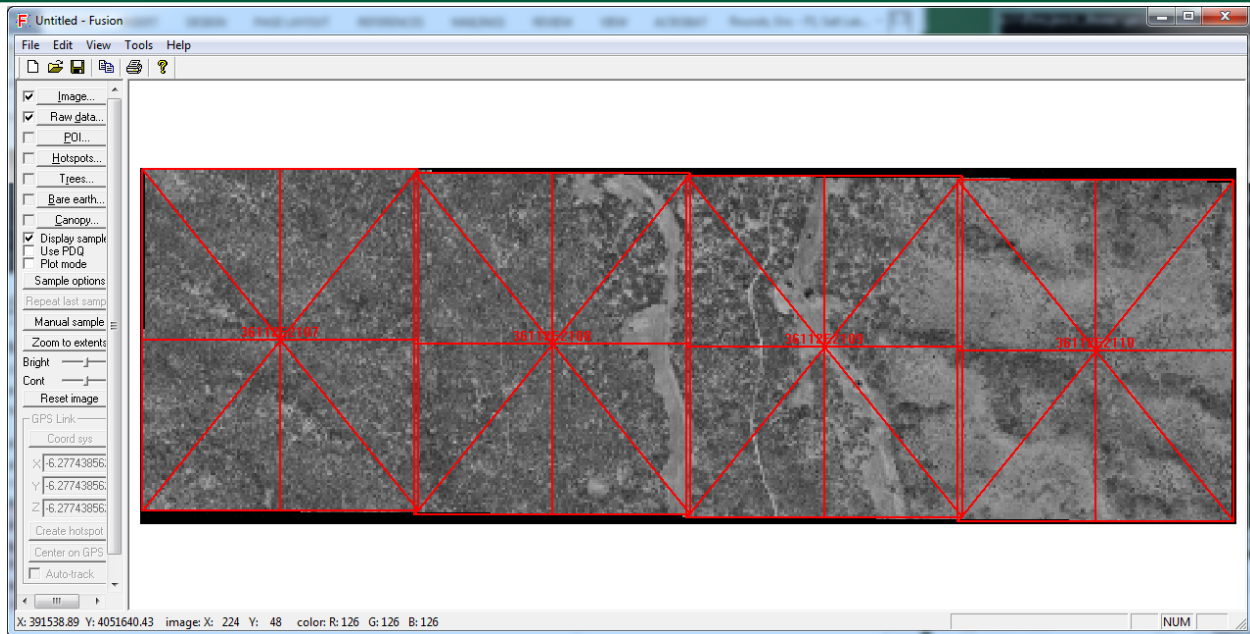
In the above figure 6.55% of the total area did not meet the specification of 8 pulses per square meter (denoted in red). You should also take notice that the spatial pattern of densities reflect the scan pattern and flight lines of the acquisition, which in most cases is OK for subsequent analysis as long as contract specifications are met across the project area.

Part 4: Visualize your lidar data in FUSION

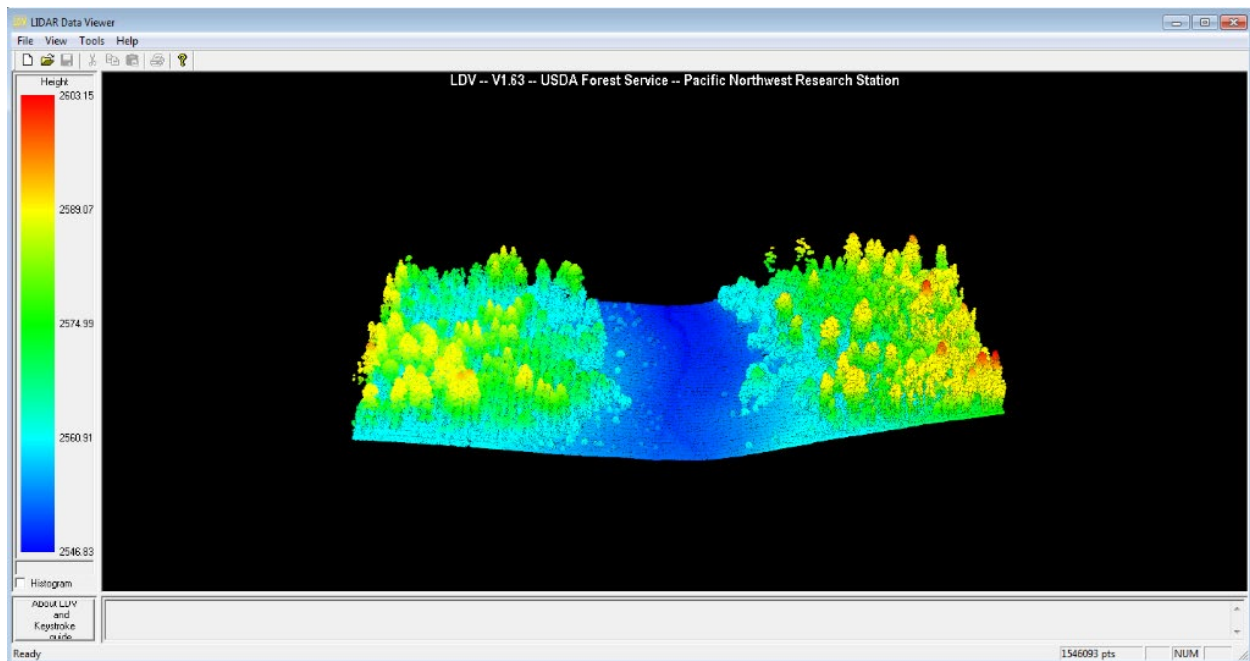
The speed at which the point clouds can be visualized in FUSION is dependent on the size and density of the point cloud as well as the processing speed of your computer. Let's visualize some of our lidar point data. We will provide you with some trouble shooting steps along the way if you find that your computer is having trouble processing the point cloud's visualization.

A. Open FUSION

1. Double-click on the handy FUSION shortcut you created in Exercise 1 or navigate to the FUSION folder on your C drive and double click Fusion.exe.
2. Click the **Image** button, navigate to `\Project_Home\products\QAQC\` and load QAQC_intensity.jpg.
 - i. A spatially referenced image is needed to visualize the data in FUSION. This is one of the primary uses of the intensity data.
3. Click the **Raw data...** button. Navigate to `\Project_Home\point\LAS\all_points\` and Load all the LAS tiles.
4. Click the check box next to the **Raw data...** button. You should now see the tile foot prints overlaid onto the intensity image as in the following figure.



5. Left click and drag a small box into one of the tiles. The larger the box you use to display a sample of the data, the longer it will take the Lidar Data Viewer (LDV) to appear.



6. If you can't get a small area to display in the LDV, click on the **Sample Options** button in the FUSION window and change the Decimation to **10** or higher, as this will only display every 10th point.
 - i. You can then click the **Repeat Last Sample** button display the previously selected sample.
7. Click the **Image** button in the FUSION window, navigate to **\Project_Home\NAIP** and load **NAIP2015.tif** as your reference image. Use the NAIP reference image to locate a variety of land cover types and visualize them in the LDV.
8. If you want to see the above ground heights on the scale in the LDV, select the **Bare earth** button in your FUSION window and add the DTM that you created in the previous exercise.



Congratulations! You have successfully completed this exercise. You now know how to perform a Quality Assessment on your delivered point data using the Catalog utility. This is the first thing you should do when receiving your data and is a crucial step in becoming familiar with your lidar data.