Using LIDAR data to produce an orienteering base-map

by David George, January 2017

Orienteering South Australia

Background

This report covers the steps that need to be performed to go from raw LIDAR data to an orienteering OCAD base map.

Most of the tools described in this report have parameters to tune them for the type of terrain (e.g. actual vegetation in the area), and, to a lesser extent, the quality of the LIDAR data available (e.g. the number of points per meter affects the ability to detect cliffs). The optimum settings for the parameters is something that will be refined over time as more data becomes available, and experience using it increases. Hopefully a repository of parameters can be maintained and refined for various Australian terrain types, allowing mappers to quickly produce base maps.

The data used for this report covers a section of Para Wirra Recreation Park in South Australia. The park is a popular orienteering venue on the outskirts of Adelaide and has an existing, good quality map to compare results to. The vegetation on the current map is out of date in some areas covered by the data however these areas are broadly known.

The sample data as provided by Airborne Research Australia. The data covered approx. 1.8km^2, contained about 79 million points of which about 35 million were ground points and most of the rest were vegetation. This gives an average density of about 43 points per square meter with just under half of those being ground points.

The steps in this report have been refined from information provided by Stefano Raus and Airborne Research Australia.

Stefano Raus is an orienteer from Italy and is in South Australia on the Coach in Residence program. He has produced maps in Italy using LIDAR data and has kindly shared his experiences with us.

Additional LIDAR data for other areas in South Australia has also been obtained from Airborne Research Australia and the internet which has assisted in the learning process for developing maps.

The information in this report is the result of ongoing experimentation, as such there will be refinements to the steps in the future.

OCAD 10 was used for mapping. All other tools used are free and the latest available versions of each were used.

Recommended approach for producing a basemap

This section contains a summary of steps which can be used to produce an orienteering basemap. Details are in later sections.

There are a number of options for producing the base map objects, some of which produce better outputs for orienteering than others. For example most tools can produce contours from LIDAR data however the smoothing and generalization of the contours varies between the tools. The contours produced by Pullautin currently seem to be best for an orienteering map.

The following steps will produce a good quality base map for orienteering:

Pullautin

Use Pullautin to process the LIDAR data. This may requires some iteration to tune the parameters to produce data that is representative of the actual terrain.

Import the following Pullautin vector files into OCAD:

Contours,

Formlines,

Intermediate contours (e.g. 2.5m contours)

Dot knolls and depressions.

Import the Pullautin vegetation and undergrowth into OCAD as background maps.

OL Laser

Use OL laser to process the LIDAR data and produce cliff data and a slope image. Again this may require some iteration to produce good quality files.

Import the OL laser cliffs into the OCAD base map file.

Import the OL Laser slope file image into OCAD as a background map.

Open Street Map Data

If the area being mapped has useful information in open street maps (e.g. paths, roads, etc.) this can be processed and imported into OCAD.

The most time consuming part of the above procedure is Pullautin processing the LIDAR data. Fortunately this can be left to run overnight. Once the tools are installed and reasonable configuration data is available the remainder of the process is reasonably quick and straight forward.

The image below shows the completed computer generated basemap for the Para Wirra area using the above process.
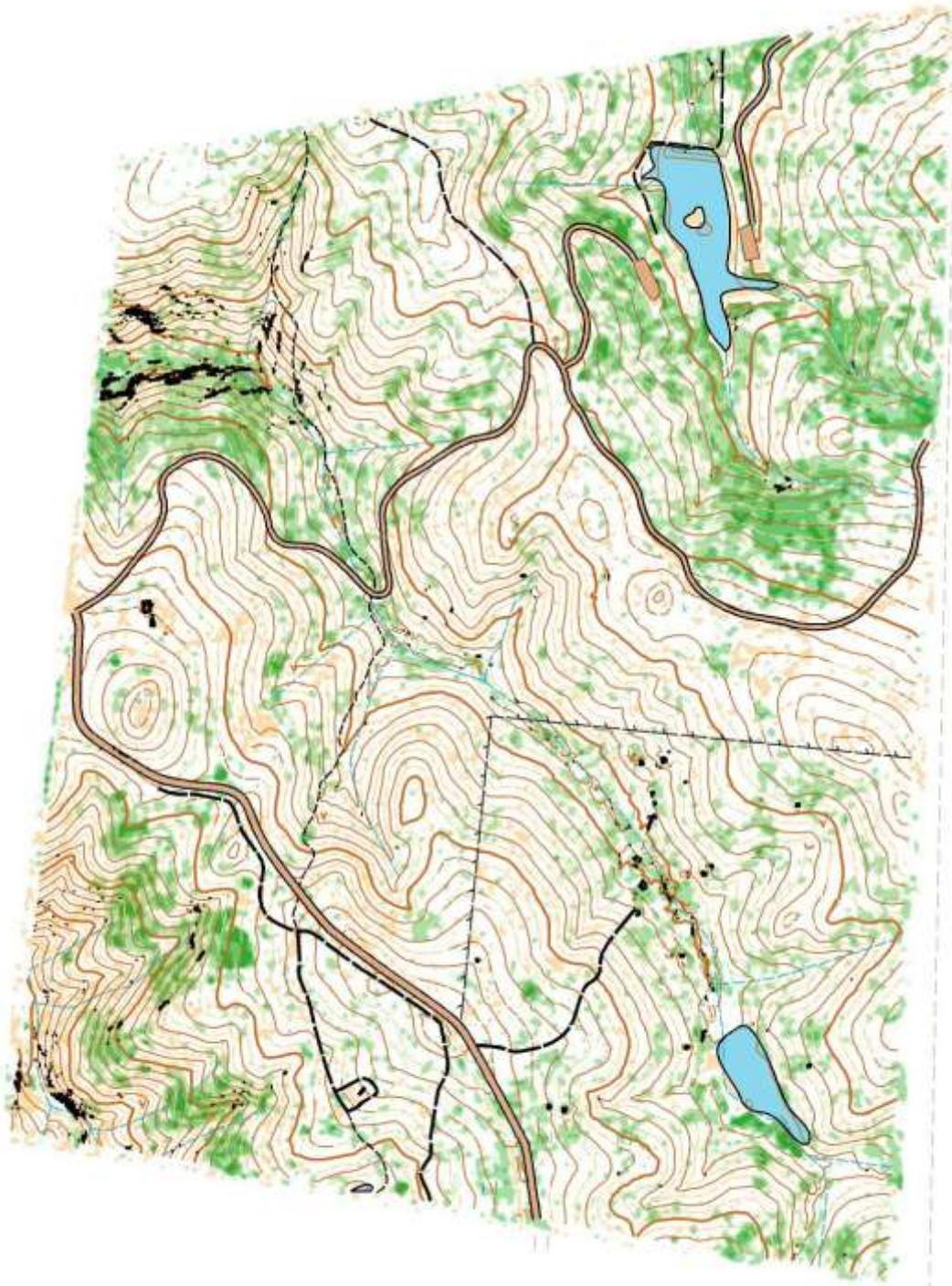
Using Pullautin to generate a base map data and other data

Resources:

  karttapullautin - standalone version: http://www.routegadget.net/karttapullautin/

Pullautin will produce contours, formlines, knolls, depressions, vegetation and cliffs.

To run Pullautin you can either drag the LIDAR file (.las or .laz) to pullautin.exe, or run from a command prompt, e.g. pullautin.exe infile.laz. The easy way to run it is to have the LIDAR file in the same directory as Pullautin.

When Pullautin first runs it creates a file pullautin.ini (if it doesn't already exist) and a temp directory which has the interesting files in.

One of the first things it does it to translate the LIDAR laz/las file into the file xyztemp.xyz, located in the temp directory. If you copy this to the Pullautin directory (rename if you like) it can be used as the input for any subsequent runs, saving the translation time.

Once Pullautin has finished running it will have produced two png image files, with corresponding world files. pullautus.png contains an image of the map. pullautus_depr.png is the same as pullautus.png except contours around depressions are marked in purple. This can be used to manually add slope lines to the depressions.

There are also a number of image files in the temp director which can be imported into OCAD and used as background maps in OCAD. vegetation.png and undergrowth.png are the most useful. Note undergrowth.png has a transparent background and you may need to select transparent for it

Depending on the version of OCAD you are using it may not import png files as a background map. Just open the file in an image editor and save as a gif or jpg file (do not resize the image). You can just change the suffix on the world files from .pgw to .jgw (for jpg) or .gfw (for gif). The transparent background on the undergrowth.png file may be difficult to import. I used gimp to translate undergrowth.png to a gif file, however using a couple of other image programs did not work.

The temp directory also contains a number of vector files which can be imported into OCAD. The dfx files have a number of layers in them for the various symbols they contain. Uses of CRT files can semi automate importing them into OCAD symbols. Suggest importing vector information into duplicated OCAD symbols to allow them to be easily managed.

The first file to import is out2.dxf, which contains the contours. Pullautin generalizes the contours to produce a better orienteering map. Import the contours then convert the contours and index contours into OCAD objects. Out2.dxf also contains 2.5m contours (contours_infered) for use if you want.

Formlines.dxf can also be imported. The density of Pullautin formlines can be tuned in pullautin.ini

dotknolls.dxf contains knolls and depressions for import.

c2g.dxf and c3g.dxf contain small and large cliffs. These files contain many lines to describe a cliff and can only be used to locate cliffs. OL Laser (described below) seems to produce better cliffs than Pullautin. Again there are cliff parameters in pullautin.ini which can be used to tune the cliffs.

pullautin.ini contains the parameters for the program. This may need to be tuned for the actual area being mapped, depending on what you are trying to get from the data. This is because the LIDAR data is a bird's eye sample of the terrain and vegetation. Basically it only contains the height data for whatever the laser hit. It does not have sufficient information to determine what the runability is like without some help. pullautin.ini contains various parameters for tuning the map outcome. The best way to tune these parameters is by knowing how the vegetation in a representative area should be mapped (e.g. from an existing map, another similar area that has a map and LIDAR data, small ground survey) then tuning the data to produce similar results. There is a pdf, greenmapping.pdf which combined with the comments in pullautin.ini give some guidance on tuning the parameters.

The image below contains Pullautin data, including the Pullautin generated cliffs. The vegetation is on the background map, all other items are OCAD objects. The intermediate contours are drawn in yellow. No manual work has been done on the map. The parameter formlinesteepness was changed to 0.2 in pullautin.ini to reduce some unnecessary formlines. The vegetation parameters were also tuned for more realistic vegetation mapping.
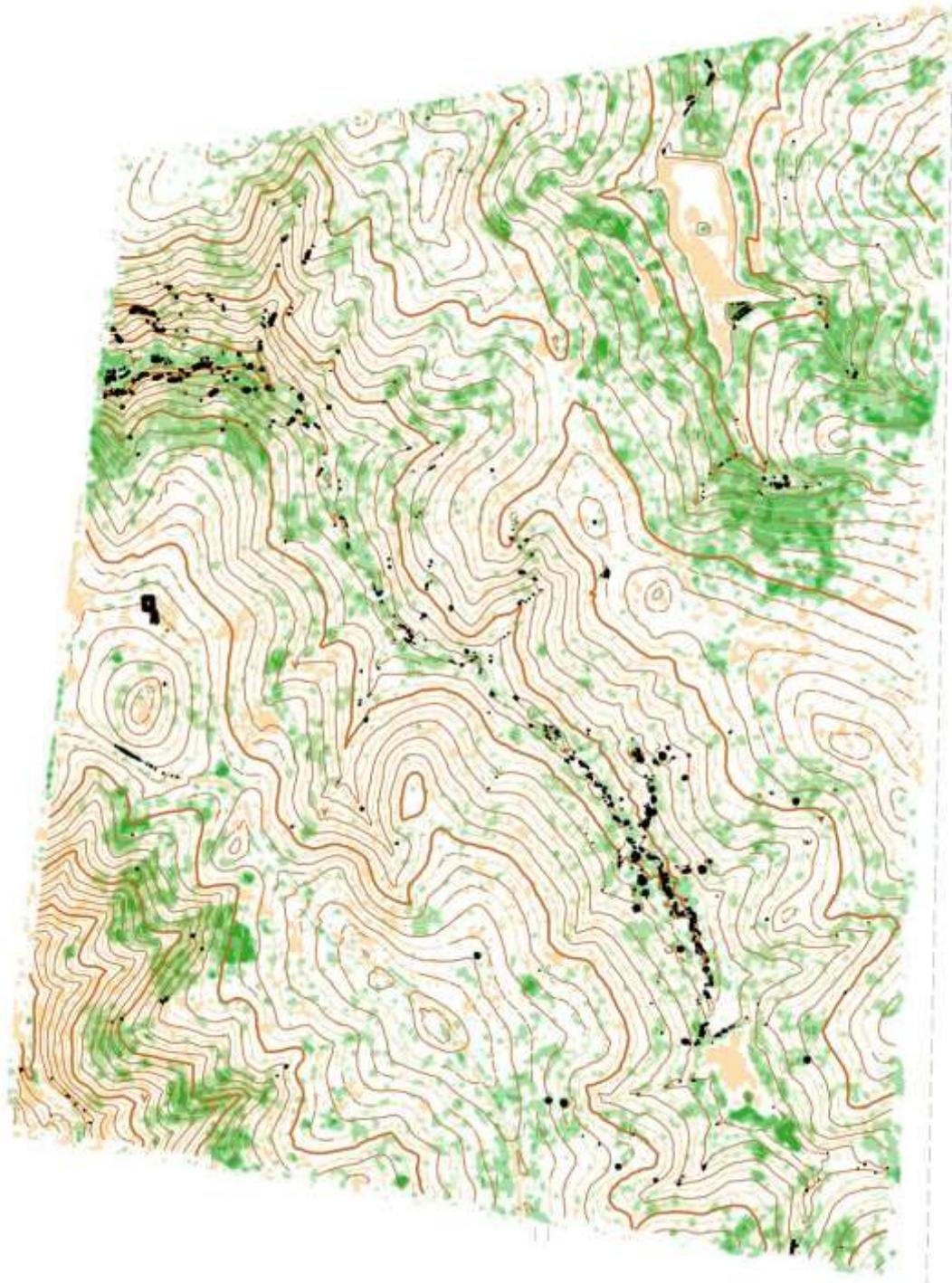
Using O-Laser

Resources:

http://oapp.se/Applikationer/OL_Laser.html, Note pare is in Swedish you may need to use a translator. Use version 1.4.0.5 as version 1.4.0.9 is only in Swedish.

O-Laser is another orienteering focused tool for processing LIDAR data. It can produce OCAD files containing contours and cliffs. It can also produce background images which are useful to the mapper.

O-Laser will not work with a .laz file, it needs to be uncompressed first. LASTools laszip can be used to un-compress a .laz file to produce a .las file.

The data used for the examples was from a 10% subset of the data as O-Laser ran out of memory trying to load the full set of data. It may be possible to improve the results by cutting the data into tiles and processing each tile. O-Laser has a batch processing function to automate this.

The basic steps to use O-Laser are:

Open the lasfile. This generated an error for me but this did not seem to affect anything.

Create a Grid / TIN. The default settings seem OK for this step.

Under O-Map objects select cliffs and then create them and then save them. This creates an OCAD file with the cliffs in. The contours produced by O-Laser are not smooth.

Under Images create a slope image and save it. It can also be viewed by checking the Draw Image box. The images created by the default settings are quite flat. To produce better images you will need to adjust the settings. The settings I used for the para-wirra data was:

$0.041 \; X^2 - 6.5 \; X + 255$, 0.5m pixel size

You may want to try some of the other image types.

The slope image is useful for picking many features from the data, and locating features on the ground when in the field.

The settings for each step can be changed under Maintenance. O-Laser allows multiple setting for each step to be saved so you can experiment and use them again.

The image below shows the O-Laser slope image with the O-Laser generated cliffs.
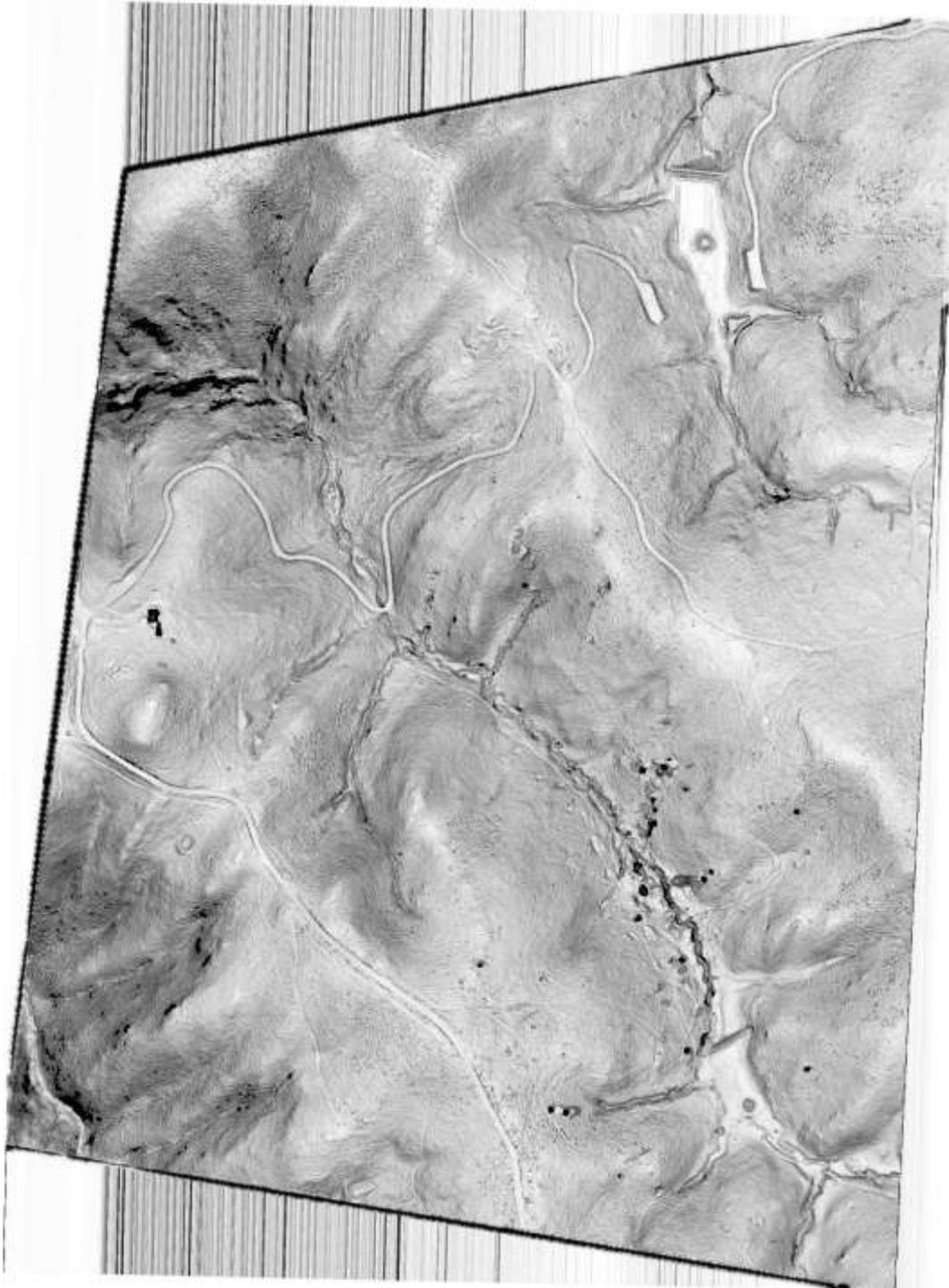
Below is a section of the slope image without the cliffs. As can be seen it is easy to pick out creek lines and other features from the image.
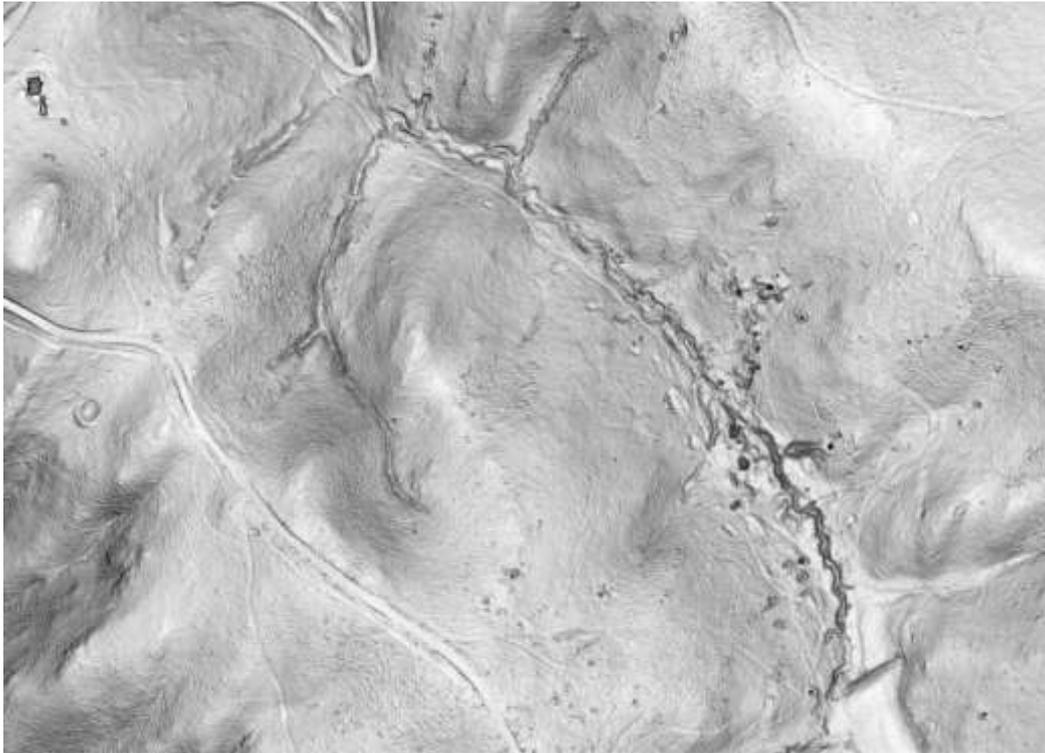
Importing data from Open Street Map using osm2xmap

Resources:

osm2xmap: https://github.com/sembruk/osm2xmap

open orienteering mapper: http://www.openorienteering.org/apps/mapper/

First thing to do is export the required data from Open Street Maps:
https://www.openstreetmap.org:

Find area of interest

Press Export

Manually select a different area

Export

Rename map.osm file that was downloaded to something meaningful and copy to directory where osm2xmap is installed.

Drag the open street map file onto osm2xmap.exe with the mouse. This will run the program.

Open out.map in open orienteering mapper (e.g. double click it).

Check the georeferecing information Map->Georeferencing… You may need to fix the UTM Zone (e.g. 54S)

Delete anything you don't want then File->Save As-> type OCAD (enter a File Name). Open orienteering mapper converts lines to curves easily; you may want to do this before exporting to OCAD.

osm2xmap uses a configuration file, ISOM_rules.yaml, and a template file, e.g. ISOM_15000.xmap to generate the map.

You can copy the template from open orienteering mapper if you want the most recent, e.g. from C:\Program Files\OpenOrienteering Mapper 0.6.7\symbol sets\15000. This template can be edited in open orienteering mapper is required, e.g. to generate duplicate symbols. You can then set ISOM_rules.yaml to create a map using the new symbols.

ISOM_rules.yaml contains the rules for translating open street map data to ISOM symbols. This file will need to be edited it you desire different symbols (e.g. you prefer 503 instead of 504 for a minor road). The default ISOM_rules.yaml has limited coverage for open street map symbols. I have a new file with some more in that I have developed if anyone wants it.

Unknown open street map symbols are drawn as grey tracks. Some of which are not interesting (e.g. council boundaries), some of which we might be. You can use QGIS to examine the Open Street Maps data to see what any missing data is and add a rule to the ISOM_rules.yaml so that it gets included the next time you generate the map.

The quality of the data in open street maps is variable. Some of it seems to have been derived from quite generalized / smoothed data while other bits are quite good.

The imported data may be on a different datum to the LIDAR data. While this can be fixed during processing it is easy to end up with the open street map data offset from the LIDAR data. An easy way to correct this is to select all objects that were imported from open street map and move it all together until it aligns with the LIDAR data. This is generally easy to do with a hillshade (see OCAD or O_Laser section) as the background. If you do this before you import any other data you can just select all objects and shift them.

Example of Open Street Maps data for all of Para Wirra, note a property boundary for a sanctuary was manually changed to the broken fence:
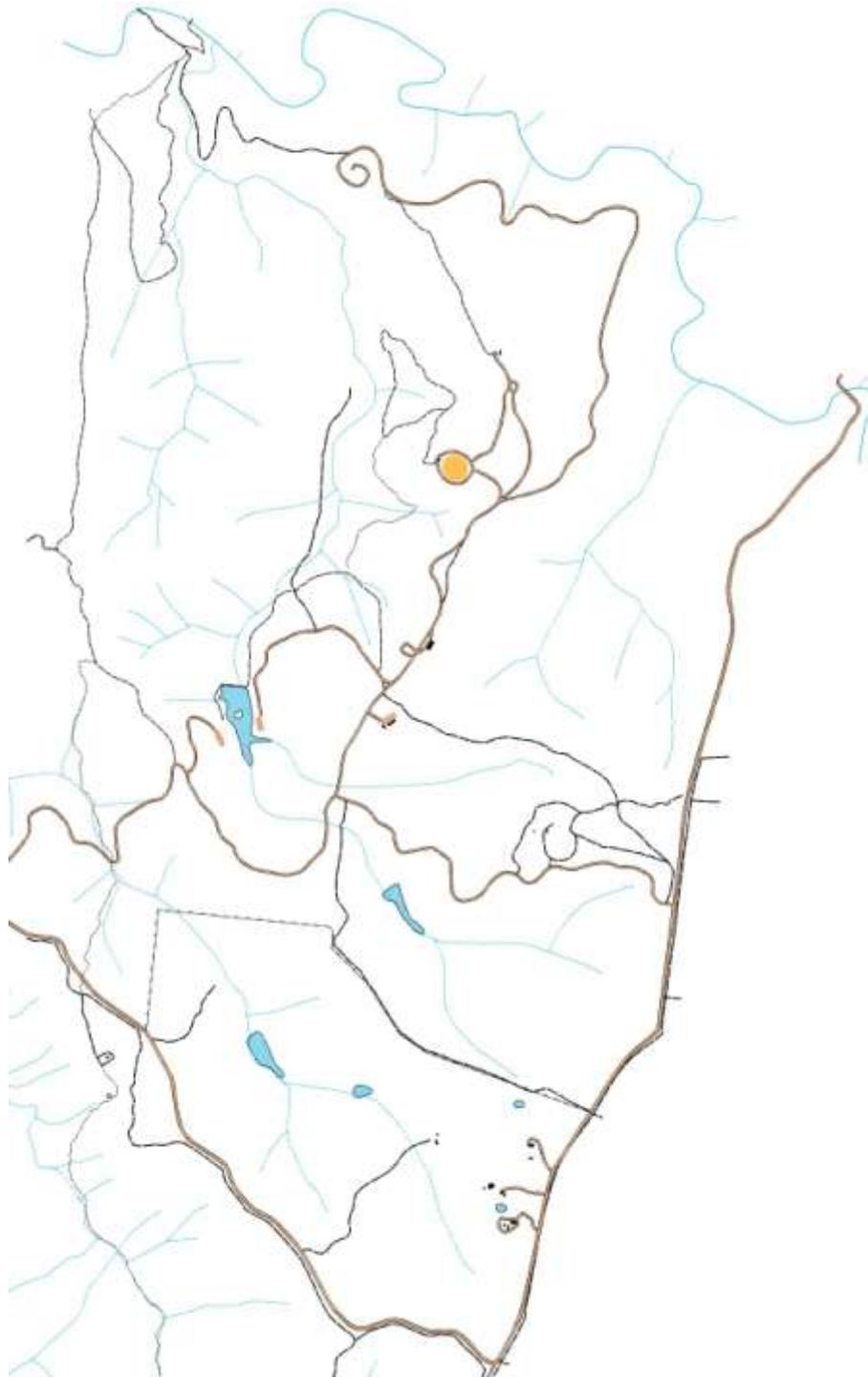
Using ocad to generate contours and hillshade

While the steps above produce good data, OCAD is also able to produce reasonable data and maybe more convenient for some mappers. The new versions of OCAD seem to produce more, and better, data than OCAD 10. The hillshade produced by OCAD 12 maybe better than the one produced by O_Laser.

OCAD can generate contours. It can also generate a hillshade (slope) image. Depending on the version of OCAD it may, or may not import the LIDAR data directly. Older versions (e.g. OCAD 10) need an xyz file to import. LASTools las2txt can generate a suitable xyz file for import into OCAD,

e.g. las2txt -i infile.laz -parse xyz -o outfile.xyz

Importing into OCAD is a 2 part process, first it needs to be imported (DEM menu), which creates an ocadDem file. This file can then be opened. OCAD will show a rectangle containing the data. OCAD may not open files that are too large, see next section for reducing the file size. The contours produced by OCAD will not be identical to those from Pullautin as OCAD due to different smoothing and generalization.

The image below contains OCAD generated contour and intermediate form lines with Pullautin generated form lines laid over the top in purple. The hillshade was generated by OCAD.
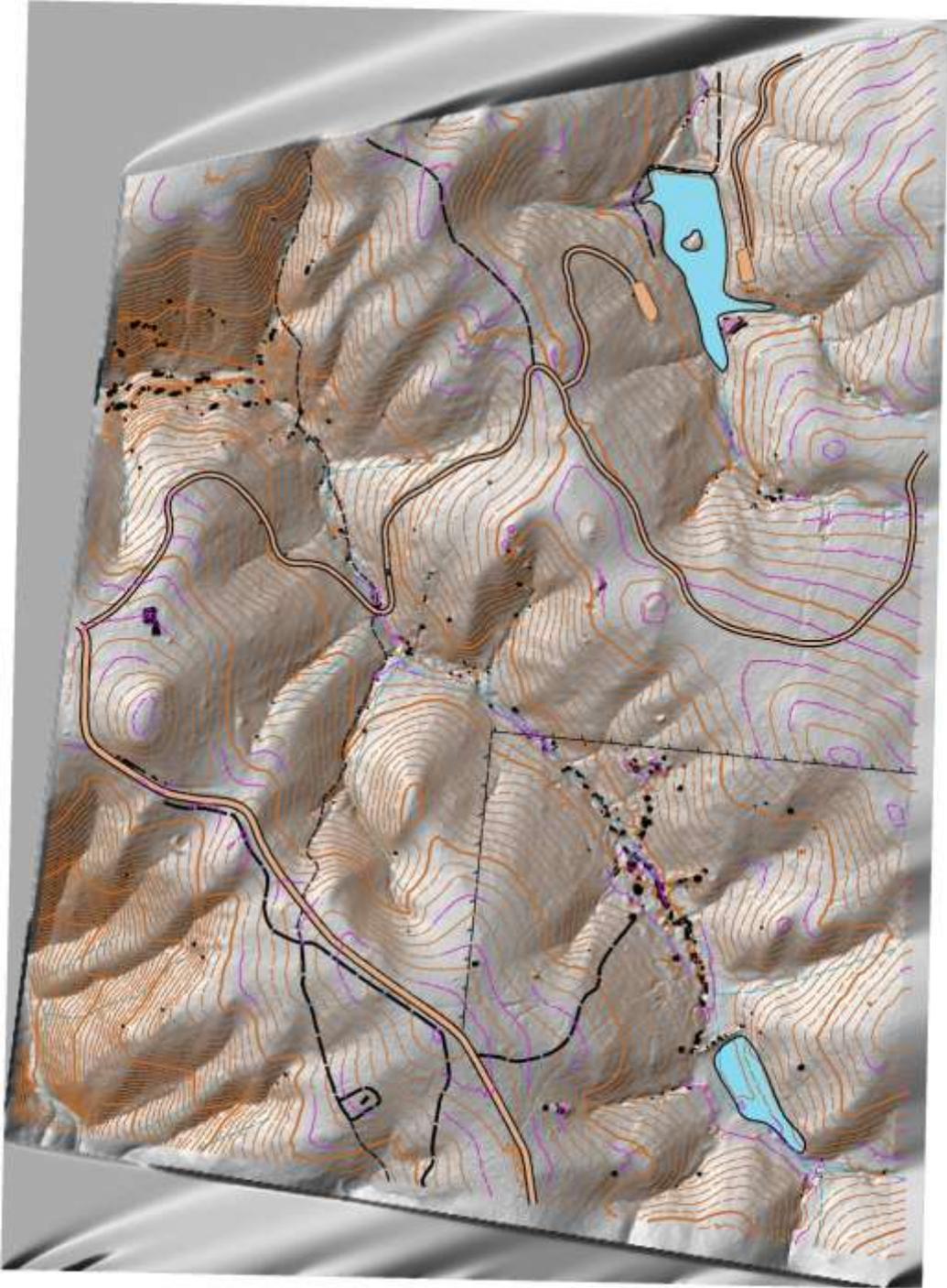
Reducing the size of LIDAR Data

Resources:

>   LASTools: https://rapidlasso.com/lastools/

Sometimes you will need to reduce the size of the LIDAR data you are working on to speed up processing, or just to get a tool to work.

There are a few strategies for reducing the size of LIDAR data file to speed up processing, or just to get the tools to read the data. There are many LASTools with many options. The LASTools directory has a README file for each tool.

What and how you wish to reduce will depend on your computer, the density and area of the LIDAR data and the tool you are using. Depending on the amount of time you have, etc. for example, while you are tuning the parameters to generating a map, you might wish to work on a small data file so you can experiment quickly. You may then leave the programme running overnight on the full data to produce the final map.

>   Reduce the density of the points, this can be done using las2las or lasthin.

>>   e.g. las2las -i inputfile.laz -o outputfile.laz -keep_random_fraction 0.1

>   Remove some of the classification or return types, (e.g. only keep ground points or last returns).

>>   e.g. las2las -i inputfile.laz -o outputfile.laz -last_only

>   Reduce the size of the area to process.

>>   e.g. lastile -i inputfile.laz -o tile.las -tile_size 500

Other tools which may be of use

LASTools

LASTools was touched upon earlier. There are many LASTools with many options. The LASTools directory has a README file for each tool. There is also an overall README file which has a brief description of each tool.

QGIS

QGIS is an open source GIS tool it has integration with LASTools, which allows you examine LIDAR data, and combine with other information.

Vector files produced by Pullautin can be opened and analysed, as can open street map data.

LASEdit (Demo)

The demo allows LIDAR data to be viewed in 3D and for cross section of the data to be viewed. The demo version is fully functional for viewing data; it will not allow any edits to be saved.

The image below shows a cross section of data.