DRONE LAND SURVEYING AND MAPPING

DRONEYBEE

Contents

Introduction

Drone surveying is the future for surveying in the industries of infrastructure, real estate, urban planning and other industries like mining.

This book is a no-fluff, distilled hand guide that will cover all aspects of drone surveying for the beginner. With this knowledge and skill in your possession, you will be fully equipped to start exploring further in the land surveying and mapping domain and perhaps start your own drone business in this area. We'll cover the following topics:

- Flight planning
- Setting up and getting the flight right
- Image capture
- Processing

- Post- Processing

WHAT IS DRONE LAND SURVEYING? ARE THE PROSPECTS REALLY THAT GOOD?

Land surveying is used to produce accurate descriptions of the surface features of the Earth in a particular plot. Tasks such as boundary surveys, topographic mapping and construction staking are done and the resulting output is then passed onto engineers and architects.

Traditionally, land surveying is accomplished using terrestrial surveying equipment like an optical theodolite, robotic total stations RTK GPS base station and optical level. With the advent of drone technology, surveying can be done faster, more reliably and accurately than ever before.

Drones have the capacity to produce sharp resolutions per pxiel and gather millions of data points in a very short amount of time. The amount of time taken to do a survey is exponentially reduced with the use of drones.

Drones also trump traditional land surveying because it can produce outputs like the orthophotography, DSM, high resolution elevation contours and point clouds. Another major advantage with drones is that you can access and survey areas that are normally difficult or dangerous to reach. Good luck trying to beat a drone with terrestrial land surveying equipment!

WHAT EQUIPMENT DO YOU NEED?

Drones come in a myriad of different price points. For surveying and mapping, you could get a fixed wing drone specifically made for it, like sensefly ebee. However, if you are just starting out then this would be overkill and quite frankly, unnecessary. If you want to be competitive you may have to get a drone that is capable of outdoing or at least, matching with your competitors.

A drone like the DJI Phantom 3 or 4 can do survey and mapping operation and are capable of producing almost every output that most of your clients will ask for. If you are a newbie and unsure of where to start, we highly recommend you start with a DJI phantom 3 or 4. Apart from being cheaper, a multirotor drone like the DJI Phantom 3 or 4 will give you greater maneuverability, ease of use and payload capacity.

However, if your budget is higher and you require a drone that offers significantly more range and stability, you could go for a fixed wing drone like the Sensefly ebee. If you want to do long distance inspections in a linear flight path (such as in pipeline inspections), a fixed wing drone will be far more ideal than a multirotor drone.

For processing and post processing, make sure you have a PC that can handle software like Pix4D, AutoCAD and QGIS. We recommend the following specifications:

- Windows 8, 10 64 bits.
- CPU quad-core or hexa-core Intel i7/Xeon.
- GeForce GPU compatible with OpenGL 3.2 and 2 GB GRAM.
- Hard disk: SSD, 30 GB Free space
- 16 GB RAM

SOFTWARE REQUIREMENTS

You will be working with the following software:

- DroneDeploy
- GPS essentials
- Google Earth Pro
- Litchi App
- Pix4D (Processing)
- QGIS or AutoCAD (Post-processing)

ACCURACY OF THE SURVEY RESULTS

Perhaps the most important question to ask with drone surveying and mapping is how accurate the results are going to be. There are two types of accuracies – Absolute accuracy and relative accuracy.

Absolute accuracy is the measure of how objects are accurately positioned on the map with respect to their actual position on the ground, with a reference frame such as the UTM coordinate system. A map with a high level of global accuracy will represent the latitude and longitude of a point in accordance with the actual GPS coordinates with a fairly good amount of precision.

Since measurements are taken and thrown into a 2D map, the objects in the map may have distorted relative accuracy. For example, buildings may appear closer than they are due to changes in elevation. To keep the representation right, maps are tweaked to have relative accuracy. With relative accuracy, if two objects are 5m apart from each other in the real world, it should be 5m apart in the map.

Ultimately, your project goals will determine the level of accuracy you require. Many projects will only require you to have relative accuracy while some projects will need to have global accuracy. You maybe tempted to think that greater accuracy is always required but this can add to time taken and cost of your project.

For projects involving small scale measurements, monitoring crop health in fields and visual inspection of progress of a construction project, relative accuracy is usually sufficient. Relative accuracy is enough if you only need information from within a map but do not need to position that map in the actual real world. Following are some example use cases, according to DroneDeploy:

- **Small-scale measurements** – e.g., area of a field, length of a fence, width of a stockpile
- **Management and oversight** – e.g., keeping tabs on general progress of a construction site
- **Crop scouting** – e.g., assessing damage after a storm, monitoring crop health
- **Marketing** – e.g., creating a time-lapse or 3D model project to share with prospective clients

On the other hand, you need absolute accuracy in scenarios such as:

- **Land title surveys**
- **Design documents and records for construction projects**
- **Environmental records**
- **Overlays of geo-referenced site plans**

In general you can expect the following levels of accuracy:

- Relative accuracy: Usually tied to the ground sampling distance (GSD) data that your drone captures. It'll be

measured in cm/pixels. We'll cover what GSD is in later chapters, but for now remember the following:

1. The horizontal relative accuracy is 2 time the GSD
2. The vertical relative accuracy is 3 times the GSD

- Absolute horizontal accuracy: Within 1 meter range. Your GPS location will be within this range of error.
- Absolute vertical accuracy: Usually 3 times worse than the horizontal accuracy.

PLANNING YOUR FLIGHT

With drone surveying and mapping, unlike aerial photography and videography, you might want to create flight plans before you head to the location and set your drone to autonomously fly over the area that has to be surveyed where it will captured the required images and data. Your flight plans will involve setting the overall path of the flight, direction, speed, camera-angle, camera-exposure, altitude and overlap of images.

In this guide, we'll use 3 different software in tandem to create our flight plans:

1. GPS essentials: Used to mark the GPS points of the boundaries of the site that has to be surveyed
2. DroneDeploy: Planning the capture of nadir images
3. Litchi: Planning the capture of oblique images

TYPES OF IMAGES

There are two types of images your drone needs to capture, depending on the project:

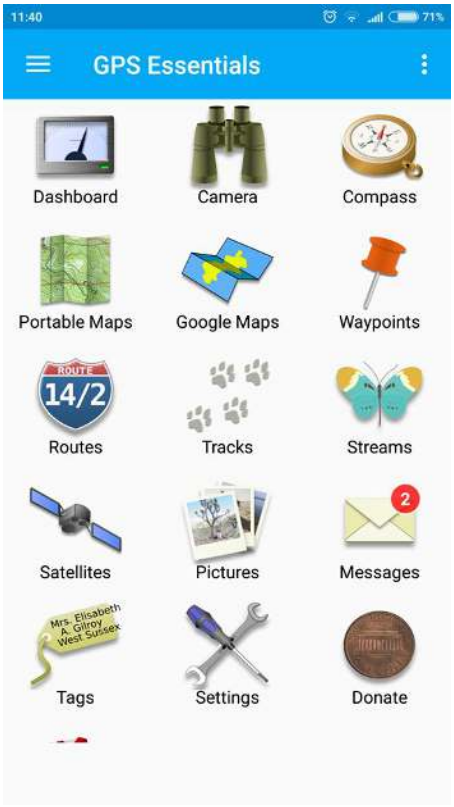
1. Nadir image : An image taken with camera pointing directly down (typically of the land and required in almost

every project)

2. Oblique image: An image of an object taken at an angle (used to survey buildings and other objects to create 3D models)

WAYPOINT SETTING WITH GPS ESSENTIALS

If your client does not give you the GPS coordinates of the boundaries of the site, then you have to go on-site and set the waypoints yourself. Download the GPS essentials app on your phone and go to each site boundary. Typically, your customer will have marked the boundaries for you on-site.



Stand on top of the site boundary point with your phone, and mark the waypoints using the app. Choose an icon that you deem appropriate. Make sure to wait until the accuracy of the waypoint is low enough (lower than 5m)


11:41
71%
Waypo...
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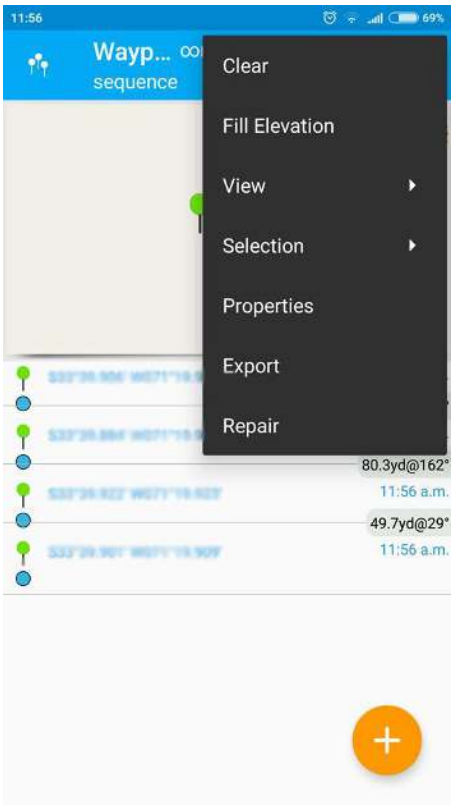
Reiterate the step by marking the waypoint on each boundary point. It is important that you do this in the right sequence. After you are done, export the file as a KML Google Earth file which will be then used to create flight plans (top right hand corner)


11:56
69%
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Repair
80.3yd@162°
11:56 a.m.
49.7yd@29°
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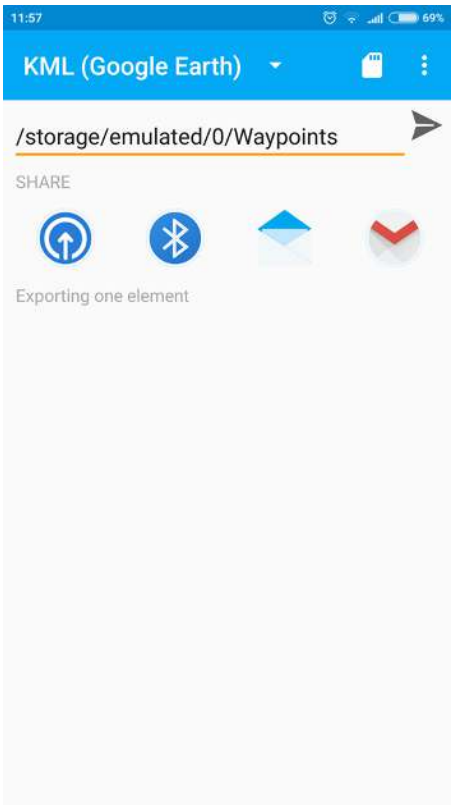


If your client gives you the boundary points in excel, you can convert this into KML file with Google maps or using a tool like the following: http://www.earthpoint.us/ExcelToKml.aspx

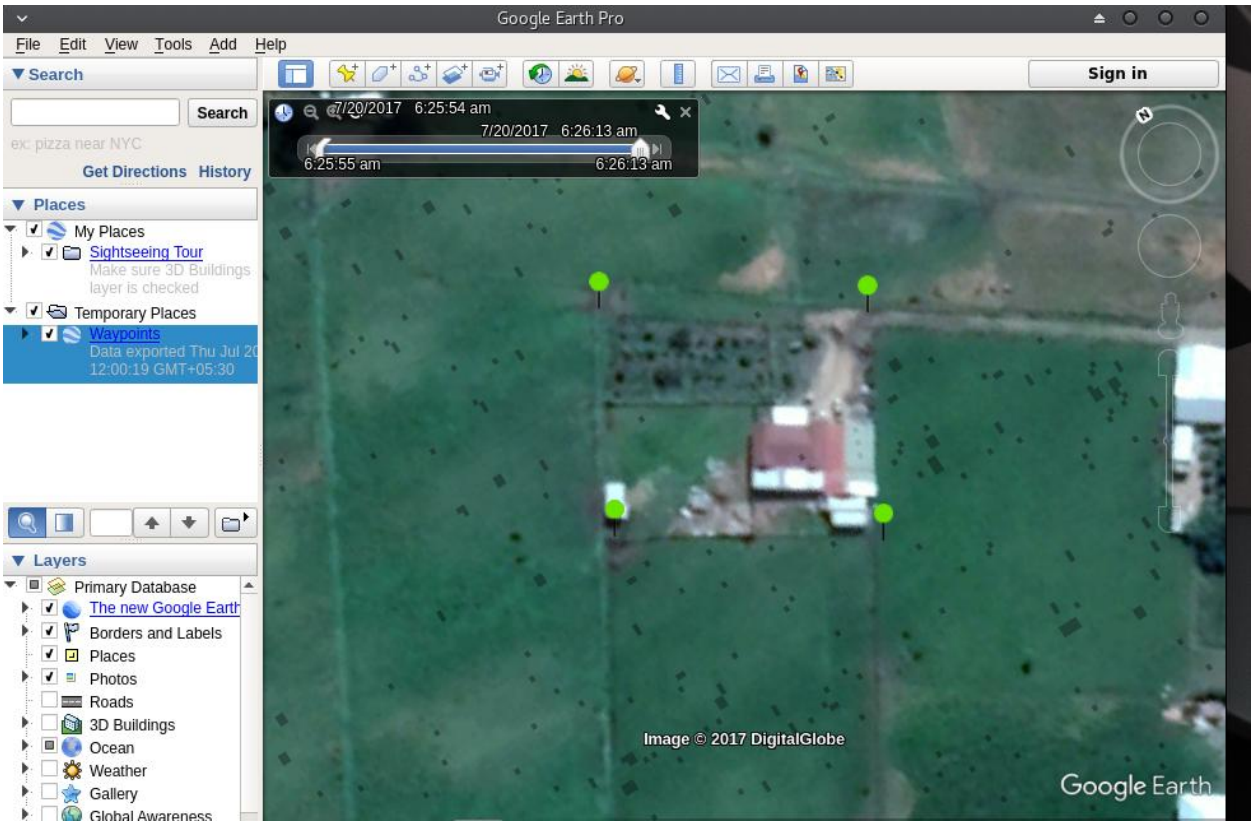
Importing image with Google Earth and creating a flight plan with DroneDeploy

In order to create a flight plan, we'll go through two steps:

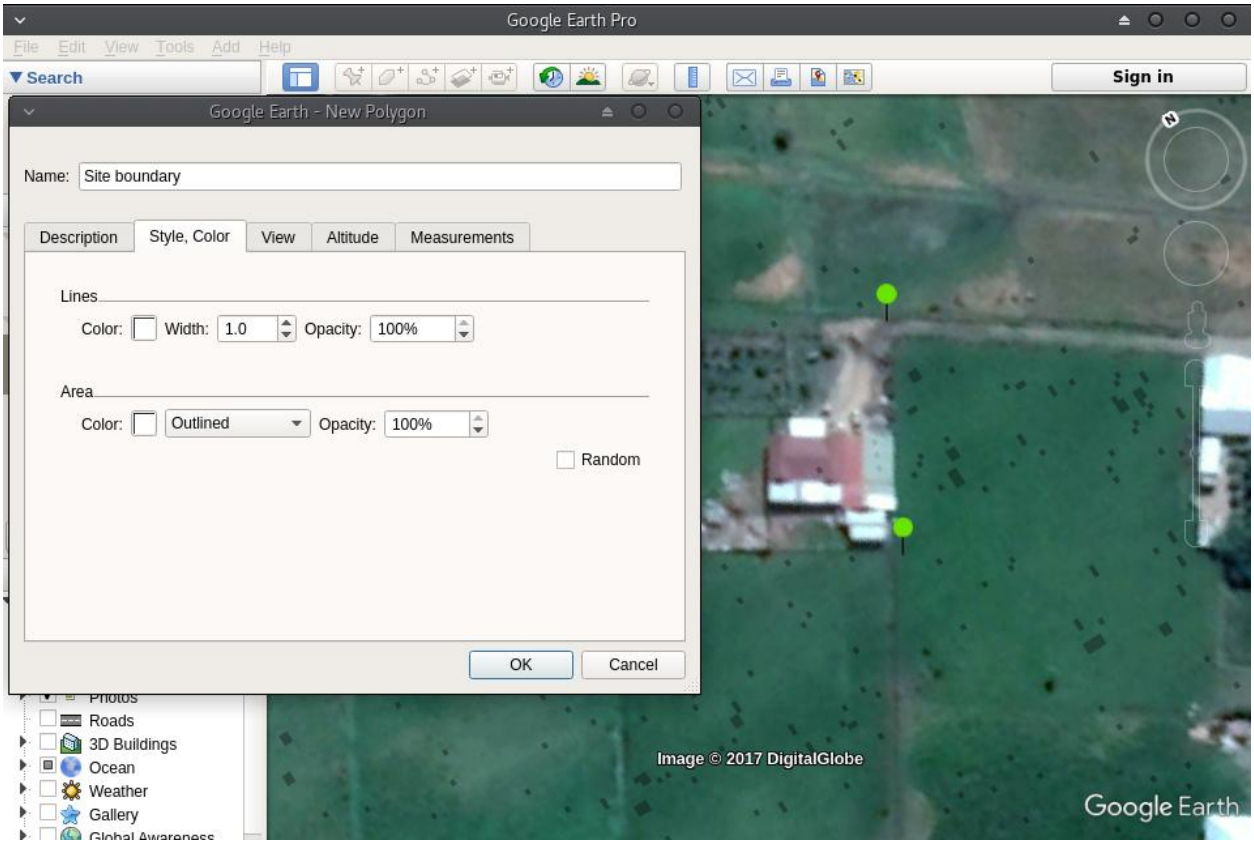
1. Create a boundary polygon with the KML file that we exported with GPS essentials (in Google Earth)

Before you can create the actual flight plan in DroneDeploy, you have to create a boundary polygon. With the GPS coordinates of the boundary points you marked with the GPS essentials app in the previous step.

First, open up the KML file that you exported with Google Earth. As soon as you do this, Google Earth will zoom into the location of the waypoints.



Create a boundary polygon connecting all the waypoints by clicking on the "add polygon" on the top of the screen and use the settings in the image below. Connect the waypoints in the right order. If you are unhappy with the boundary, you can click on the vertices of the polygon and drag it to fit the correct boundary of the site


Google Earth Pro
File Edit View Tools Add Help
Search
Sign in
Google Earth - New Polygon
Name: Site boundary
Description
Style, Color
View
Altitude
Measurements
Lines
Color:
Width: 1.0
Opacity: 100%
Area
Color:
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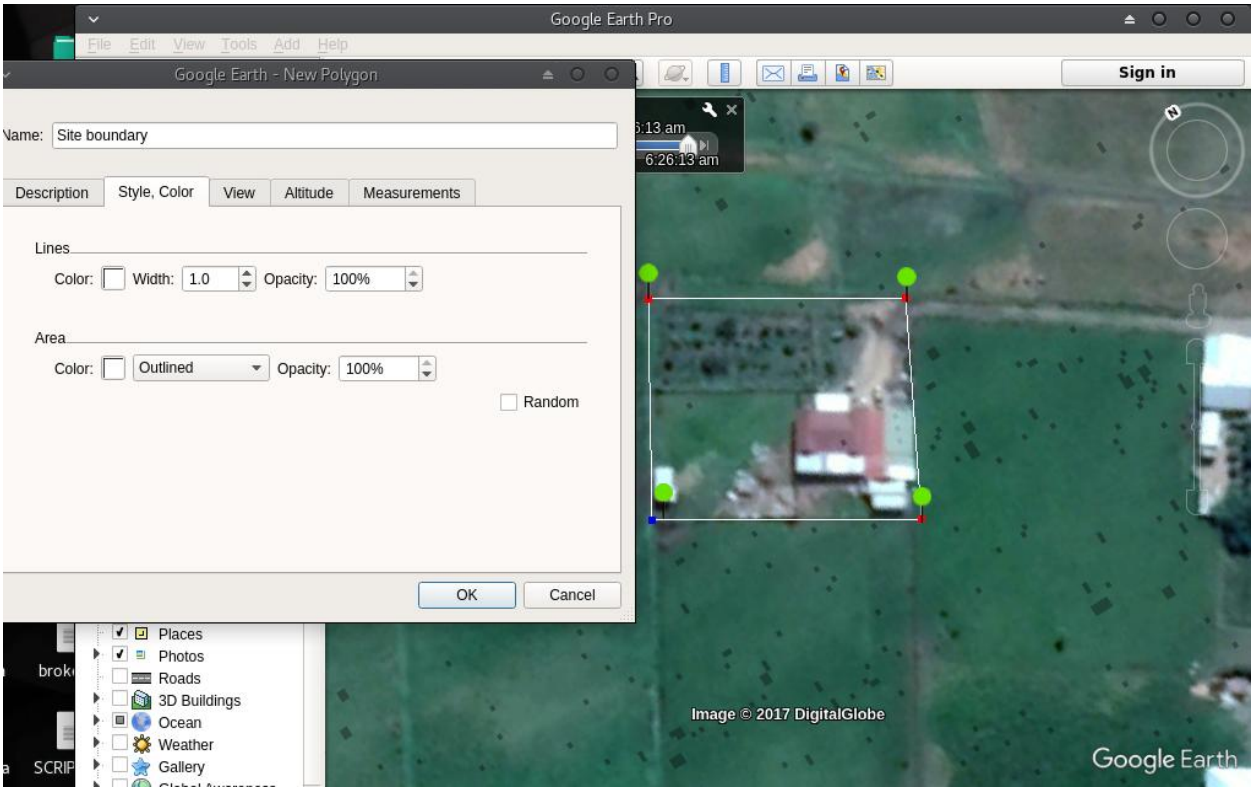
Opacity: 100%
Random
OK
Cancel
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
Image © 2017 DigitalGlobe
Google Earth

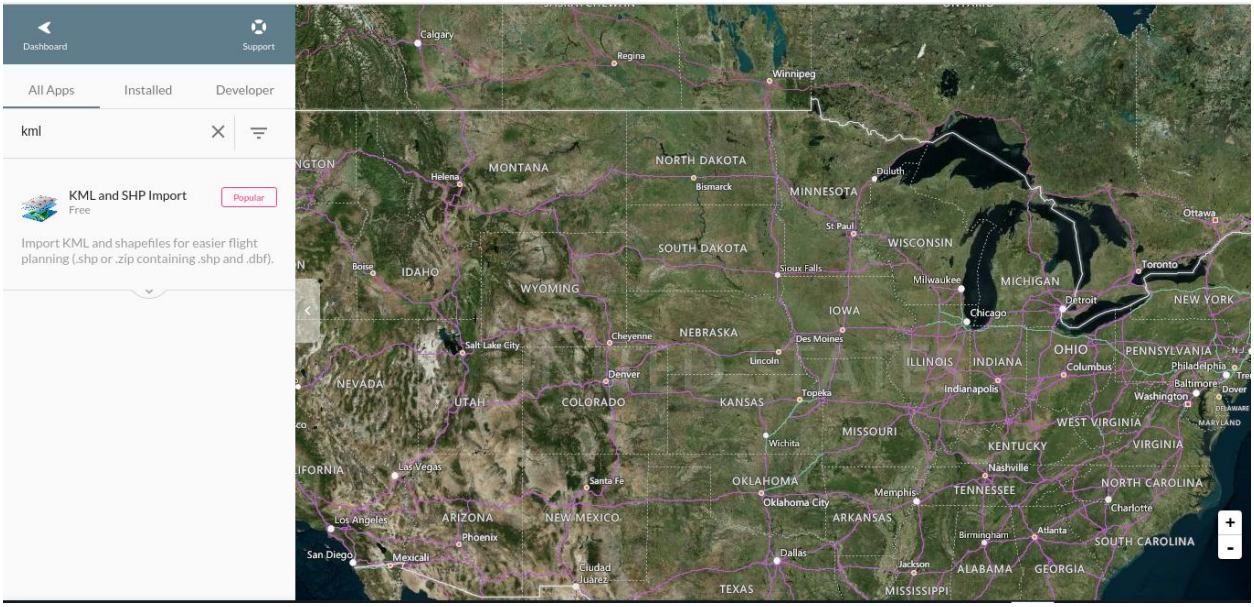


Next, save the boundary polygon as a KML file by right clicking on the polygon under the places tab.

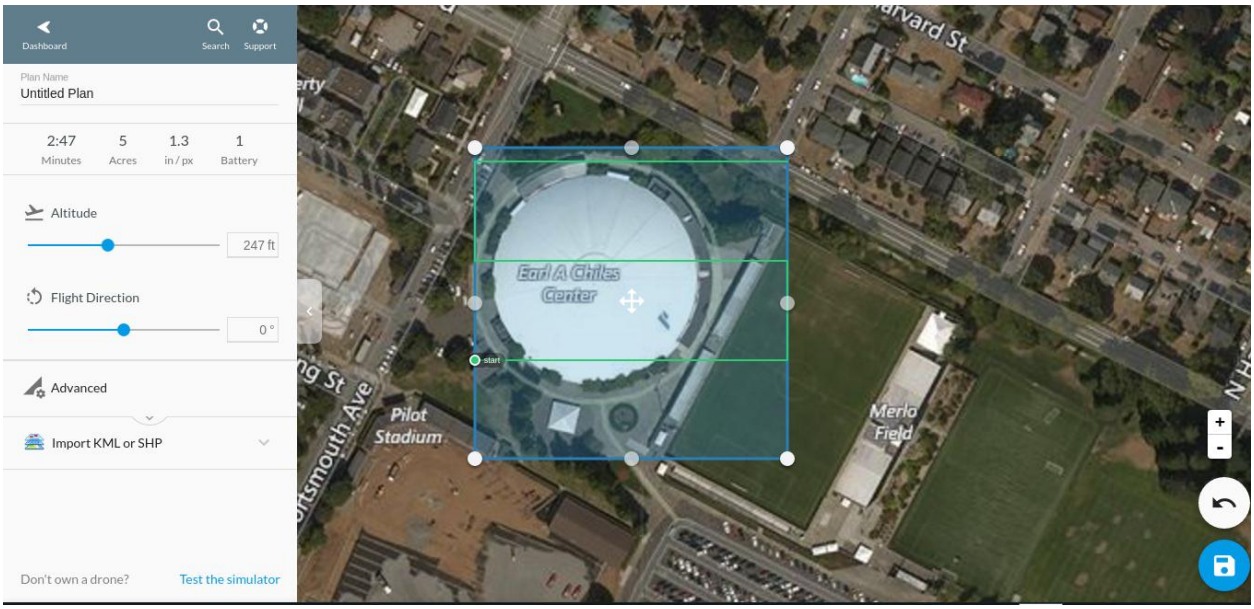
2. Use the boundary polygon in DroneDeploy to create a flight plan.

Note that we'll be working with the DroneDeploy desktop app to create the flight plan. This is the best approach as it will make things easier. The flight plan will then be synced onto your mobile app before you head out to fly your drone on-site.

Open up DroneyDeploy and before you do anything, go into app market and install KML and SHP import.



With this installed, you will now be able to import the KML file of the site boundary polygon that we created in the last step. Create a new flight plan and do just that. Note that you might have to actually search for an existing flight plan in the dronedeploy and click on it to enable the import KML option.



Click on Import KML or SHP at the bottom left and select the boundary polygon that you saved with Google Earth.

The boundary polygon will be automatically converted into a flight plan like magic!

Next, extend the boundary polygon (slightly) by dragging the white dots to ensure that the no part of the site will be missed during the actual flight survey.

The other settings on the flight plan are:

- **Altitude:** By default, this will be set to 75m. This is a decent altitude that will give you a good amount of resolution (GSD). If you increase the altitude, the quality of the resolution will decrease. Make sure to adjust this according to the flight time and the amount of battery it will take. Ultimately, it will depend on your client's requirements.
- **Flight direction:** Adjust this according to where you want the drone to start and end up in. This is especially useful if your flight plan involves changing the battery in the middle of a mission. For example, you may have to position yourself near to the drone so that it can come back to you without running

out of battery. Plan the flight direction according to all these factors.

- **Advanced settings:** Sidelap and front lap is usually set higher to get higher quality maps. Higher numbers will increase the number of lines across the site area that the drone will pass through to get higher quality maps which is needed incase you need more detail (for example, in 3D modeling).
- Flight speed settings will be adjusted automatically according to sidelap, front lap and altitude so it is best not to tinker with flight speed separately.
- Make sure to set the starting waypoint according to where you'll be starting your drone flight in the site area.
- Automatic camera settings are best left at ON and orbit at the end of mission is set to OFF, because we'll be using Litchi App for orbit missions.

Save the plan and move on to Sync it to your DroneDeploy Mobile app.

WHAT IF THE NUMBER OF WAYPOINTS OF YOUR SITE IS BEYOND DRONEDEPLOY'S CAPACITY?

Sometimes, the number of waypoints that you create using the GPS essentials app will be too much for the drone to handle (typically the case with most DJI phantom drones). In such instances, you might get an error return stating that the file is not supported when you try to import it in DroneDeploy

To work around this, you will have to divide the map into multiple maps in Google Earth Pro.

1. First, copy the KML file to create a second KML file of the same map and rename the second KML.
2. Uncheck the first KML file and right click on the second KML file and click properties
3. Choose 2 points that will divide the map into two (Or more, depending. Here will only look at splitting into two). The split will happen where you connect the 2 points into an imaginary line.
4. Click on the lowest point relative to the first point and delete the vertices till you reach the point that you have chosen to split. Do the same for the second point to create the exact half of the map
5. Do the same for the first KML file by unchecking the second KML file. Choose the same 2 points and this time, click on the highest point relative to the first point and delete the

vertices before you move on and do the same for the second point. This will create the other half of the map.

6. After you have created the two halves, make sure that there is some overlap between the polygons of the two halves. This is so that no area goes missing during the survey. Push the edges of the halves into each other to do this by dragging the points.
7. Go to drone deploy and import the halves.

LITCHI APP: CAPTURING OBLIQUE IMAGES OF BUILDINGS AND OBJECTS FOR 3-D RENDERING

Oblique images are important to capture if you want to create an accurate 3-D model. In our experience ,Litchi is the best tool for this so far. First, you must go to the litchi website and create the waypoints for the path your drone will take while capturing oblique images. (go to flylitchi.com/hub).

Login (register if you don't already have an account) by clicking on the button at the top right hand corner. Create waypoints around the object that you want to take oblique images of (click on the spots). This is where your drone will fly to. The image waypoints in the image below may look messy but the drone has to fly in a manner that will capture according to your client requirements.

Now, create the point of interest at the center of the object (right-click). This is where the camera of your drone will be focusing on, during the flight. In most instances, this is going to be the center of the object.

Save the mission and then load it onto your phone app (Litchi App)

Tap on the first waypoint to select the altitude and change the gimbal pitch mode to focus POI (or the camera will not focus on the point of interest). Repeat the same step for each waypoint.

Now, tap on the point of interest and select the altitude of the point of interest. This altitude is going to determine the vertical angle at which the camera is going to focus on the POI. Typically, you want the altitude of the point of interest to be half of the height of the object of focus. For example, if the building's height is 40 meters, you want the altitude of the point of interest to be 20 meters. This will ensure that the camera will not only focus on the set POI, but will do so at 20 meters which is half the height of the building. What does it mean? This means that the focus is at the exact center of the object at all times. This will help capture the entire building.

THE PRE-FLIGHT AND ACTUAL FLIGHT

PRE-FLIGHT CHECKLIST

Before you go to the survey site with your drone, here are a couple of pre-flight checklists:

- Be aware of the safety and regulations in your area. Make sure to check out knowbeforeyoufly.org.
- Make sure the batteries are charged (both drone and transmitter batteries).
- Make sure the propellers are tight and balanced.
- Make sure you carry sun glasses, especially if it is sunny. This will help you spot your drone in the sky.
- Know how many batteries you will need and make sure you carry that many to the site.
- Carry battery chargers. A car charger is a bonus.
- Make sure you carry your phone in which the apps are installed and the cable that is used to connect the phone to the transmitter.
- Carry a take-off and landing pad for the drone. You do not want the gust of wind from the drone trying to take off and land to throw sand on your face!

- Make sure you carry a range extender.
- Make sure your internet connection device is functional.

Pre-Flight marking

In post-processing, we'll have to mark boundaries of the site on top of the orthophoto, contours and other outputs that we'll get from processing the image. In order to make this process possible, you will have to go to the site that is to be surveyed and mark the boundaries manually.

While you do not need anything fancy to do this, you will need to mark the boundaries with something that will be clearly visible from the altitude that your drone will fly at. Mark an 'X' on each of the vertices of the boundaries of the site with either brick powder, lime powder or anything that you think will make it clearly visible from the sky, depending on the color of the ground.

WHERE TO TAKE-OFF FROM?

The ideal take-off point for your drone would be near or at the center of the flight plan. This will ensure that your batteries are used optimally. Starting at an extreme end of the flight plan would unnecessarily drain the battery either at the beginning of the flight (if you start the flight away from the first way point) or in the middle or end of the mission when the drone has to return to you.

Starting at the center and with the use of a range extender will ensure (in most cases) that the drone remains in range during the entire course of the flight.

- Keep a safe distance from your drone at all times
- Make sure to pick an open field with little to no people and pets around for take-off . If the place is wide open with no objects like trees, then it is even better.
- If the drone is crashing immediately turn the throttle off. This will not only minimize the damage to the propellers and motors of your drone, but also to people, pets or objects it might potentially crash onto.
- Make sure that the take-off is done at the highest point (in case there are buildings that may come to obstruct your drone at the set altitude)

THE FLIGHT

Over the course of the flight here are a few things you may want to take note:

- Make sure you and/or your spotter has eye on the drone at all times
- Monitor the battery level
- During flights where you need to drain multiple batteries, you may want to change the starting point of the take off after recharging the battery during the second, third etc flights.

To perform the flight, connect the transmitter to the phone using the cable. Place the drone on a level surface, ideally on a take-off and landing pad. Now, start the DJI Go app and select calibrate the drone under settings tab and follow the instruction. Before you close the DJI Go app, take a test shot with the camera in the app.

Now, close the DJI Go app, launch the DroneDeploy app, make any necessary changes and launch the flight by pressing the button at the bottom right. Your drone will now fly over the flight plan and capture the images. Once it is done, it will automatically return to you with the captured images.

QUALITY VERIFICATION AND CREATING A SECONDARY FLIGHT PLAN

Once you take the SD card out and plug it into your computer, make sure the quality of the images are good enough. Make sure the images are not blurred out or overexposed.

Next, upload the images onto DroneDeploy in your PC and check if the area coverage is completed fully. If not, you will have to fly your drone again through the site area that was not covered by the drone.

Before you do this, you will have to create another flight plan by editing the original flight plan and deleting the vertices of the area that was already covered and then adjusting the remaining vertices.

PROCESSING THE CAPTURED IMAGES

After we have captured the images and the data associated with it, we are far from done. We need to process those images to get specific outputs which we will then post-process and hand it over to our clients. In this chapter, we'll mainly look at how to process the captured images using Pix4D. It has to be the most reliable and accurate software out there for this purpose.

WHAT DO WE GET AFTER PROCESSING?

Here are the main outputs we're looking to extract from our images by processing:

THE DEM

The digital elevation model or DEM is a 3-D representation of the terrain's surface. There are two types of DEM outputs we'll be looking to generate:

- The digital surface model (DSM) : Is the surface with all objects on the terrain like trees, buildings etc. It captures the elevations of all objects on the terrain.
- The digital terrain model (DTM) : The ground without any objects

3-D MODELS

3-D modeling is the process of developing a mathematical representation of any surface of an object in three dimensions. You can process 3-D models of buildings and sites using the oblique images that you capture during the drone survey mission.

POINT-CLOUD

Point-clouds are sets of data points in the coordinate system. For our purposes, the each data-point in the point-cloud will have a 3-D (x,y,z) value. It is a representation of the surface of any 3-D object or terrain.

CONTOURS

Contours are lines on a map that connect points of equal elevation. They can be used to measure and compare the elevation at any point on the map. They are used to measure the steepness of the elevation differences between different points on the map.

The elevation interval setting determines how precisely you want the contour lines to be drawn on the map. You can set the elevation interval according to your client's requirement and it can be as small as 10 cm in a drone survey mission.

Regardless of the elevation interval, the closer the contour lines are to each other, the steeper the elevation difference.

ORTHOPHOTO

A normal aerial photograph is not a map and cannot be used to measure real distances due to the large number of distortions and displacements caused by camera tilting and topography.

An orthophoto or "orthomosaic" is an aerial photography that is geometrically corrected, making it uniformly scaled throughout. The distortions are taken care of. Since they are uniformly scaled, it is possible to measure directly on an orthophoto unlike other maps. Orthophoto is usually used as a base layer onto which other map information are overlaid.

PROCESSING WITH PIX4D

Pix4D uses the images you captured during the drone survey to generate orthophotos, point clouds, digital surface, contours and terrain models, textured models and so on. These outputs will then be post-processed before handing over to the client (covered in the next section of this book) .

There are two versions of the Pix4D – cloud and desktop. In the cloud, you upload all the images onto the cloud and the processing takes place in the Pix4D servers. In the desktop version, the processing happens locally. You can create outputs such as DSM, 3-D models and the orthophoto. You can also do distance and area measurements.

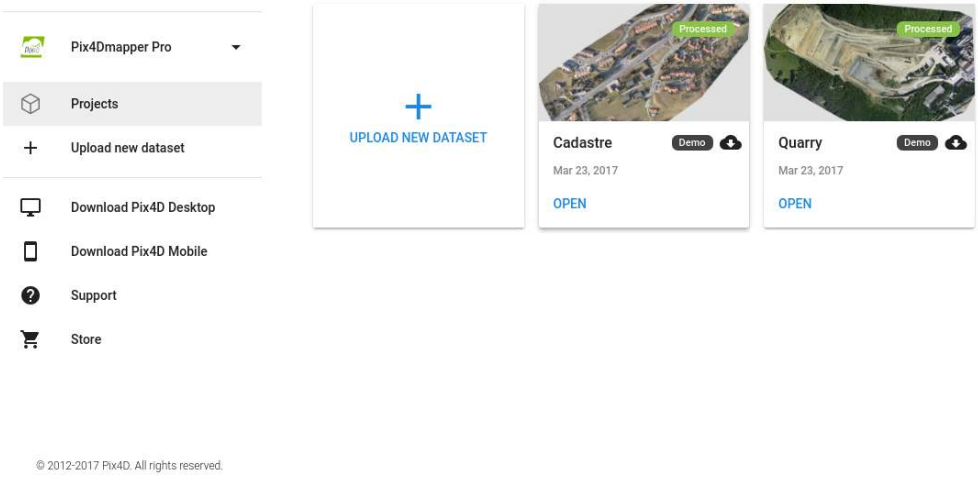
With the desktop version, you have more control. You can do advanced analytics, processing and visualization that you will not be able to do with the cloud version. Do note that you will need the appropriate system configuration (mentioned in the first chapter) for processing images locally.

PROCESSING WITH PIX4D CLOUD

To access Pix4D cloud, go to https://cloud.pix4d.com/ and signup if you do not already have an account. You can get a 15 day trial after which you'll have to pay up.

After you have logged in, you'll have the option to either download the Pix4D desktop or use the Pix4D cloud. Select the Pix4D cloud version to access.

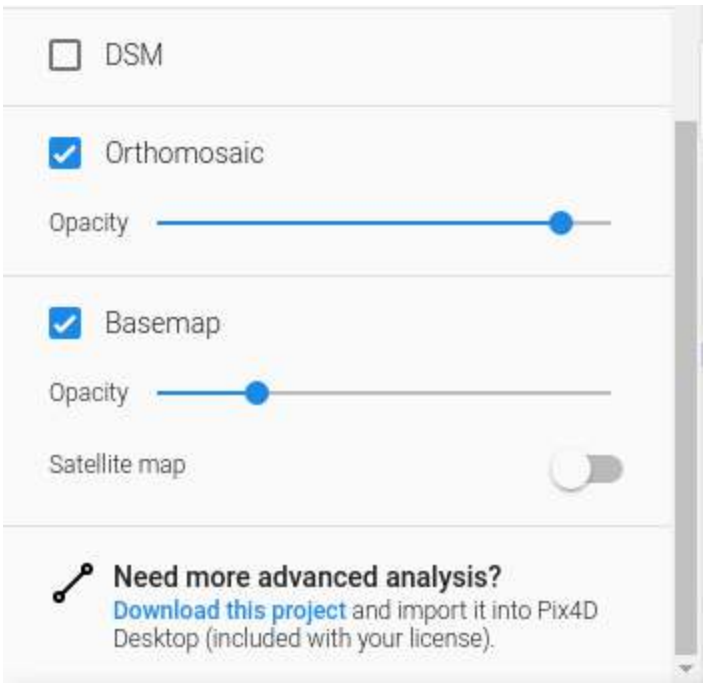
Once you've logged in you'll be presented with the following screen:



You have to option to select Pix4Dmapper pro, Pix4Dbim, Pix4Dag and Pix4Dmodel on the left hand side.

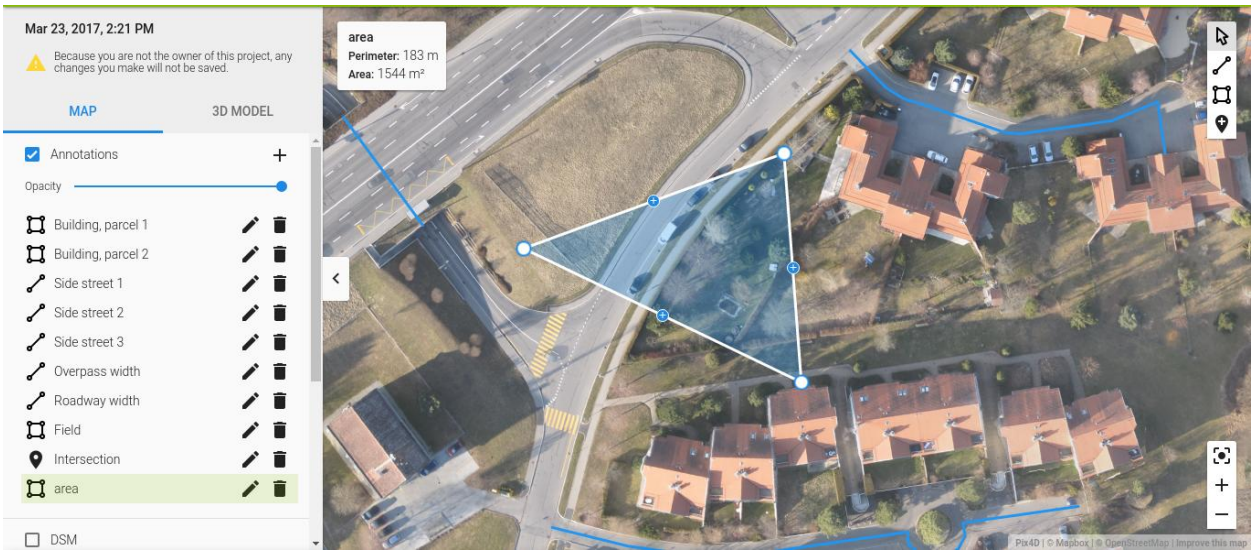
For surveying and mapping, you'll be primarily working with Pix4Dmapper pro. If you check out the example project, you'll be able to quickly see what you can do with it:

In the map tab, you can see the DSM, the Orthomosaic (orthophoto) and the base map that has been processed for this map. You can also toggle the satellite map on and off. You can add annotations to the project and toggle them on and off too. In the 3D tab, a 3D model of the site will be generated.



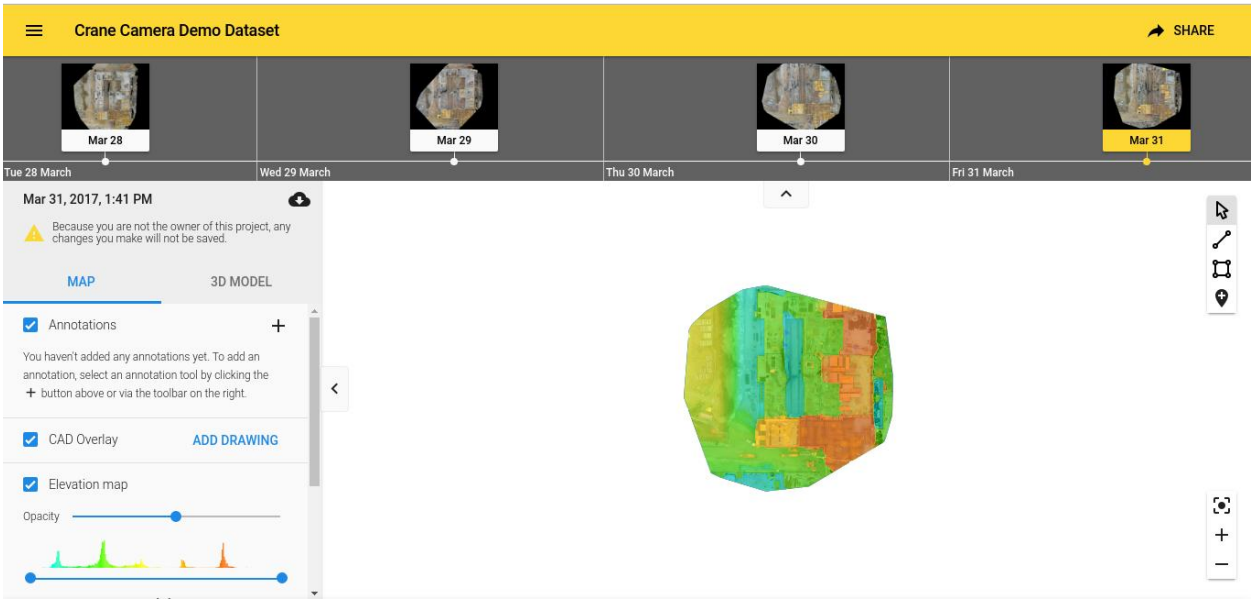
You can also measure the area and distance of a particular area on the map using the buttons on the top right hand corner. To do this, select the measure distance or measure area at the top right

hand corner of the map and select the part of the map you want to measure. After you are done, Pix4D will prompt you to add an annotation. Give it a name and the result will display at the top left hand corner of the map. You can also add markers in the map.



If you click on the download tab at the top right, you'll be presented with the option to download the images, the orthomosaic, the DSM, the obj file, the fbx file, point cloud, processing log and quality report. You can also export the project to Pix4D desktop and continue working locally in case you want advanced analytics and processing.

Pix4Dbim has similar outputs, but the interface is presented in a timeline fashion. That is, you can see the changes in a project overtime. This is very useful in construction, inspection and earthworks.



Pix4Dag is used for agriculture and is beyond the scope of this book. Lastly, Pix4Dmodel generates a 3D model which is useful for real estate. The Pix4Dmodel does not produce any other output.

Processing the images that you've taken is extremely easy. You just have to click on the "upload new dataset" option at the left hand corner of the screen (the same home screen that you land on when

you log in) and upload all the images. After that's done, click on "start processing"

PROCESSING WITH PIX4D DESKTOP

Processing with Pix4D desktop will take longer than if you do it on the cloud version, but the amount of control and flexibility you will have is far greater. If you have the recommended PC specifications, go ahead and download the Pix4D desktop version after logging in to the cloud.

Installing it and generating the basic outputs – the orthomosaic, DSM, DTM, point-clouds etc are pretty straight forward. Pix4D has put up free tutorials on their YouTube channel that you can refer to. As a beginner, it is everything you will ever need:

- https://www.youtube.com/user/pix4dsoftware/videos
- Here's a tutorial on creating your first project on Pix4D desktop: https://www.youtube.com/watch?v=3ary1Axka-c

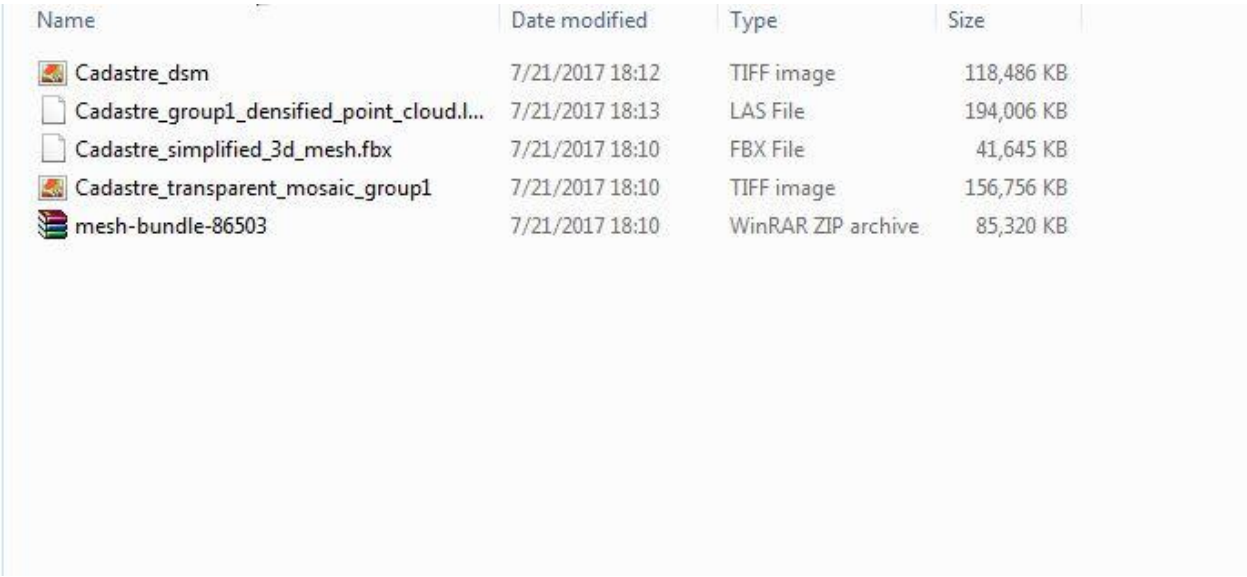
Post-Processing

What are we looking to achieve?

While the outputs you get from Pix4D will be quite comprehensive (especially with the desktop version), post-processing will make them useful to your clients. With post-processing, we're going to look at making the outputs workable with software like QGIS and AutoCAD.

POST-PROCESSING WITH QGIS

The best place to start working with post-processing if you are out of budget is QGIS. It is a free and open-source geographic information system. Download (or export) the outputs you generate from Pix4D into a folder and then post-process them with QGIS.



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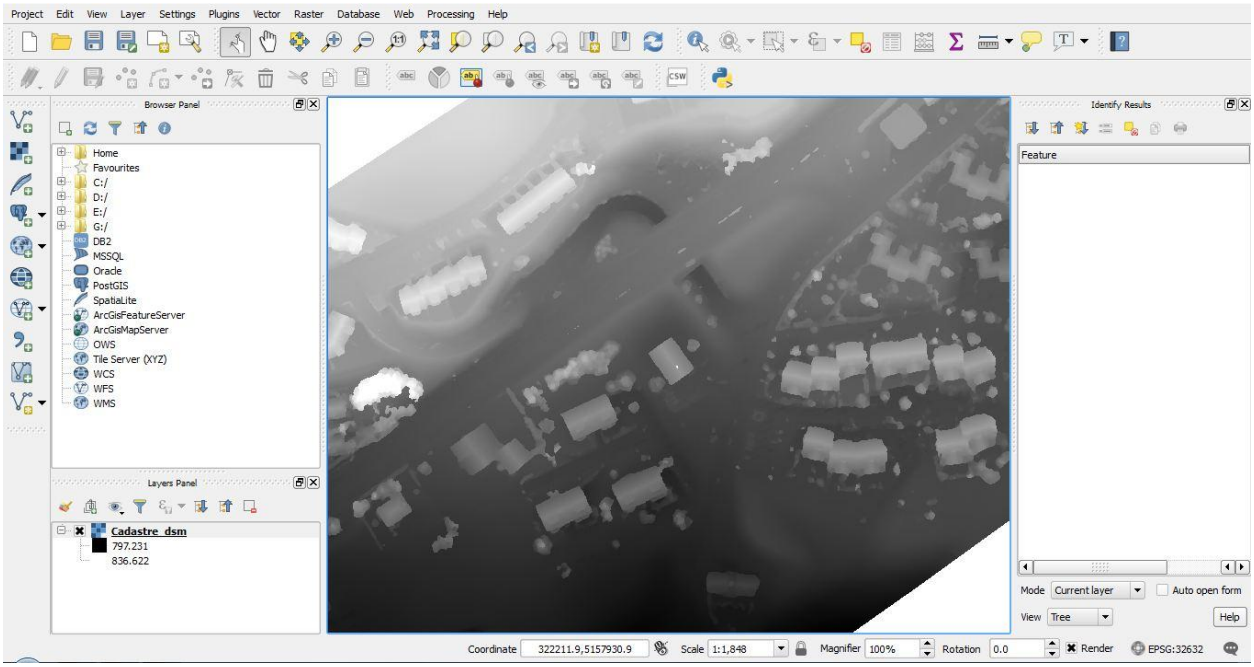
Cadastre_simplified_3d_mesh.fbx	7/21/2017 18:10	FBX File	41,645 KB
Cadastre_transparent_mosaic_group1	7/21/2017 18:10	TIFF image	156,756 KB
mesh-bundle-86503	7/21/2017 18:10	WinRAR ZIP archive	85,320 KB

WHERE TO INSTALL QGIS?

You can download QGIS at http://www.qgis.org/en/site/forusers/download.html for a wide variety of operating systems. While installing, make sure you install GRASS GIS and GDAL also. In the latest versions (as of writing this book) , they come installed when you install QGIS by default.

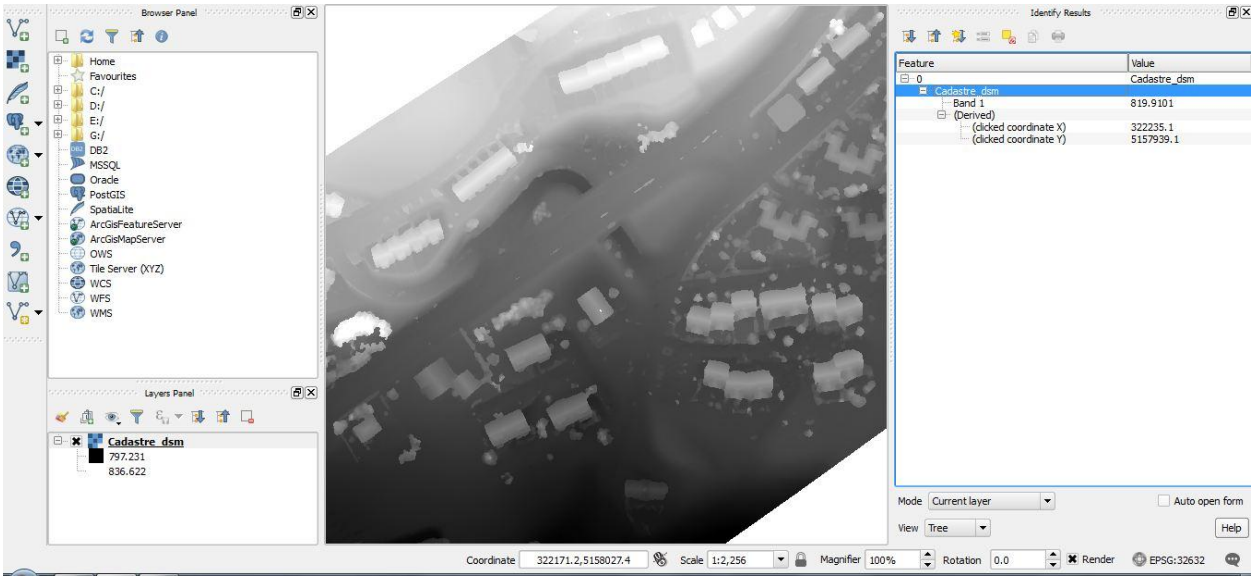
POST-PROCESSING THE DSM AND GENERATING CONTOURS

Open QGIS (QGIS desktop) and to work with the DSM, drag and drop the DSM output onto the QGIS application. You could also do this by dragging and dropping it onto the orthophoto, overlaying it on top of it. Once you are done, you will be able to see the coordinates of the point where the mouse hovers.



Getting the coordinates of a point in DSM

Click on identify button (a button at the top of the screen with the "i" mark) and click on any point in the DSM

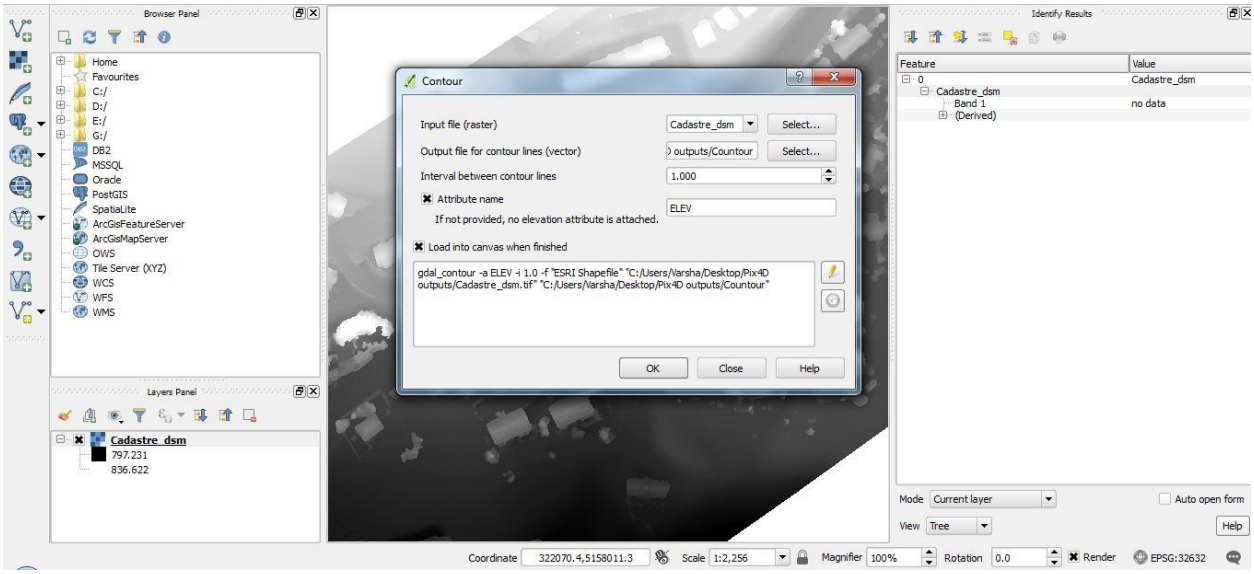


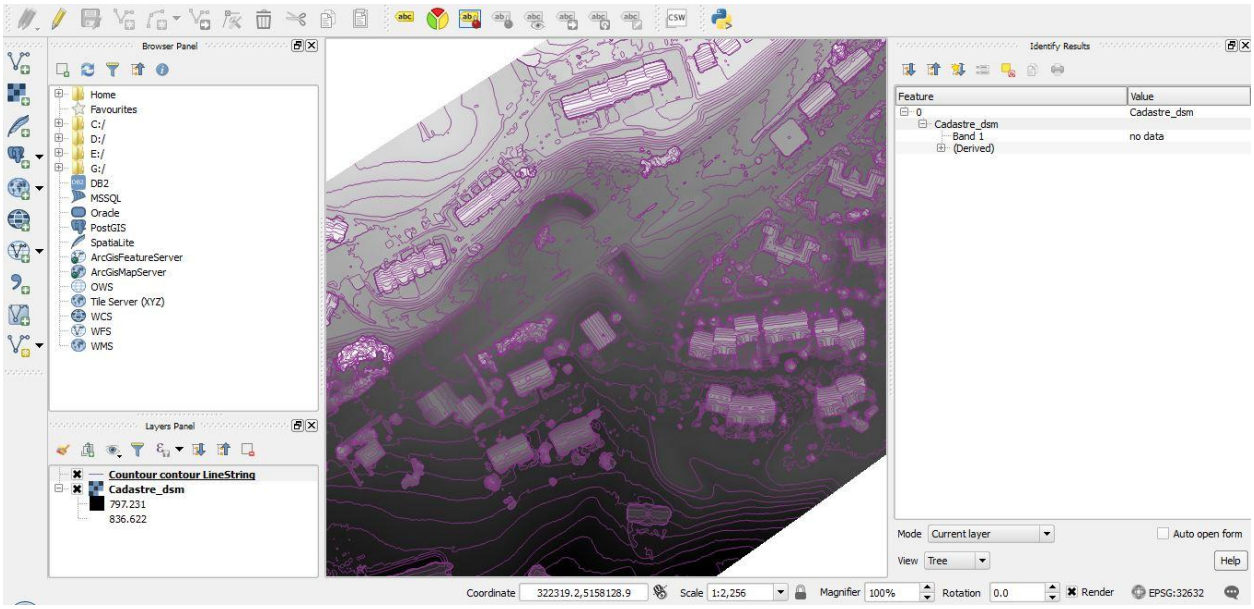
Once you do this, you can see the elevation value under "band 1" and the x and y coordinates under "derived". You may have to scroll the "identify" tab horizontally or increase the width to see the results. The elevation value is useful to find the height of a particular object like a building by comparing it with the elevation of a point close to the building.

Generating contours from the DSM

Go to raster (at the top of the window) -> extraction -> contour. Select the raster layer as the DSM, create an output contour file and name it (it won't work if you do not do this). After this, you can select the interval for the contours. This will of course, depend

on what your client needs. The lesser the interval value, the more the contours that will be generated, showing the elevation differences of more points. Next, select the attribute box and specify the column of the elevation (ELEV). Keep the "load into canvas when finished" button checked and click on OK to generate the contour.



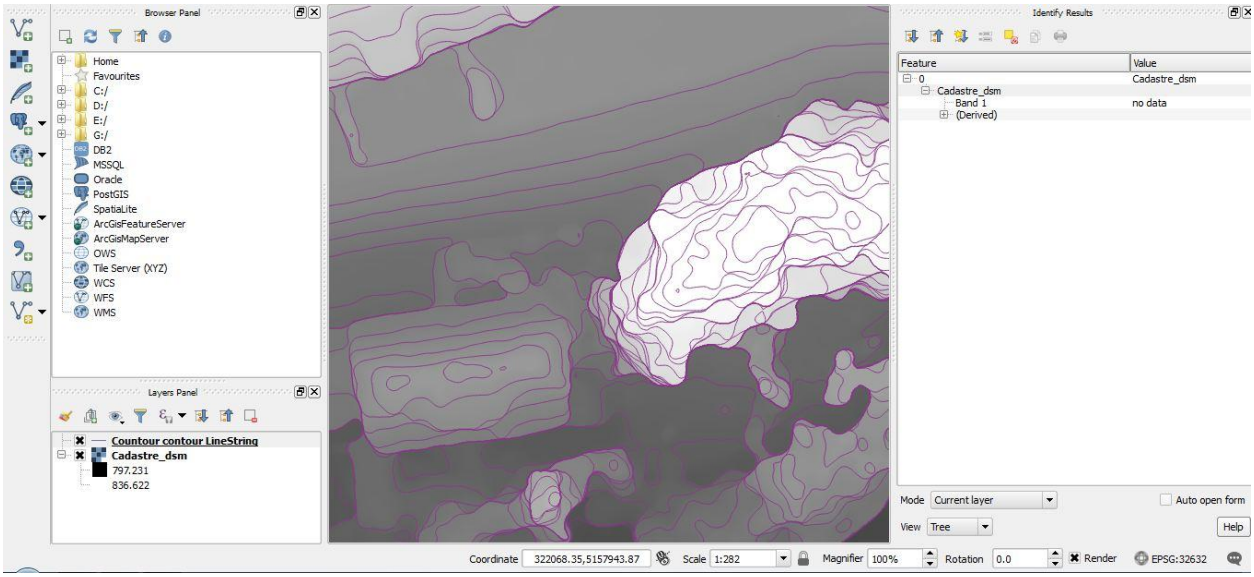


POST- PROCESSING THE CONTOURS

Post-processing the contours involve noise reduction and smoothing.

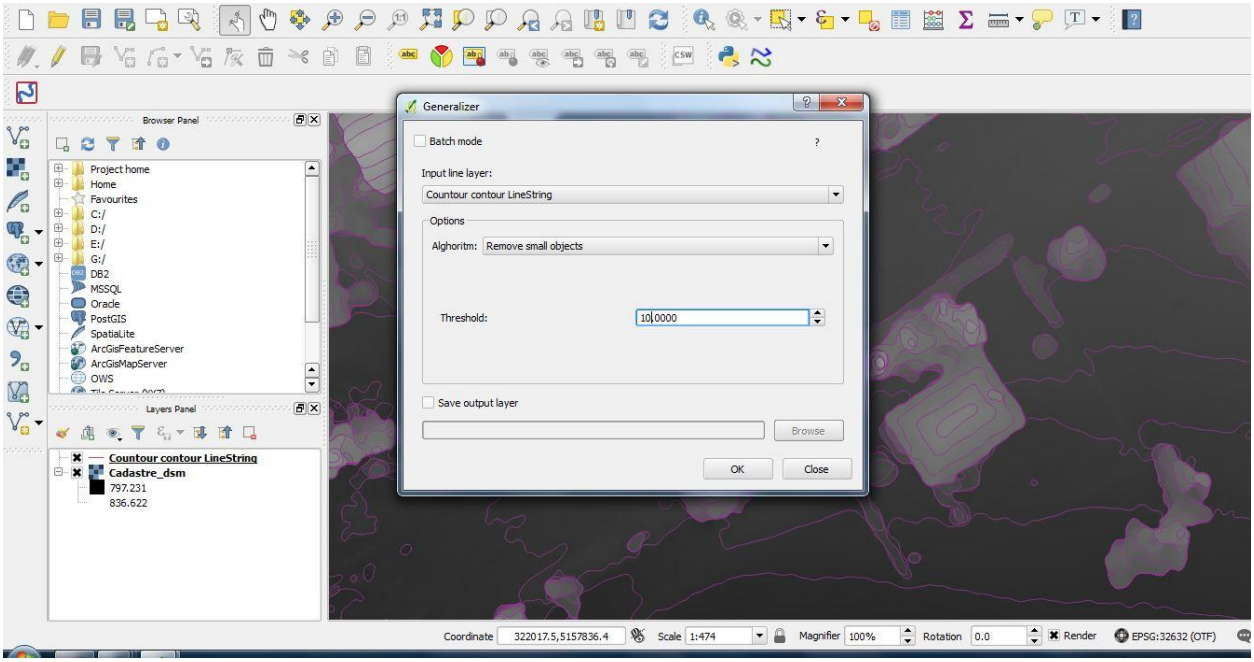
Removing unnecessary noise

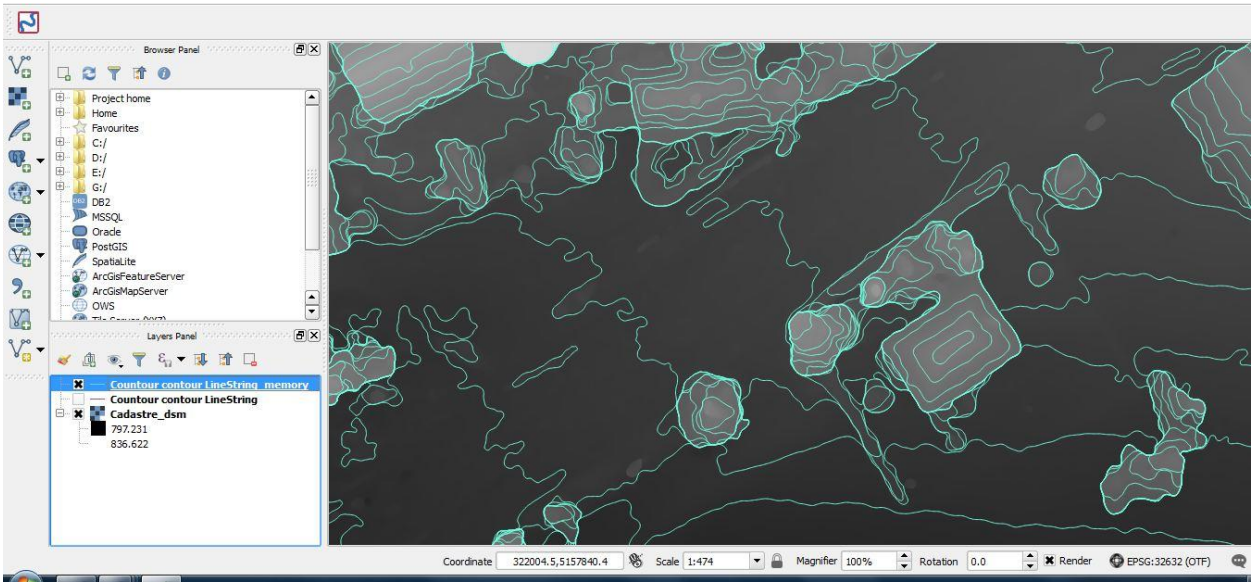
When you generate contours by giving a small elevation values, QGIS tends to generate contours for every single object, even the small insignificant ones. This can make the output look messy and difficult to deal with.



Removing this excess noise is the first step to post-processing contours. To do this, click on the generalizer tool -> select remove small objects under "algorithm" -> Set a threshold value (you have to experiment with various threshold values -> Click ok -> Click Ok again and wait for a new layer with the noise reduction applied, to

be generated. Compare it with the original layer and see if you are happy with the results. If so, delete the original layer or disable it. If not, delete the new layer and try again with a different threshold value in the generalizer tool.

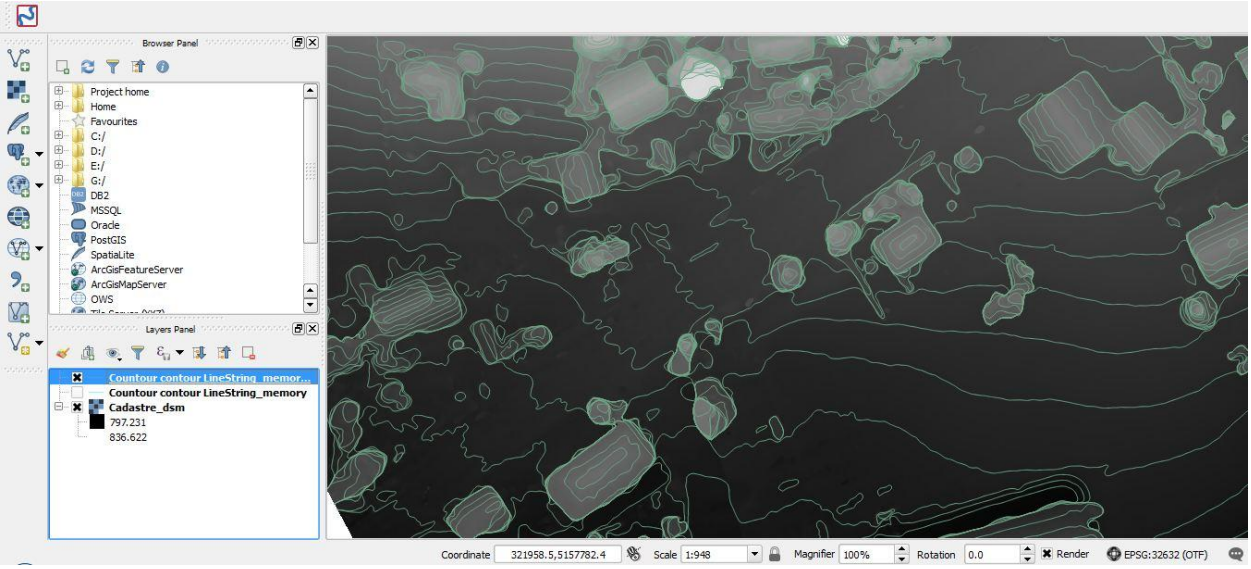




Once you are happy, delete the original layer and keep the noise reduced layer.

Smoothing the contours

You may find that the contour edges are too sharp. To get around this, we'll have to smoothen the contours. To do this, select the generalizer tool -> under algorithms, select a smoothing algorithm (You may have to experiment with a few different algorithms till you are happy with the results for your particular scenario) -> Select a value (look-ahead, again experiment with different values) -> click ok -> Click Ok again to generate a new layer with smoothened layer. Compare the two layers and if you are not happy with the results, delete the layer and try again with a different value.



NOTE: If you do not have the generalizer tool in QGIS, then download the plugin from https://plugins.qgis.org/plugins/generalizer/ and extract the file into C:/users/{your user name}/.qgis/python/plugins. Next, in QGIS, go to plugins -> Manage and Install plugins -> Search for generalizer and enable the plugin. Make sure you download the latest version or the plugin may be reported as "broken".

Finding the elevation of each contour line

To find the elevation of each contour line, simply select the "identify" option and select on the contour line. The results will be shown on the right hand side of the screen.

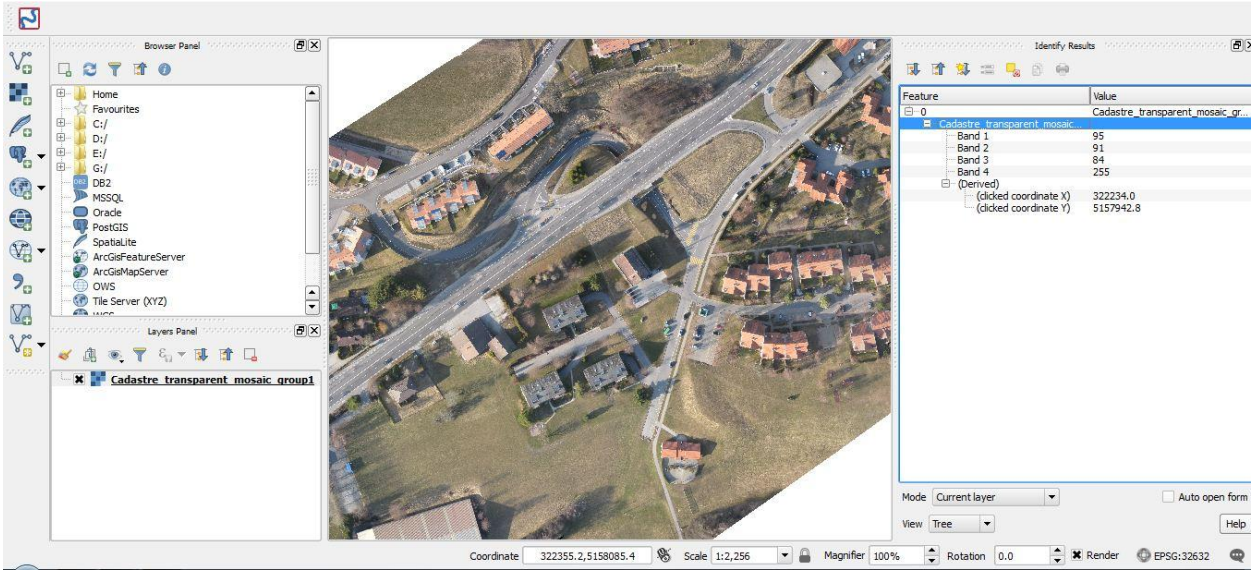
Saving the contour file

Simply right click the layer and save the contour file into a folder of your choice.

POST-PROCESSING THE ORTHOPHOTO

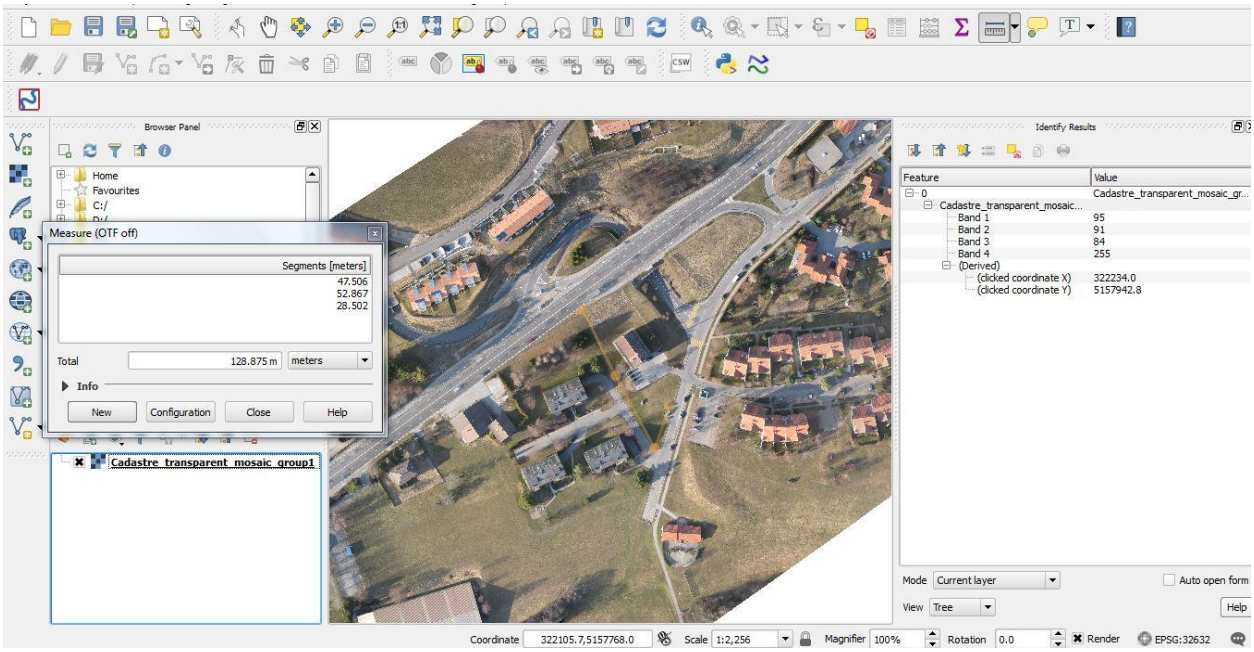
In order to "post-process" and find data from the orthophoto in QGIS, create a new project and drag and drop it into QGIS.

You can find the coordinates of a particular point on the orthophoto by clicking on the identify button and clicking on any point on the orthophoto. Under the derived tab, you will be able to see the X and Y coordinates.



In order to find the distance between any two points, click on measure line (at the top, with the scale icon) and select the unit.

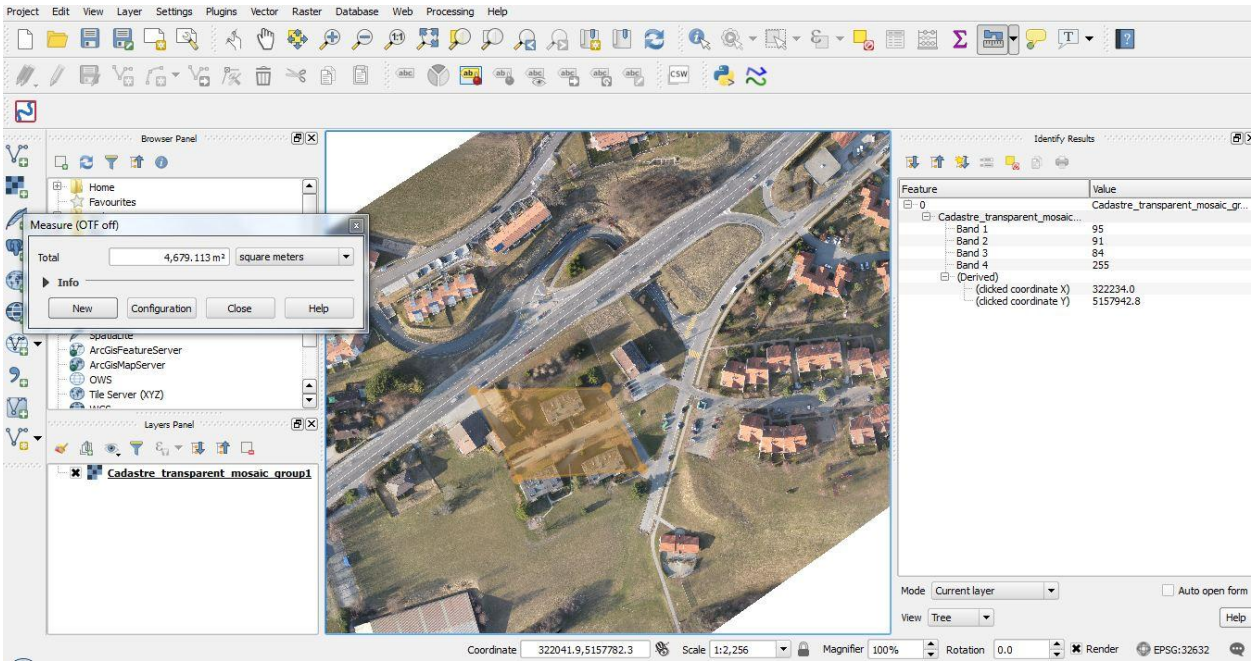
Now, select the first point and then the second point on the map to measure the distance between the two points. The output will be shown in the box where you select the unit.



You can of course, keep going and increase the number of points to find out the perimeter of a region, for example.

In order to find the area of a region, select measure area and select the unit of measurement

Select the points across where you want to measure area and it will be shown in the box.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Browser Panel
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Measure (OTF off)
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QGIS TO AUTOCAD

With QGIS, you can do some processing on the outputs from Pix4D to make them more workable with AutoCAD.

Creating a tfw file

- The tfw file is necessary to scale and georeference the orthophoto in AutoCAD. In order to create a tfw file, click on raster -> projections -> extract projection.
- Now select the orthophoto and click on OK. This will create a world file with the rotational information, X, Y and world coordinates in the same folder as the orthophoto. Our job now is to convert it into a tfw file. Simply rename the file extension into a .tfw and you are done.

MAKING THE CONTOURS COMPATIBLE WITH AUTOCAD

- Select plugins -> Grass -> new mapset
- Choose a location for the database directory and select next
- Name a new location and select next -> select next again without any changes -> select next again, no changes -> give a name for the mapset -> next and finish.
- Next, open grass tools from plugins -> Grass -> grass tools.

- In the filter tab, search for "importvector" and select the import loaded vector.
- Now select the contour layer and give the output vector map a name and click on "run".
- Select view output and you will be able to see output vector map as a new layer
- Now convert this vector from 2D to 3D. In order to do this, search for "3D" in the grass tools filter and select the option "Performs transformation of 2D vector into 3D with height based on attributes".
- Select the input vector as the output vector map that you want to convert from 2D to 3D and give the new 3D vector output a name. Select the column with the elevation value (ELEV) and click on run.
- Now select view output and you will see the output vector map (3D) as a new layer. Right click on this and click save as AutoCAD DXF to save it onto a folder of your choice. This will be the file that you will be working with, in AutoCAD.