TerraScan Guide & Reference 2
Point Classification & Macros
REMS 6085,
Centre of Geographic Sciences, NSCC

Overview

This document is the second in a series of user guides designed to help you gain an understanding of Bentley's Microstation and TerraSolid's TerraScan software packages. The following topics are discussed in this guide:

Data Viewing

- Viewing points using profiles
- Viewing profiles along a line

Point Classes

- Standard point classes
- User-defined classes
- Displaying points by class
- Displaying point classification distribution

Point Classification

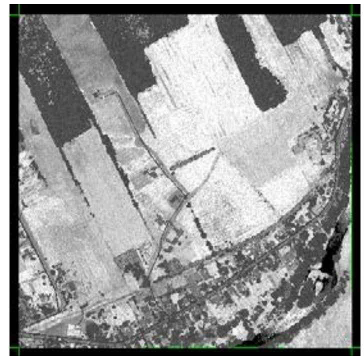
- Manual point classification using brushes & regions
- Automatic point classifications
    - isolated points, low points, ground points, buildings, etc.

Automation & Macros

- Creating & running macros for project-based point processing

Note, that while the sections in this guide are partially organized in the order you may typically perform them, they are not intended as a rigorous step-by-step tutorial. Please **read through the entire guide before starting** as it will help your understanding of the overall process.

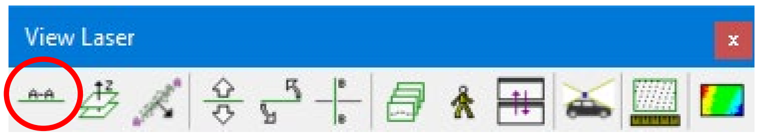
Using Profiles in TerraScan



While the planimetric perspective that is often used to display the LiDAR points (right) can be useful for gaining an understanding of the overall terrain and data coverage, it can also be helpful to look more closely at particular sections of your data.

A *profile* allows you to display a “sliver” of the LiDAR points from a sideways/horizontal perspective. This angle can be useful for validating point classifications, analyzing flightline misalignments or simply to gain a better understanding of the 3D shape of features.

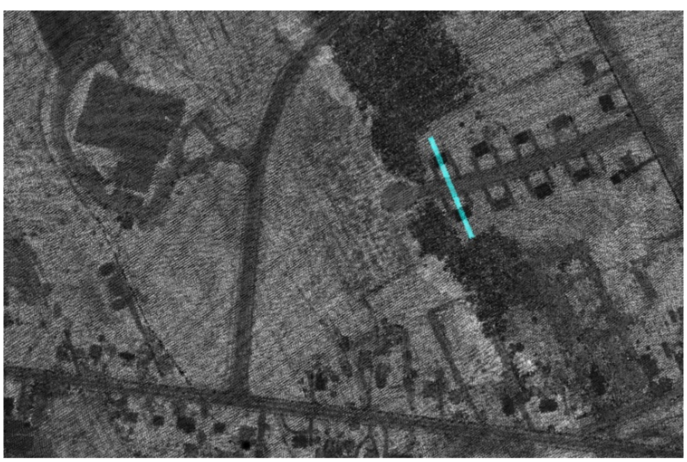
Creating a Profile

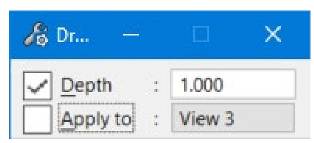


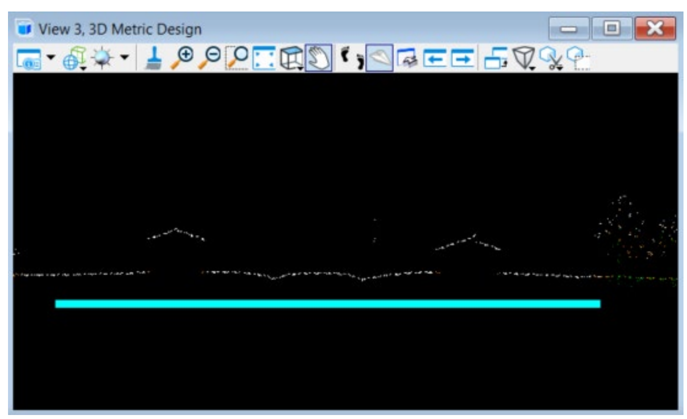
The *Draw Vertical Section* tool within the *View Laser* TerraScan toolbar (circled right) is used to create a profile. Once activated, click at the start of the profile line then move the mouse to where you wish to end the profile and click again (left below). At this point moving the mouse will allow you to specify the depth (or thickness) of the profile; clicking a third time will end the profile delineation.

Rather than manually specifying the thickness of the profile using the mouse, you may precisely state what you would like its depth to be through the **Draw Vertical Section** window (top right below).

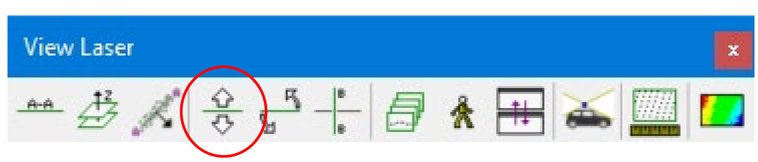
Once you’ve stated where to extract the profile from, you must then click a fourth time within one of the Microstation views to tell TerraScan where to draw the profile points (bottom right below).



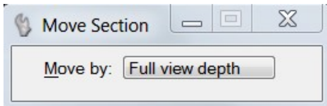




Moving the Profile



Once created and displayed, you may use the *Move Section* tool (circled right) to move the profile section forward or backward to view the “next” portion of the point data. Once selected, left-click within the profile view (*View 3 in this example*) to move forward and right-click to move backward.

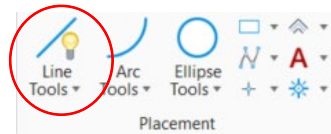


The **Move Section** window (left) allows you to state how far the profile shifts when you click. This can be either the full depth of the profile or ½ the depth of the profile.

Notice that there are many other tools in the toolbar that allow you to precisely control the movement of the profile slice (e.g. *Travel Path* can move along the edge of a cliff or the width of a road).

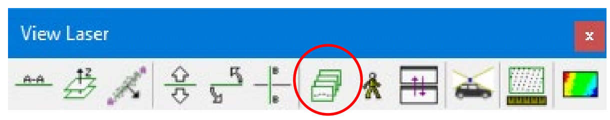
Following a Track

An alternative to simply moving the profile forward and backward, TerraScan allows you to travel along a designated line element (e.g. a road or shoreline).

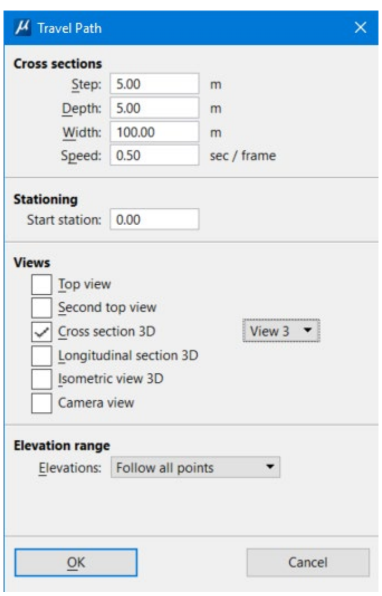


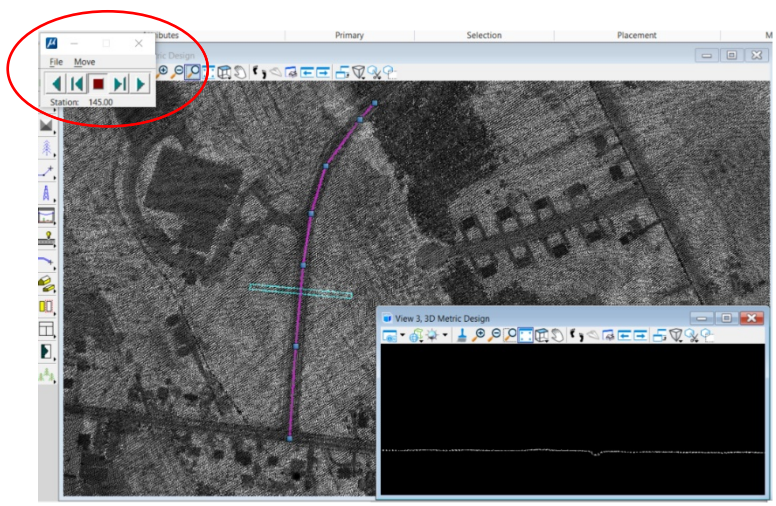
Begin by using the *Place SmartLine* tool (circled right) to delineate the path to follow (below). You may wish to close the *AccuDraw* tool when attempting to draw intricate lines (it tends to force perpendicular lines).

Once created, select the element and then open the *Travel Path* tool (circled below) in the TerraScan toolbar.



Within the **Travel Path** window (left below), you can specify the distance to move between steps (e.g. 1.5 m), the depth of the profile (e.g. 3 m), the width of the profile (across the travel path) and the View to display the cross-section (e.g. *View 3*).





Clicking OK closes the *Travel Path* window and enables the **Travel Player** (circled above). The profile view (e.g. *View 3*) will automatically update to display the current section of points as defined by the profile box. Clicking on the “forward” and“backward” buttons in the *Travel Player* moves the profile box along the selected line. Turns are made automatically to ensure that the profile is always perpendicular to the travel line.

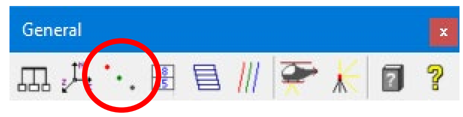
Point Classes

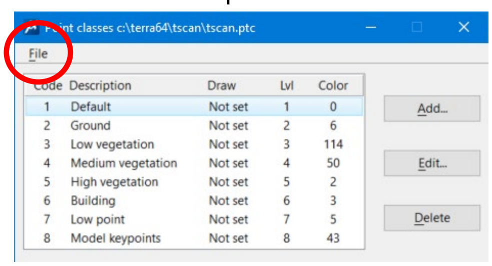
One of your goals while processing LiDAR will often be to classify the various points according to their positions, distribution or relationship to other points. By default, TerraScan provides a list of possible point classes (based upon the ASPRS LAS standard) that can be used:

Class	Name	Description
1	Default (Unclassified)	Has not been classified
2	Ground	Identified as being “solid ground”
3	Low Vegetation	Low-lying vegetation (e.g. shrubs)
4	Medium Vegetation	Elevated vegetation (e.g. small trees)
5	High Vegetation	Taller vegetation (e.g. trees, canopy etc.)
6	Building	Ideally building rooftops; any “smooth” impenetrable surface
7	Low Point (noise)	Erroneous points
8	Model Keypoints (mass point)	Points identified as being critical to represent the terrain
9	Water	Lakes, streams, bays, etc.

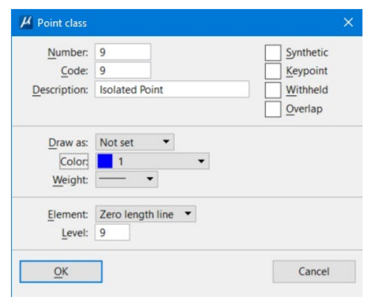
User-Defined Classes

While these will cover many of the landscape features you may be interested in, TerraScan allows you to define your own classes as well. Selecting the *Define classes* tool (circled right) within the TerraScan General toolbar opens the **Point Classes** window (below).





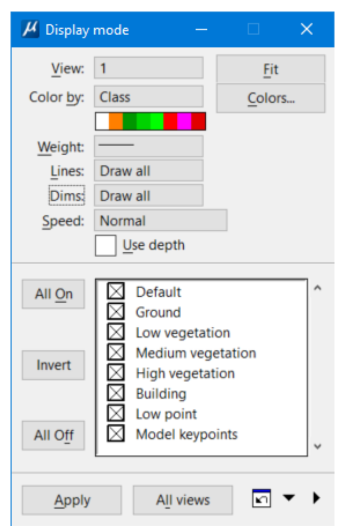
Within this window you may add, change or delete class definitions. For example, if you wish to create an `Isolated point` class press the *Add* button to open the **Point Class** window (right), then provide a class number, description and color (when viewing points by class).



Your custom point classes can then be saved using *File / Save* as (circled left).

Viewing Classes

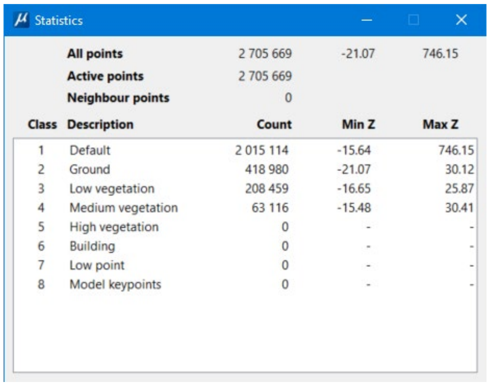
As described in the previous guide, you may display your LiDAR points colored by class through the **Display mode** window (under the *View* menu of TerraScan’s main window). You can do this for any views within your Microstation session (e.g. *View* and *Color by* fields; shown right).



Class Distribution

In addition to displaying points by class, you may also wish to view how many points are currently classified into which classes.

The **Statistics** window (under the *Tools* menu of TerraScan’s main window) shows the number of points currently loaded in memory, their min/max Z values and number of points within each point class (below).



Statistics

		Count	Min Z	Max Z
	All points	2 705 669	-21.07	746.15
	Active points	2 705 669		
	Neighbour points	0		

Class	Description	Count	Min Z	Max Z
1	Default	2 015 114	-15.64	746.15
2	Ground	418 980	-21.07	30.12
3	Low vegetation	208 459	-16.65	25.87
4	Medium vegetation	63 116	-15.48	30.41
5	High vegetation	0	-	-
6	Building	0	-	-
7	Low point	0	-	-
8	Model keypoints	0	-	-

For the example shown left, it appears that the LiDAR points have already been classified. However, the points have actually been assigned numeric values (in their point class fields) based upon their "return code". That is, whether the point was the first, second, third, etc. point returned from the laser pulse.

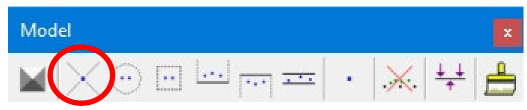
There is a separate "echo code" value associated with each point (in the LAS file) that also provides this information so it is not necessary to retain this initial point classification scheme.

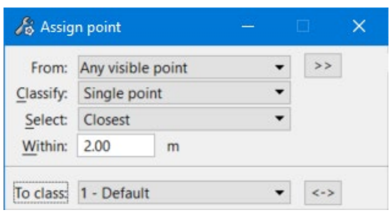
Manual Point Classification

While there are several automated routines available (see next section) to perform point classification, sometimes a more hands-on approach is necessary (e.g. to remove building edges from the ground class). A few of the more commonly used manual classification tools are described below.

Assign Point Class

One of the simplest approaches is to use the *Assign Point Class* tool (circled right) in the TerraScan toolbar. This tool allows you to classify a *single point* from one class (or any) to another.



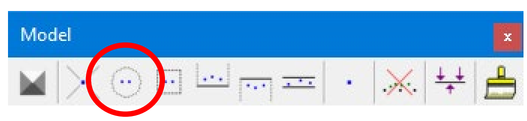


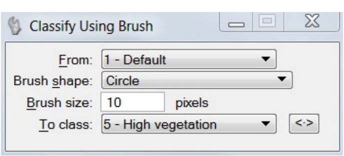
The **Assign Point Class** window (left) lets you to state which points you wish to reclassify (e.g. any point class) and which class to move them into (e.g. `Default`).

After activating the tool, any point within the profile view (e.g. *View 3*) that you click near (e.g. with 2 m) will be reclassified. Right-clicking ends the tool and returns the cursor to its normal use.

Classify Using Brush

Another simple approach is to use the *Classify Using Brush* tool (circled right). When using this tool you have a small circular or rectangular "brush" area that dictates which points will be classified. The *Classify Using Brush* window (below) allows you to specify the size of this brush.





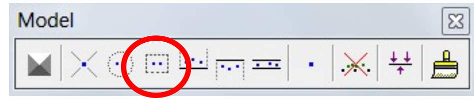
This window also allows you to state which points you wish to reclassify (e.g. only points from the `Default` class) and which class to place them in (e.g. `High vegetation`).

After selecting the *Classify Using Brush* tool, click within your profile view (e.g. *View 3*) to begin classifying points.

If you hold the left mouse button down, you may move the "brush" around to classify your points of interest (right). Releasing the mouse button will end the classification mode.

However, if you click and then immediately release the button, you will enter "sweep" mode. Once in this mode anywhere you move the brush (cursor) will be re-classified (left-click ends). This mode can be easily entered accidently **so be very careful where you move the mouse when using this tool**.

Classify Using Fence



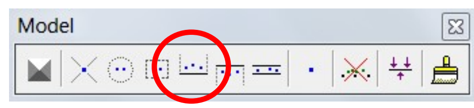
The *Classify Fence* tool (circled right) allows you to classify only those points (of a specified class) within a specified polygon (or "fence"). This may be useful when working with points in close proximity or when you wish to classify large areas of points.

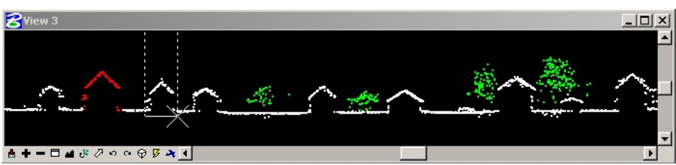
After selecting the tool, click within the profile view (e.g. *View 3*) to start delineating the fence (left). Each successive click will add an additional vertex to the fence.

To close the polygon, click back on the first vertex (it will automatically snap when you're close enough). Once closed, click again to classify the points within that area (above right). At any time you may right-click to cancel the operation.

Classify Above Line

Similar to the *Classify Fence* tool, the *Classify Above Line* tool allows you to draw a line across the profile view and all points (of a specified class) above that line will be reclassified into the stated class.



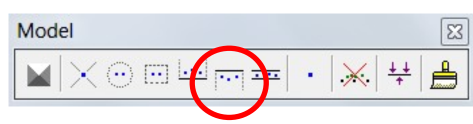


After selecting the tool, click within the profile view (e.g. *View 3*) to start the line. You will see a pair of vertical dotted lines drawn in the view (left); these delineate the region that will be reclassified.

After choosing the span you wish to use, click again to end the selection process and classify the points (right). As before, right-clicking will cancel the process.

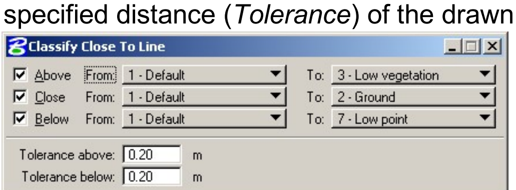
Classify Below Line

The *Classify Below Line* tool (circled right) works the same as the *Classify Above Line* tool except that all points *below* the drawn line will be reclassified.



Classify Close to Line

The *Classify Close to Line* tool (circled right) combines the *Classify Above* & *Below Line* tools, but also classifies any points within a specified distance (*Tolerance*) of the drawn line.



The **Classify Close to Line** window (left) allows you to choose which classification operations (above, close & below) to perform as well as which *From* and *To* classes to use for each of them (e.g. classify any `Default` points with 0.2 m of the line into the `Ground` class).

Automated Point Classification

The manual classification tools are useful for careful classification of points and features; however doing this for an entire block or even hundreds of blocks quickly become infeasible. Fortunately, TerraScan offers a wide variety of automated classification routines which can be found under the *Classify* menu in the main TerraScan window.

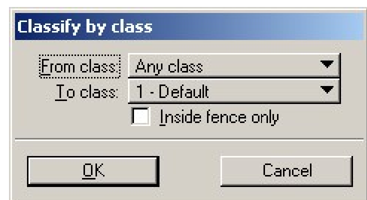
While several classification routines (and other processing algorithms) are available, the more commonly used routines are described in the following sections.

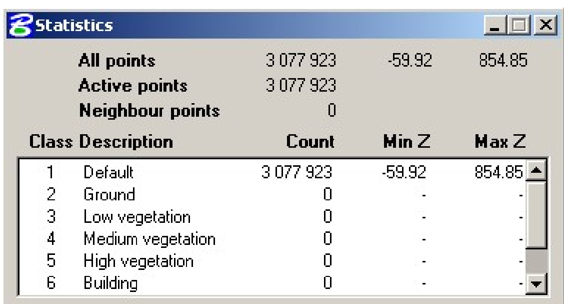
Classifier	**Description**
By class	Reclassify points from one class to another.
Low points	Find points that appear unusually lower than others in the area.
Isolated points	Find points that appear “alone” (few or no neighbors).
Ground	Solid ground points (“bare earth”).
By height from ground	Points that are within a specified distance from the “bare” ground.
Buildings	Points that form solid planes (e.g. rooftops).

Please review your class notes for more details on these classification routines and their particular parameters.

By Class

A very simple classification routine that takes all points from a specific class (or all classes) and re-labels them into a single output class. For example, recall that the LiDAR points are initially classified by return codes, something that will interfere with further classification.



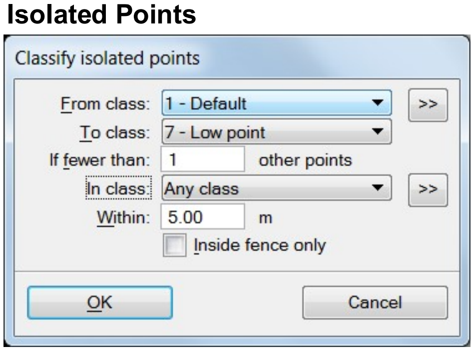


Within the **Classify by class** window (right) select `Any class` to classify from and `Default` to classify them into.

Although not used in this guide, take note of the *Inside fence only* option; this allows you to limit the classification routine to only those points within a selected element (polygon).

After completion, check the *Statistics* window (under the *Tools* menu) to verify that the points have been classified correctly (right). In this case, all of the points should reside within class 1 (`Default`).

Isolated Points



Sometimes the laser scanner will detect returned energy from particles/objects high above the ground or misplace points due to multi-path/scattering. In these cases, the LiDAR point cloud will contain several points that stand “alone”; that is there are not any other points within a certain distance.

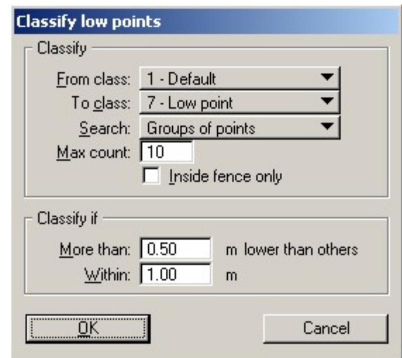
It can be useful to remove these points (i.e. classify them into a “noise” category) since they will affect the statistical analysis of many of the other algorithms.

The *Classify isolated points* routine (above) allows you to identify individual points (or small groups of points) that appear to be “isolated” from the others. As with the other routines, you can specify which input and output class you wish to operate with.

You are also required to state a search radius and maximum number of points. If there are fewer than that many points within the search region, then those points are considered to be “alone”.

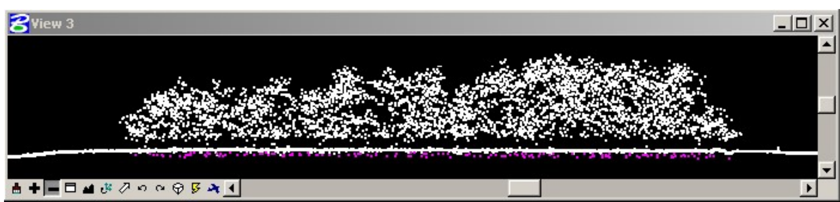
Low Points

Similar to isolated points, occasionally the laser scanner will misplace or poorly estimate the range to the point's location. For example, the profile below shows a series of trees and the solid ground beneath them. However, close inspection shows that there is a “haze” of points that are below what appears to be the actual ground.

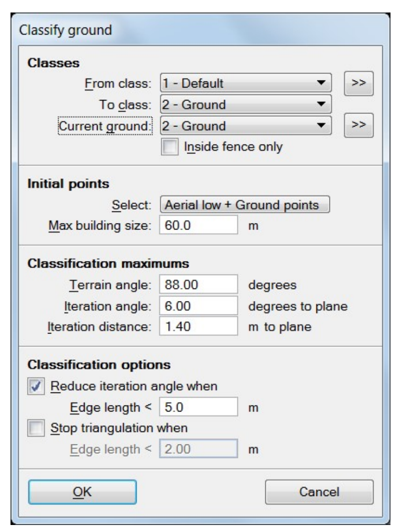


The *Low points* classifier allows you to attempt to find and classify these unusual points. Similar to isolated points you must specify a search radius and maximum point count. You must also state how close those points must be in elevation to their neighbors.

Upon running this routine it will (ideally) identify these points (see below) and place them into your specified output class. It may take careful selection of the various parameters in order to achieve an effective classification for the above example.



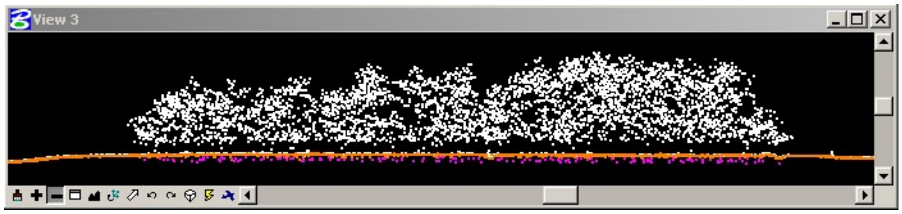
Ground



One of the most widely used products from LiDAR data is the “bare earth” point cloud. In order to create this you must first determine which points are solid ground and which are elevated (non-ground) features (e.g. buildings, trees, etc.).

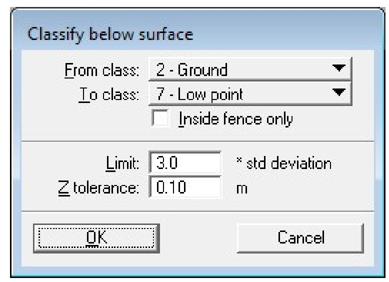
The parameters for the *Classify ground* routine are complex and are not discussed in this guide (refer to your class notes). However, much like the other classifiers you need to specify an input and output class. In addition you have various parameters describing how to decide which points belong to the ground and which are “too elevated” (non-ground).

Upon running this classifier on the example points, you can see that the routine has done a reasonable job at deciding which points belong to the ground (orange in the profiles shown below).



Below Surface

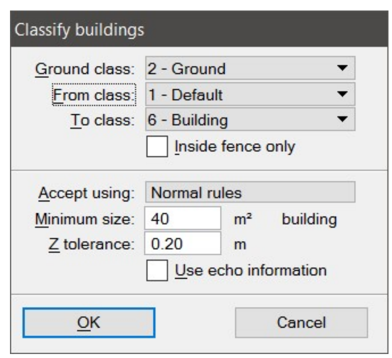
Although the ground classifier makes a good attempt at determine which points represent “solid ground” it can often be confused by “soft” surfaces (e.g. low lying brush) or sensor errors resulting in several points that appear to be erroneously below what appears to be the natural surface (the “haze” of points below forested areas in the *Low Points* example above).



The *Below Surface* classifier analyses a set of points (e.g. those classified as ground) and attempts to identify points that do not appear to belong to the surface (i.e. too far below).

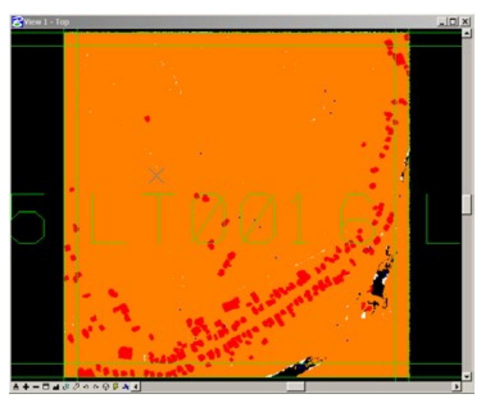
For each point, the closest 25 points are used to create a localized planar surface. If the point is within *Z tolerance* (e.g. 10 cm) then it belongs. If not, and the points is more than *Limit* standard deviations below (which allows somewhat noisy surfaces) then it is classified as “below the surface”.

Buildings



Generally buildings are rather complex structures, however in many cases they are still composed of one or more flat surfaces. The *Classify buildings* routine attempts to find various hard (e.g. single returns) relative smooth surfaces (e.g. all points within 40 cm of each other).

This routine requires that a ground classification be performed and provided as it uses this information to help decide what are “hard” features (e.g. elevated points with no ground points below them).



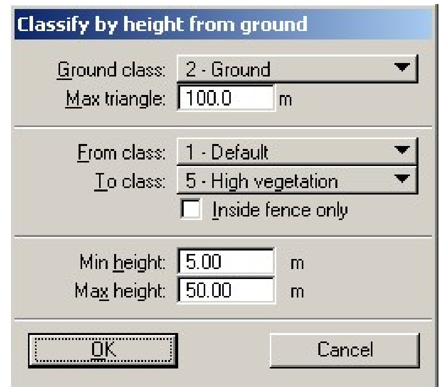
Other parameters include minimum surface size (e.g. ignore decks) and a “flatness” tolerance (how close points must be in elevation, horizontal or sloped).

Finally, if the information is available, the *Use echo information* can greatly improve the overall quality of the classifier as it helps guide the “hard” vs. “soft” decision process.

Viewing the same profile as used in the classifier discussed previously it can be seen that overall the various rooftops of the buildings have been correctly classified (red point right and below).

It is worth noting however that the sides of the buildings have not been identified since the routine does not consider vertical features such as this to be "flat surfaces".

By Height from Ground



Once a ground classification has been performed, those points can be used to create a rough surface to use as a baseline for classifying "elevated" features (e.g. shrubs, trees, buildings, etc.). The *Classify by height from ground* routine (right) allows you to classify points by their "above ground" elevation.
Only a rough estimate of the ground surface is created, but the level of detail can be controlled through the *Max triangle* parameter. As discussed in class, this value essentially states the longest distance between any two points in the surface; the lower the value the more detail that is retained in the surface.

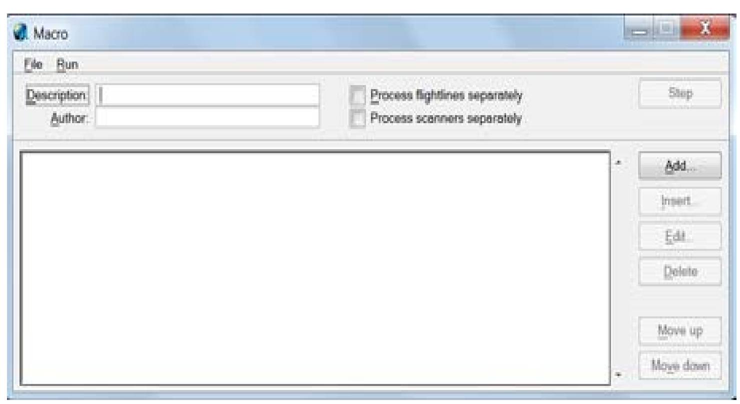
Finally, the *Min height* and *Max height* parameters allow you to state the range of "above ground" elevations to include in the output class (e.g. all points between 5 and 50 m above ground).
In the example above, the *Classify by height from ground* routine was used to broadly extract "high vegetation" (e.g. trees). Looking at the profile (below) you can see that although it did select many of the trees, the lower portions of the trees remain unclassified (e.g. those less than 5m above the ground). In this case it may be necessary to incorporate additional classification routines (or even manually classify those sections).

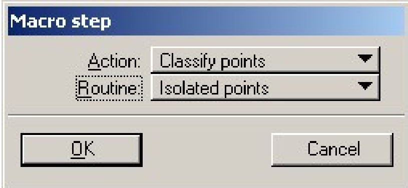
Processing using Macros

TerraScan has a wide variety of other tools that can be used to help correct and manipulate your LiDAR points. These, as well as the automated classification routines can all be combined into user-defined scripts (or macros) in order to apply a series of processing algorithms to each block in your TerraScan project.

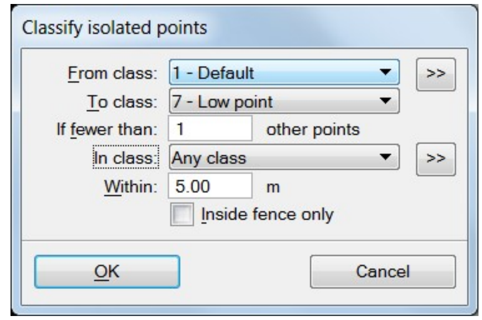
Creating Macros

The **Macro** window (under the *Tools* menu in the main TerraScan window) allows you to select which routines to run, their specific parameters and even the order that they are applied. Macros can be run on points loaded in memory (useful for experimenting), points residing in a single or set of files, or on all the blocks of a TerraScan project (discussed below).

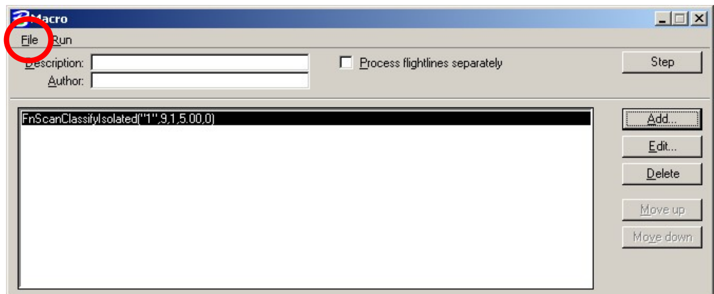




Pressing *Add* within the *Macro* window will provide you with a list of routines (left) that can be applied to the LiDAR points.



Choosing one of these routine will open its corresponding parameter window (e.g. such as the classification routines earlier). For example, selecting the *Isolated points* routine will open the *Classify isolated points* window (right).



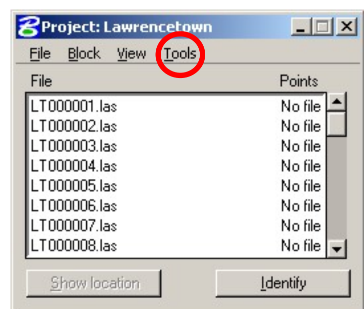
As additional routines are added to the macro you may then use the *Edit*, *Delete* and *Move Up/Down* buttons to change their settings or rearrange the order the tasks are to be performed.

Once you are happy with your macro you can save it using *File / Save As* under the *Macro* window (circled left). This will create a `.mac` file (actually a simple text file which can be opened in Notepad) that can be loaded and run at any time.

Running Macros

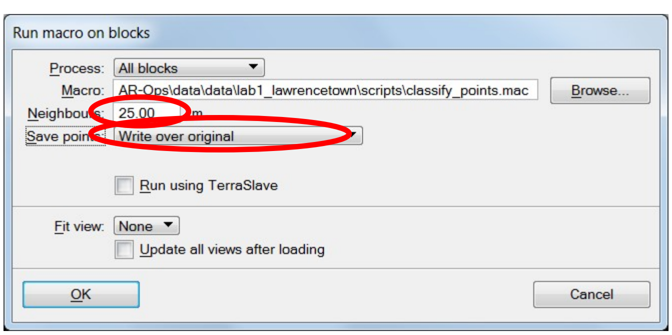
If you are working with a small set of points loaded in memory you can run a macro by selecting *On loaded points* from the *Run* menu within the *Macro* window.

If you are working with just a few files (without a TerraScan project) you may run your macro directly on those using *On selected files*. In this case you select the file or files to operate on and state whether to overwrite the original files or to create new versions in a separate output folder.



Typically though you will be working with large datasets that have been tiled (e.g. blocks created) through a TerraScan project.

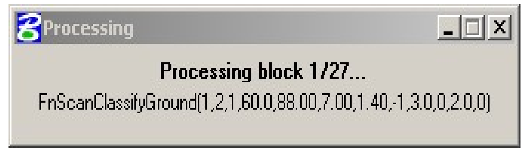
In this case open your TerraScan *Project* window (select *Define project* under the TerraScan toolbar) and select *Run macro* from the *Tools* menu (circled right) to open the **Run macro on blocks** window (below). Select the macro file (`.mac`) to run and specify to process *All blocks* or *Selected blocks* (use only those selected in the *Project* window).

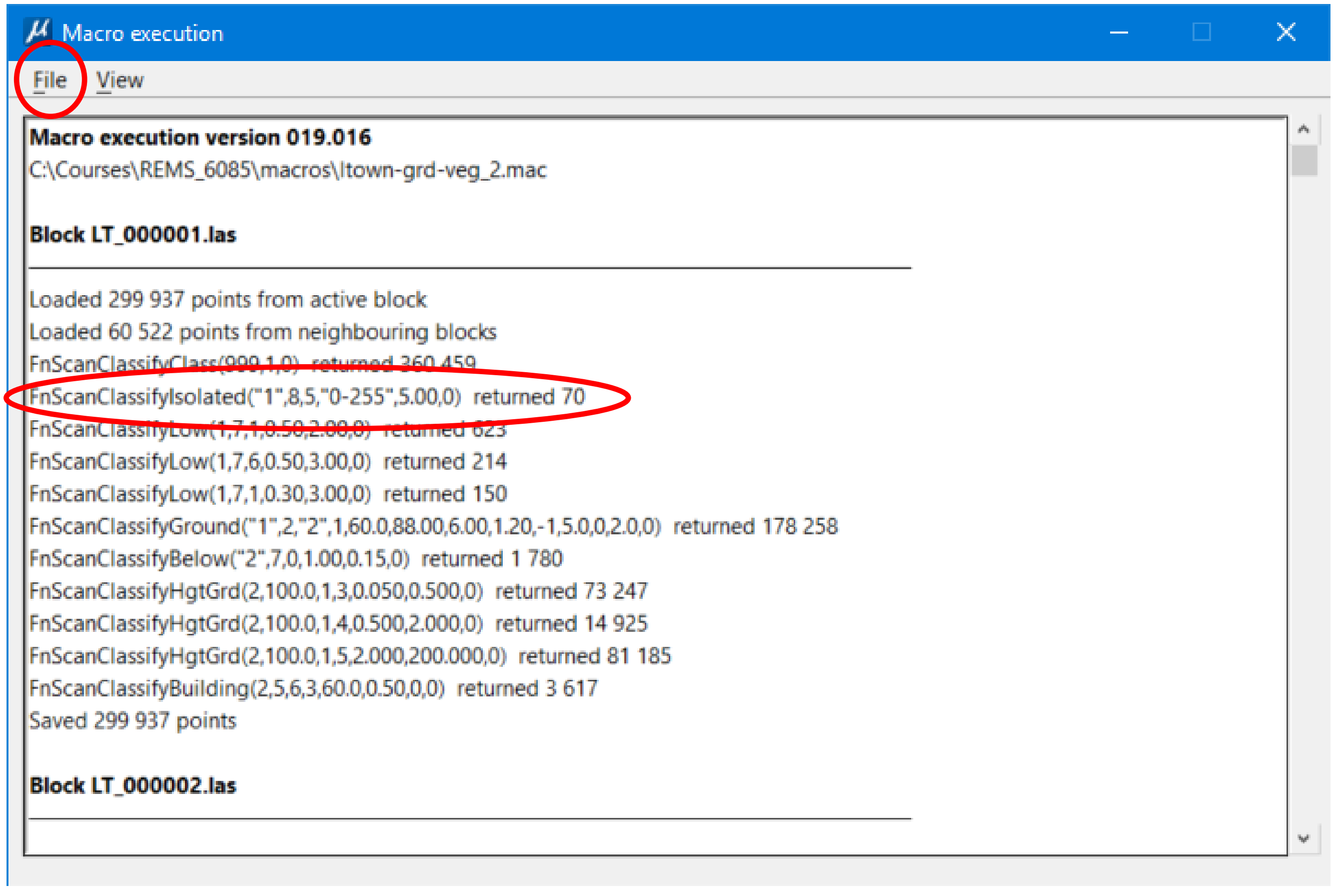


Set *Neighbors* to 25 m if you created the project blocks with no overlap. Had we designed the project blocks with an overlap built in, we would set the *Neighbours* parameter to 0m.

Finally, set it to save the results with *Write over original* (to replace the points with their updated classes). While other options are available, care must be taken to keep track of the various input and output files (i.e. adjusting the TerraScan project to use different input/output folders).

Pressing OK will open a progress window (right) and begin the processing. Although this window attempts to update as each step progresses it is common for its contents to be outdated (e.g. more processing has been performed than it indicates).





When the macro has been applied to all of the blocks in your project a **Macro execution** window appears (above) showing the results of the processing performed.

For each block, the results of each of the routines applied to its points are displayed (e.g. 70 isolated points were identified within the block 1 (circled above)).

This report should be saved (*File / Save as text* circled above) as it allows you to verify that the processing was performed as expected.