Tools, Tips, and Workflows

Automatic Stockpile Toe Extraction

LP360, versions 2015.1 and above

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1   Introduction

LP360 includes a Point Cloud Task (PCT) that will automatically digitize the toe of a clean stockpile and can allow for the classification of overhead structures such as conveyors. This tool saves considerable time when computing stockpile volumetrics.

A "clean" stockpile is one with a clear demarcation of the boundary from a 3D perspective that allows you to clearly distinguish the base at all points along the pile. On the other hand, sometimes a pile is ill defined, with close by vegetation and uneven terrain making distinguishing the base difficult. Our automatic stockpile toe extractor will not properly function on this type of configuration. The toe will have to be manually edited using Feature Edit tools.

2   Using the tool

The following sections provide step by step guidance on using the Toe Extractor.

2.1   Creating an Instance of the Toe Extractor Point Cloud Task

The automatic Toe Extractor is implemented as an LP360 Point Cloud Task (PCT). It requires either the Standard license level or Topolyst.

The PCT template for automatic toe extraction is called "Toe Extractor." You create your own custom version of this by selecting Toe Extractor from the Point Cloud Task dropdown, "Add Task", providing a Task Name and, optionally, a Task Description (Figure 1).
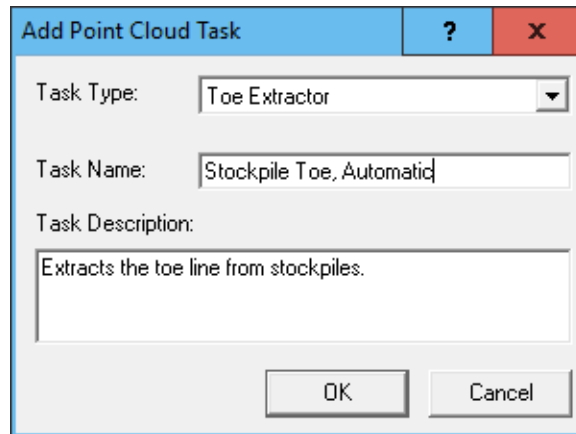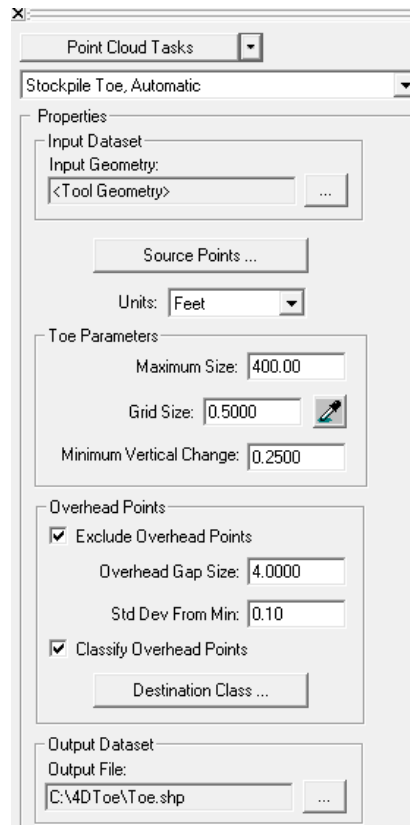
Figure 1: Creating a toe extractor instance

2.2   Tuning Parameters

Once you have added this PCT, you will be presented with the PCT settings dialog (Figure 2). The settings for this dialog determine the accuracy with which the toe can be extracted for a given data set. These settings are described in the following subsections.

Figure 2: Automatic Toe Extractor

2.2.1   Input Geometry (Seed points)

The Toe Extractor requires a location point to indicate the area of extraction. This point can be input by:

- Interactively digitizing a point ("Tool Geometry")
- Points (2D or 3D) from a Shape file
- Points (2D or 3D) on an LP360 Map Layer
- The Toe Extractor input and output parameters are set via the PCT Input/Output Manager (IOM) accessed by the ellipses beside any input or output in the PCT (Figure 3).
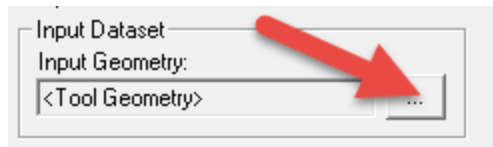

Figure 3: Invoking IO Manager to set the input seed point(s)

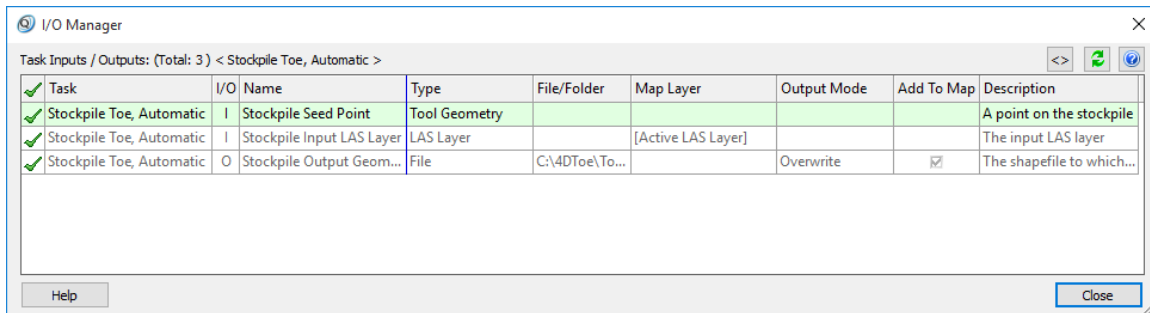This brings up the IOM dialog (Figure 4).

Figure 4: The Input/Output Manager (IOM) for the PCT System

We have set the input method to Tool Geometry, meaning we will interactively digitize our start (also referred to as "seed") points.

2.2.2   Source Points

This is the PCT Source Points setting dialog. Use it to filter the point cloud points that should be considered part of the stockpile and surrounding ground when extracting a toe. If, overhead points have been classified then those points can be excluded from consideration.

As with all PCTs, the input filter can be used to exclude points based on any point attribute, in this case Conveyor points (Figure 5).
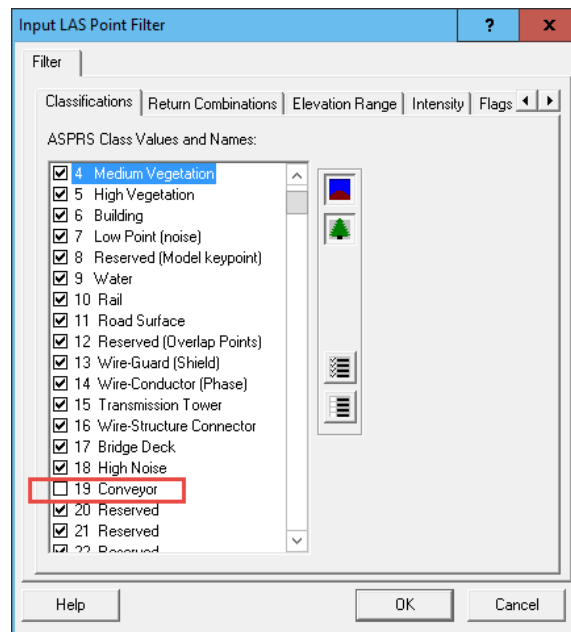
Figure 5: Excluding the "Conveyor" class

2.2.3 Units

As with all PCTs, the Units setting allows you to optimize parameters in units of Feet or Meters, regardless of the units of the data. Also ensure that the Map View units are set to the units of the point cloud data.

2.2.4 Maximum Size

This setting is used simply to prevent a "runaway" algorithm. It is used to specify the maximum area enclosed by a toe. The default is 400 ft.

The Maximum Size parameter defines a search square, Maximum Size on edge, centered at the "Seed" point.

If large stockpiles are "squared off" then increase this parameter.

2.2.5 Grid Size

The point cloud data in the neighborhood of the toe computation is partitioned into cells (grids) that are Grid Size on each edge. Some statistics such as minimum Z, maximum Z and so forth are computed for each cell. When the toe extractor looks for slopes, it does so at the horizontal granularity of the grid size. There must be sufficient points within each cell to compute these statistics. Thus the grid size must be two or more times the nominal point spacing of the point cloud data. A grid size that is too

small will cause the algorithm to fail. A grid size that is too large will cause either a very coarse toe (jagged) or will result in too much level surface being included in the toe.

We recommend that you simply use the eye dropper tool to allow the program to determine this value automatically from your data (Figure 6).
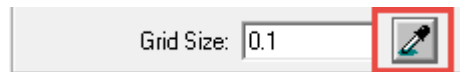

Figure 6: Grid size sampling tool

2.2.6   Minimum Vertical Change

This value should be set to roughly the sum of the absolute vertical accuracy of the point cloud and the size of the aggregate of the pile (for example, you can assume the size of sand is zero). This and the grid (cell) size are the most critical tunable parameters.

The toe algorithms steps "out" from the seed point in all directions and looks at the vertical change in all of the cells over the step distance. If the vertical change exceeds the Minimum Vertical Change, the algorithm assumes that it is still traversing down the stockpile (or up, if it happens to be "hunting" in the uphill direction). If this occurs, the algorithm includes the current cell in the toe "cluster", steps to a new, adjacent location and continues to search.

A minimum vertical change larger than needed will cause the algorithm to step out well beyond the actual toe. A minimum vertical change smaller than needed will cause the algorithm to hunt around in vertical noise, resulting in a noisy toe.

2.3   Setting the Output File

The output file determines the location of the file containing the extracted toe. This is set within the Input/Output Manager (IOM) of the PCT system.

A good practice is to use the Project Path as the root location of the output file. This allows you to use the same task output file setting, regardless of project location. In our example, we use:

"<LP360_PROJECT_PATH>3D Toe\Toe.shp"

This creates a subdirectory under your project directory called "3D Toe" and places the data in a file called "Toe.shp."
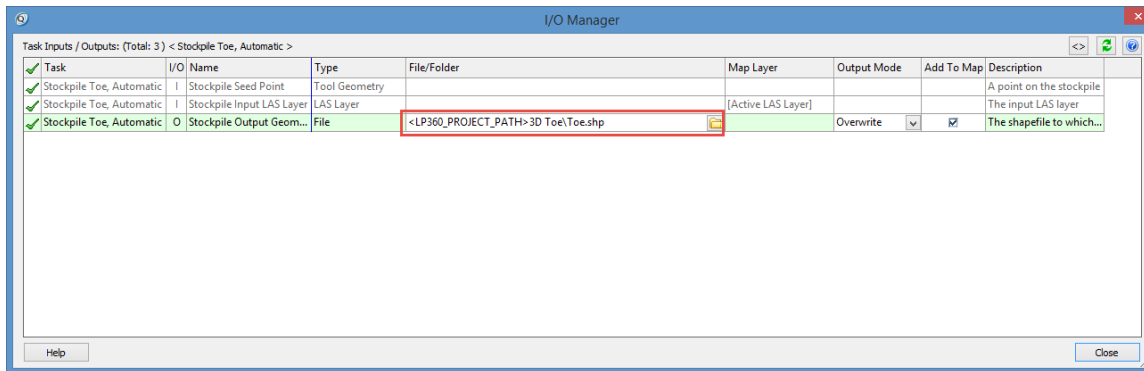
Figure 7: Setting the output file location

2.4   Executing the Task

If you are using the interactive method of digitizing each seed point (i.e. you have the IO Manager input set to Tool Geometry) then the task is executed by clicking the Point tool (Figure 8) on the PCT toolbar (it will be the only enabled tool) and clicking near the top of the stockpile for which you wish to find the toe.

Figure 8: The Point PCT tool

If you are executing the task from points preset in a shape file or layer (as set by the input method in IO Manager), then the task is executed by pressing the Project button on the PCT Toolbar (Figure 9).

Figure 9: The File PCT Tool

2.5   Forcing a Toe Location

The Reshape and Split geometry tools are the tools of choice for editing a toe. Don't resort to manipulating the toe at the individual vertex level until after you have performed gross corrections using these two tools.

Both of these tools will perform their actions on a feature without the need of preselecting the feature. The reshape tool is used to replace a section of a feature with the polyline that you draw with the tool. The replaced section will start with the feature segment to the right of your first intersection of the feature and end with your last intersection. If you unintentionally draw in the opposite direction, just use the Undo function to restore the feature.

The Split tool will split a feature at each segment where it enters a polygon and then exits the polygon. You can split multiple times in a single draw action. Again, you can recover from a bad split by pressing the undo tool in the Feature Edit toolbar.

There are numerous feature edit tools introduced in LP360 2016.2 to facilitate the editing of the automatically extracted toes.

3   Classifying Overhead Structures

The Toe Extractor includes the capability to exclude overhead points from the toe computation and to, optionally, classify the overhead points to a designated class.

When using the LP360 Volumetrics Point Cloud Task (PCT), it is important that components that should not be included in the volume computation be moved to a class that will not form part of the hull in the volumetrics computation. For example, points on an overhead conveyor could be classified as belonging to the Conveyor class and explicitly excluded from the volumetric source points. (Figure 10)
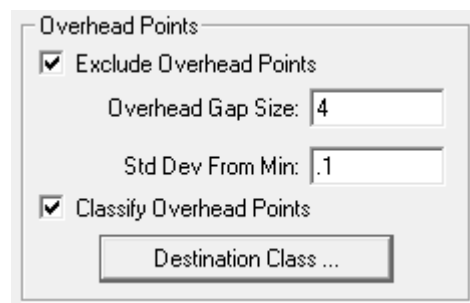

Figure 10: Overhead Points section of Toe Extractor dialog

3.1   Enabling Overhead Point Exclusion

To enable the exclusion of overhead points, check the "Exclude Overhead Points" option (Figure 10). Note from the prior discussions that the area being investigated for the stockpile toe is subdivided into an analysis grid with square cells of width/length "Grid Size."

3.2   Overhead Gap Size

The algorithm for overhead point investigation analyzes each cell for the vertical range of the elevation within the cell. If that range exceeds the setting of Overhead Gap Size, the cell is considered to contain overhead points that should be excluded from the toe extractor computation. Thus, this value should be set larger than the anticipated vertical dimension of the surface components of the cell (due to both slope and noise) but not so large as to consider overhead structures to be part of the stockpile. The

default setting is 1 foot. You will need to increase this for steeply sloped stockpiles with large grid sizes. For example, a stockpile with a slope of 45 degrees and a grid cell of 5 (this would be an example of very large nominal point spacing LIDAR data) would have a natural vertical displacement of 5 feet for the surface material over the span of the cell. Thus an Overhead Gap Size less than 5 would potentially exclude some of the surface points.

3.3   Standard Dev(iation) from Min(imum Z)

Once a cell is determined to have overhead points, a computation is performed on each point to see if it should be included as part of the stockpile surface for toe computation or considered an overhead point.

The standard deviation in the vertical direction (σz) is computed for the points in the cell. Any points that are within Std Dev from Min are considered to be part of the stockpile surface and will be included within the surface computations. Any points beyond this value are considered overhead points.

A value that is too large will result in overhead points being included in the toe computation. A value that is too small will exclude some surface points in the toe computation. The default value is 0.25 feet.

3.4   Classify Overhead Points

Checking this option and setting a destination class will move all points considered to be in the Overhead category to the specified destination class.

It is difficult to conceive of a situation where you would be excluding overhead points from the toe computation but not moving them to a different class since this is the only practical way of excluding the points from the Volume computations.

3.5   Undoing an Overhead Classification

It is often the case that you will need to experiment a bit to get the parameters set correctly for your data set.   The toe polygon is easily rewritten by simply having the Overwrite mode set in I/O Manager.

You can undo the overhead points classification by pressing the undo button on the Classification toolbar (Figure 11).
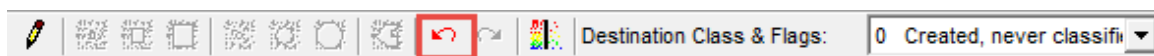

Figure 11: Undo a point classification

4   Default Parameters

The default parameters for the settings for the Toe Extractor are listed in Table 1.

Table 1: Default Parameters

Parameter	*Default (in feet)*
Source Points	All, no filters
Units	Feet
Maximum Size	400
Minimum Vertical Change	0.25
Grid Size	0.5 but use Eyedropper
Overhead Gap Size	1.0
Std. Dev. from Min.	0.25

5   Tuning Procedure

The Toe Extractor default parameters are optimized for Dense Image Matching (DIM) data sets collected using cameras on a small Unmanned Aerial System (sUAS) followed by point generation using a tool such as PhotoScan or Pix4D. These point clouds typically have ground sample distances (GSD) of 5 cm or so and vertical noise at a comparable level. If the GSD varies greatly from this or the noise is larger, it will be necessary to tune the default parameters.

When trying to change the performance of the toe extractor by adjusting parameters, it is important to adjust only one parameter at a time.

When adjusting parameters, we recommend that you set the Maximum Size parameter to some reasonably small value to limit the length of time the algorithm will run when you have ill adjusted parameters.

First set the Grid Size parameter using the eye dropper tool. In some rare cases, you may have to manually set the Grid Size parameter. This should be at least twice the nominal point spacing of the point cloud data.

If the default for the Minimum Vertical Distance is not giving good results, have a look at the extent of the noise and aggregates in the profile view. Try to start this parameter so that it reflects this range. Again, set the Maximum Size parameter to a small value while tuning to limit your wait time. Do not vary the Minimum Vertical Distance parameter by large amounts – try 0.25 or so increments both above and below the default value. Note that values below about 10 cm can usually create bad polygons and they take a very long time to run!

Note that if there is no separation between areas of the overhead points and the stockpile, the overhead separation/classification will result in erroneous classification. This can often occur if the

conveyor was in operation during the imaging operation. Rocks falling from the conveyor to the stockpile are imaged and included in the surface model.   All you can do in these cases is manually clean up the overhead/pile points with the manual classification tools. You should note, however, that if an adequate separation does exist everywhere along the toe line (which is usually the case), a proper toe line can still be automatically extracted. In these cases, use the exclude overhead points option but do not use automatic classification (unless you find it more expedient to clean up the misclassification rather than manually classify the overhead).

It is sometimes the case that the automatic toe extractor simply cannot find a proper toe no matter how long you play around with the parameter settings. In this case, simply edit the toe using feature edit tools.

Please reference the following article for more information on stockpile toes: Tips for Defining Stockpile Toes.