Data Management

This chapter introduces the basic tools commonly used for point cloud and raster data processing. Contents include: point cloud tools, raster tools, clip tools, format conversion and data extraction.

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Point Cloud Tools

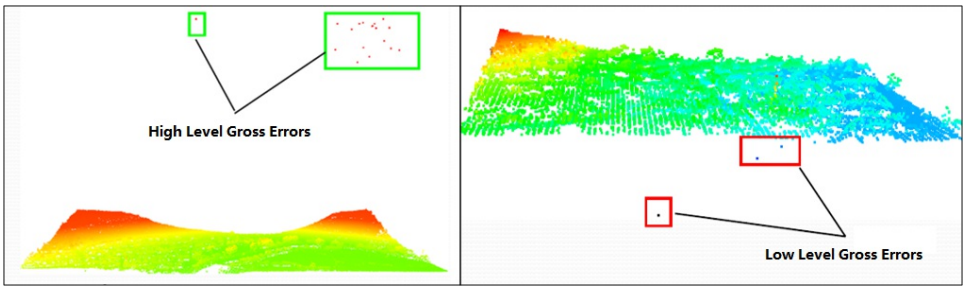
The Point Cloud Tools include Outlier Removal, Noise Filter, Normalization, Tile, Merge, Boundary, Subsampling, PCV, Projection, Extract Color from Image, subdivision and Transformation.

- Outlier Removal
- Noise Filter
- Normalization
- Normalization by Ground Class
- Tile
- Merge
- Boundary
- Subsampling
- PCV
- Define Projection
- ReProject
- Extract Color from Image
- Subdivision
- Transformation

Outlier Removal

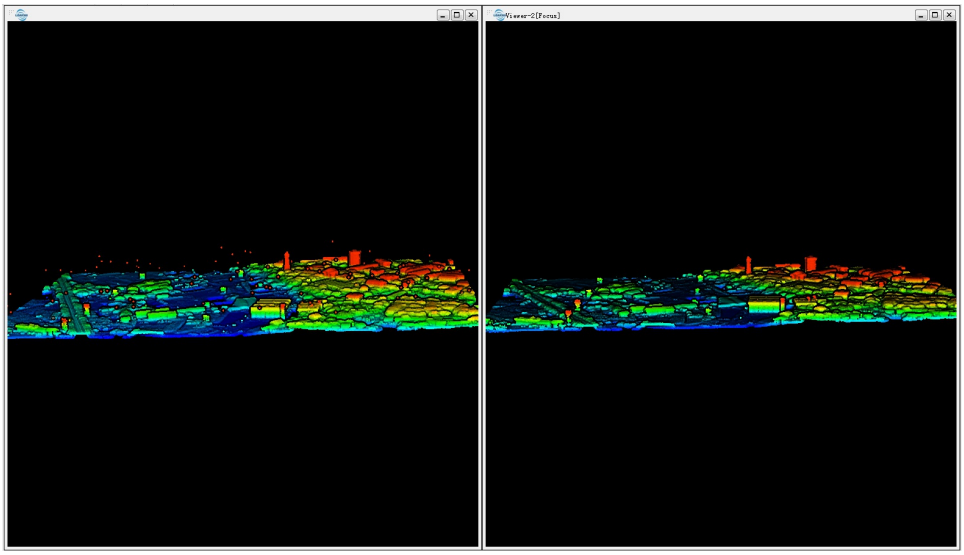
Brief

Common noises include high-level and low-level gross errors. As shown below, high-level gross errors are usually caused by returns from high-flying objects (such as birds or aircraft) during data collection, while low-level gross errors are returns at extremely low altitudes caused by the multipath effect of a laser pulse. The Outlier Removal tool aims to remove these errors as much as possible and thus improve data quality.



The algorithm will first search for each point's neighboring points within a user-defined area and calculate the average distance from the point to its neighboring points. Then, the mean and standard deviation of these average distances for all points are calculated. If the average distance of a point to its neighbors is larger than maximum distance (maximum distance = mean + n * standard deviation, where n is a user-defined multiple number), it will be considered as an outlier and be removed from the original point cloud.

Effect picture:



Usage

Click *Data Management* > *Point Cloud Tools* > *Outlier Removal*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Neighbor Points (default value is "10")**: The number of points required in the neighborhood to calculate the average distance of each point. If there are not enough points found, the algorithm will not be executed.
- **Multiples of std deviation (default value is "5")**: The factor multiplied by the standard deviation to calculate the maximum distance.
- **Same With Origin File Name**: Whether to use the same file name of origin file name.
- **Output path**: Path of the output file. After the algorithm being executed, a new file will be generated. When more than one files are entered, the path needs to be set to a folder.
- **DefaultValue**: If this button is clicked, all parameters will be set to default values.

> Note: The algorithm can be performed repeatedly to improve the denoising results. The outlier removal results is limited if the noises are to dense.

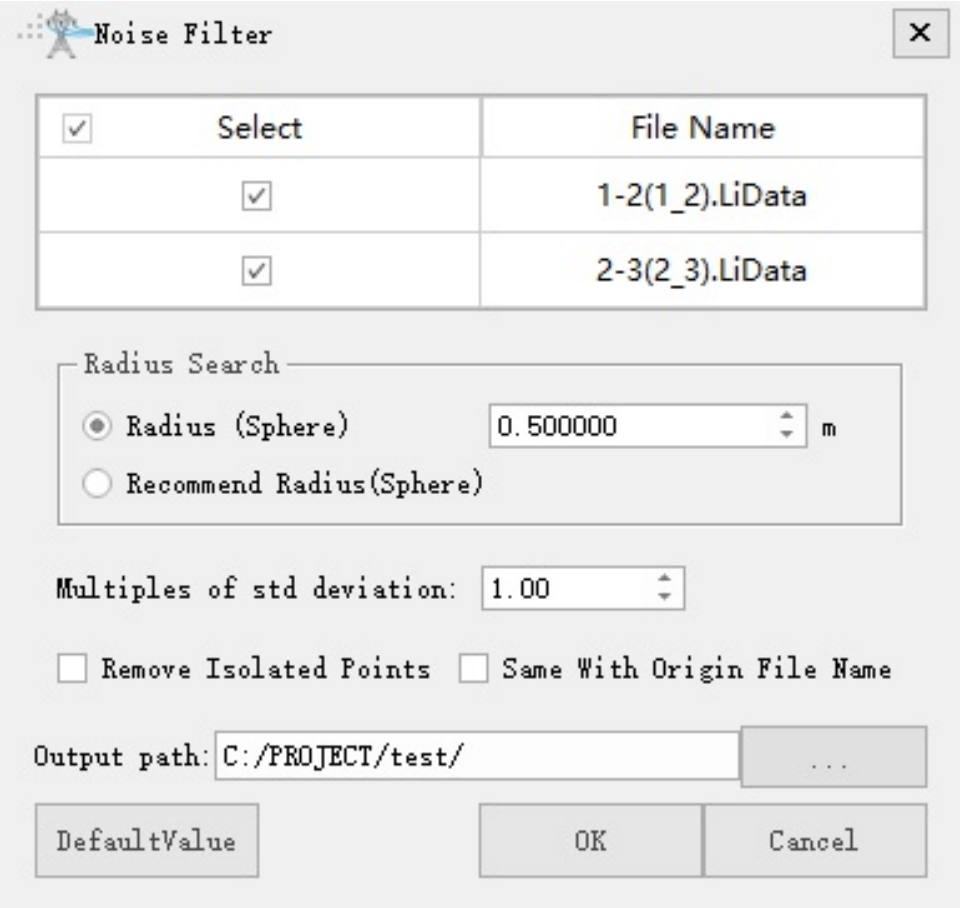
Noise Filter

Brief

Remove noise from a point cloud. Unlike the denoising function, this function works better for objects with planar surfaces (e.g., walls, tunnel interiors, ground) and can filter out more noise points.

Usage

Click *Plugins* > *Point Cloud Tools* > *Noise Filter*



Parameter Settings

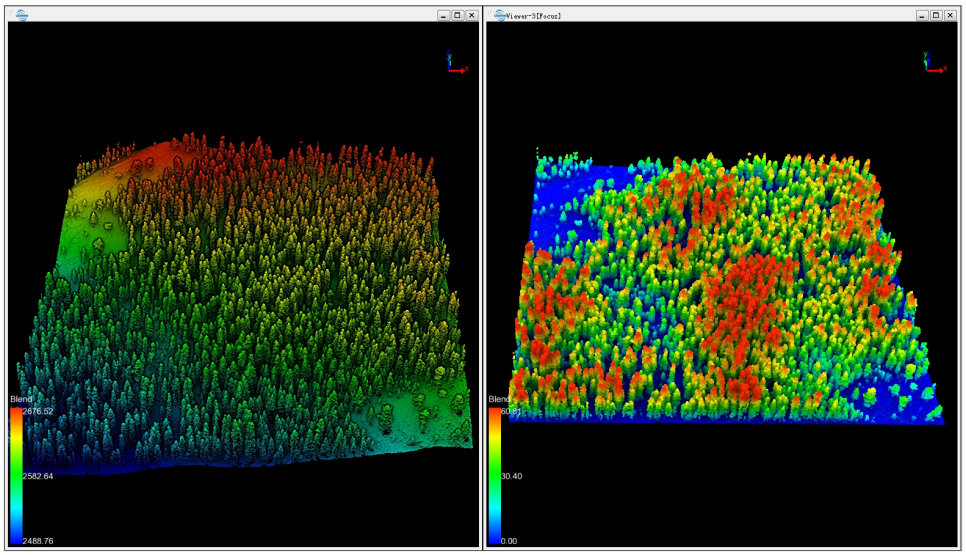
- **Input Data**: The input file can be a single point cloud data file or a point cloud dataset.
- **Radius Search (meters) (default is "0.5")**: Set the radius for fitting the plane. This method can be used when the user knows the approximate density of the point cloud.
- **Recommended Radius Search**: Automatically calculate a suitable search radius based on the input point cloud.
- **Standard Deviation Multiplier (default is 1.0)**: Use the relative error (sigma) as the denoising criterion. The program automatically calculates the standard deviation (stddev) of the plane fitted to the neighborhood of each point P. If the distance d from the point to the plane is less than sigma*stddev, the point P will be retained. Decreasing this value will result in more points being removed, and vice versa. Changing this value does not affect efficiency.

- **Remove Isolated Points**: If the number of points within the search radius is less than four (insufficient for plane fitting), the point is considered isolated. Users can choose whether to remove such points based on this parameter.
- **Same With Source File Name**: If checked, a new file with the same name as the source file but with noise removed will be generated in the output directory. Otherwise, the string "_NoiseFilter" will be appended to the source file name.
- **Output Path**: The output folder path. After the algorithm is executed, a new file with noise removed will be generated in this directory.
- **DefaultValue**: If this button is clicked, all parameters will be set to default values.

Normalization

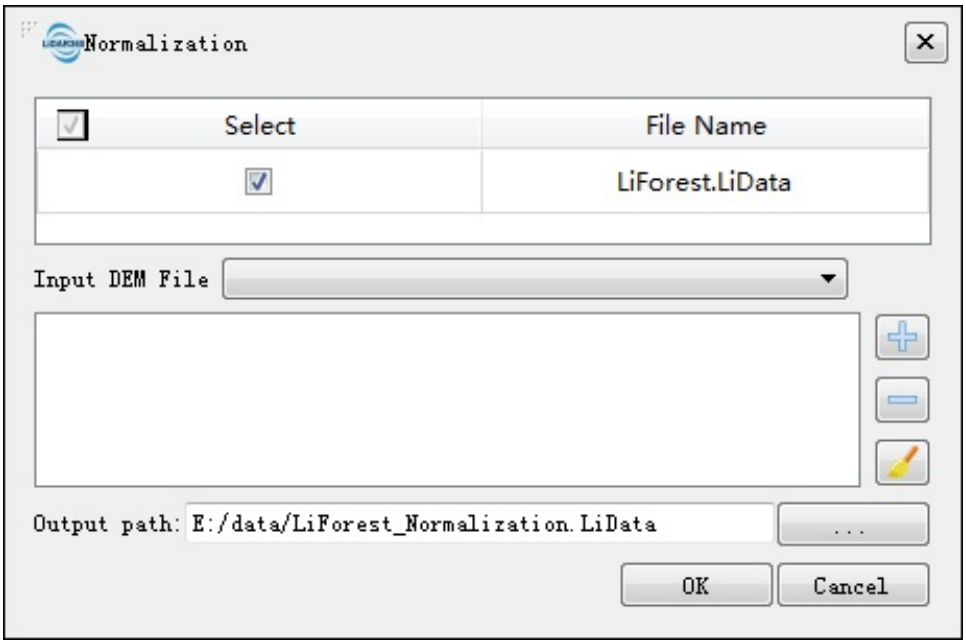
Brief

The normalization tool can remove the influence of terrain relief on the elevation value of the point cloud data. This function requires that the extent of the DEM overlaps with the extent of the point cloud data. During normalization, each point's Z value is reduced by the terrain elevation interpolated from the DEM at that point. The output of this function is similar to Normalization by Ground Class.



Usage

Click *Data Management* > *Point Cloud Tools* > *Normalization*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Input DEM File**: Users can select single or multiple single-band TIFF image files from the drop-down list. File format: *.tif.
- : Users can add external DEM file data.
- : Users can select a file in the list and click this button to remove the file from the list.
- : Click this button to clear all the data in the list.
- **Output path**: Path of the output file. After the algorithm being executed, the new normalized file will be generated. When entering more than one file, the path will need to be set as a folder.

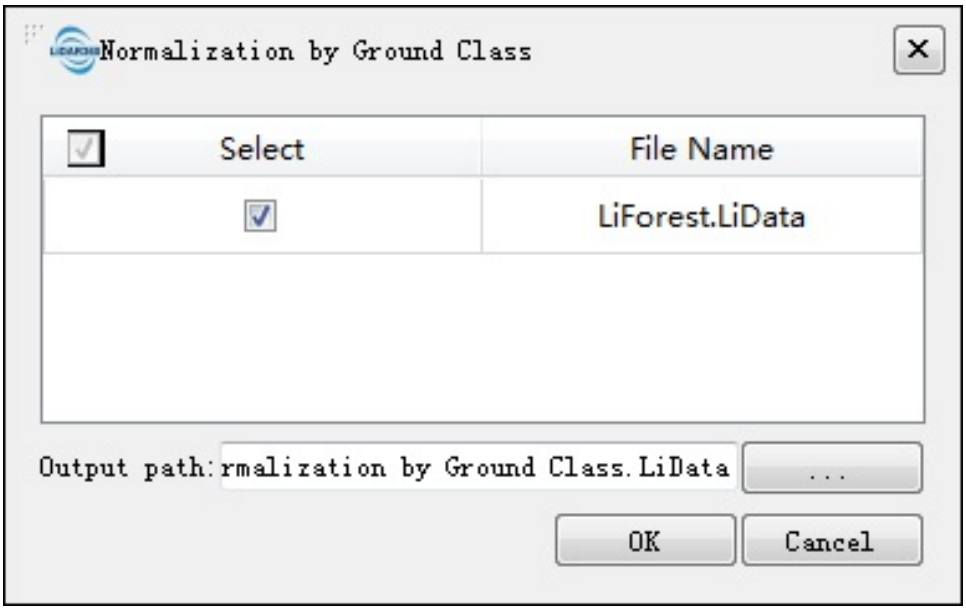
Normalization by Ground Class

Brief

The normalization tool can remove the effects of topographic relief on the elevation value of point cloud data. This function requires that the input data has already been classified into ground points and non-ground points. During normalization, every point's Z value is reduced by the terrain elevation at that point, where the terrain elevation is taken from the nearest ground point to each point. The output of this function is similar to Normalization.

Usage

Click *Data Management* > *Point Cloud Tools* > *Normalization by Ground Class*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Output path**: Path of the output file. After the algorithm being executed, the normalized new file will be generated. When entering more than one file, the path needs to be set as a folder.

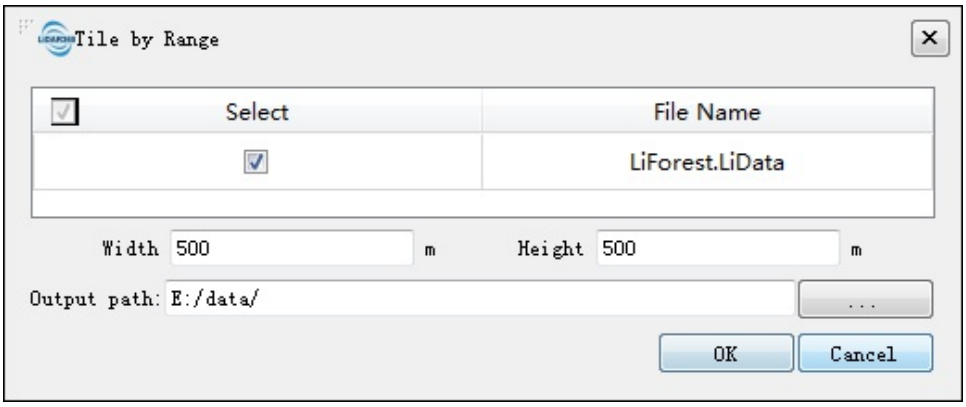
Tile

Brief

Tile by Range divides the point cloud into a series of small data files based on the user-defined width and length of the small data file. This process begins from the lower-left corner of the input file's bounding box.

Usage

Click *Data Management* > *Point Cloud Tools* > *Tile*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Width (default value is "500")**: The width of the data block size, which is the length in the X-axis direction.
- **Height (default value is "500")**: The length of the data block size, which is the length in the Y-axis direction.
- **Output path**: Path of the output folder. After the algorithm being executed, new files will be generated.

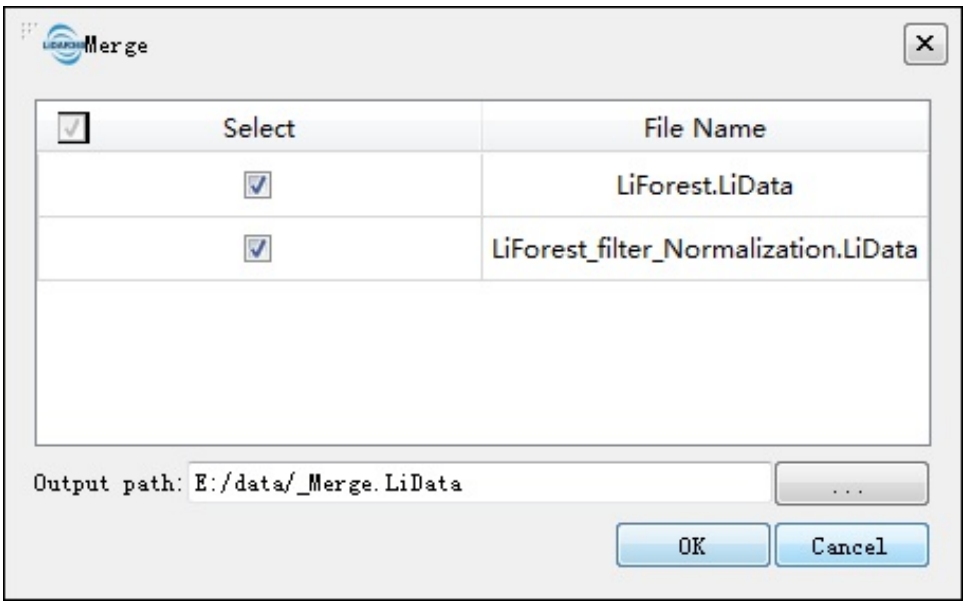
Merge

Brief

Merge multiple point cloud files into a single point cloud file. This function is the reverse operation of Tile.

Usage

Click *Data Management* > *Point Cloud Tools* > *Merge*



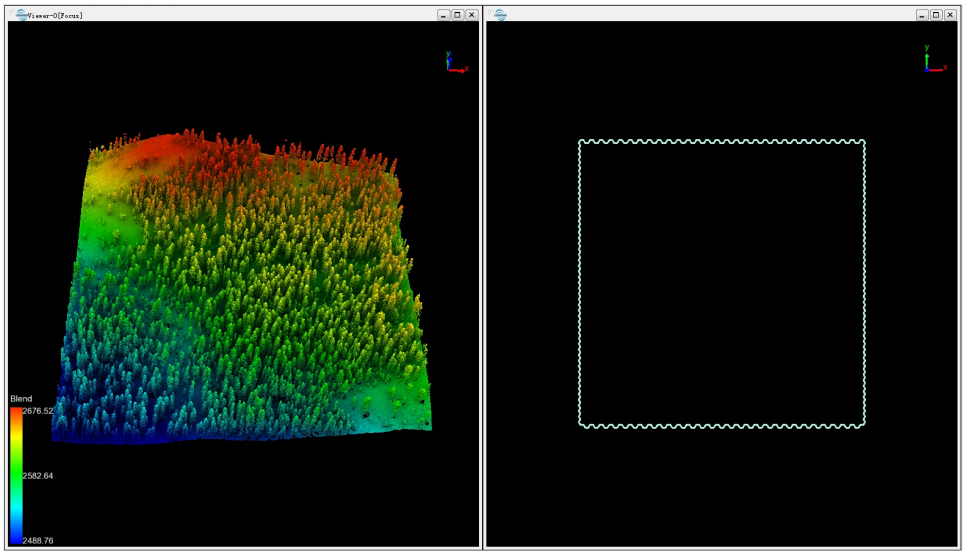
Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Output path**: Path of the output folder. After the algorithm being executed, a new file will be generated.

Boundary

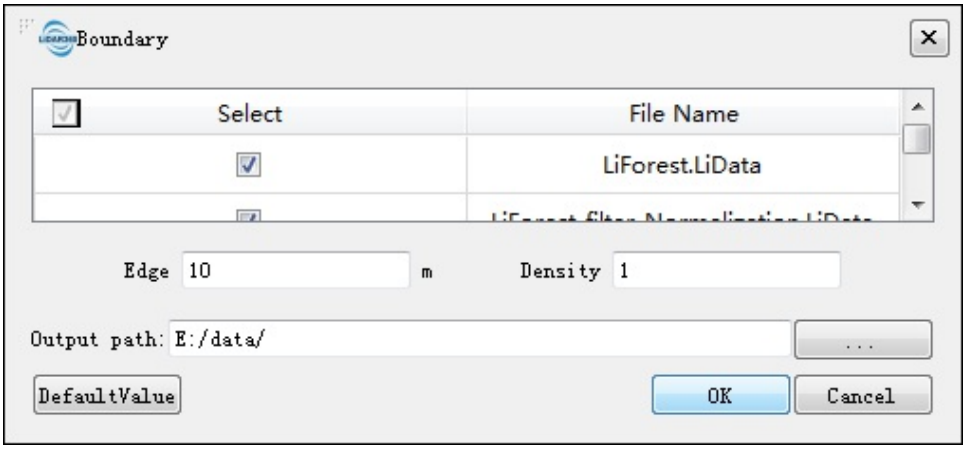
Brief

Use a regular hexagon to extract the boundary of a point cloud data. According to the **Edge**, determine the height of each regular hexagon, and draw each hexagon based on the bounding box of the point cloud data. If the number of points within a hexagon is greater than or equal to the user-defined **Density** value, this hexagon will be kept and merged with its connected hexagons. The ultimate output file is the final border vector file.



Usage

Click *Data Management* > *Point Cloud Tools* > *Boundary*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Edge (default value is "10")**: The height of the hexagon, which is used to set the size of drowning a hexagon.
- **Density (default value is "1")**: The thresholding number of points in a hexagon, below which no hexagon will be drawn.

- **Output path**: Path of the output file. A new boundary vector file will be generated after the algorithm is executed. File format: *.shp.

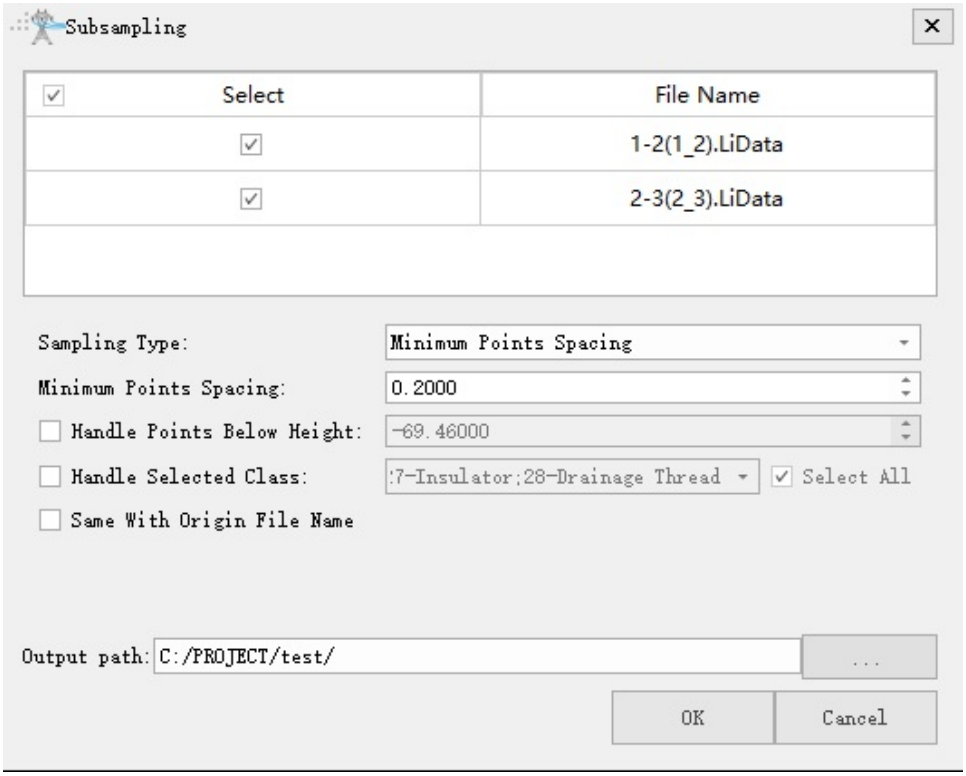
Subsampling

Brief

Subsampling point clouds, namely, reducing the number of point clouds, LiPowerline offers three methods for resampling: minimum point spacing, sampling rate, and octree.

Usage

Click *Data Management* > *Point Cloud Tools* > *Subsampling*



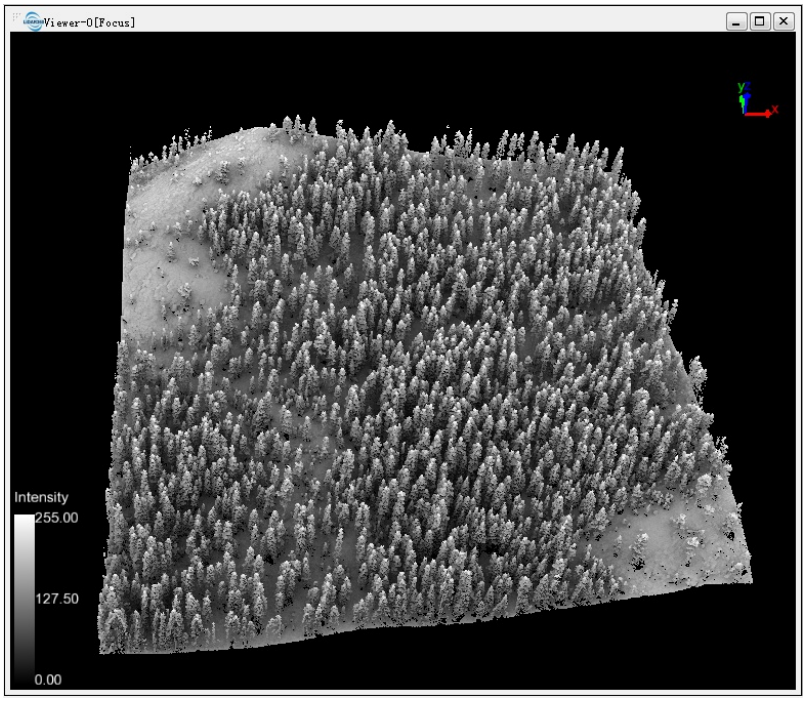
Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Sampling Type**: This parameter defines the resampling method.
- **Minimum Points Spacing (default, default value is "0.2000")**: Users need to set a minimum point spacing between two points so that the minimum three-dimensional distance between any two points in the sampled point cloud will not be less than this value. The larger the value is set, the fewer points will be kept.
- **Handle Points Below Height**: If this item is checked, only points below that elevation are processed.
- **Handle Selected Class**: If this item is checked, only the points of the target category are processed.
- **Same With Origin File Name**: Whether to use the same file name of origin file name.
- **Output path**: Path of the output file. New file will be generated after the algorithm being executed.

PCV

Brief

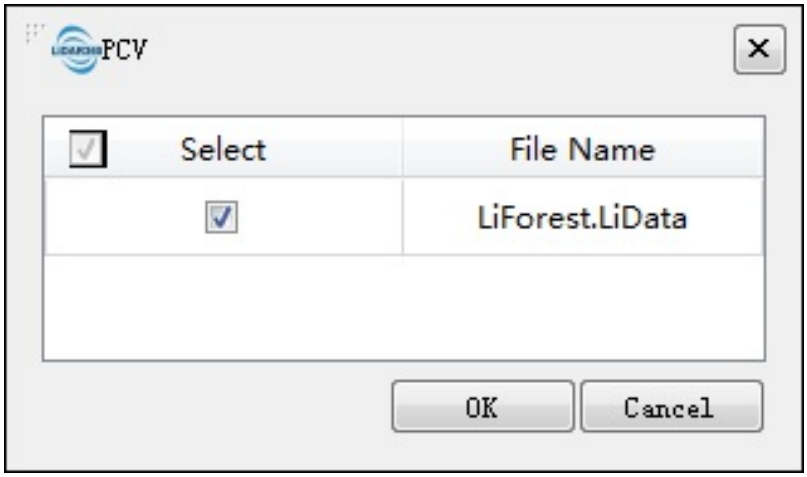
PCV tool can be used to improve visualization effect of a point cloud. The principle of the PCV (Portion of Visible Sky) algorithm is to evenly distribute multiple light sources at the top of the hemisphere or sphere calculate, and then calculate the cumulative number of times when the light can be irradiated by illuminating each point in a point cloud. The last statistical result will be used as the intensity of the point cloud. The rendering effect of the point cloud intensity after PCV calculation is shown in the figure below.



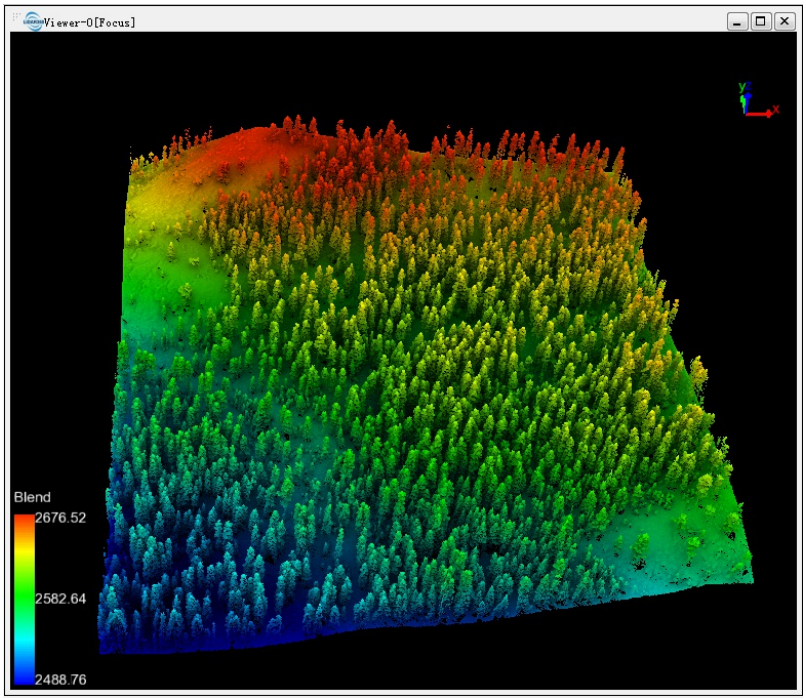
Usage

Click *Data Management* > *Point Cloud Tools* > *PCV*

Select the point cloud data that needs to be processed by PCV.



After the PCV process, the intensity range of a point cloud will be 0-255. By clicking on display by intensity or clicking display by the mixed mode, users can see the boundary between different land covers more clearly in the point cloud after PCV process. The figure below shows an example of intensity and height blend displaying effect after PCV calculation.



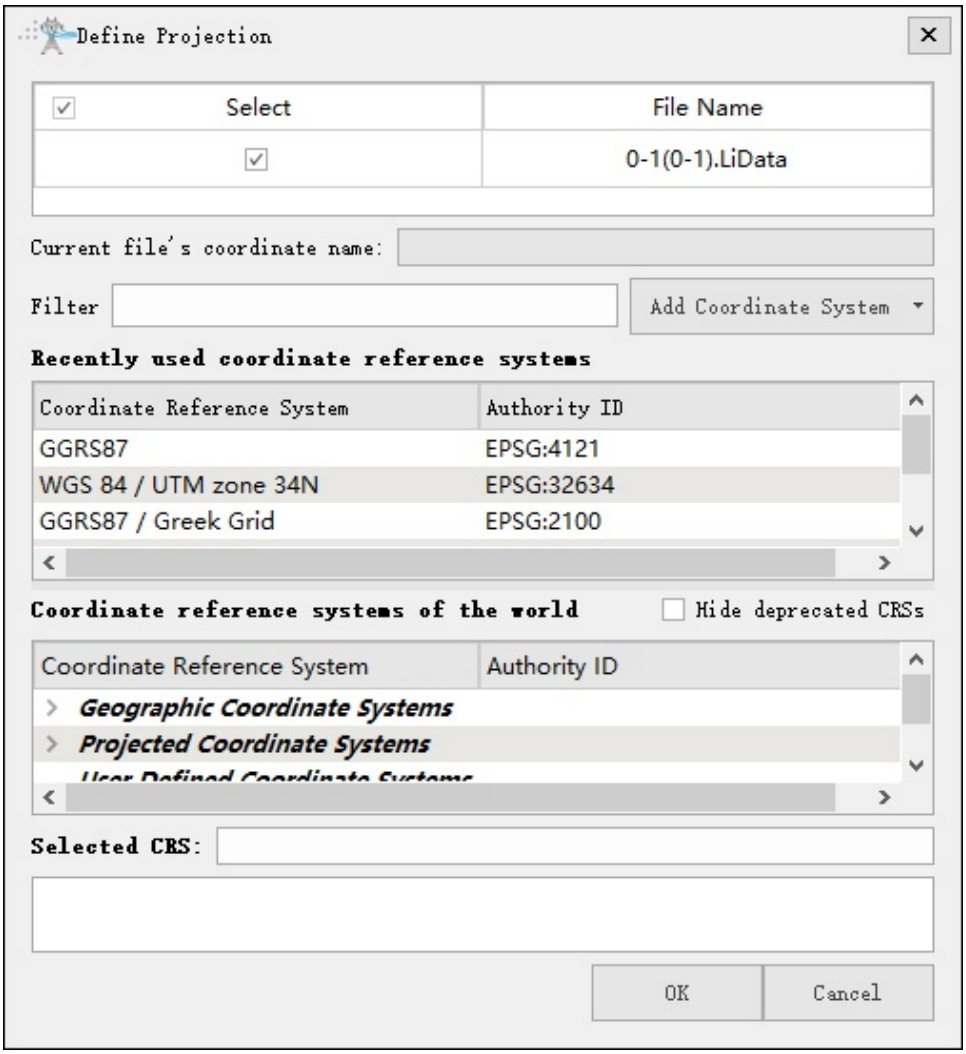
Define Projection

Brief

Define projection information for point cloud data, including geographic coordinates (usually latitude and longitude coordinates) and projection coordinates (plane coordinates converted by projection).

Usage

Click *Data Management > Point Cloud Tools > Define Projection*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File format: *.LiData.
- **Filter**: Type keywords to search for a coordinate system in the **Coordinate reference systems of the world** table. For example, to set the point cloud to WGS 84 / UTM Zone 49N, type UTM 49N in the filter for a quick match, or enter its EPSG number 32649. You can also import external coordinate system settings with the **Add Coordinate System** button.

- **Add Coordinate System**: Users can add external coordinate system settings or customize coordinate system settings. LiPowerline software provides four ways to add external coordinate system:
  - **Import from WKT**
  - **Import from PRJ**
  - **Add Geographic Coordinate System**
  - **Add Projected Coordinate System**
- **Hide deprecated CRSs**: Hide deprecated coordinate systems.

Import from WKT

WKT format can refer to the following way:

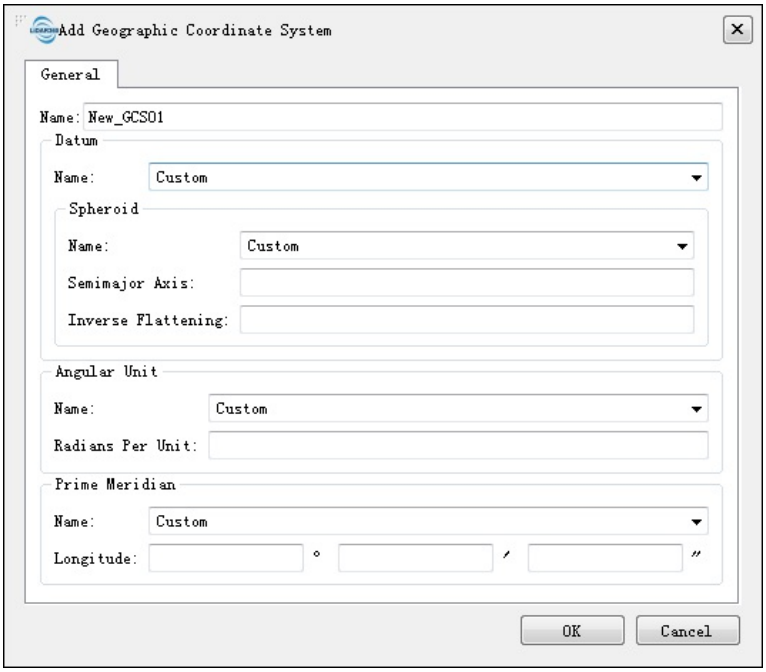
```
    GEOGCS[
        "GCS_Beijing_1954"
      ,DATUM["D_Beijing_1954",SPHEROID["Krasovsky_1940",6378245.0,298.3]]
        ,PRIMEM["Greenwich",0.0]
        ,UNIT["Degree",0.0174532925199433]
        ,AUTHORITY["EPSG",4214]
    ]


    PROJCS[
        "MyProjCS"
        ,GEOGCS["WGS84",DATUM["WGS_1984",SPHEROID["WGS84",6378137,298.257223563,AUTHORITY["EPSG","7030"]],TOWGS84[0,0
,0,0,0,0,0],AUTHORITY["EPSG","6326"]]
        ,PRIMEM["Greenwich",0,AUTHORITY["EPSG","8901"]]
        ,UNIT["degree",0.0174532925199433,AUTHORITY["EPSG","9108"]]
        ,AUTHORITY["EPSG","4326"]]
        ,PROJECTION["Transverse_Mercator"]
        ,PARAMETER["latitude_of_origin",0]
        ,PARAMETER["central_meridian",-81],PARAMETER["scale_factor",0.9996]
        ,PARAMETER["false_easting",500000]
        ,PARAMETER["false_northing",0]
        ,UNIT["Meter",1]
    ]
```

Import from PRJ

PRJ format can refer to the following way:

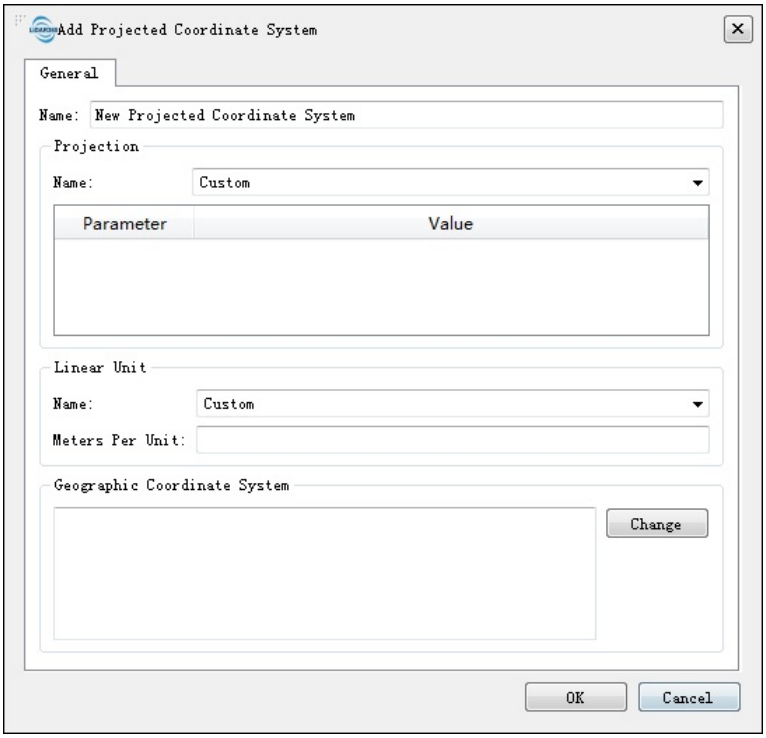
```
    +proj=longlat +ellps=aust_SA +towgs84=-117.808,-51.536,137.784,0.303,0.446,0.234,-0.29 +no_defs
```

Add Geographic Coordinate System



- **Name**: Users can customize a geographic coordinate system name.
- **Datum**:
  - **Name**: Users can customize a datum name or select a known datum from the drop-down list.
  - **Spheroid**: If a user selects the datum from the drop-down list, the ellipsoid parameter does not require user to enter.
    - **Name**: The name of the spheroid.
    - **Semimajor Axis**: Spheroid's major semi axis.
    - **Inverse Flattening**: Inverse flattening of the spheroid.
- **Angular Unit**:
  - **Name**: Users can customize the angle unit name, or select the angle unit name from the drop-down list.
  - **Radians Per Unit**: Define the unit of arc in the geographic coordinate system.
- **Prime Meridian**:
  - **Name**: Users can customize the name of the central meridian, or select the name of the central meridian from the drop-down list.
  - **Longitude**: Input the central meridian longitude.

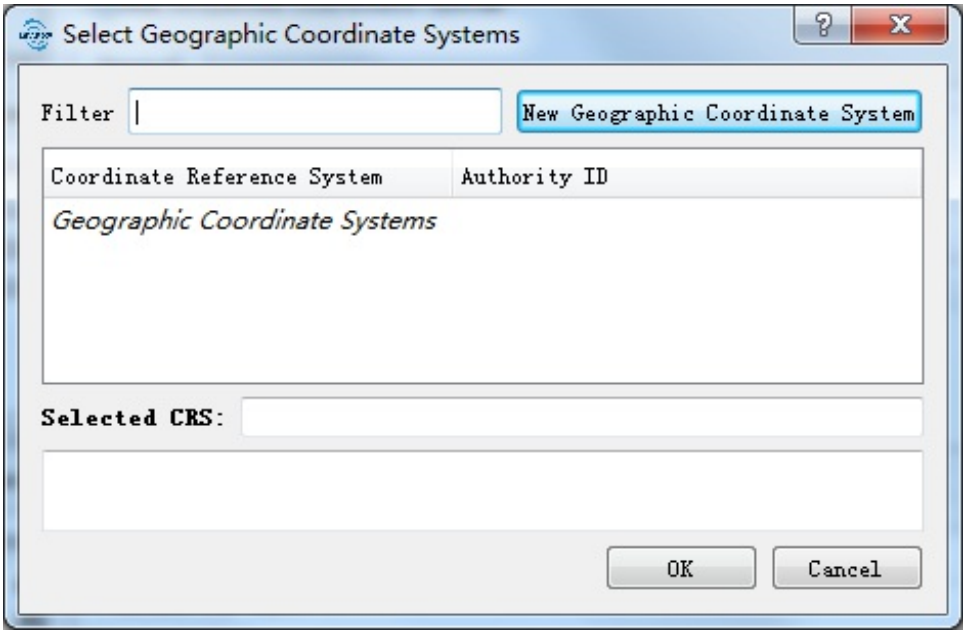
Add Projected Coordinate System



- **Name**: Users can customize the name of a projection coordinate system.
- **Projection**:
  - **Name**: Users can customize a projection name or select a known projection from the drop-down list. It should be noted that user-defined projections can be modified from a projection template selected from the drop-down list.
- **Linear Unit**:
  - **Name**: Users can customize the linear unit name or select the linear unit name from the drop-down list.
  - **Meters per Unit**: Input meters per unit.
  - **Geographic Coordinate System**: Users can paste the geographic coordinate system parameters into the text box, or click **Change**.

Change

When the user clicks on the Modify button, the following dialog box will pop up for modifying the geographic coordinate system.



The user can filter out the needed coordinate system through the filter operation, or can also add the geographic coordinate system through the **New Geographic Coordinate System** and the setting method is the same as Add Geographic Coordinate System.

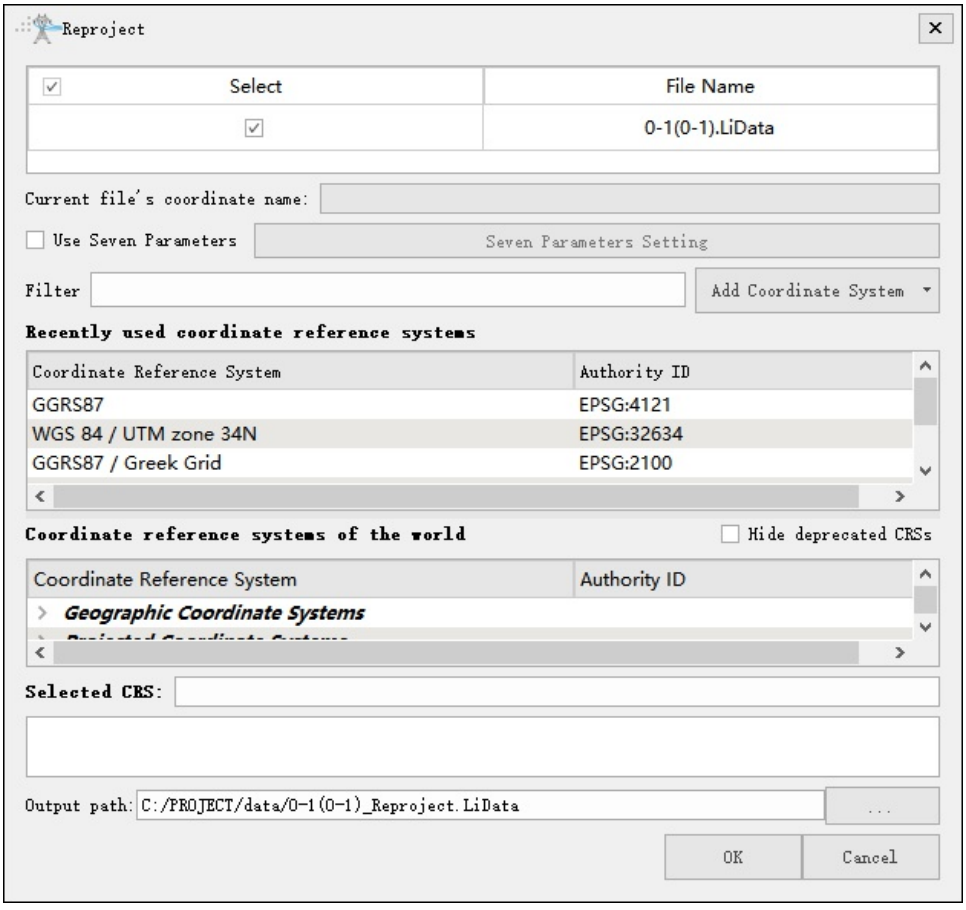
Reproject

Brief

The point cloud can be converted by projection, including the conversion between geographic coordinate system and projected coordinate system. When different geographic coordinate systems are converted to each other, due to the differences between the ellipsoid used and the reference plane, it will involve the conversion between ellipsoids. LiPowerline provides the seven-parameter transformation model. Select the "using the seven-parameters" option and click the "Seven Parameters Setting" button. The user can enter the values for X-translation, Y-translation, Z-translation, X-axis rotation, Y-axis rotation, Z-axis rotation, and scale values for seven-parameter transformation.

Usage

Click *Data Management* > *Point Cloud Tools* > *Reproject*



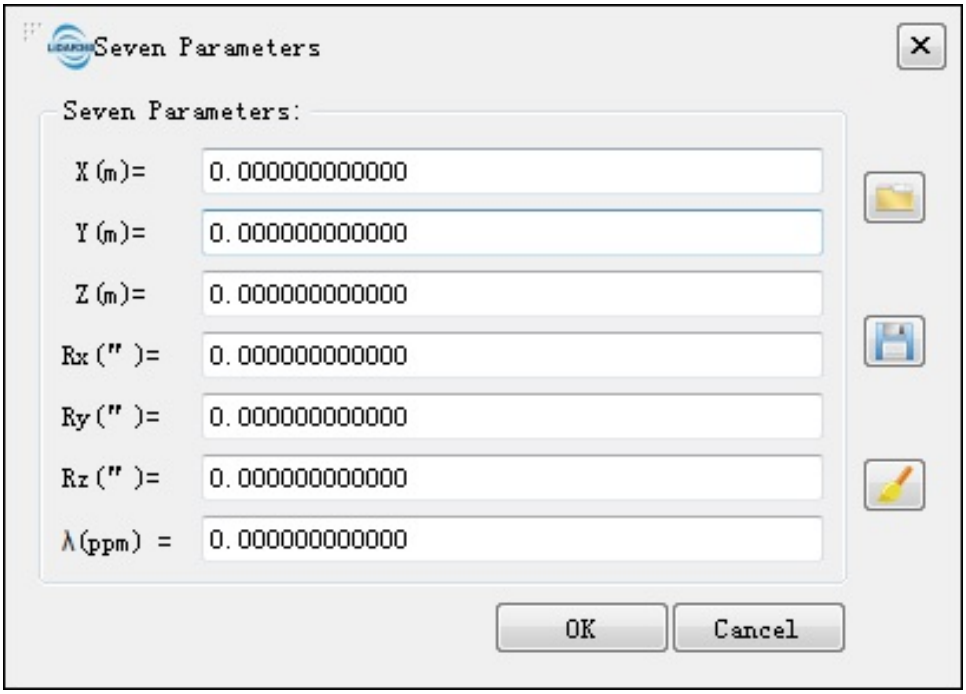
Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Use Seven Parameters**: User decides whether to use seven parameters for re-projection, if checked, seven parameters will be used.
- **Seven Parameters Setting**: Select the **Use Seven Parameters** option, click the **Seven Parameters Setting** button, and the Seven Parameters Dialog will pop up. Click to fill the seven-parameter values by opening

a txt file; click to save the set value as a txt file; click to clear the entered value.

- **X (m)**: The X translation in seven parameters.
  - **Y (m)**: The Y translation in seven parameters.
  - **Z (m)**: The Z translation in seven parameters.
  - **Rx (")**: The X-axis rotation in seven parameters.
  - **Ry (")**: The Y-axis rotation in seven parameters.
  - **Rz (")**: The Z-axis rotation in seven parameters.
  - **λ (ppm)**: The zoom scale in seven parameters.

- **Filtering**: Type keywords to search for a coordinate system in the **Coordinate reference systems of the world** table. For example, to set the point cloud to WGS 84 / UTM Zone 49N, type UTM 49N in the filter for a quick match, or enter its EPSG number 32649. You can also import an external coordinate system with the **Add Coordinate System** button.
- **Add coordinate systems**: For details, refer to Define Projection Parameter Settings.
- **Hide deprecated CRSs**: Hide deprecated coordinate systems.
- **Output path**: Path of the output file. New files will be generated after the algorithm is executed.



> Note: The reprojected point cloud must already have projection information. To check whether the current point cloud has projection information, users can select the data in the data list and its projection information will be displayed in the current file coordinate system.

Extract Color from Image

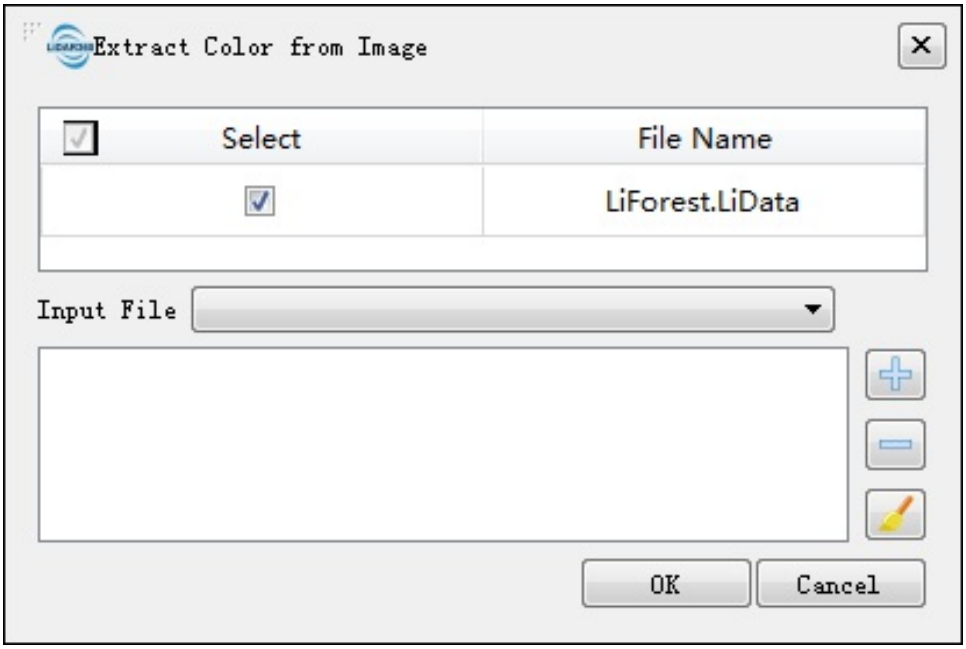
Brief

Extract Color from Image tool can extract RGB information from multi-band imagery and assigned them to each point in a point cloud. The user is required to enter one or more multi-band images that overlapping with the extend of the point cloud data.

After the process is completed, the display mode of the point cloud data will automatically change to RGB display (you can also click  on the toolbar Button, to display the point cloud in RGB).

Usage

Click *Data Management* > *Point Cloud Tools* > *Extract Color from Image*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Input File**: The user needs to enter one or more multi-band images that are geographically overlapping with the point cloud data. If the image data has already been opened in the software, click the drop-down button to select the data, or you can click  to open the external image data. Click to remove selected images from the list and click  to clear the image data list. File format: *.tif.

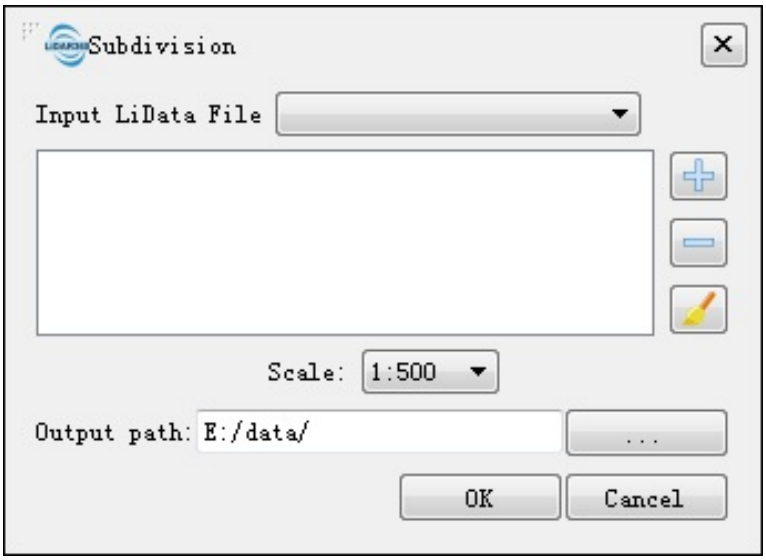
Subdivision

Brief

Subdivision tool can divide a point cloud to a series of frames based on the user defined scales. Currently, LiPowerline supports four subdivision scales: a scale of 1:5000 (taken to 1 km), 1:2000 (taken to 0.1 km), 1:1000 (taken to 0.1 km), and 1:500 (taken to 0.01km). Moreover, only subdivision in rectangular is supported currently. The frame ID will be named by the coordinate number, which is composed of the southwest corner of the frame (Y coordinate + X coordinate). After the operation is completed, a vector file will be generated in shp format recording each subdivided frame.

Usage

Click *Data Management* > *Point Cloud Tools* > *Subdivision*



Settings

- **Input LiData File**: Input the point cloud data to be subdivided. If the point cloud data is already open in the software, click the drop-down button to select the data; or you can click to open external point cloud data. Click to remove the selected data. Click to clear the image data list. File format: *.LiData.
- **Scale**: User-defined scale. LiPowerline has four scales: 1:500, 1:1000, 1:2000, 1:5000.
- **Output path**: Path of the output folder. After the algorithm is executed, a new shp file will be generated.

Transformation

Brief

LiPowerline software supports multiple coordinate conversion methods. Users can select a conversion type to perform point cloud data conversion according to their needs.

The four supported coordinate conversion methods are:

- **Linear**
- **XYMultiply**
- **Translate and Rotate**
- **3D Affine**

Steps

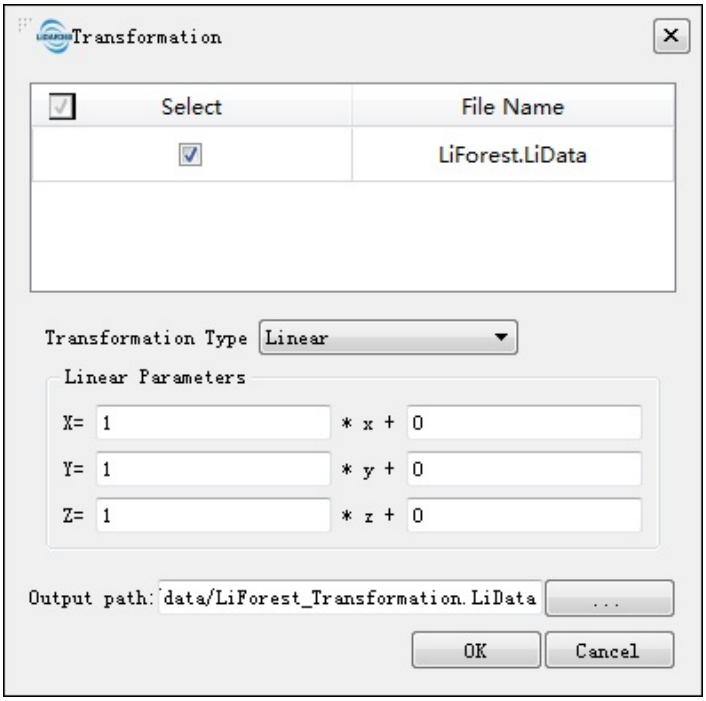
1. **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
2. Select the **Transformation Type**. The user selects the desired conversion type from the drop-down box and sets the relevant parameters.
3. **Output path**: Path of the output folder. After the algorithm is executed, new files after transformation will be generated.

Usage

Click *Data Management* > *Point Cloud Tools* > *Transformation*

Settings

Linear

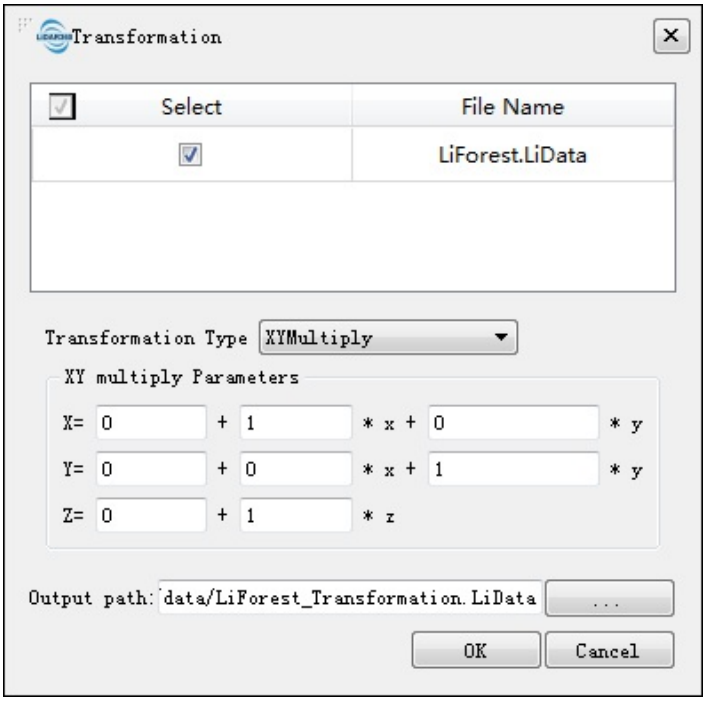


The linear transformation is used to pan and zoom a point cloud. A panning and scaling parameter need to be set to the X, Y, Z coordinates, respectively. The targeted coordinates are calculated using the following formula:

$$\begin{cases} X = S_x * x + P_x \\ Y = S_y * y + P_y \\ Z = S_z * z + P_z \end{cases}$$

Among them: Sx, Sy, Sz are the scaling factors for the x, y, and z coordinates. Px, Py, and Pz are the panning parameters for the x, y, and z coordinates. x, y, and z are the original coordinates, and X, Y, and Z are coordinates obtained after the linear transformation.

XYMultiply

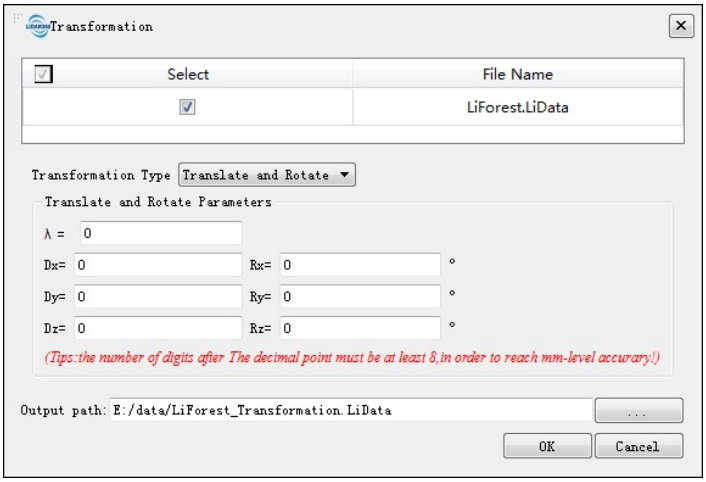


The target coordinates are calculated using the following formula:

$$\begin{cases} X = P_x + a * S_x + b * S_y \\ Y = P_y + c * S_x + d * S_y \\ Z = P_z + e * S_z \end{cases}$$

Among them, Px, Py, Pz, a, b, c, d, e are the transformation parameters, Sx, Sy, Sz are the original coordinates, and X, Y, Z are the transformed coordinates. This is often used as a 2D Helmert transformation.

Translate and Rotate



The target coordinates are calculated using the following formula:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = (1+\lambda) \begin{bmatrix} R_{11} & R_{12} & R_{13} & D_x \\ R_{21} & R_{22} & R_{23} & D_y \\ R_{31} & R_{32} & R_{33} & D_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

R11, R12, R13, R21, R22, R23, R31, R32, R33 are calculated as follows:

R11 = cos(Ry) * cos(Rz)

R21 = cos(Ry) * sin(Rz)

R31 = -sin(Ry)

R12 = sin(Rx) *sin(Ry)* cos(Rz) - cos(Rx) * sin(Rz)

R22 = sin(Rx) *sin(Ry)* sin(Rz) + cos(Rx) * cos(Rz)

R32 = sin(Rx) * cos(Ry)

R13 = cos(Rx) *sin(Ry)* cos(R_z) + sin(Rx) * sin(Rz)

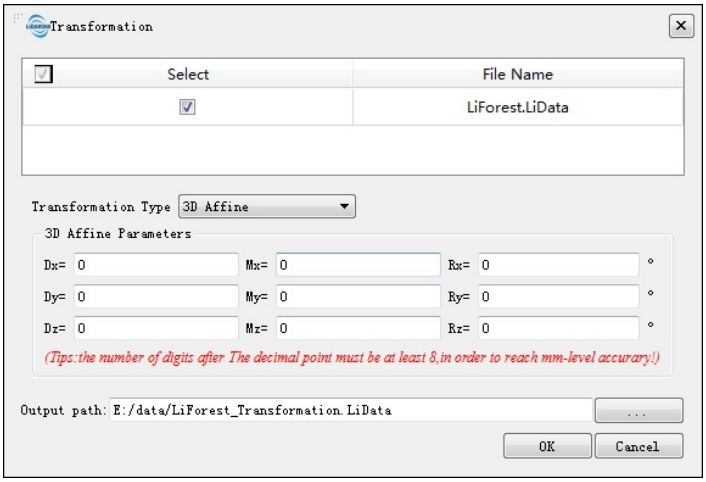
R23 = cos(Rx) *sin(Ry)* sin(Rz) - sin(Rx) * cos(Rz)

R33 = cos(Rx)* cos(Ry)

- **λ (default value is "0")**: Scale conversion factor applied to X, Y, Z.
- **Dx, Dy, Dz (default value is "0")**: Panning values added to X, Y, Z.
- **Rx, Ry, Rz (default value is "0")**: The angle of rotation about the X, Y, and Z axes in degrees.

> Note: To achieve millimeter-level accuracy, there should be at least eight decimal places after the decimal point.

3D Affine



The target coordinates are calculated using the following formula:

$$\begin{cases} X = D_x + (1 + M_x) * x + R_z * y - R_y * z \\ Y = D_y + (1 + M_y) * y - R_z * x + R_x * z \\ Z = D_z + (1 + M_z) * z + R_y * x - R_x * y \end{cases}$$

- **Dx, Dy, Dz (default value is "0")**: Panning values added to X, Y, Z.
- **Mx, My, Mz (default value is "0")**: Scale factor applied to the X, Y, and Z axes.
- **Rx, Ry, Rz (default value is "0")**: The angle of rotation about the X, Y, and Z axes in degrees.

> Note: To achieve millimeter-level accuracy, there should be at least eight decimal places in the user inputs.

Raster Tools

Raster tools include **Band Calculation**, **Raster Mosaic**, and **Raster Subdivision**.

- Band Calculator
- Raster Mosaic
- Raster Subdivision

Band Calculator

Brief

Band Calculator tool can generate a new raster image based on a user-defined map algebra equation from two single-band images.

Band operator functions and operators include: Basic operations: plus (+), minus (-), multiply (×), and divide (÷); Trigonometric functions: sine sin(x), cosine cos(x), tangent tan(x), arcsine asin(x), arc cosine acos(x), arc tangent atan(x); Other mathematical functions: natural exp(x), natural logarithm ln(x), logarithm to base a log(a, x), square root sqrt(x), quadratic power Power2, cubic power Power3, round integer part, inverse

The band operation function can be applied to single or two raster images, and the input data must meet the following conditions:

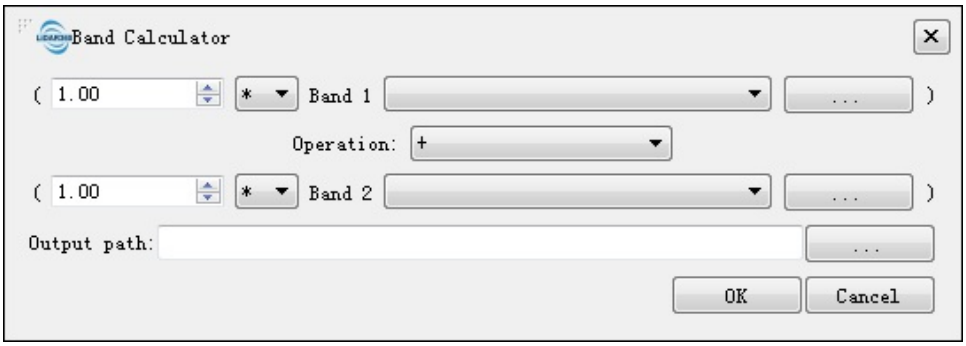
(1) The input data must be a single-band image;

(2) The input data must have the same spatial resolution;

(3) The spatial range of the input data must have intersections.

Usage

Click *Data Management* > *Raster Tools* > *Band Calculator*



Settings

- **Output path**: Path of the output folder. After the algorithm is executed, a new file will be generated after the band operation.

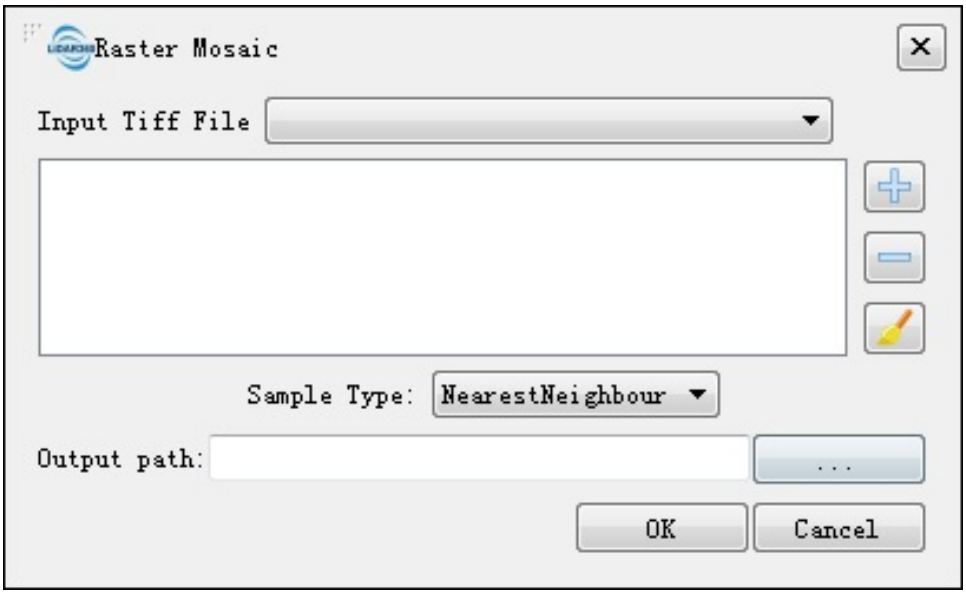
Raster Mosaic

Brief

Raster Mosaic refers to the technical process of merging two or more images to one image. LiPowerline provides seven sampling methods: **Nearest Neighbour**, **Bilinear**, **Cubic**, **CubicSpline**, **Lanczos**, **Average**, and **Mode**. It is the reverse operation of Raster Subdivision.

Usage

Click *Data Management* > *Raster Tools* > *Raster Mosaic*



Settings

- **Input Tiff File**: Users can select multiple files (>1) to be processed from the drop-down list.
- : Users can add multiple external images for image mosaic.
- : Click this button to clear all images in the list.
- **Sample Type**: Users need to select the sampling type from the drop-down list.
  - **NearestNeighbour (default)**: Nearest neighbor, sampled from the nearest neighbor.
  - **Bilinear**: Bilinear sampling (2 x 2 cores).
  - **Cubic**: Cubic convolution approximation (4 x 4 kernels).
  - **CubicSpline**: Cubic B-spline approximation (4×4 kernel).
  - **Lanczos**: Lanczos Window Sine Interpolation (6×6 Cores). Lanczos can be used as a low pass filter or to smoothly interpolate the value of a digital signal between its samples.
  - **Average**: Calculate the average of all non-value pixels.
  - **Mode**: Select the most frequently occurring value for all sampling points.
- **Output path**: Path of the output folder. After the algorithm is executed, a new file will be generated.

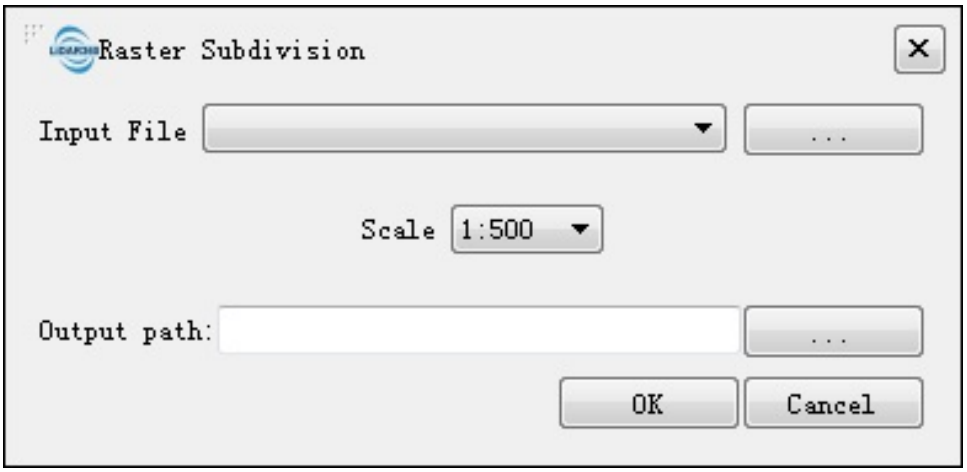
Raster Subdivision

Brief

The raster subdivision tool is the inverse operation of raster mosaic. The frame number adapts the coordinate number and consists of the southwest corner of the frame (Y coordinate + X coordinate). A scale of 1:5000 is taken into 1 km, 1:2000 and 1:1000 to 0.1 km, and 1:500 to 0.01 km.

Usage

Click *Data Management* > *Raster Tools* > *Raster Subdivision*



Settings

- **Input File**: Users can select the file to be processed from the drop-down list.
- ... : Users can add external files that need to be processed.
- **Scale (default "1:500")**: Users can select a targeted scale. LiPowerline has four scale options: 1:500, 1:1000, 1:2000, and 1:5000.
- **Output path**: Path of the output folder. After the algorithm is executed, new subdivided files will be generated.

Clip

The clipping tools include **Clip by Circle**, **Clip by Rectangle** and **Clip by Polygon**.

- Clip by Circle
- Clip by Rectangle
- Clip by Polygon

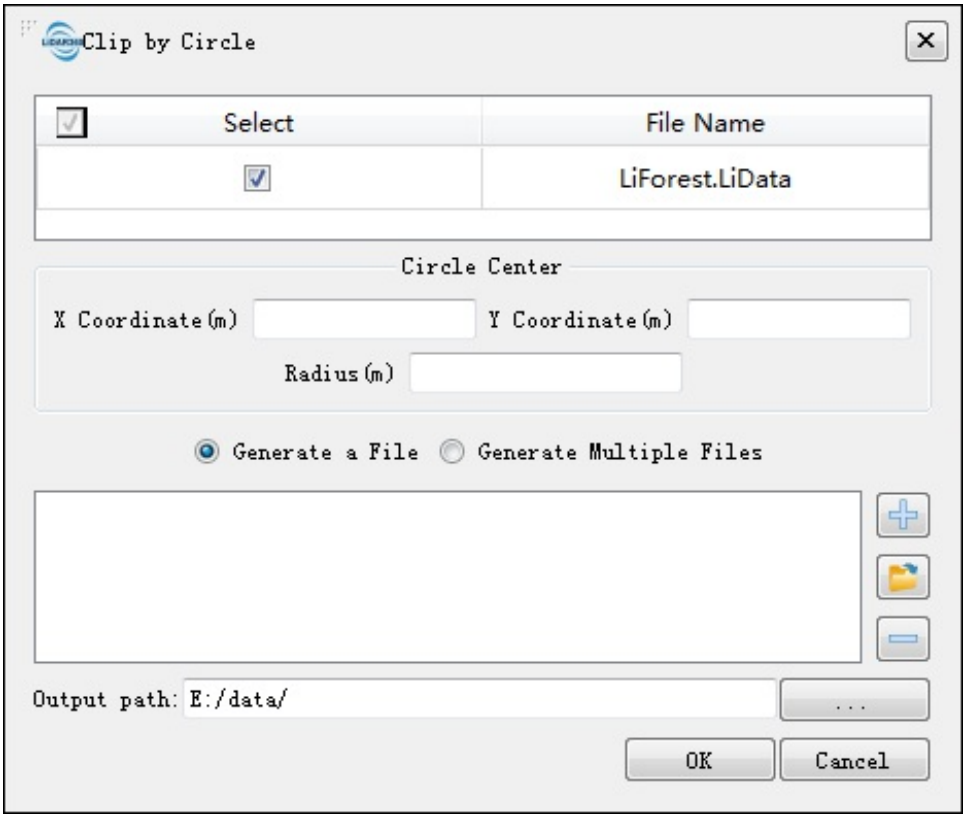
Clip by Circle

Brief

Clip by circle tool extracts the point cloud data within user-defined circle(s), and the extracted points can be saved in one or multiple files.

Usage

Click *Data Management* > *Clip* > *Clip by Circle*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **X Coordinate (m)**: Enter the X coordinate of the circle center.
- **Y Coordinate (m)**: Enter the Y coordinate of the circle center.
- **Radius (m)**: Enter the radius of the circle.
- **Generate a File**: Extract all the point cloud data within 2D circle(s) to one file.
- **Generate Multiple Files**: Extract the point cloud data within each circle and save them to one individual file. The file is named by its center and radius by default.
- : Click this button to add the coordinates and radius of a circle to the processing list. Perform the same operation to add multiple clipping circles.
- : Click this button to load external data files. The file format refers to the Clip Range File Format in the appendix.
- : Click this button to remove the selected row(s) in the processing list.

- **Output path**: The generated file will be saved in this output path.

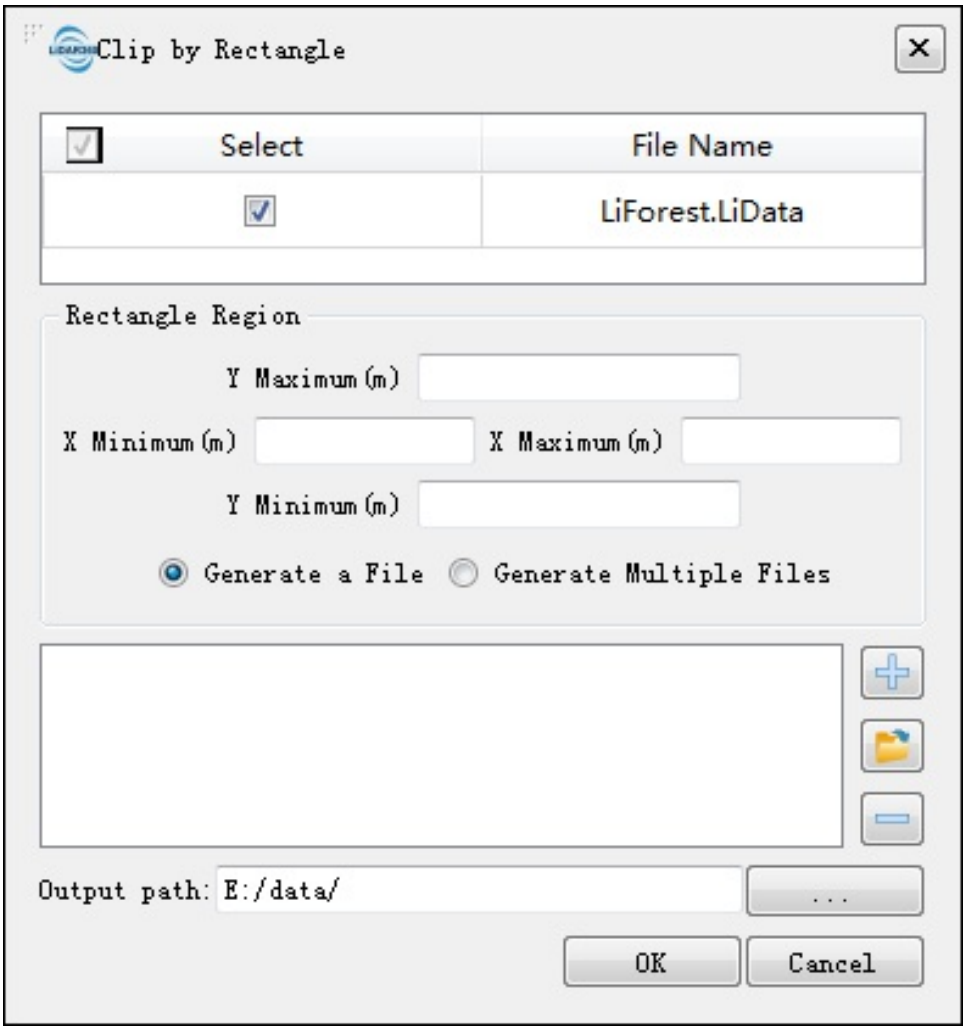
Clip by Rectangle

Brief

Clip by rectangle tool extracts the point cloud data within user-defined rectangular(s), and the extracted points can be saved in one or multiple files.

Usage

Click *Data Management* > *Clip* > *Clip by Rectangle*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **Y Maximum (m)**: Enter the maximum Y coordinate of the rectangle.
- **Y Minimum (m)**: Enter the minimum Y coordinate of the rectangle.
- **X Minimum (m)**: Enter the minimum X coordinate of the rectangle.
- **X Maximum (m)**: Enter the maximum X coordinate of the rectangle.
- **Generate a File**: Extract all the point cloud data within the rectangle to a file.
- **Generate Multiple Files**: Extract the point cloud data within each rectangle and save them to one file. The

file is named by the rectangle's lower left corner coordinate and the rectangle's width and height by default.

- : Click this button to add the entered rectangle range to the processing list. Perform the same operation to add multiple clipping regions.
- : Click this button to load external data files. The file format refers to the Clip Range File Format in the appendix.
- : Click this button to remove the selected row(s) in the processing list.
- **Output Path**: The generated file will be saved in this output path.

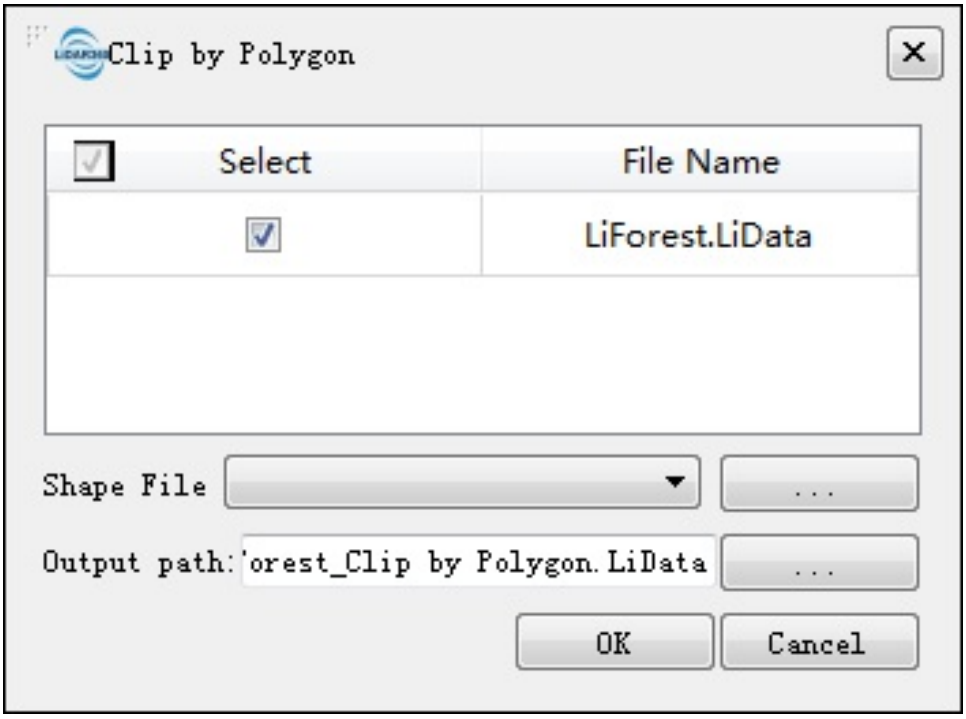
Clip by Polygon

Brief

Clip by polygon tool extracts the point cloud data within user-defined polygon vector file, and the extracted points will be saved in one file.

Usage

Click *Data Management* > *Clip* > *Clip by Polygon*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **Shape File**: Select the vector file loaded into LiPowerline software from the drop-down menu, or click the button ... to load the external vector data file.
- **Output Path**: The generated file will be saved in this output path.

> Note: The vector data file used to clip the point cloud data must be a polygon file (not point or line file), and currently MultiPolygon files are not supported.

Conversion

Conversion Tools contain **Convert to LiData**, **Convert LiData to LiData**,**Convert to Las**, **Convert to ASCII**, **Convert to Raster**, **Convert to Shape**, **Convert to DXF**, **Convert Image to LiModel**, **Convert to Texture LiModel**, **Convert LiModel to Image**.

- Convert to LiData
- Convert LiData to LiData
- Convert to Las
- Convert to ASCII
- Convert to Raster
- Convert to Shape
- Convert to DXF
- Convert Image to LiModel
- Convert to Texture LiModel
- Convert LiModel to Image

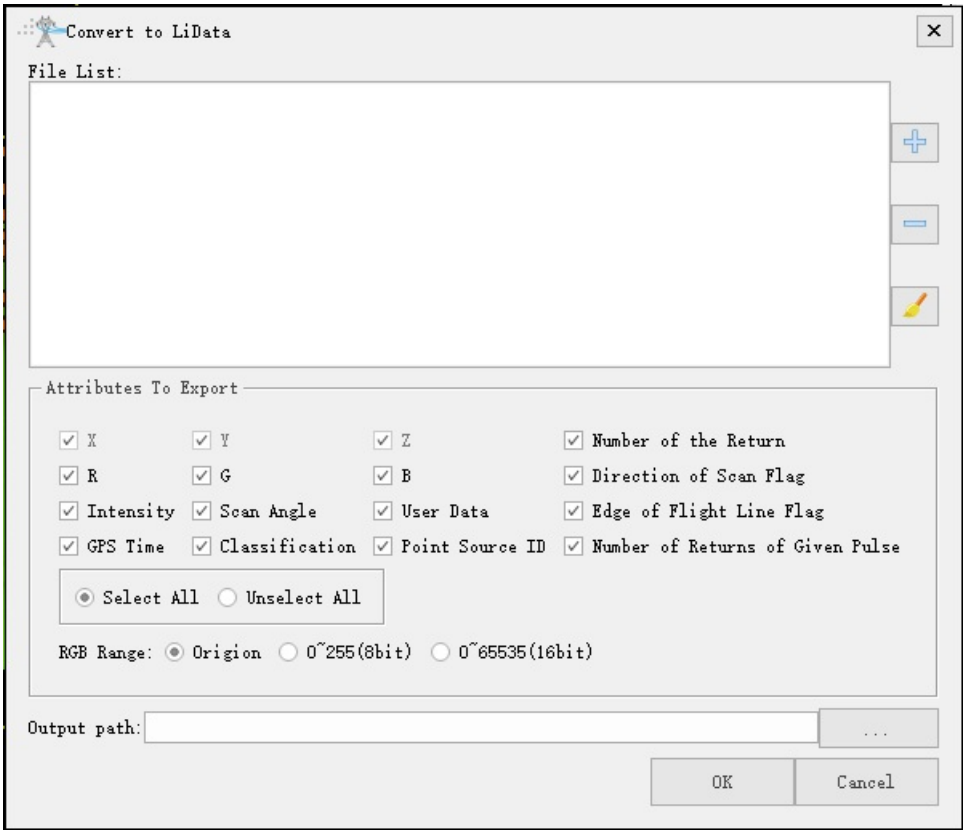
Convert to LiData

Brief

Convert to LiData can convert point cloud data in LAS or LAZ formats to LiPowerline customized point cloud format (LiData format).

Usage

Click *Data Management* > *Conversion* > *Convert to LiData*



Settings

- **File List**: Import the file that needs to be converted. The file formats currently supported are : .las, .laz. Users need to click to select the point cloud data; users can select one or more file(s) in the existing list and click to delete them from the list; users can click to remove all files in the list.
- **Attributes to Export**: Users can select the attributes that need to be exported. All Las attributes are supported.
- **RGB Range**: User can select the RGB range of the output file, which can be output by the source file or converted to 8 and 16 bits.
- **Output Path**: Path of the output folder. After the conversion is executed, the converted new file(s) will be generated.

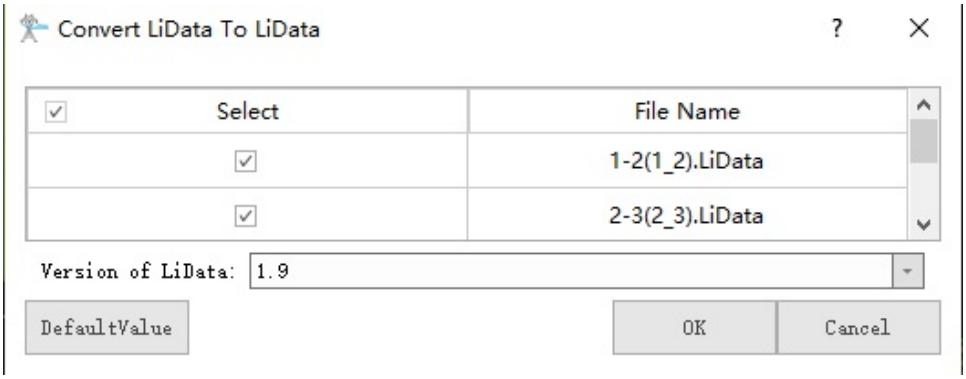
Convert LiData to LiData

Brief

Convert the current point cloud to another version of the LiData format.

Usage

Click *Plugins* > *Conversion* > *Convert LiData to LiData*



Parameter Settings

- **File List**: Input file to be converted(.LiData).
- **LiData Version**: The version of output LiData file.

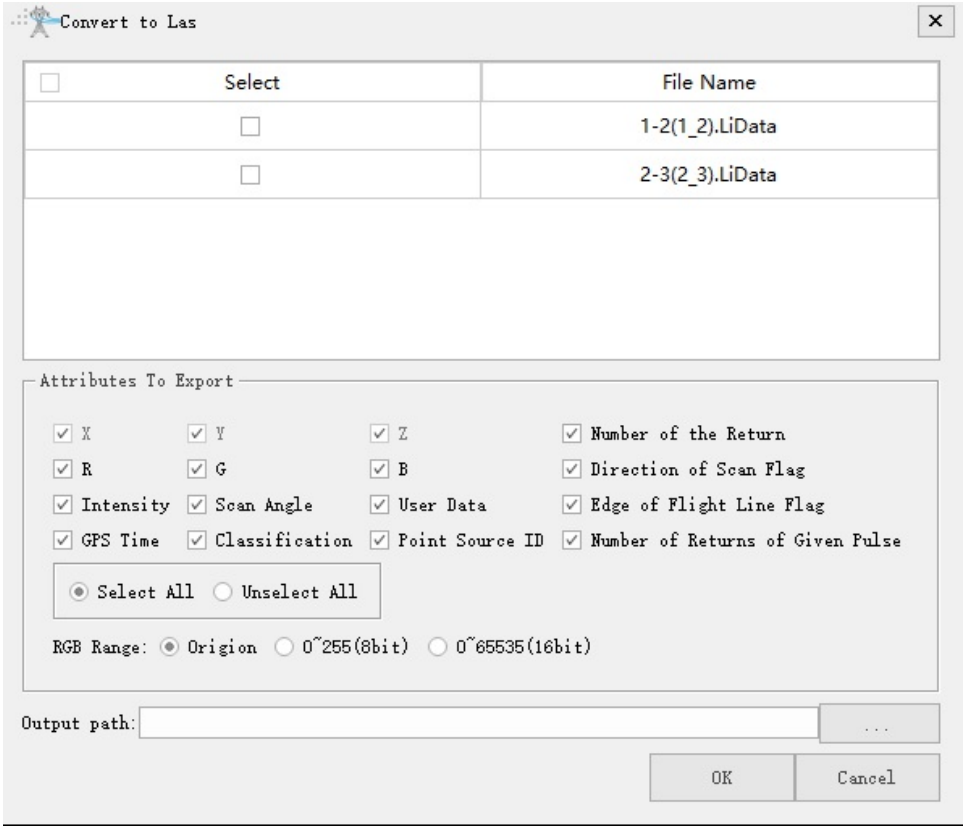
Convert to Las

Brief

Convert to Las can convert point clouds in LiData format to LAS format, namely the standard Lidar point cloud data format.

Usage

Click *Data Management* > *Conversion* > *Convert to Las*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Attributes to Export**: Users can select the attributes that need to be exported. All Las attributes are supported.
- **RGB Range**: User can select the RGB range of the output file, which can be output by the source file or converted to 8 and 16 bits.
- **Output Path**: Path of the output folder. After the conversion being executed, the converted new file(s) will be generated.

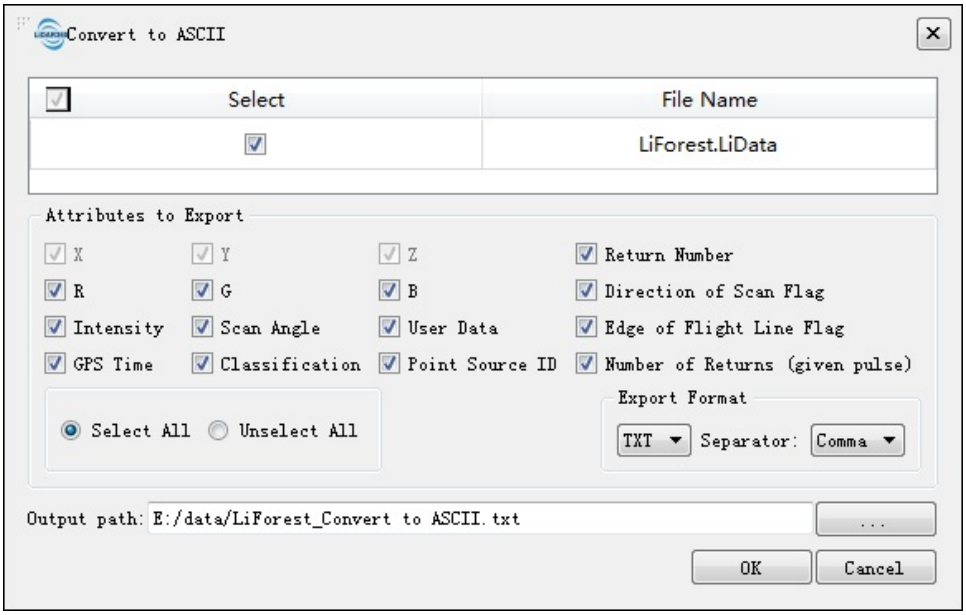
Convert to ASCII

Brief

The Convert to ASCII tool can convert the LiData point cloud to ASCII format, a text format that can be easily viewed in a text editor.

Usage

Click *Data Management* > *Conversion* > *Convert to ASCII*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Attributes to Export**: Users can select the attributes that need to be exported. All Las attributes are supported.
- **Export Format**: LiPowerline supports two suffix formats: txt and csv, and support separators are: commas, spaces and TAB.
- **Output path**: Path of the output folder. After the conversion is executed, the converted new file(s) will be generated.

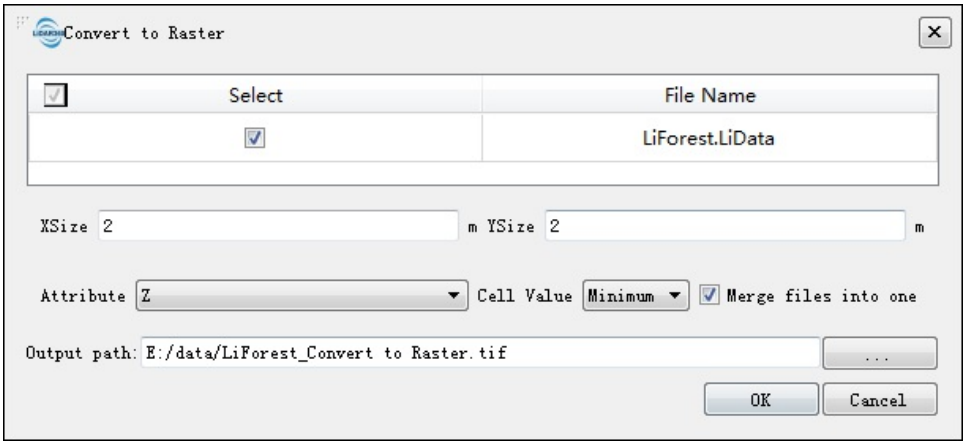
Convert to Raster

Brief

The Convert to Raster tool can convert LiData point cloud data to raster images according to the **Attribute** of the points in **Cell Value** method.

Usage

Click *Data Management* > *Conversion* > *Convert to Raster*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **XSize (m, default value is "2")**: The X pixel resolution of the output raster.
- **YSize (m, default value is "2")**: The Y pixel resolution of the output raster.
- **Attribute (default is "Z")**: Select the point attribute used to calculate the raster cell value.
  - **Z (default)**: Generate the raster data using the Z value of the point cloud data.
  - **Intensity**: Generate raster data using the intensity values of the point cloud data.
  - **Scan angle**: Generate raster data using the scan angle of point cloud data.
  - **Return number**: Generate raster data using the return number of the point cloud data.
  - **Number of returns of given pulse**: Raster data is generated using the number of returns of given pulse of the point cloud data.
- **Cell value**: Choose how to fill raster pixel values.
  - **Minimum (default)**: Use the smallest attribute value as the value of a raster cell.
  - **Average**: Use the average of attribute values of all points within a raster cell as its value.
  - **Maximum**: Use the largest attribute value as the value of a raster cell.
- **Merge files into one**: Users can set merging all raster into one data file. If not checked, each point cloud data will be generated into a separate raster file.
- **Output path**: Path of output folder. After the algorithm is executed, the converted new file is generated.

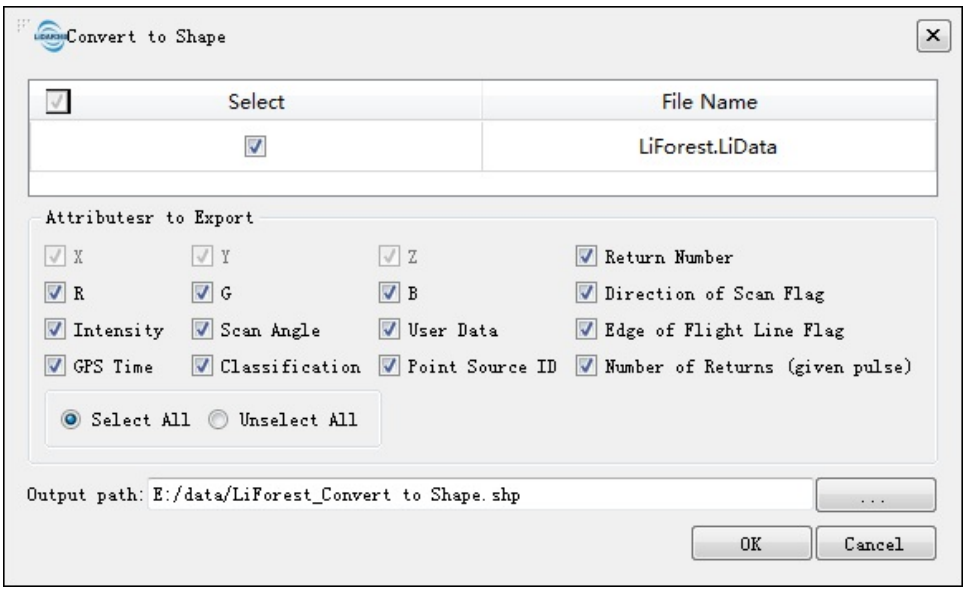
Convert to Shape

Brief

The Convert to Shape tool can convert point cloud files in LiData format to point files in vector format.

Usage

Click *Data Management* > *Conversion* > *Convert to Shape*



Settings

- **Input data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **Attributes to Export**: Users can select the attributes that need to be exported, and all Las attributes are supported. The selected attributes will be written in the attributes of the shape file data.
- **Output path**: Path of the output folder. After the conversion being executed, the converted new file will be generated.

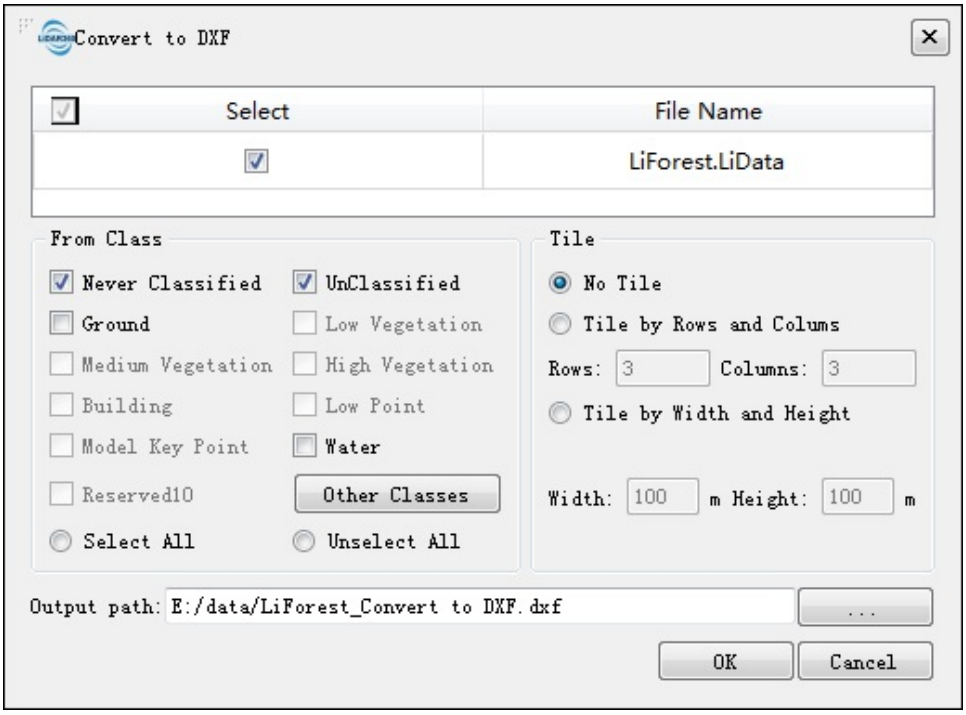
Convert to DXF

Brief

The Convert to DXF tool can convert LiData format point cloud files to point vector data in DXF format. LiPowerline software exports DXF files in ASCII format.

Usage

Click *Data Management* > *Conversion* > *Convert to DXF*



Settings

- **Input Data**: The input file can be a single point cloud data file or multiple data files. File Format: *.LiData.
- **From Class**: Source class (es).
- **Tile**: Since the amount of point cloud data is often large, the software provides an optional tile mode that can split the input data file to a number of tiles.
  - **No Tile**: Export a single DXF file.
  - **Tile by Rows and Columns**: According to the boundary of the point cloud data, the point cloud will be split into a total number of rows * columns data blocks evenly, and a single DXF file will be generated.
    - **Rows (default value is "3")**: User-defined number of rows that the point cloud want to be split into.
    - **Columns (default value is "3")**: User-defined number of columns that the point cloud want to be split into.
  - **Tile by Width and Height**: The point cloud will be split into a number of tiles from the lower left corner by the specified width and height, one DXF file per block.
    - **Width (m, default value is "100")**: User-defined block width.
    - **Height (m, default value is "100")**: User-defined block height.
- **Output path**: Path of the output folder where the converted new file(s) will be generated.

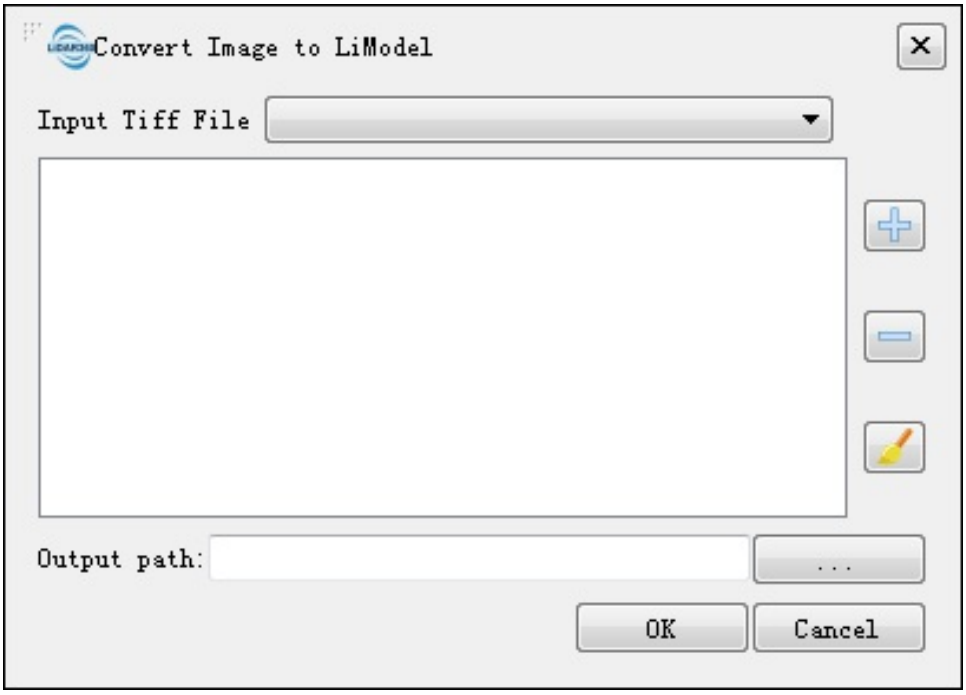
Convert Image to LiModel

Brief

Convert image to LiModel tool can convert single-band raster data (DEM, DSM, CHM, etc.) to LiModel format. The LiModel format is a LiPowerline software customized format that allows the converted single-band raster data to be displayed and edited in a 3D window.

Usage

Click *Data Management* > *Conversion* > *Convert Image to LiMode*



Settings

- **Input Tiff File**: Users can select the file to be processed from the drop-down list.
- : Users can add files to be converted that have not been opened.
- : Users can select a file in the list and click this button to remove the file from the list.
- : Click this button to clear all files in the list.
- **Output path**: Path of the output folder. After the conversion being executed, the converted new file(s) will be generated.

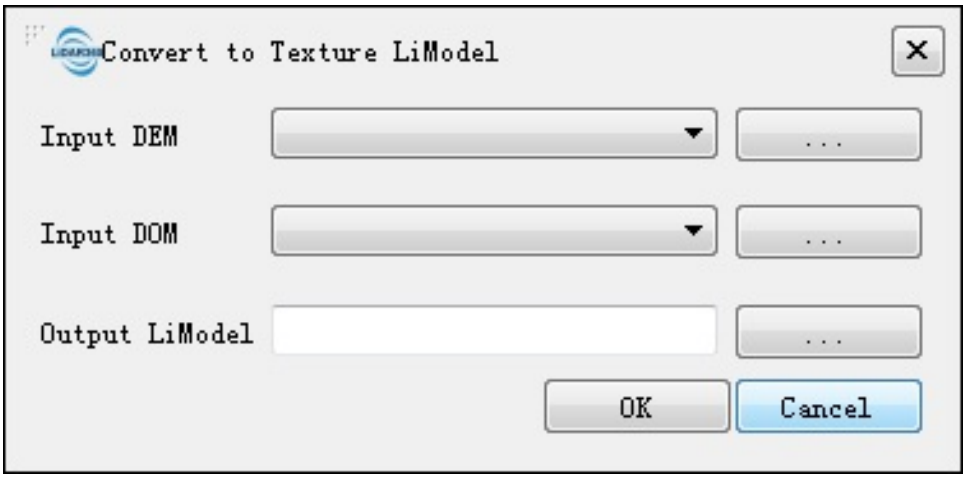
Convert to Texture LiModel

Brief

Convert to Textured LiModel tool is based on the Convert Image to LiModel tool, which maps color values of a DOM data to the LiModel model for display. This function only supports single file data conversion.

Usage

Click *Data Management* > *Conversion* > *Convert to Texture LiModel*



Settings

- **Input DEM**: Users can select a file to be converted from the drop-down list or use the button ... to load an external data file. Single-band raster data is required.
- **Input DOM**: Users can select a desired file from the drop-down list or use the button ... to load an external data file. The selected color image needs to have at least three bands.
- **Output LiModel**: Path of the output file. After the conversion being executed, the converted new file will be generated.

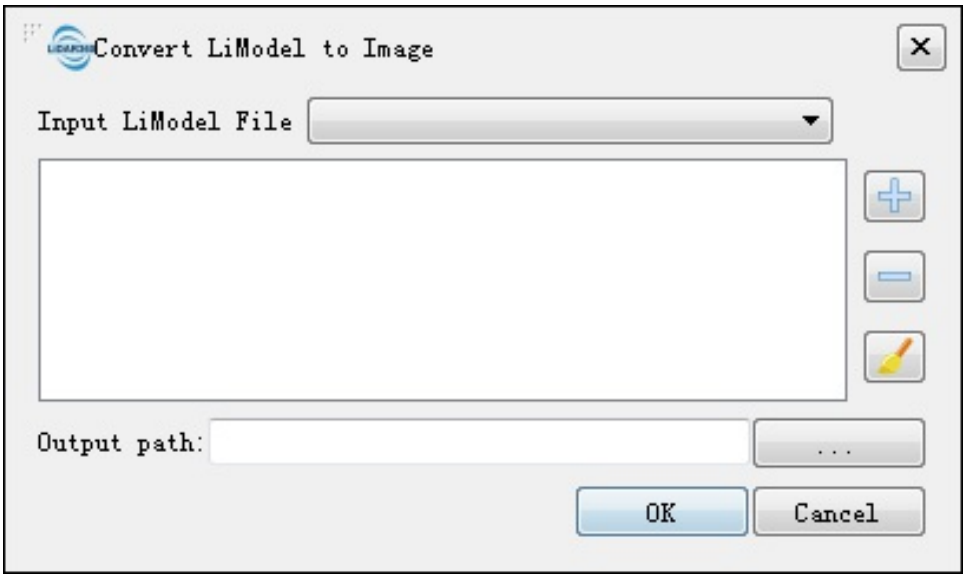
Convert LiModel to Image

Brief

Convert LiModel to Image tool converts LiModel format files to raster images in TIFF format. After editing LiModel data, users can use this function to convert the data to TIFF format.

Usage

Click *Data Management* > *Conversion* > *Convert LiModel to Image*



Settings

- **Input LiModel File**: User can select a file to be processed from the drop-down list.
- : Users can add external data files to be converted.
- : Users can select a file in the list and click this button to remove the file from the list.
- : Click this button to clear all the data in the list.
- **Output path**: Path of the output folder. After the conversion being executed, the converted new file will be generated.

Extract

Extraction tools include **Extract by Class**, **Extract by Elevation**, **Extract by Intensity**, **Extract by Return**, **Extract by Time**, and **Extract by Serial Time**.

- Extract by Class
- Extract by Elevation
- Extract by Intensity
- Extract by Return
- Extract by Time
- Extract by Serial Time

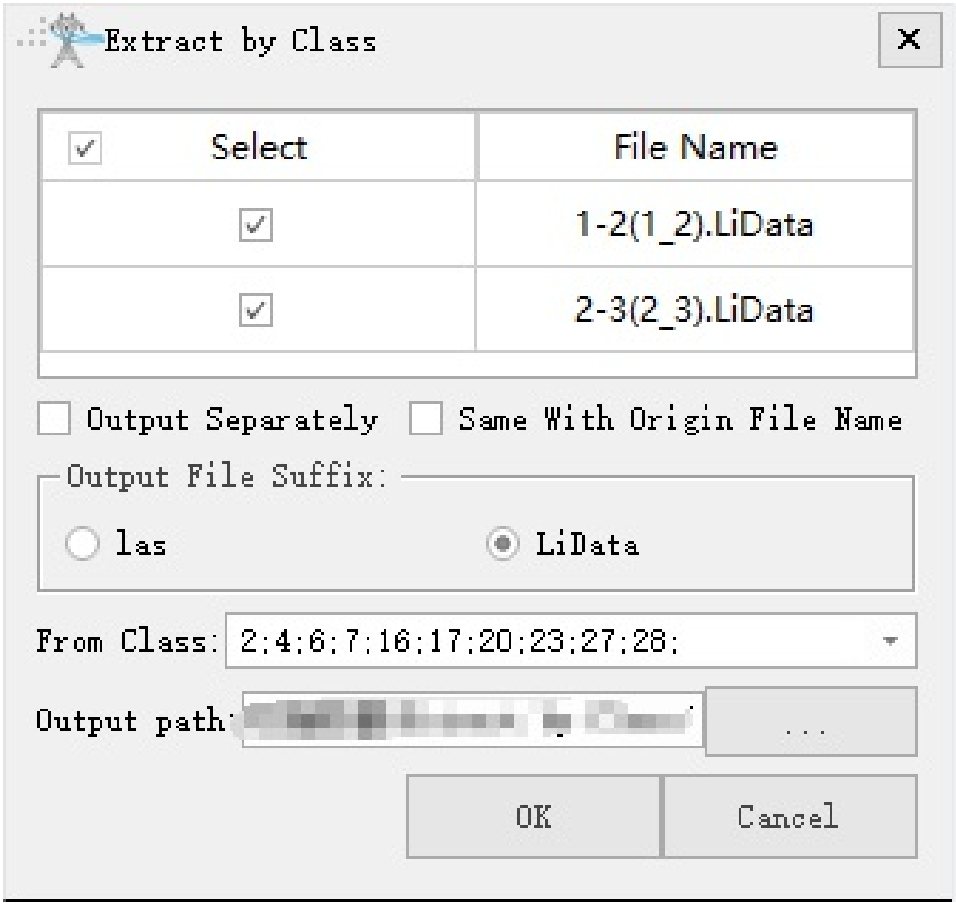
Extract by Class

Brief

Extract by class tool can extract all the point cloud data of the user-selected class, and save the data in one file. This function supports multiple file operations.

Usage

Click *Data Management* > *Extract* > *Extract by Class*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **Output Separately**: This parameter is not selected by default. If it is selected, one file is output for each category.
- **Same With Origin File Name**:This parameter is deselected by default. If it is selected, the output file name is the same as the source file.
- **Output File Suffix**: Suffix of output file.
- **From Class**: Users need to select the class to be extracted from the drop-down list. The unavailable status in the drop-down list represent the corresponding category that does not exist in the file.
- **Output path**: Path of the output folder. After the algorithm being executed, the extracted new file(s) will be generated.

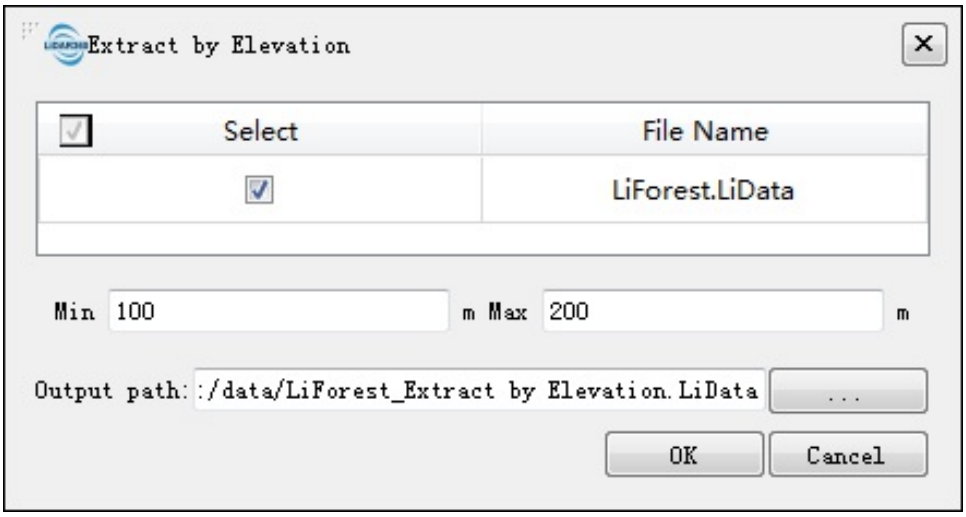
Extract by Elevation

Brief

Extract by Elevation tool can extract the point cloud data in the user-defined elevation range to a file. This function supports multiple file operations.

Usage

Click *Data Management* > *Extract* > *Extract by Elevation*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **Min (m, default value is "100")**: Users need to enter the minimum elevation value of the point cloud data to be extracted.
- **Max (m, default value is "200")**: Users need to enter the maximum elevation value of the point cloud data to be extracted.
- **Output path**: Path of the output folder. After the algorithm being executed, the extracted new file(s) will be generated.

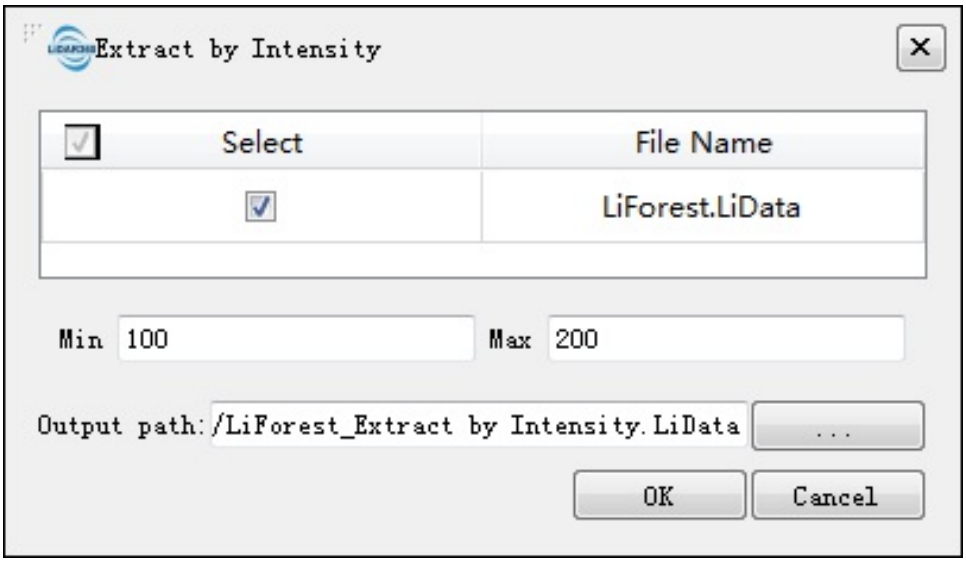
Extract by Intensity

Brief

Extract by Intensity tool can extract all the point cloud data within the user-defined intensity range. This function supports multiple file operations.

Usage

Click *Data Management* > *Extract* > *Extract by Intensity*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **Min (default value is "100")**: Users need to enter the minimum intensity value of the point cloud data to be extracted.
- **Max (default value is "200")**: Users need to enter the maximum intensity value of the point cloud data to be extracted.
- **Output path**: Path of the output folder. After the algorithm being executed, the extracted new file(s) will be generated.

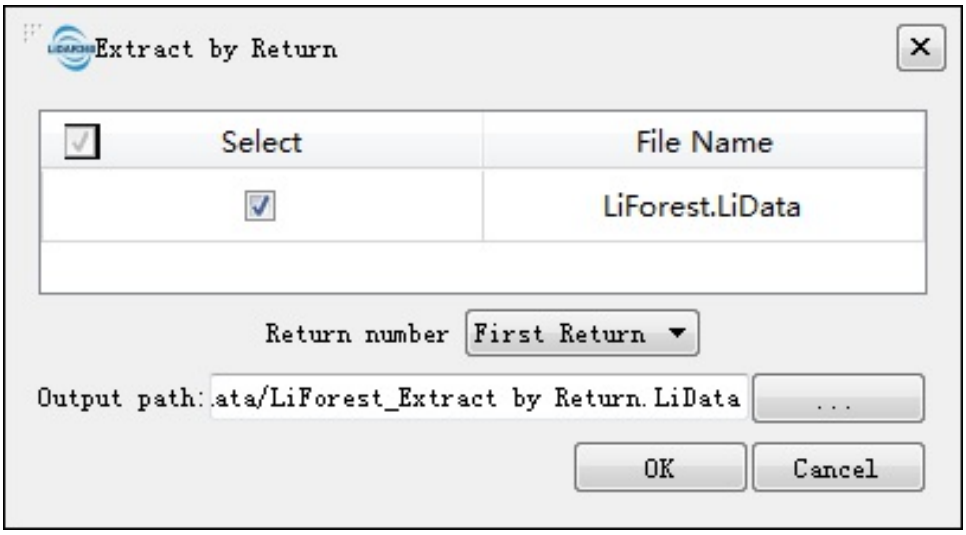
Extract by Return

Brief

Extract by Return tool can extract all the point cloud data of the user-defined return number, and saved the data in a file. This function supports multiple file operations.

Usage

Click *Data Management* > *Extract* > *Extract by Return*



Settings

- **Input Data**: Input one or more point cloud data files. File Format: *.LiData.
- **Return number**: Users need to select the return number of the point cloud data to be extracted. Click on the drop-down menu to select the return number, including: first return, last return, 2nd return, 3rd return, 4th return, and returns after 4th.
- **Output path**: Path of the output folder. After the algorithm being executed, the extracted new file(s) will be generated.

> Note: If the data does not have the return number selected by the user, the extraction will not be executed.

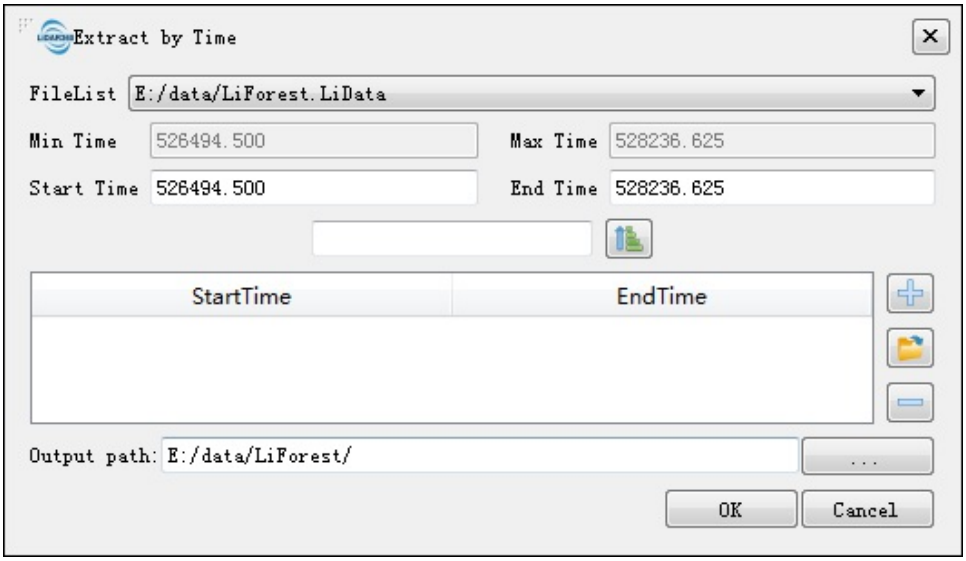
Extract by Time

Brief

Extract by GPS time tool can extract all the point cloud data within the user-defined GPS time range, and save them in a file.

Usage

Click *Data Management* > *Extract* > *Extract by Time*



Settings

- **File List**: Select the file to be processed from the drop-down list.
- **Min Time**: Displays the minimum GPS time value in the point cloud file selected by the user. This value does not require user settings.
- **Max Time**: Displays the maximum GPS time value in the point cloud file selected by the user. This value does not require user settings.
- **Start Time (default value is "min Time")**: Input the minimum GPS time value of the point cloud data to be extracted.
- **End Time (default value is "max Time")**: Input the maximum GPS time value of the point cloud data to be extracted. This value must be larger than the start time.
- : If you want to extract the point cloud at a specified interval, enter the interval value in the text box, and then click this button, the values of the start time and end time will increase at the set interval.
- : Add the input time range to the range list. All point cloud data in the time range will be extracted into one file.
- : Users can click this button to load external GPS range file. The time range in the file needs to be between the **min Time** and the **max Time**. The file format can be referred to the appendix for information in the GPS time file format.
- : Users select a row in the time range list and click this button to remove the row from the list.
- **Output Path**: Path of the output folder. After the algorithm being executed, the extracted new file will be generated.

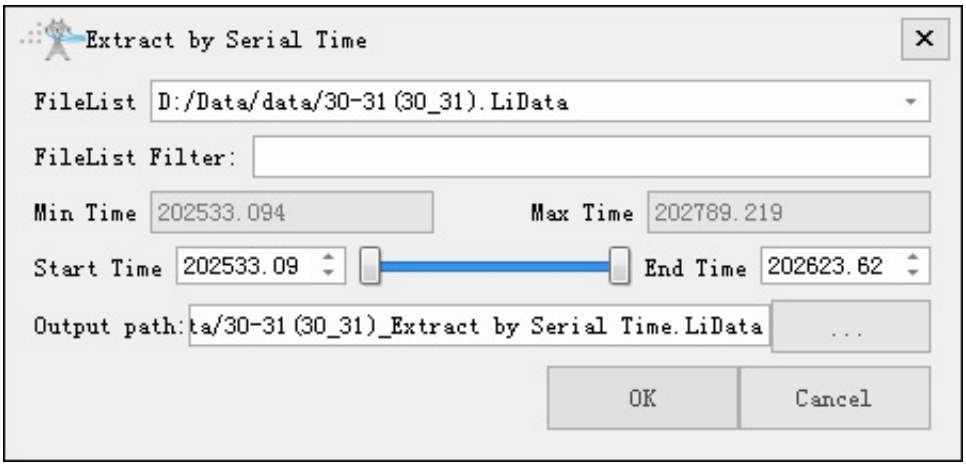
Extract by Serial Time

Summary

Extract by Serial Time tool helps the user to extract the points in customized GPS time period and save them to a separate file.

Usage

Click *Data Management* > *Extract* > *Extract by Serial Time*.



Settings

- **File List**: Select the file to be processed from the file list.
- **File List Filter**: Automatically select files to be processed based on the fields entered by the user.
- **Min Time**: Display the minimum GPS time value in the point cloud file selected by the user. This value does not require user settings.
- **Max Time**: Display the maximum GPS time value in the point cloud file selected by the user. This value does not require user settings.
- **Start Time (default value is "Min Time")**: Input the minimum GPS time value of the point cloud data to be extracted.
- **End Time (default value is "Max Time")**: Input the maximum GPS time value of the point cloud data to be extracted.
- **Output Path**: The path of the output file.

Classify

LiPowerline can be used to classify unclassified point cloud, or to reclassify points that have already been classified.

- Classify by Attribute
- Classify Ground
- Classify Low Points
- Classify by Below Surface
- Classify Isolated Points
- Classify Air Points
- Classify by Height Above Ground
- Classify by Min Elevation
- Classify Closeby Points
- Class Conversion
- Classify Buildings
- Classify Model Key Points

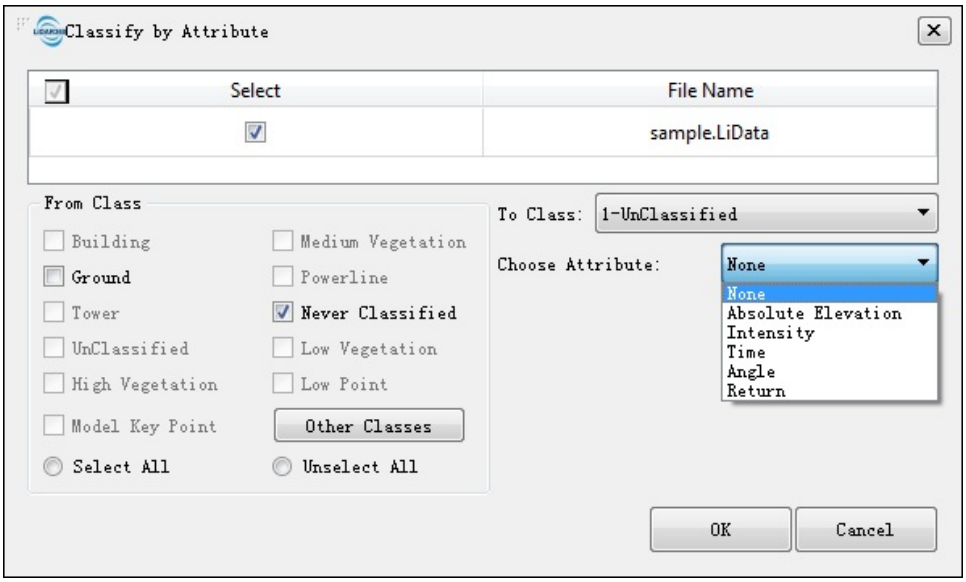
Classify by Attribute

Brief

This function classifies the point cloud into another class according to their attributes. Currently available classification attributes include Absolute Elevation, Intensity, GPS Time, Scan Angle, and Return Number. In addition, the function can restore all classes and/or reclassify the point cloud for undesirable classification results.

Usage

Click *Classify* > *Classify by Attribute*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Choose Attribute**: The selected attribute will be used to classify the point cloud.
  - **None (default)**: The default setting will change all points in the **From Class** option to **To Class**.
  - **Absolute Elevation**: Classified by elevation range. If the elevation value of a point is between the specified range, it will be assigned to the **To Class**.
  - **Intensity**: Classified by intensity range. If the intensity value of a point is between the specified range, it will be assigned to the **To Class**.
  - **Time**: Classified by GPS time. If the GPS time value of a point is between the specified range, it will be assigned to the **To Class**.
  - **Angle**: Classified by scan angle. If the scan angle value of a point is between the specified range, it will be divided into the **To Class**.
  - **Return**: Classified by the return number. If the return number at a point is between the specified range, it will be assigned to the **To Class**.

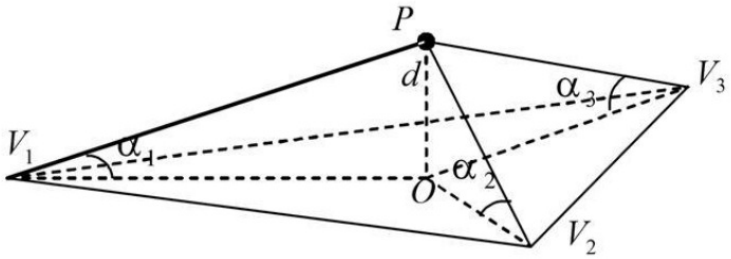
Classify Ground

Brief

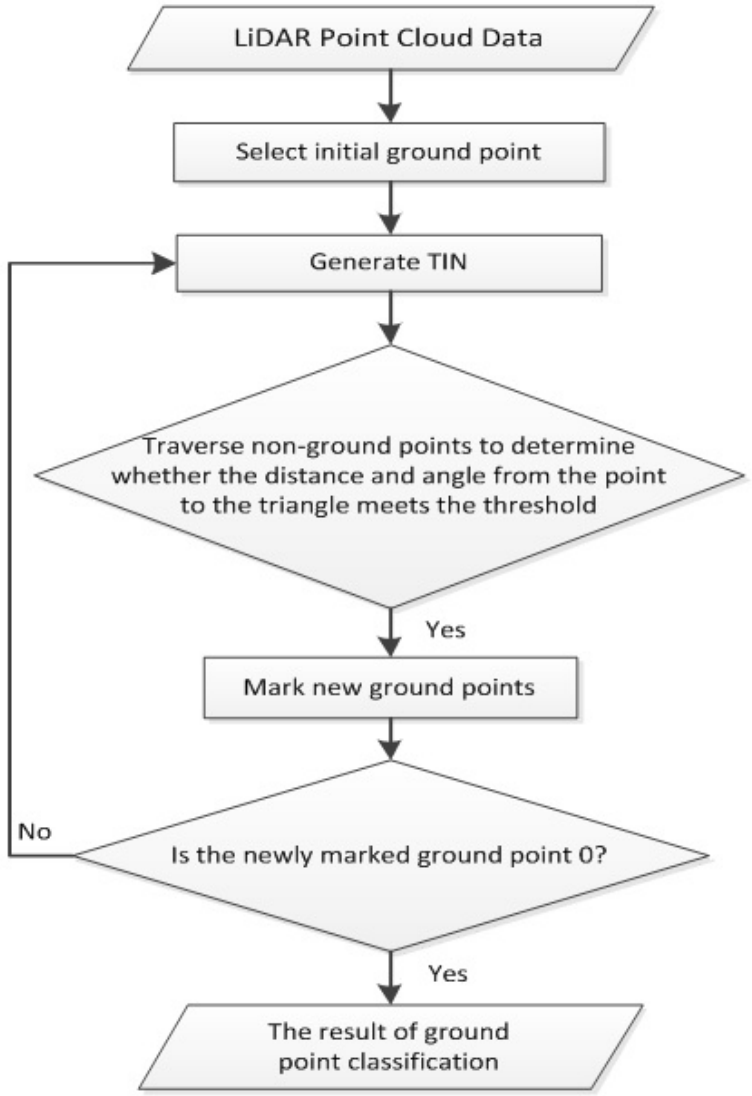
Ground points classification is an important operation of point cloud preprocessing, which can be implemented in LiPowerline with an improved progressive TIN densification filtering algorithm (Zhao et al.,2016).

The algorithm first generates a sparse triangulated irregular network(TIN) through seed points, and then iteratively processes layer-by-layer densification until all ground points have been classified. The specific steps of the algorithm are described as follows:

1. The initial seed point selection. If the point cloud contains buildings, the **maximum building size** is taken as the grid size to grid the point cloud, and for the point cloud without the building, the default value is used as the grid size. Take the lowest point in the grid as the starting seed point.
2. Build a TIN. The initial TIN was constructed using the initial seed point.
3. Iterative densification process. Traverse all the unclassified points, query the triangles that each point belongs to in the horizontal projection plane; Calculate the distance(d) from the point to the triangle and the max angle between the point and three vertices with the triangles plane. As shown in the figure below, the distance and max angle are compared with the **Iteration distance** and **Iteration angle**, separately. If it is less than the corresponding threshold, then the point is classified as a ground point and added to the triangulation. Repeat this process until all ground points have been classified.

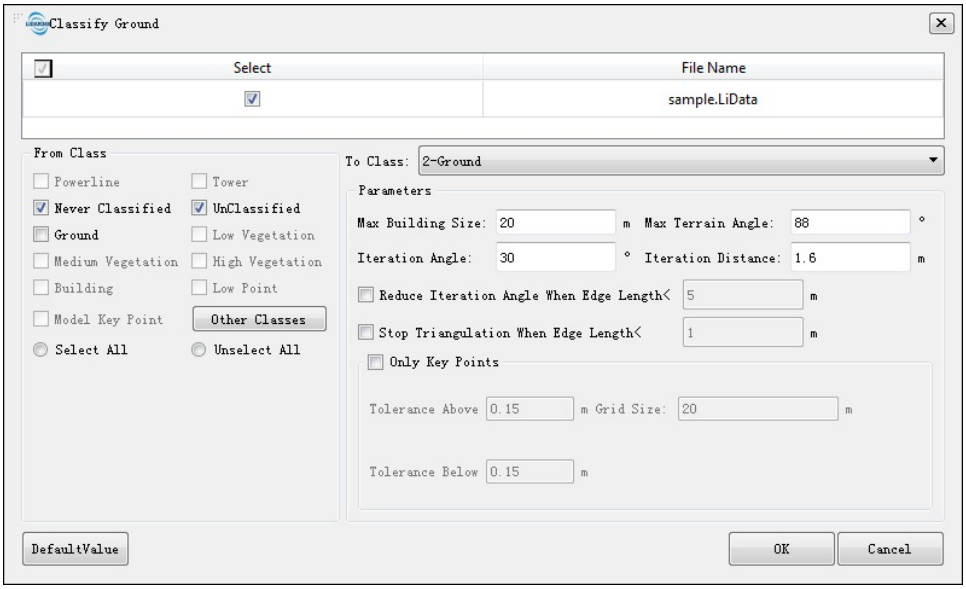


The flow of algorithm is shown in the figure.



Usage

Click *Classify* > *Classify Ground*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Max Building Size (m, default value is "20")**: The maximum length of the building edge that exists in the point cloud scan. If this parameter is set too small, the flat roof of the building may be mistaken as the terrain. When there is a building in the point cloud data, the maximum building size can be measured by using the Length Measurement in the menu bar. The value of this parameter should be greater than the measured value. For point cloud data without buildings, this parameter can use the default value of 20m.
- **Max Terrain Angle (°, default value is "88")**: The maximum slope of the terrain shown in the point cloud. This parameter can determine whether the points nearby the ground points belong to the ground or not. Usually, the parameter can be set as default.
- **Iteration Angle (°, default value is "30")**: The allowable range of angles between unclassified points and ground points. For areas with large topography and undulations, it can be bigger.Generally, it is set between 10 to 30 degrees. In addition, the iteration angle should adjust with the iteration distance.
- **Iteration Distance (m, default value is "1.6")**: Distance threshold between the unclassified points and the triangle in the triangle mesh. When the topography is highly undulating, it should be set to a larger value. The general setting is 1~2 meters.In addition, the iteration distance should adjust with the iteration angle.
- **Reduce Iteration Angle When Edge Length < (m, default value is "5", Optional)**: When the triangle edge of a point to be classified is shorter than this threshold, the iteration angle is reduced accordingly. Increase the threshold to obtain sparser ground points.
- **Stop Triangulation When Edge Length < (m, default value is "1", Optional)**: When the triangle edge of a point to be classified is shorter than this threshold, densification of the triangulation network is stopped. This prevents locally generated ground points from becoming too dense. A larger value yields sparser ground points, and vice versa.
- **Only Key Points (Optional)**: Extract key points of terrain model on the basis of ground point filtering. This function can preserve the key points on the terrain and sparse the points on the flat area. For the specific usage, please see Classify Model Key Points.

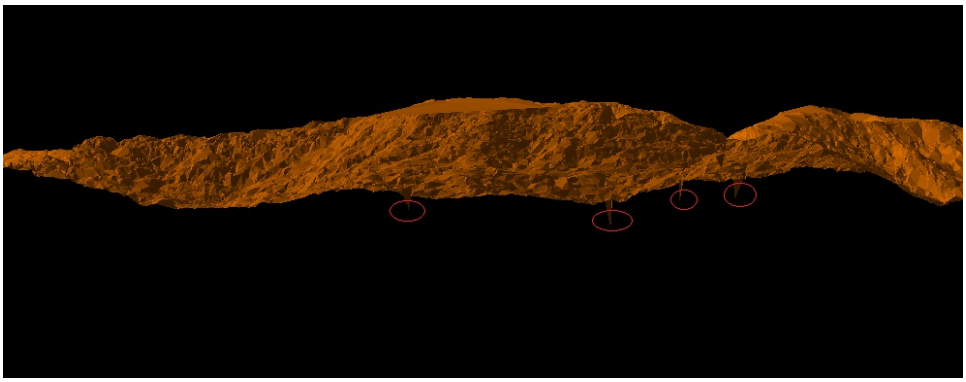
> Note: Because the actual terrain is complex and changeable, when using this function to perform ground point classification, different parameters needs to be adjusted in order to achieve relatively ideal results. In addition, the classification result in local area can be reclassified by Classify Ground by Selected and the Classify by Interactive Editing tool.

```
@inproceedings{
    author={Zhao X Q, Guo Q H, Su Y J and Xue B L},
    title={Improved progressive TIN densification filtering algorithm for airborne LiDAR data in forested areas},
    booktitle={ISPRS Journal of Photogrammetry and Remote Sensing,117:79-91},
    year={2016}
}
```

Classify Low Points

Brief

The low point refers to the noise point that is lower than the actual terrain. Low points interfere with ground point extraction, because the progressive triangulation filtering algorithm builds on seed points located at the lowest point of the gridded point cloud. Therefore, filtering out low points is a preprocessing step that directly affects filtering results, digital model generation, and contour line quality. The triangulated terrain model created by the ground points with low points is shown below.

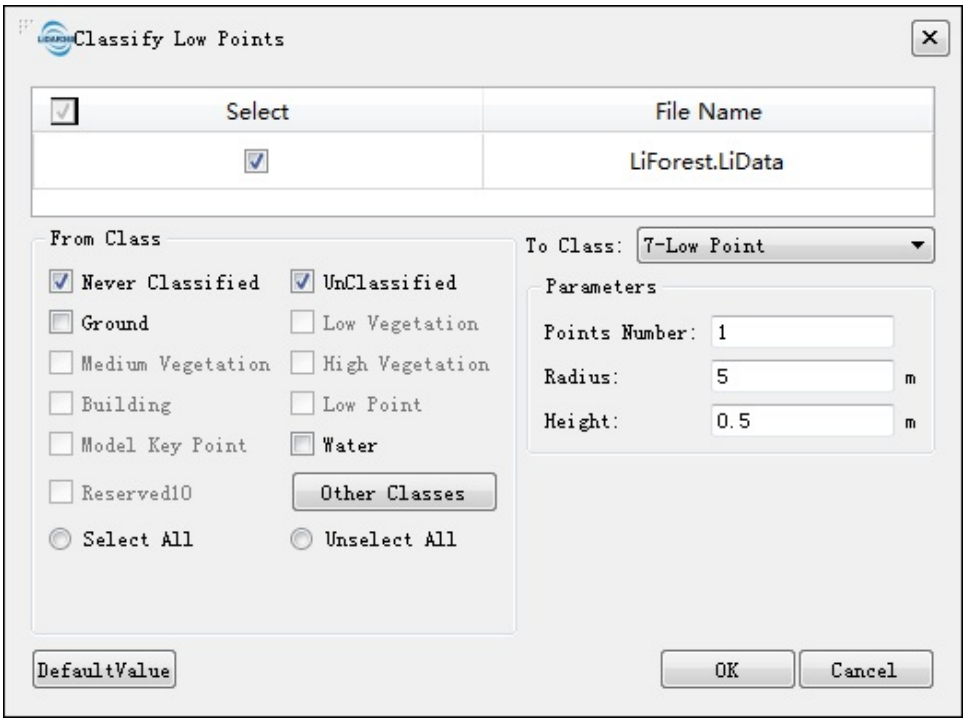


The distribution of low points is divided into individual points or clusters. The algorithmic flow of this function is:

1. Traverse the point cloud and search for points to be classified within a certain range of **radius** of the current single point or point cluster.
2. Calculate the maximum **height difference** between the current point and the neighboring point, which is compared with the threshold.
3. If the value is greater than the threshold, the current point is considered to be a low point, otherwise, it is not classified as a low point.

Usage

Click *Classify* > *Classify Low Points*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Points Number (default value is "1")**: When the number of points is set to 1, the single low point is classified. If it is greater than 1, cluster low points are classified.
- **Radius (m, default value is"5")**: The radius threshold between the unclassified point and the neighboring point.
- **Height (m, default value is"0.5")**: The **height difference** threshold between the unclassified point and the neighboring point.
- **DefaultValue**: Click this button to set all parameters as default.

Classify by Below Surface

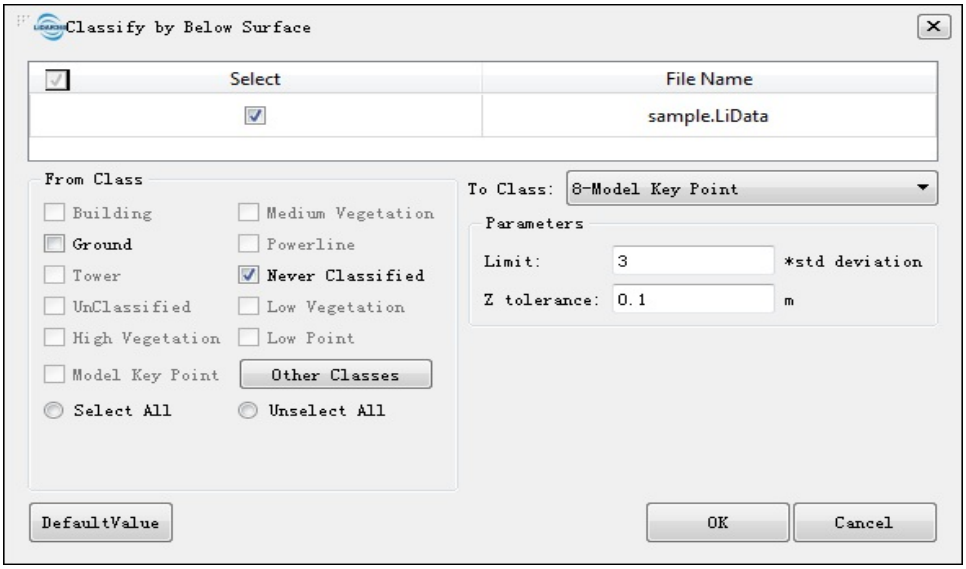
Brief

This function classifies points in the initial category that are below the elevation of the surrounding neighborhood. For example, when the starting category is ground, this method can be used to classify points lower than the surface elevation to be the lower-than-the-surface point. The main algorithm idea of this function is:

1. Search for a certain number of nearest points for the current point in initial class.
2. Fit the plane with the nearest point.
3. Calculate the absolute value of the height difference between the current point and the plane. If the value is less than the set **Z tolerance**, it is not categorized. If it is greater than the tolerance, go to the next step.
4. Calculate whether the difference between the current point elevation and the average value of the neighboring points is greater than the **Limit** of the standard deviation. If it is greater than, then it is classified as the target category; otherwise, it is not classified.

Usage

Click *Classify* > *Classify by Below Surface*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Limit (default value is"3")**: The multiple of the mean squared error of the neighboring point fitting plane of the unclassified points. The larger the value, the less points will be classified into the target class.
- **Z tolerance (m, default value is"3")**: The threshold of height difference. The point to fit plane distance less than this value is not classified. The larger the value, the less points will be classified into target class.
- **DefaultValue**: Click this button to set all parameters as default.

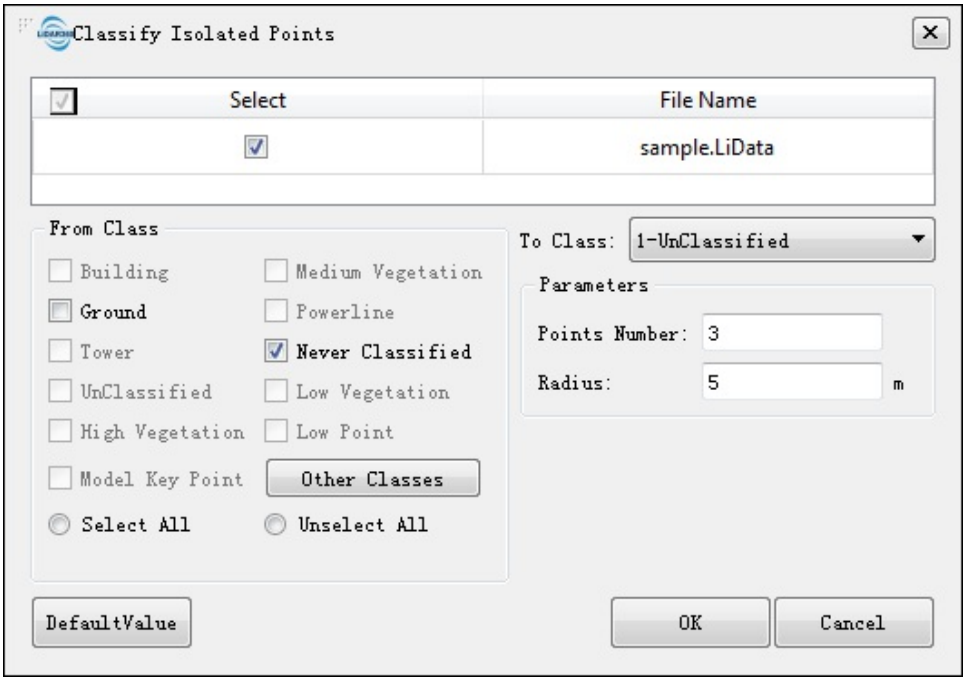
Classify Isolated Points

Brief

This function classifies points in a certain area of point cloud, which is generally used to find outliers in the air or below the ground.

Usage

Click *Classify* > *Classify Isolated Points*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Points Number (default value is"3")**: If the number of points in the neighboring radius are less than or equal to the value, the point is considered as an isolated point.
- **Radius (m, default value is"5")**: Neighboring search radius.
- **DefaultValue**: Click this button to set all parameters as default.

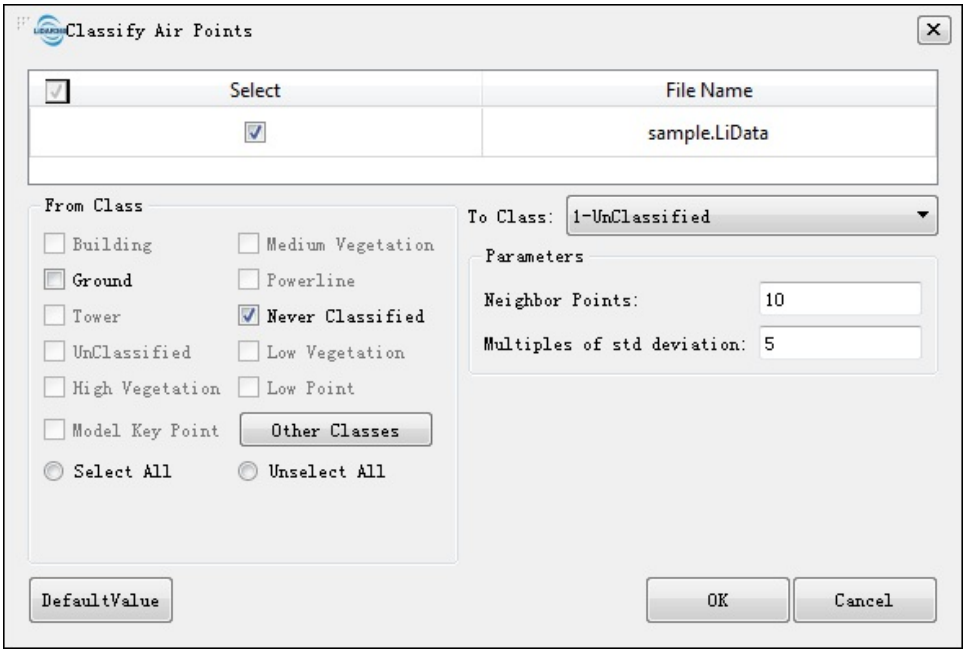
Classify Air Points

Brief

This function classifies points that are significantly higher than the surrounding points into airborne noise points. The idea of the algorithm is the same as the principle of Outlier Removal in the data management module.

Usage

Click *Classify* > *Classify Air Points*



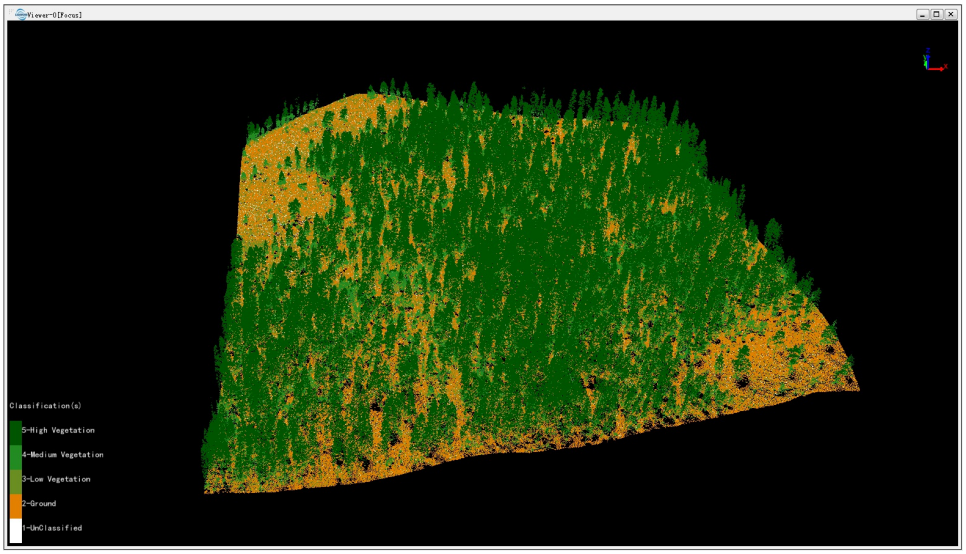
Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Neighbor Points (default value is"10")**: The number of neighbors that will be used to determine whether a point is a noise in the sky. Calculate the distance between each point to the nearest point and calculate the standard deviation of the nearest distances.
- **Multiples of std deviation (default value is"5")**: If the deviation of points beyond the minimum allowable threshold, they are considered as noise in the sky. The larger the threshold, the less the noise will be divided into.
- **DefaultValue**: Click this button to set all parameters as default.

Classify by Height Above Ground

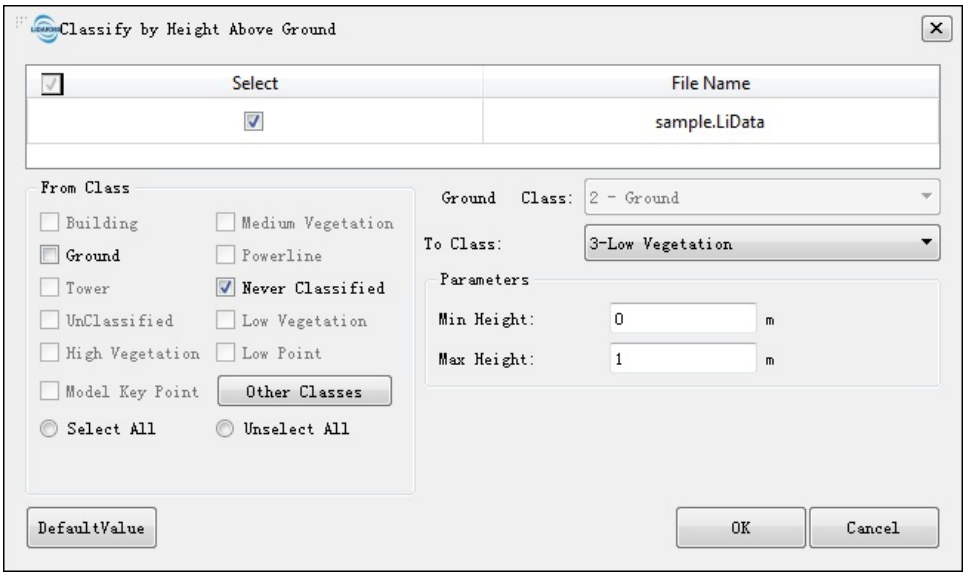
Brief

This function classifies the points on the surface of the terrain with a certain height, which can quickly classify vegetation at different heights. For example, this classification can be performed three times to separate low vegetation (0-1m), medium vegetation (1-10m), and high vegetation (10-100m), see the figure below.



Usage

Click *Classify* > *Classify by Height Above Ground*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud data set, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).

- **Ground Class**: The default ground point is 2-class.
- **To Class**: Target class.
- **Min Height (m, default value is "0")**: The minimum height difference of the area to be classified above the ground points.
- **Max Height (m, default value is "1")**: The maximum height difference of the area to be classified above the ground points.
- **DefaultValue**: Click this button to set all parameters as default.

> Note: This function need to contain the ground point in the cloud.

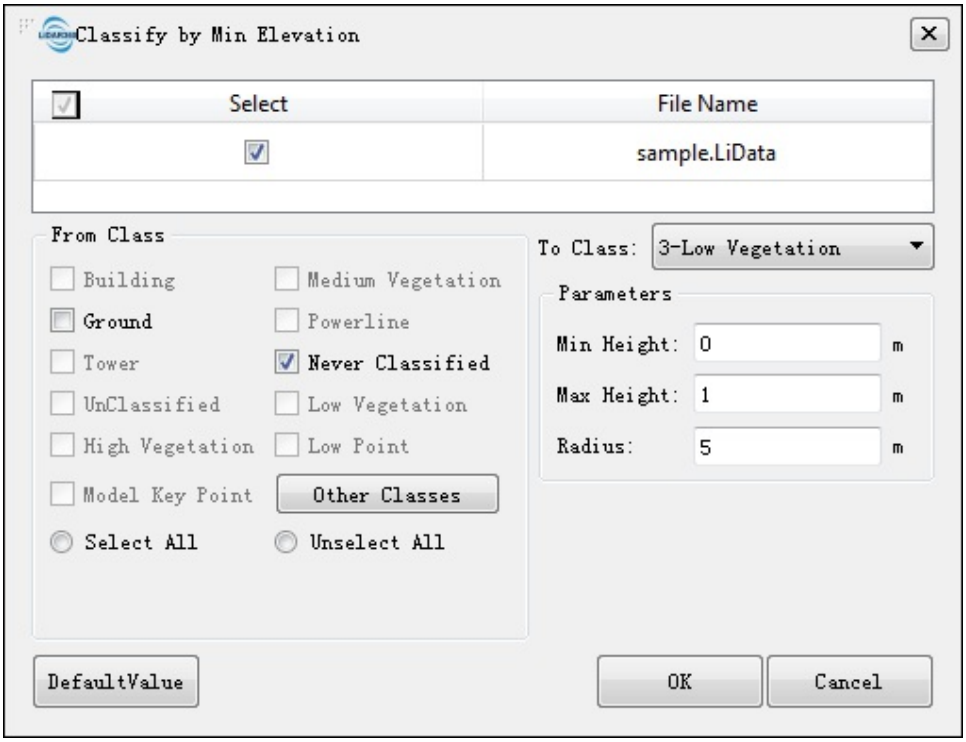
Classify by Min Elevation

Brief

This function classifies the points at a certain height within a certain radius in the source class.

Usage

Click *Classify* > *Classify by Min Elevation*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud data set, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Min Height (m, default value is"0")**: The minimum height difference in the area to be classified above the lowest point within the radius.
- **Max Height (m, default value is"1")**: The maximum height difference in the area to be classified above the lowest point within the radius.
- **Radius (m, default value is"5")**: The radius of the area needs to be classified at the current point, which needs to be classified.
- **DefaultValue**: Click this button to set all parameters as default.

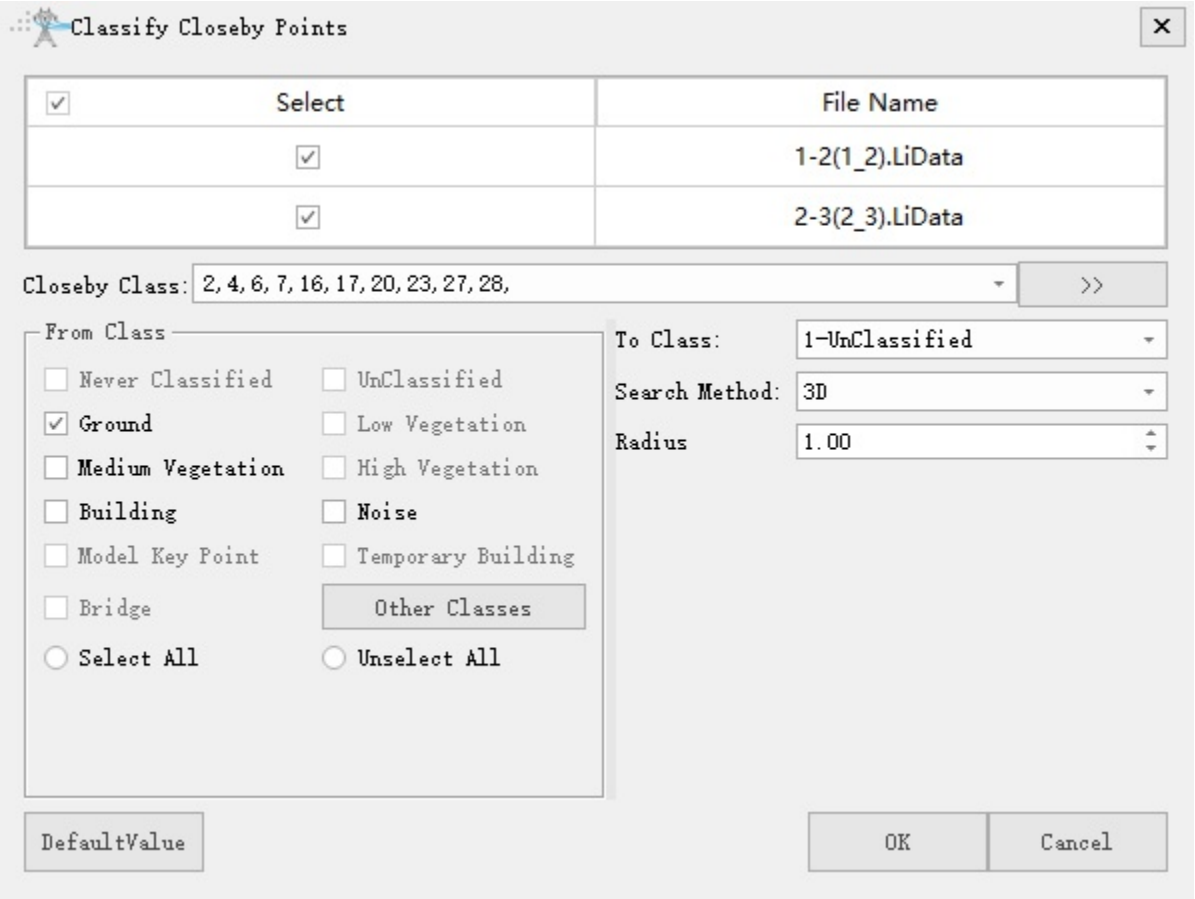
Classify Closeby Points

Summary

This tool can classify point clouds close to other classes. For each point in the "from class", the software looks for the point cloud in the specified 2D or 3D neighborhood, and determines whether these points meet certain conditions (such as containing a specified class). If the conditions are met, the point is classified into the "to class".

Usage

Click *Classify* > *Classify Closeby Points*



Parameters

- **Input Data**: The input data can be single or multiple, must have been opened in LiPowerline.
- **Closeby Class**: If class in from class is detected in neighbour area, that point will be reclassified.
- **from Class**
- **to Class**
- **Search Method**: Support 2D or 3D neighbourhood.
  - **Radius**: Neighbourhood search radius.

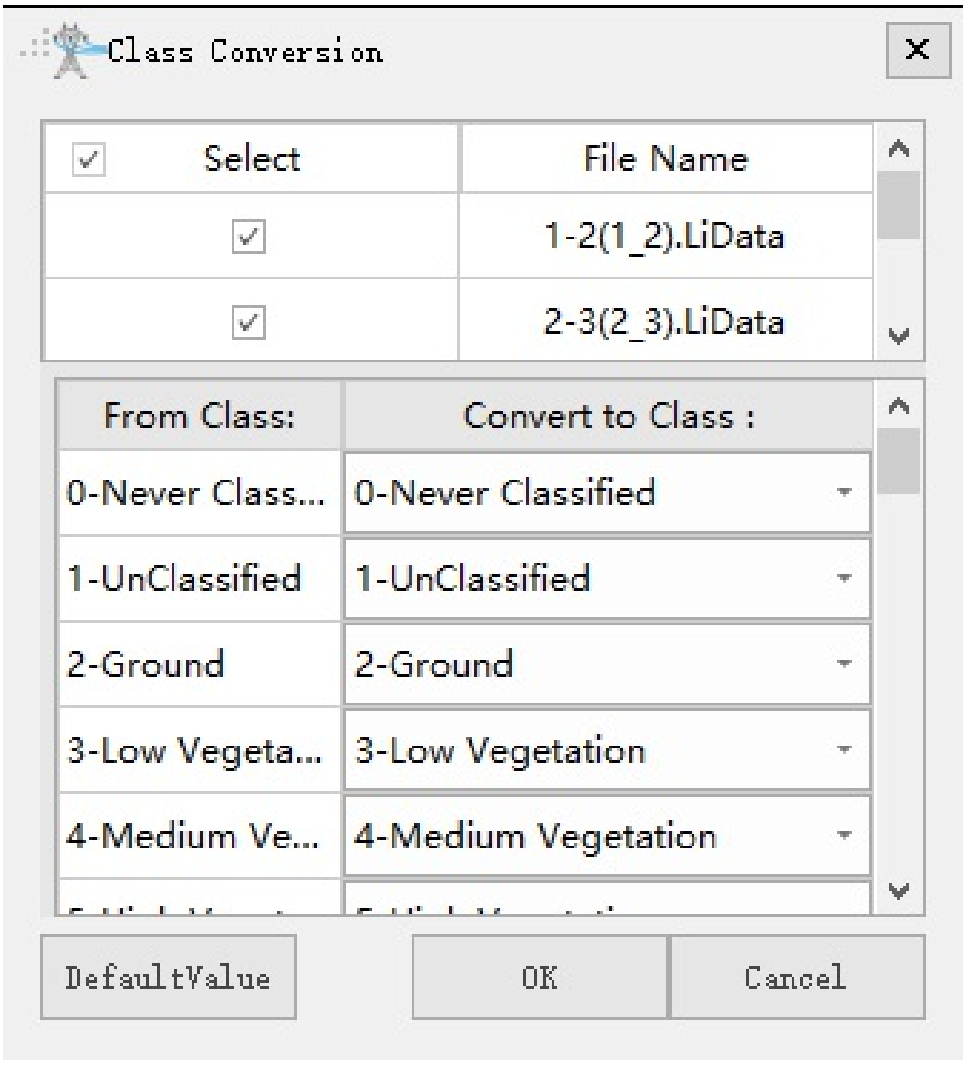
Class Conversion

Summary

A certain class of the point cloud can be converted into another class according to attribute characteristics in batches. Currently available tools include: absolute elevation,intensity, GPS time, scan angle and return times. If you are unsatisfied about the classification result and wish to do it all over again, you can use this tool to recover point cloud class.

Usage

Click *Plugin* > *Classify* > *Class Conversion*



Parameters

- **Input Data**: The input data can be single or multiple, must have been opened in LiPowerline.
- **from Class**
- **to Class**
- **Attribute**: Classify by attribute.

- **None(by default)**: Change all points in "from class" to "to class".
- **Absolute Elevation**: Classify by absolute elevation.
- **Intensity**: Classify by intensity.
- **GPS time**: Classify by GPS time.
- **Scan Angle**: Classify by scan angle.
- **Return Times**: Classify by return times.

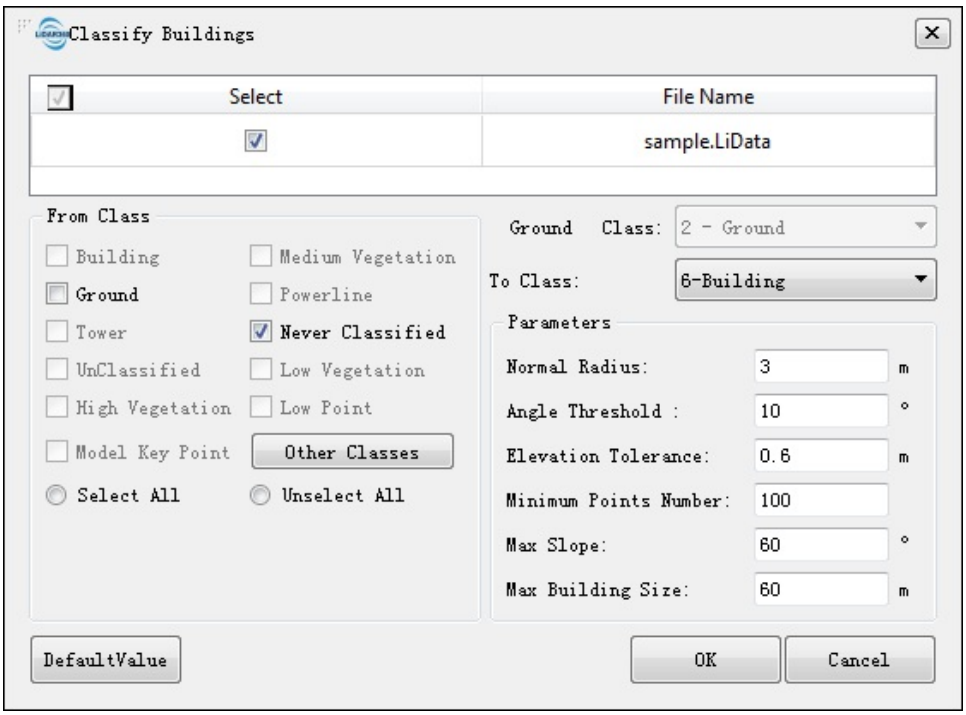
Classify Buildings

Brief

This function classifies buildings in point cloud data.

Usage

Click *Classify* > *Classify Buildings*



Settings

- **Input Data**: The input file can be a single point cloud data file or a point cloud dataset, which must be opened in the LiPowerline software and has already been classified by ground points.
- **From Class**: Source class(es).
- **Ground Class**: The default ground point is 2-class.
- **To Class**: Target class.
- **Normal Radius (m, default value is "3")**: The radius of the neighborhood when calculating the normal vector of each point in the point cloud. Usually set to 4-6 times the distance between points.
- **Angle Threshold (°, default value is "10")**: The angle threshold between two points in plane clustering. When the actual angle of two points is less than the threshold, the two points will be clustered into the same group.
- **Elevation Tolerance (m, default value is "0.6")**: The distance threshold from point to plane in plane clustering, which is expected to be slightly larger than the average point distance. When the actual distance is less than the threshold, the point and plane will be clustered into the same group.
- **Minimum Points Number (default value is "100")**: The minimum points number of building patches.
- **Max Slope (°, default value is "60")**: The angle between the plane and the vertical direction. Greater than this value is not considered as the top of the building but the wall or other classes.

- **Max Building Size (m, default value is "60")**: The maximum length of buildings, which was used for the detection of building patches between blocks.
- **DefaultValue**: Click this button to set all parameters as default.

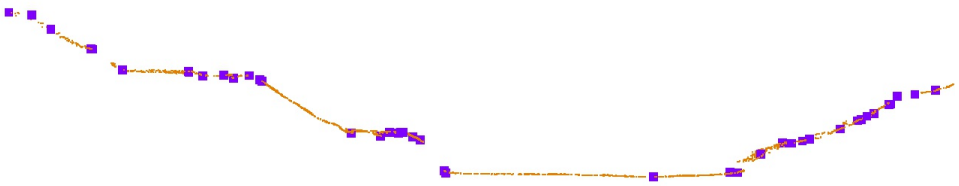
> Note: Using this function requires that the point cloud has been classified by ground points.

Classify Model Key Points

Brief

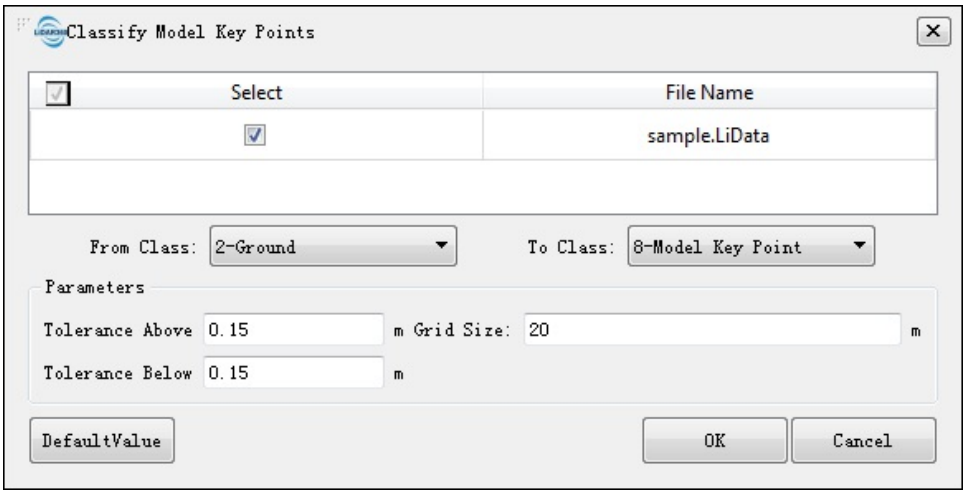
This function can thin a certain level of the classified points. It is generally used to generate a sparse point set that retains the key points in the complex terrain area and thin the points in the flat area from the extracted dense ground points.

The idea of the algorithm is: first, meshing of point cloud data, and then use the seed points in the grid to establish the initial triangulation network. According to the upper and lower boundary thresholds, the points that meet the conditions are added to the triangulation network. The process is iterated until all of the key points of terrain model are classified. In the following figure, the yellow point is the ground point and the purple point is the key point of terrain model.



Usage

Click *Classify* > *Classify Model Key Points*



Settings

- **Input Data**: The input file can be a single point cloud data or a point cloud dataset, which must be opened in the LiPowerline software.
- **From Class**: Source class(es).
- **To Class**: Target class.
- **Tolerance Above (m, default value is"0.15")**: The maximum allowable elevation tolerance value over the triangulation model composed by the original points. The larger the value, the more sparse the key points will

be extracted, and vice versa.

- **Tolerance Below (m, default value is"0.15")**: The maximum allowable elevation tolerance value under the triangulation model composed by the original points. The larger the value, the more sparse the key points will be extracted, and vice versa.
- **Grid Size (m, default value is"20")**: The value is used to ensure the density of key points extracted from the model. For example, if you want to ensure that there is at least one point in the grid every 20 meters, this value is set to 20.
- **DefaultValue**: Click this button to set all parameters as default.

Terrain

The terrain module contains a range of products required for terrain production. The Digital Elevation Model (DEM) indicates the bare earth surface with vegetation and other objects removed.

- DEM

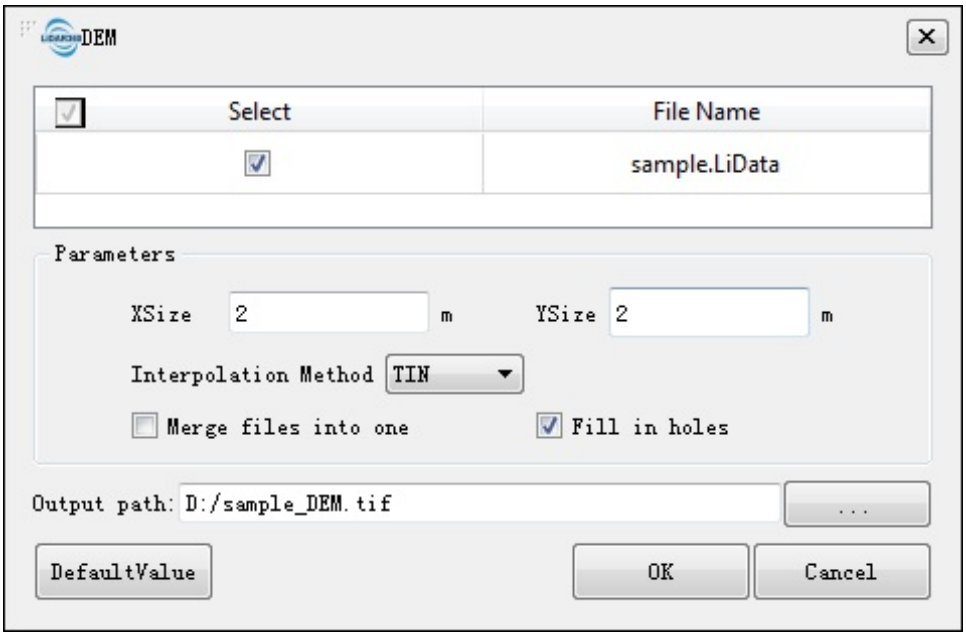
DEM

Brief

A Digital Elevation Model (DEM) is a digitized simulation of the terrain derived from limited topographic elevation data—in other words, a digital representation of the terrain surface form. It represents ground elevation as an ordered numerical array and is a branch of the digital terrain model, from which all other terrain feature values can be derived.

Usage

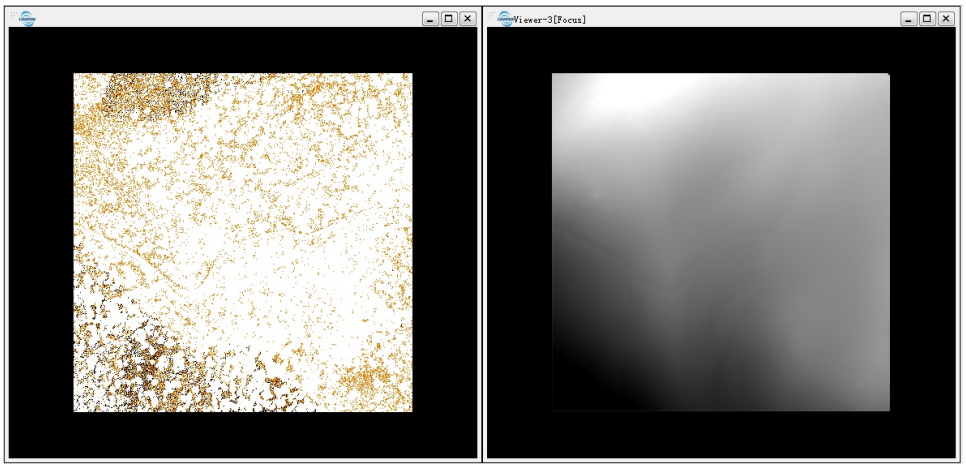
Before you can generate a digital elevation model, first classify ground point cloud. Click on the *Terrain* > *DEM*.



Settings

- **Input Data**:Make sure that each input point cloud data is a classified ground point; the input file can be a single point cloud data file or a point cloud dataset; The data to be processed must be already opened in LiPowerline software.
- **Parameter Settings**
  - **XSize(m)(default value is "2")**:Set the X size of the grid.
  - **YSize(m)(default value is "2")**:Set the Y size of the grid.
  - **Interpolation Method**:Select an interpolation method, including IDW (Inverse Distance Weight) interpolation, Kriging interpolation, and TIN (Triangulated Irregular Network) interpolation.
  - **Power(default value is "2")**:Set the power value; it is only available when the IDW interpolation method is selected.
  - **Merge Files into One**:Not checked by default; check it to merge all generated raster files into one file.
  - **Fill in Holes**:Checked by default; uncheck it to disable this function.
- **Output Path**:Save DEM file to a path.
- **Default Value**:Click this button to restore all parameter defaults.

The original point cloud (left below) and the DEM(right below).

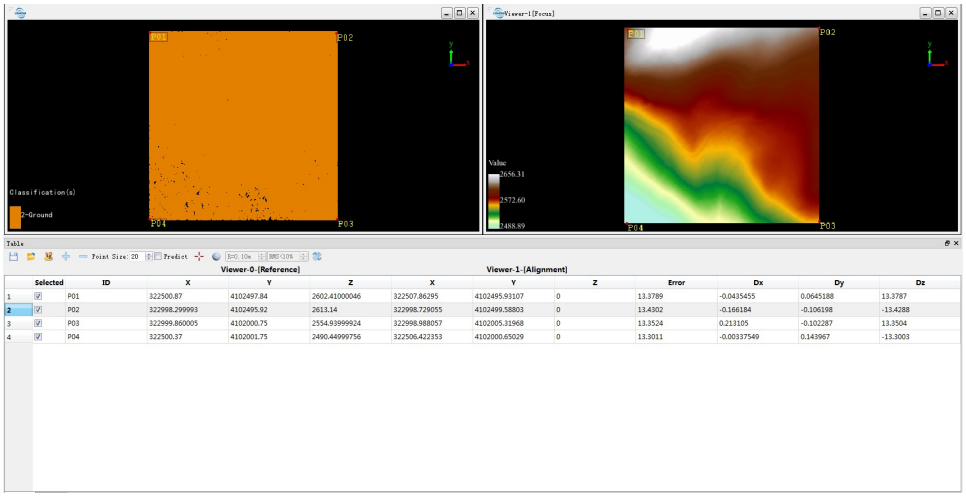


> Note: Point clouds that are used to generate DEM need to contain ground points.

Rectify



Brief: This tool is used for coordinate rectification of to-be-aligned data with respect to reference data. The two datasets can be "point cloud and point cloud", "point cloud and image", or "image and image". At least 3 pairs of homologous points(or fitted spheres in point cloud) should be added in the datasets, which are displayed in separate windows, before the calculation of transformation parameters. You can evaluate the accuracy using the residuals of homologous points listed in the table window.



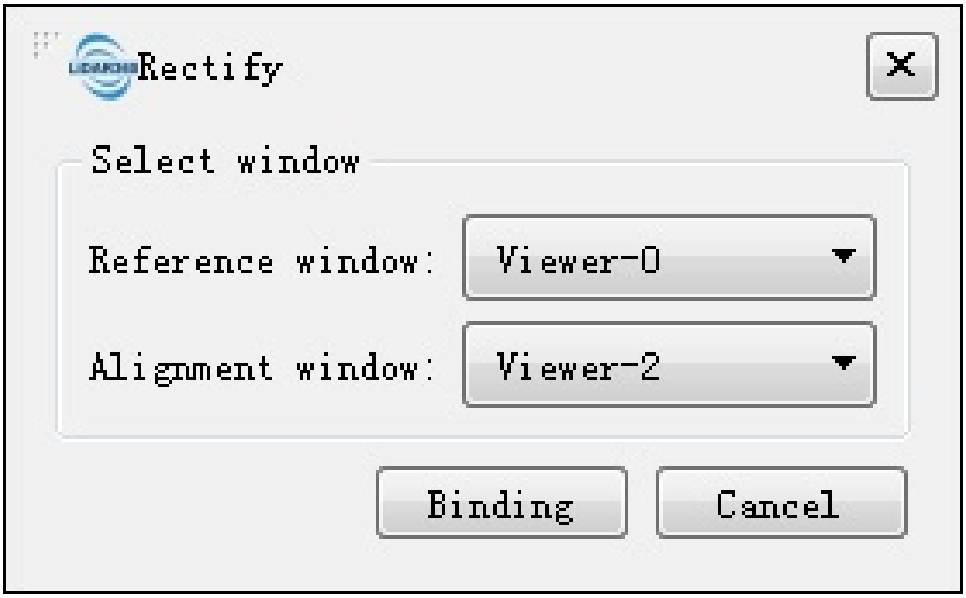
Usage

Click *Plugins* > *Rectify*

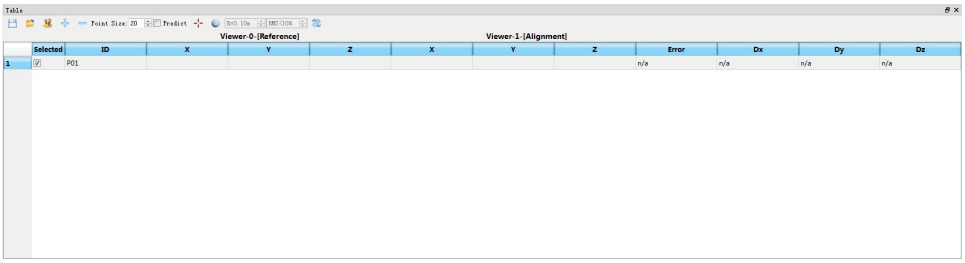
> Note: You have to create at least two display windows (except the profile window) before using this tool.

Steps

1. Create two display windows and load the reference data and the to-be-aligned data into separate windows. Click the **Rectify** tool to open the following dialog.



2. Select **Reference window** for the reference data and **Alignment window** for the to-be-aligned data. Then click the **Binding** button. The following table window with a series of tools pops up.



3. **(Optional)** Click the Change Datum button to exchange the reference window and alignment window, if they were mistaken.

4. **(Optional)** Click the Load Data button to load homologous points from existing file. Then you can skip the manual measurement (steps 5, 6, 7).

5. Click Pick Point or Pick Registration Sphere to measure a pair of homologous points (or fit a pair of spheres) in reference window and alignment window. If spheres are fitted, their centers are used as homologous points.

6. Click the button Add Point to add blank row for a new pair of homologous points.

7. Repeat steps 5 and 6 to pick at least three pairs of homologous points (or spheres).

8. **(Optional)** If the option Predict is checked and there exist at least 3 pairs of homologous points, the corresponding position in the reference window will be predicted after picking a point in the alignment window.

9. **(Optional)** The user can exclude a pair of homologous points in the calculation of transformation parameters: (1) Uncheck the row of the homologous points in the table; (2) Or click the Delete Point button after selecting the corresponding row.

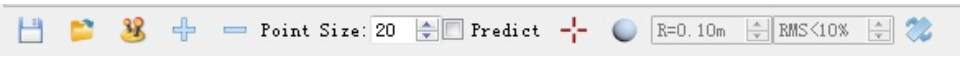
10. **(Optional)** The user can modify the coordinates of added homologous points: (1) Pick point again in the alignment window and reference window after selecting a row of homologous points; (2) Or double click the coordinates in a row, then input new values directly.

11. **(Optional)** The user can view each homologous point quickly for quality check: Double click a row in the table to jump to the corresponding positions in the display windows.

12. **(Optional)** Click the Save Data button to save the homologous points to file.

13. Click the button Transform to calculate transformation parameters and generate aligned data.

Toolbar



Following functions are integrated in the toolbar.

Save Data: Save homologous points to file.
Load Data: Load homologous points from file (Please refer to File Format of Homologous Points).
Change Datum: Exchange reference window and alignment window. The homologous points are also exchanged.
Add Point: Add blank row for a new pair of homologous points in the table.
Delete Point: Delete selected row in the table.
Point Size (Default: "20"): Point size of homologous points in display windows.

Predict (Default: Unchecked): If this option is checked and there exist at least 3 pairs of homologous points, the corresponding position in the reference window will be predicted after picking a point in the alignment window.

Pick Point: Pick homologous points in reference window and alignment window.
Pick Registration Sphere: If target ball is used for point cloud registration, this function can fit sphere automatically after clicking the target ball in point cloud. The sphere center is used as homologous point.
R: Radius for sphere fitting. Please input the actual radius of target ball.

RMS: The threshold of root mean square error for sphere fitting. Please set larger value for point cloud of low quality in case of fitting failure.

Transform: The coordinates are rectified based on homologous points. While processing image data, the user can specify different methods, which include polygonal correction and polynomial correction. The polynomial correction varies depending on N pairs of homologous points.

Polynomial Correction	Condition
Primary Polynomial	3 <= N < 6
Quadratic Polynomial	6 <= N < 10
Cubic Polynomial	10 <= N

Search Toolbox

Summary

Quickly search for and use the tools in Data Management, Classify, and Terrain.

Usage

Click *Plugins* > *Search Toolbox*.

