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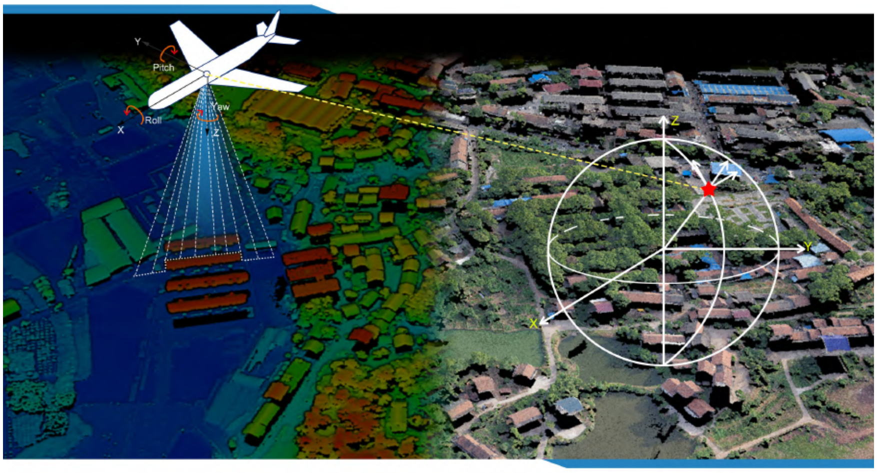
GreenValley International

LiGeoreference User Guide

LiDAR point cloud georeferencing software



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GreenValley International

LiGeoreference V1.2

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Imprint and Version

Document Version 1.2

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Dear Users,

Thank you for using LiGeoreference software. We are pleased to be of service to you with LiDAR point cloud manipulation solutions. At GreenValley International, we constantly strive to improve our products. We therefore appreciate all comments and suggestions for improvements concerning our software, training, and documentation. Feel free to contact us via info@greenvalleyintl.com. Thank you.

Date printed: 9th July 2020

Introduction

LiGeoreference is a self-developed LiDAR point cloud georeferencing software by GreenValley International.

The main functions include:

- Georeference Process
- Trajectory Process
- Point Cloud Roam
- Point Cloud Process
- Laser Scanner Calibration
- Camera Calibration
- Report

Other useful tools include:

- Project Management
- Measurement Tools
- Profile Tools
- Batch Process
- Viewing Tools
- Colorbar Tools
- Selection Tools
- Export
- Account
- Download Base Station Data
- Prjection Transformation

Installation

System requirements

The recommended system requirements are as follow:

- **RAM**: at least 8G or more.
- **CPU**: Intel® Core™ i5/i7; Dual-core processor.
- **Hard Drive**: SSD for data processing is recommended, transfer speed beyond 100M/s.
- **Display Adapter**: NVIDIA graphics card is recommended, video memory no less than 2GB.
- **Operating System**: Microsoft Windows 7(64-bit), Microsoft Windows 8(64-bit), Microsoft Windows 10(64-bit), Microsoft Windows Server 2012 or higher.

> For Windows 8 and 10, if the software is installed in system disk, please remember to set "Run as administrator".
>
> To enable high-performance graphics mode for running the software.

Set up

1. Run LiGeoreference Setup Wizard.
2. Click *Next* in the welcome interface.
3. Click *I agree* to accept License Agreement.
4. Choose the installation path(or use default path), then click *Install*.
5. Click *Finish*.

License manager

The software license can be provided in two ways: USB dongle or activation key. For USB dongle, user should not format, delete or copy it.

1)USB dongle

Users need to plug the dongle into USB port, and it can be detected by software instantly.

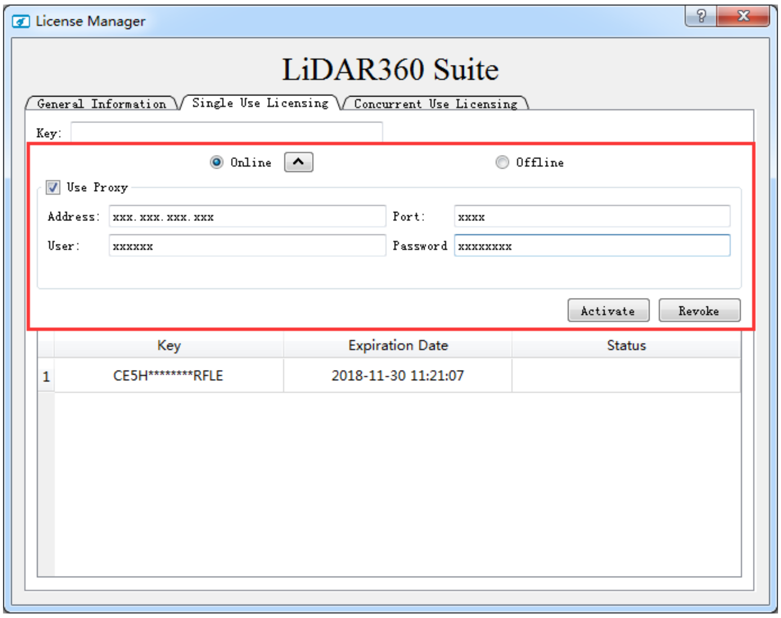
2)Activation key Please activate the software by following steps:

1. Run the software.
2. Click *Help* > *License Activation*, and the License Manager window will pop up.
3. Fill in your name and company, select the modules you want to activate, and then click *Copy*.
4. Email the copied information to info@greenvalleyintl.com.
5. There are two kinds of license mode: single-seat and concurrent-seat. After receiving the activation key, activate (or revoke) the license online or offline.

- **Single-seat license**

- **Activation/Update**

  Online Activation/Update: When connecting to the Internet, enter the authorization key under "Single-seat License" tab. Then select *Online*, and click *Activate* to activate or update. Activation information, such as expiration date, will displayed below. You can also check the expiration date for each module. You can click to use proxy, set up address, port, user name, and password.

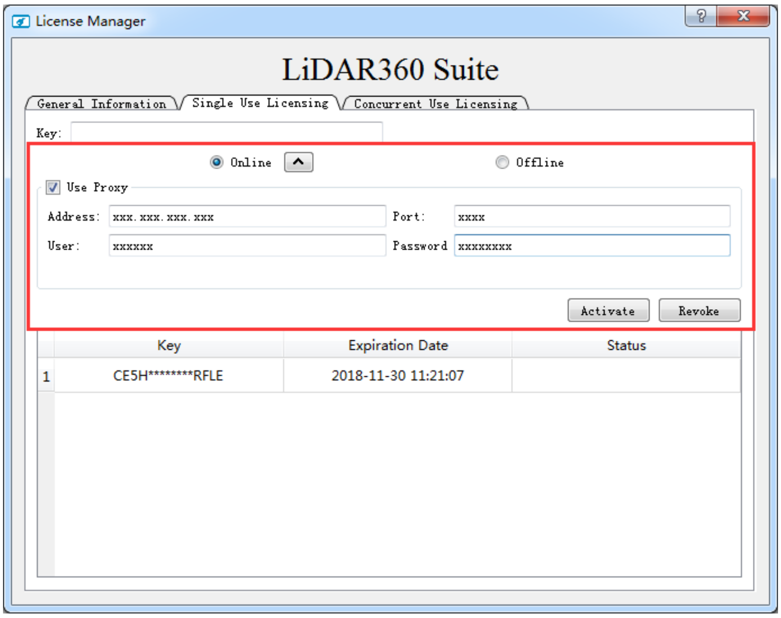
  

  Offline Activation/Update: Firstly,click *Generate Request File* to generate the request file(.req). Secondly, use a computer with Internet connection to browse https://user.bitanswer.cn. Then enter the activation key to log in, click *Update* and upload the request file(.req), and download the generated upgrade file(.upd). Go back to the License Manager window, and click *Apply Permission File*.

- **Revoke**

  To unbind an activation key from a computer, users can revoke the activation key online or offline. After that, the key can be used on other devices.

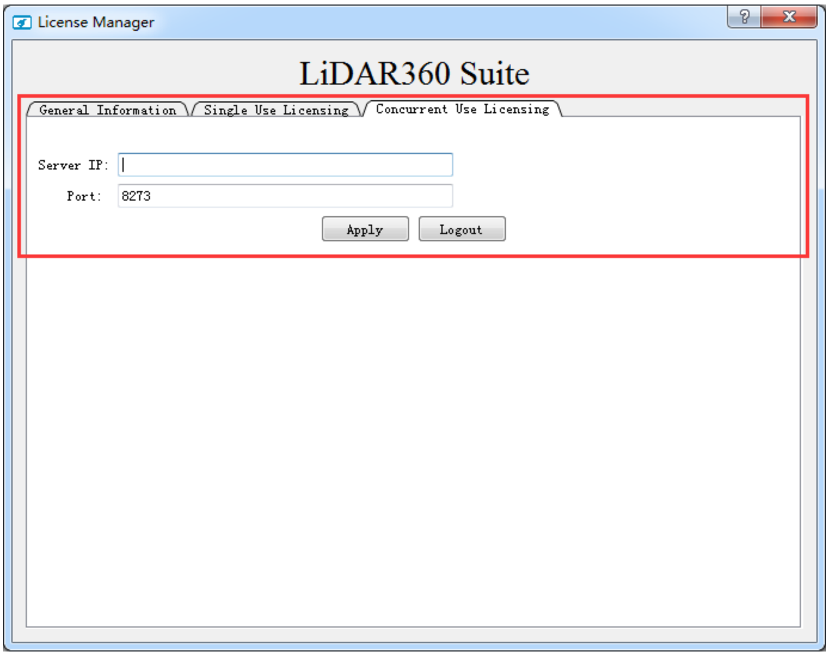
  Online Revoke: Enter the activation key under *Single-seat license* tab, then select *Online* and click *Revoke* to revoke the key. Or select activation key in the list and right click, then select *Revoke ket*. You can click to use proxy, set up address, port, user name, and password.



Offline Revoke:Enter the activation key and select *Offline*, click *Generate revoke file* to generate request file(.req).use a computer with Internet connection to browse https://user.bitanswer.cn. Then enter the activation key to log in, click *Revoke* and upload the request file(.req), and download the generated upgrade file(.upd). Go back to the License Manager window, and click *Apply Permission File*.

  - **Delete** To delete authorized information from the computer, right-click on the activation key and select "Delete Key". After being deleted, the same activation key can only be used on the same computer.

- **Concurrent license** Install enterprise activation tool on the server to activate the key online or offline. Other users can use the activation windows to input the server's IP address to activate the software. The default port is 8273. Click *Apply*.



> Note: If software has been opened while updating the license, please restart it to make the license effective.
>
> Note: If users want to use the activation key for another device, they should revoke it from the old device before they can activate on another one.If the activation key has been deleted, it need to be reactivate on the same computer firstly.
>
> Note: Please contact info@greenvalleyintl.com for inquiry and purchase.

New/Open project

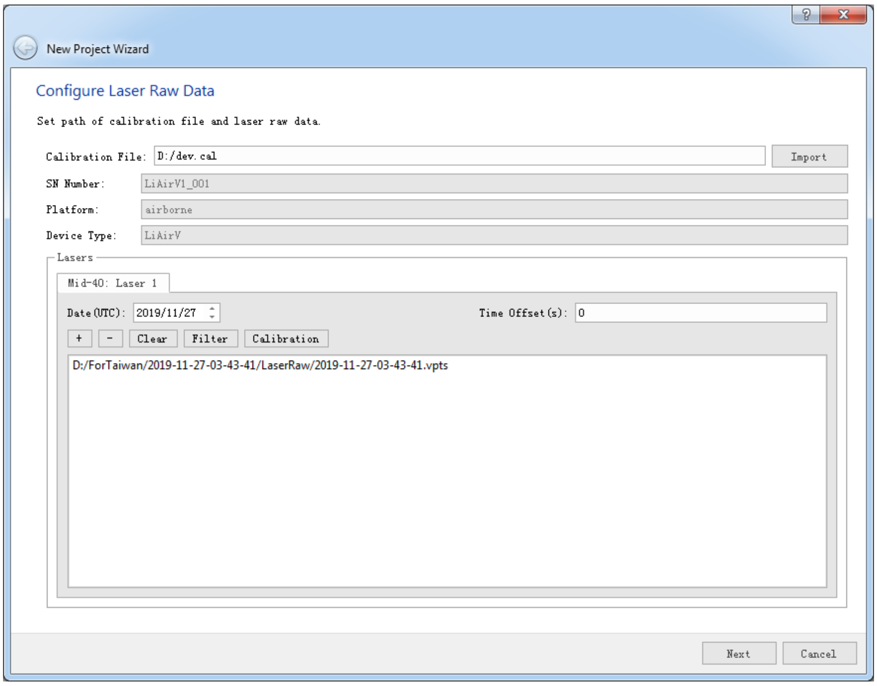
Before data processing, it is recommended to put all data into some certain working space under local disk. Also, the software can directly open *.live project file generated by LiAcquire, and automatically generate new project file.

New project

The new project wizard includes five pages: *Configure laser raw data*, *Configure camera raw data*, *Configure POS raw data*, *Target coordinate system*, and *Output*. If invalid setting appears at certain page, it will be not able to proceed to the next page. When project is created, users can also change parameters in *Georeference* > *Set*.

Configure laser raw data

Select *New*, click *New project*  , and there goes the new project wizard window:



- **Calibration file**: This file is necessary for creating new project. For each device produced by GreenValley International, there's a calibration fie in *.cal format bounding to it.For customized device, users need to contact our technique supporter to generate configuration file.
- **SN number**: The system serial number of the device. The SN number is exclusive for each device.
- **Platform**: The platform supported by the device, mainly by airborne or by mobile car. The calibration parameters of devices on different platforms cannot be shared.
- **Date(UTC)**:The date of data collection.

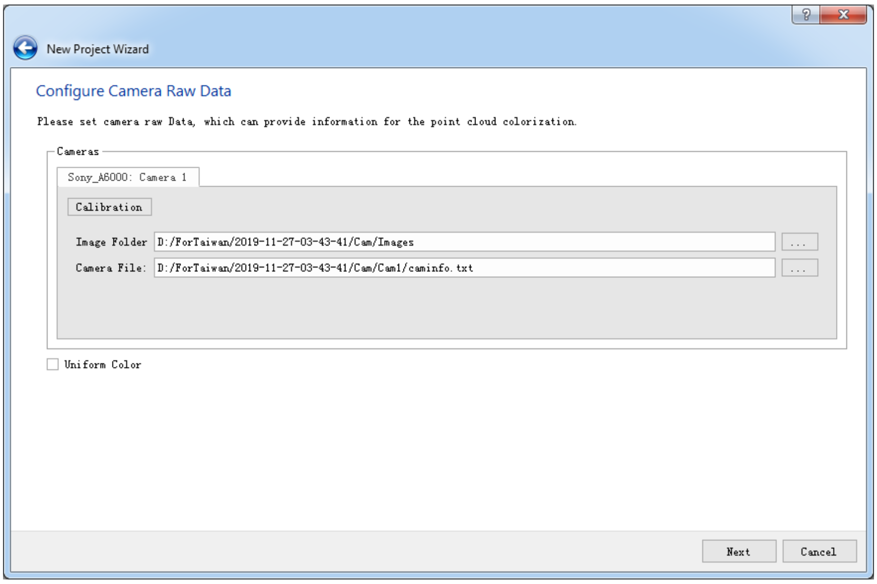
- **Time offset**: The timestamp offset between raw point cloud data and POS data.(The point cloud data and POS processed by LiGeoreference are both UTC time, so the difference will be zero. However, if POS file is imported externally, there might be difference. For example, if the POS file imported is recorded by atomic time, leap seconds need to be added as the offset.
- **+**: Add point cloud data.
- **-**: Delete point cloud data.
- **Clear**: Clear point cloud data.
- **Filter**:There are several filter options for point cloud data processing.
    - **Reflectance**:Filter by reflectance.
    - **Amplitude**: Filter by amplitude.
    - **Distance**: Filter by distance, where distance refers to the distance between point cloud and laser scanner center.
    - **Angle**: Filer by angle, where angle refers to the angle between point cloud to laser scanner center, 0 degree at forward direction and increase clockwise.
    - **Laser line**: Filter by laser line. Only save the point cloud data when its line id is checked.
    - **Thin points**： Thin the point cloud according to multiples.
    - **Split by Number of Points**: Split the point cloud according to the number of points. if the point number in the original point cloud exceeds the number by user, the point cloud file will be splited when performing georefence.
    - **Split by Time Interval**: Split the point cloud according to time interval. if the time span exceeds the time interval by user, then the point cloud file will be splited when perform georeference.
- **Calibration**: The calibration parameters of laser scanner center to carrier center, imported by calibration file, users can also edit.

- **Convert to SDC**: Convert raw point cloud data to SDCformat.
    - **Auto**: Restore MTA automatically.
    - **None**: Don't restore MTA.

Configure camera raw data

Only for device with a camera.

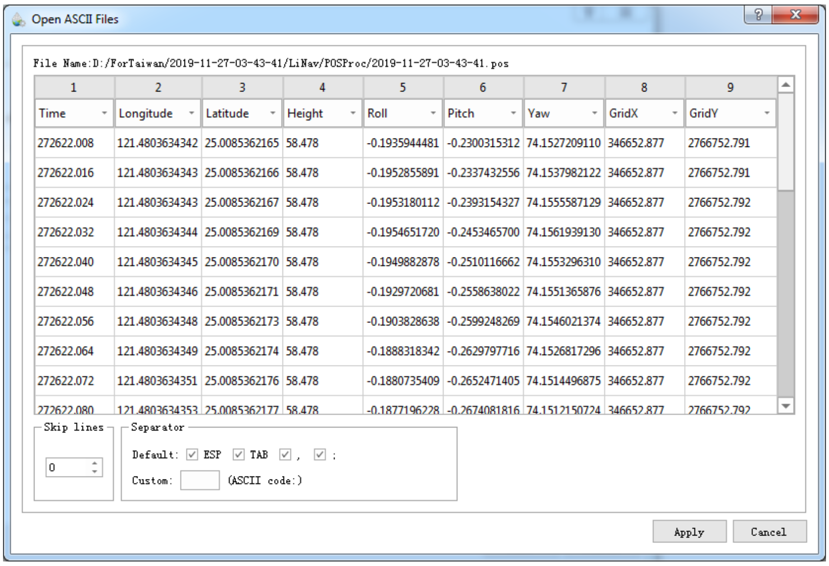
- **Calibration**: The calibration data for camera, imported by calibration file, users can edit.
- **Image folder**: Folder where camera data(*.jpg,*.PNG etc)stored.
- **Camera file**: Folder where camera file(*.txt) stored. Camera file records exposure position and attitude.
- **Uniform color**： To uniform the colorization or not.(Only by airborne)
- **Resolution**: Device resolution.(Only by airborne)

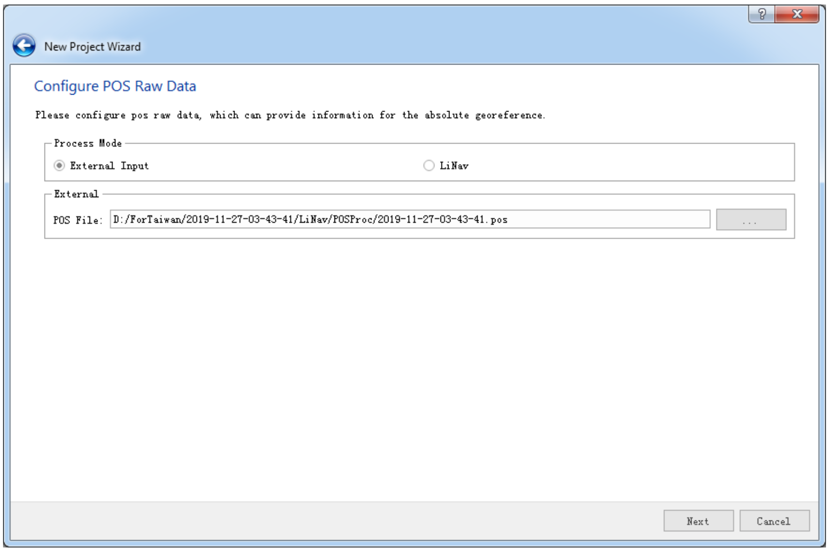


Configure POS raw data

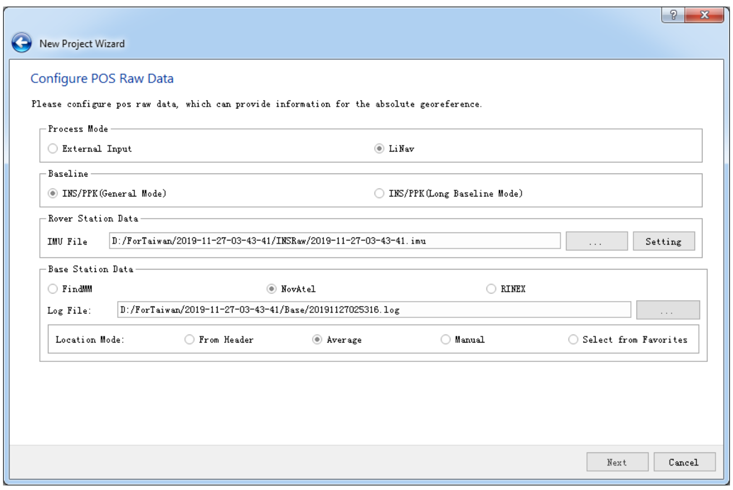
POS file can be imported externally or post-processed by LiNav module.

- **Open ASCII file**: Import POS file externally.



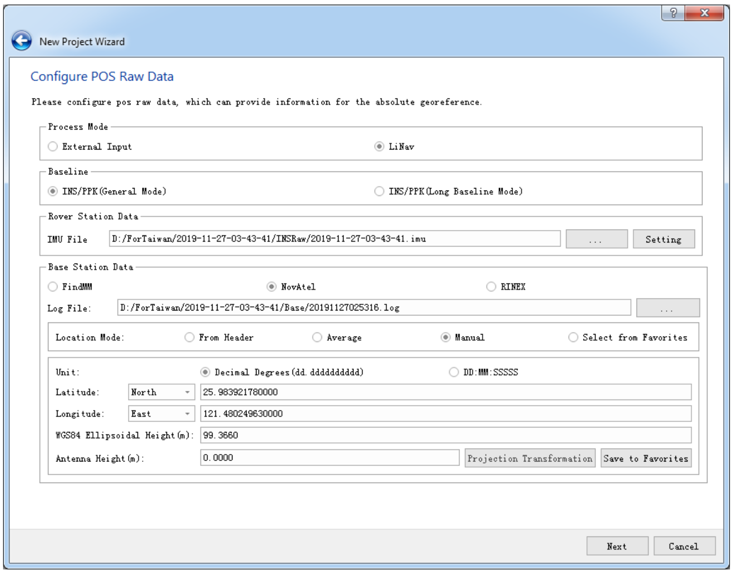


- **LiNav**: Post-process POS file by LiNav module. Click *LiNav* and turn to LiNav page, set base station and rover station data. The result POS file is in .pos format.
  - **Baseline**:Select the baseline mode. Single base station selects INS/PPK (general mode), multiple base stations select INS/PPK (long baseline mode).
  - **Rover station file**: Import rover station data acquired by field acquisition equipment (*.imu)
  - **Base station data**:The base station data has three modes: FindMM, NovAtel, and RINEX.
    - **FindMM**: Download from LiCloud, extra charge needed.
    - **NovAtel**: For NovAtel base stations set up, click the button on the right to select the base station raw data (*.log).
    - **Rinex**: The general format suitable for setting up data conversion of other types of base stations, click the button on the right, select the base station observation (RINEX OBS) file, ephemeris (nav, cnav, gnav) file. It should be noted that OBS and NAV files are mandatory files, and other files are optional.

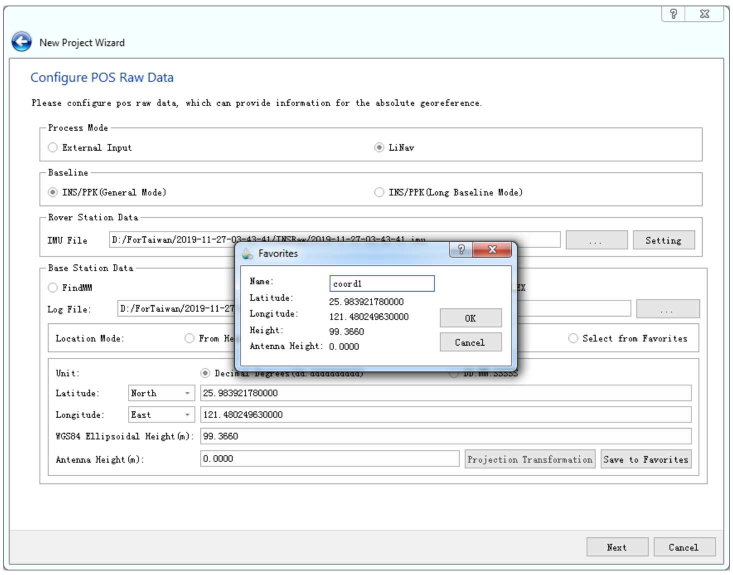


  - **Location mode**: Calculation mode of base station coordinates.

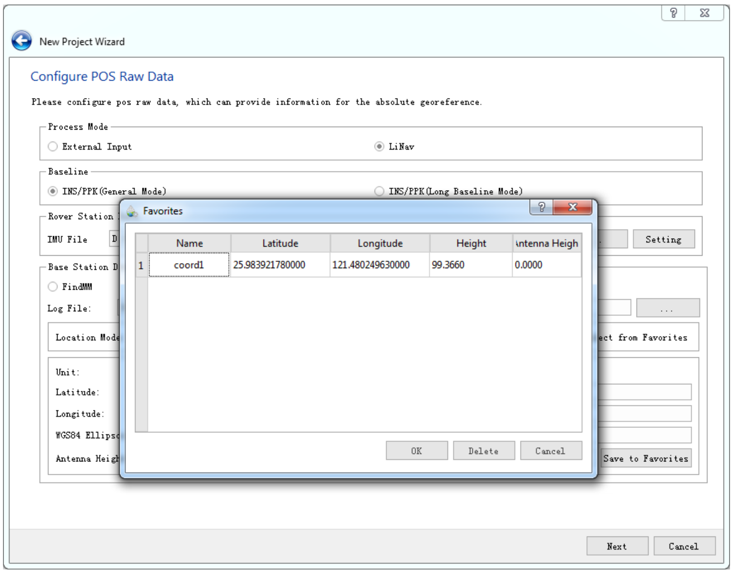
- **Average**:Calculate by average. The default selection when the base station is NovAtel.
- **From header**: Read from header. The default selection when the base station is Rinex.
- **Manual**:Manual input. Enter the WGS84 latitude and longitude coordinates (in degrees, minutes and seconds or degrees), ellipsoid height and antenna height. When setting the latitude and longitude, the actual latitude is positive, you should choose North, otherwise choose South. When the actual longitude is positive, you should choose east, otherwise choose west, fill in the latitude and longitude values are positive. Sometimes, if coordinate conversion is needed, you can click the **Projection Transformation** button to transform coordinate. The method for manually adding base station coordinates is shown in the following figure:



Click *Save to favorite* to save current settings.



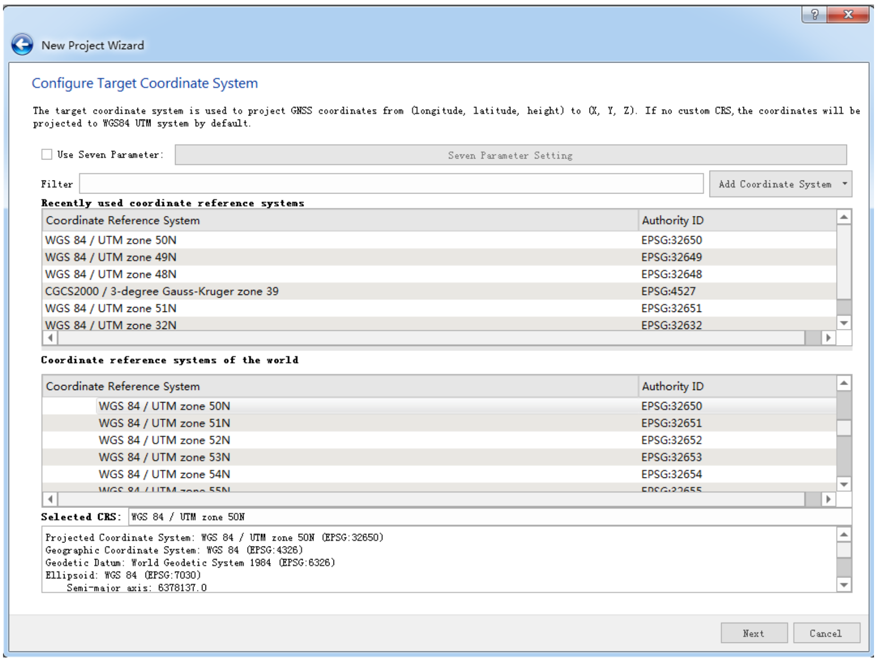
- **Select from favorite**: Select base station parameters from favorite list. The list is empty at first. You need to enter manually and save it to favorite list. Click this button and check coordinates list, double click to select. If you want to delete it, click and delete.



Set target coordinate system

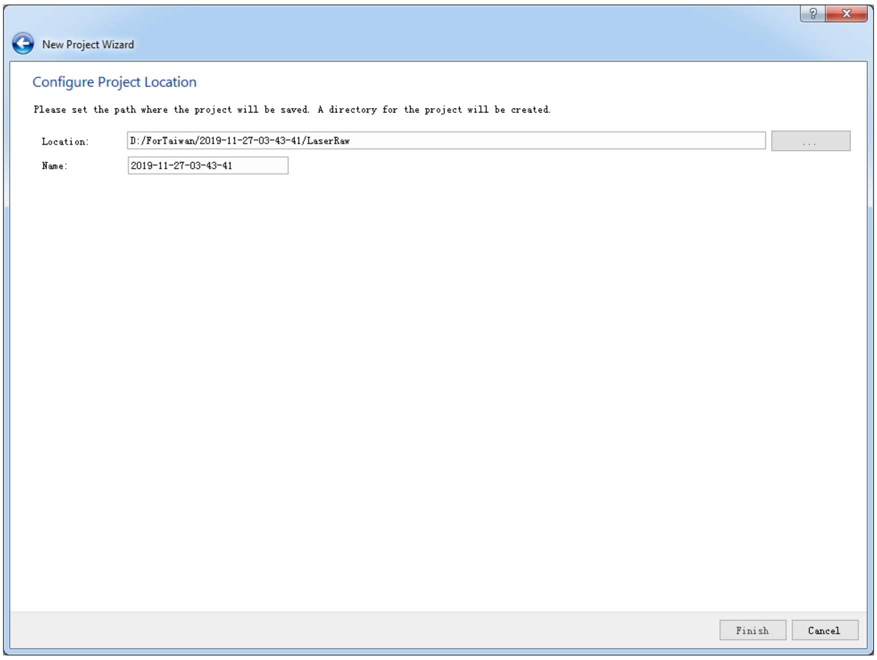
Set target coordinate system for POS file. By default,the coordinate system will be the 6-degree band of WGS84 UTM where the current acquisition is located. When transforming the vertical coordinate, responding vertical datums should be download, please refer to vertical datums for detail.

- **Use seven parameter**: Use seven-parameter transformation. Click the seven parameter setting button to define the seven parameters.
- **Filter**: Select the coordinate system of the reprojection. By entering the keyword of the coordinate system, users can quickly filter out the target coordinate system from the coordinate series table (for example, to set the point cloud coordinate system to WGS 84 / UTM Zone 49N, users can enter UTM in the filter option 49N quickly filter, or enter its EPSG number: 32649 for a quick search), users can also click the Add button to import the coordinate system from the outside.
- **Selected CRSs**: If a coordinate reference system is selected, its name and details will be displayed here.



Output

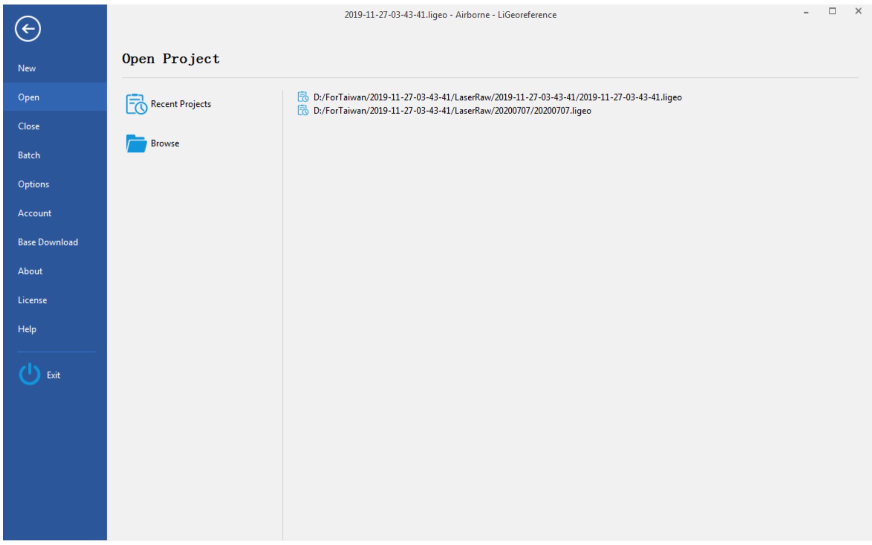
Users can change output directory and project name at this page. The default output directory is the same as laser scanner file directory. Click *Finish* to finish project configuration.



Open project

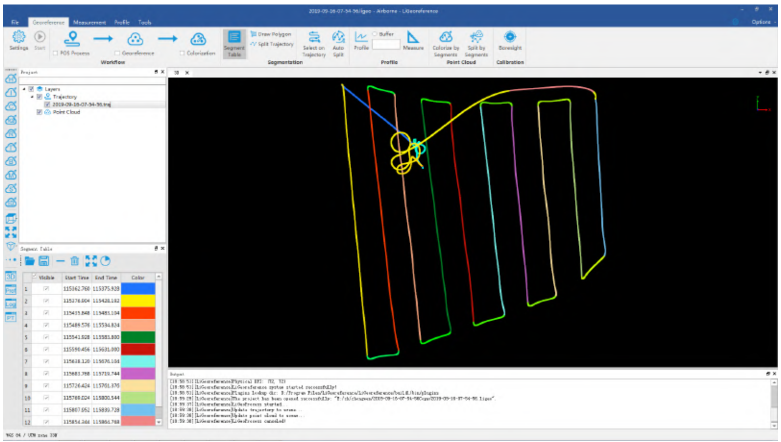
When launch LiGeoreference, click *Open* and select recently opened project or open specific folder.

- **Recent projects**： Open recently used project, double click to open.
- **Browse**: Browse specific folder.


2019-11-27-03-43-41.ligeo - Airborne - LiGeoreference
New
Open
Close
Batch
Options
Account
Base Download
About
License
Help
Exit
Open Project
Recent Projects
Browse
D:/ForTaiwan/2019-11-27-03-43-41/LaserRaw/2019-11-27-03-43-41/2019-11-27-03-43-41.ligeo
D:/ForTaiwan/2019-11-27-03-43-41/LaserRaw/20200707/20200707.ligeo

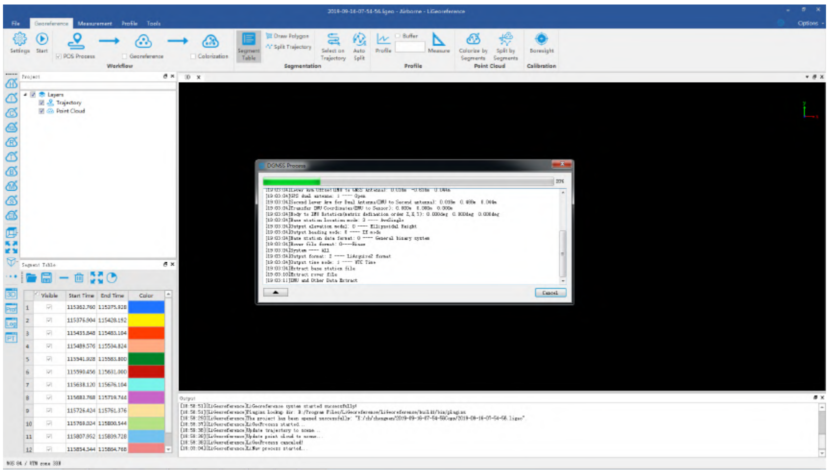
Georeference process

1. Select *Georeference* tab.
2. Choose georeference process. By checking the box of steps to control procedure. LiGeoreference supports below steps:
    - **POS process**: To process raw POS file to get POS data with high-accuracy.
    - **Point cloud georeference**: To process raw point cloud, to get point cloud data with real geographical coordinate.
    - **Colorization**: To colorize point cloud and get point cloud data with RGB information.

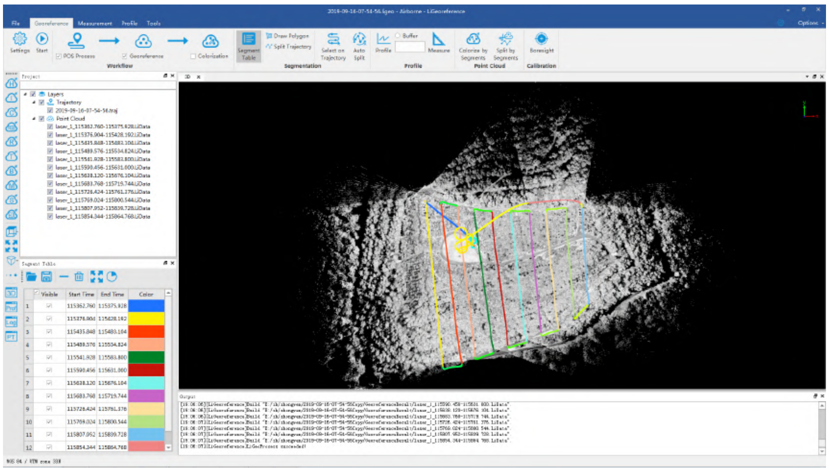
    

3. Parameters setting
   The software has default setting for data processing. If users want to customize, click *Settings*, and change parameters in the setting windows. The parameters are described as follow:
    - **Laser scanner setting**: To set parameters for raw point cloud data. See Configure point cloud data for detailed information.
    - **Camera setting**: To set parameters for camera. See camera parameters setting for detailed information.
    - **POS process setting**: To set parameters for POS processing. See POS process parameters setting for detailed information.
    - **Target coordinate system setting**: To select target coordinate system. See Target coordinate system setting for detailed information.
4. Segment trajectory(Optional)
   For users' convenience, when a new project is created, the software will automatically cut the take-off, descending and 8-figure parts of trajectory(Only available for airborne platform). Users can go to *trajectory segments table* to check detailed information of trajectory segments. Please see Segments processfor detailed information.

5. Start georeferencing.
   When parameters setting is done, click *Start* to start georeferencing, this may take some time. Georeferencing starts:



Georeferencing result:



6. Recolorization(Optional)

   See recolorization for detailed information.

7. Check report.

   See Reportfor detailed information.

Trajectory Process

The software supports manual editing of the trajectory.

Before starting editing, change the top menu to *Trajectory* tag. (In order to facilitate users to segment the trajectory before processing, the *georeference* page also has trajectory segmentation related operations)

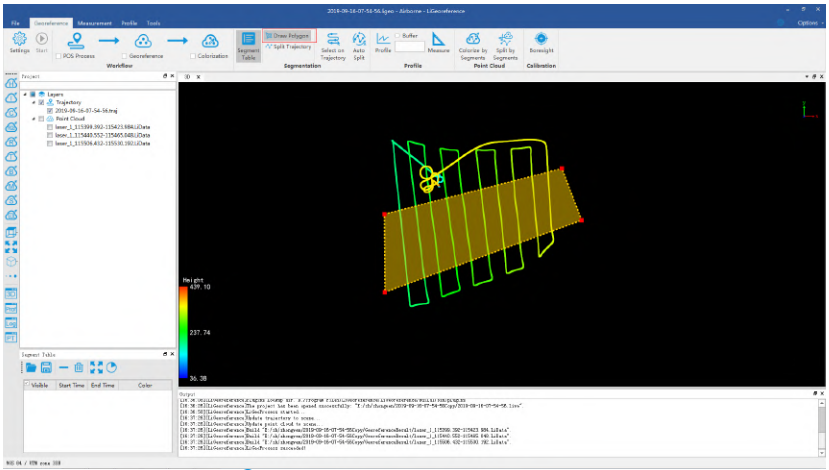
- Trajectory Segments
  - Segment Method
  - Segment Table
  - Trajectory Graph
  - Colorize by Segments
  - Split by Segments
- Trajectory Display
  - Trajectory Display by Time
  - Trajectory Display by Height
  - Trajectory Display by Quality
  - Trajectory Display by Specified Color

Segmentation Method

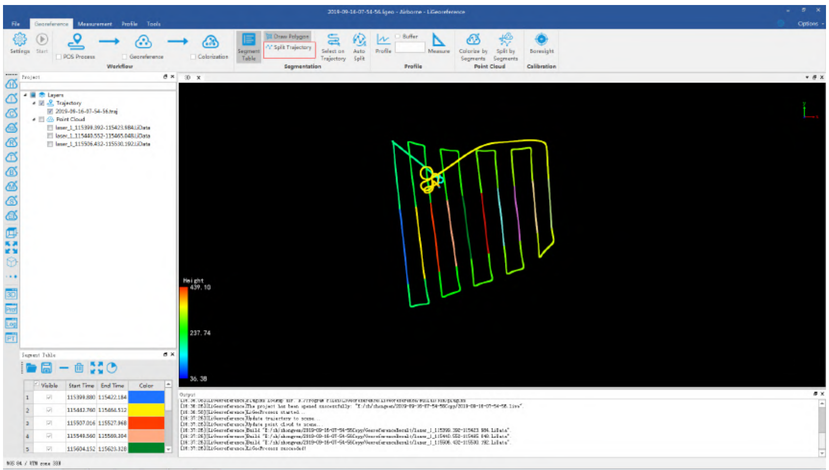
Segment by Polygon

Steps

- Click the *Draw Polygon* button in *Trajectory* tag .
- Click around the area of interest in the 3D display window to select multiple points and draw a polygon.



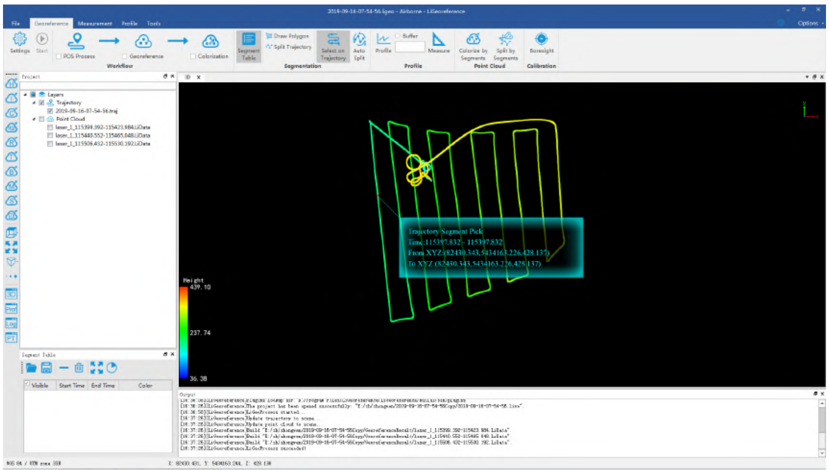
- Click *Split Trajectory*  button to segment the trajectory in the polygon area.



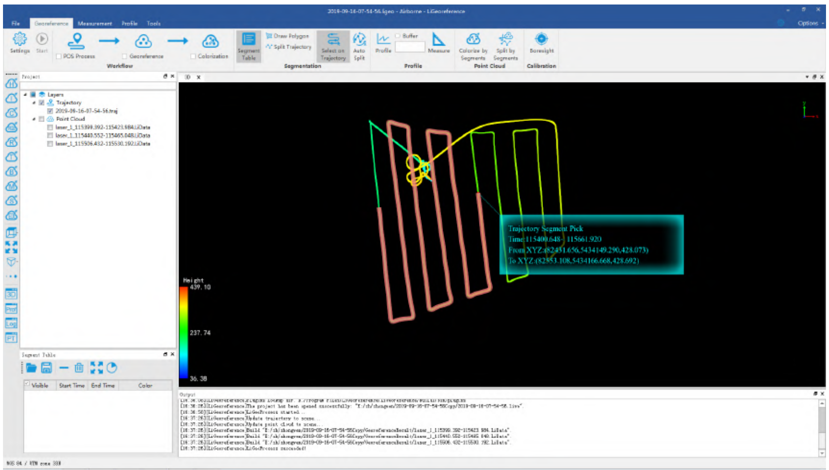
Segment by Click on Trajectory

Steps

- Click the *Select Trajectory*  button in the *Trajectory* tag.
- Click on the processed trajectory in the 3D display window to select the starting point of the segment.



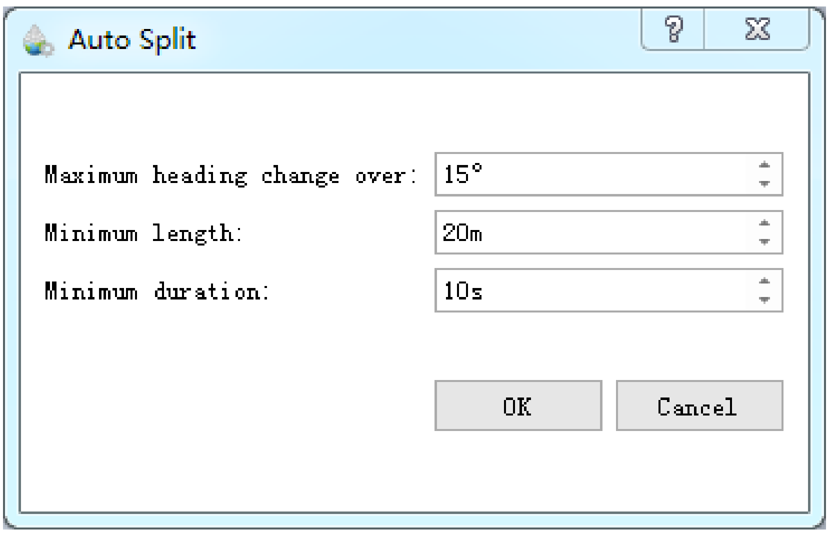
- Select the segment end point along the trajectory, and the segment between the start point and the end point on the trajectory will be divided.



Automatic Segment

Steps

- Click the *Automatic Segment*  button in the *Trajectory* tag, and the parameter settings dialog will pop up.



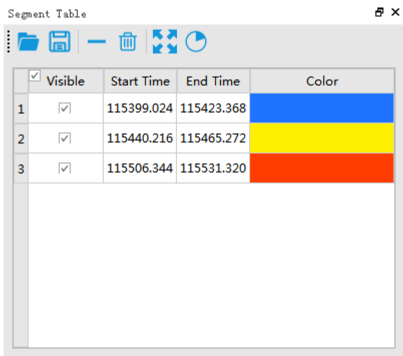
- Set the parameters and click *OK* to start automatic segment.

Settings

- **Maximum Heading Change**: The change in heading angle of the trajectory automatically segmented will not exceed the set value
- **Minimum Length**: The length of the trajectory automatically segmented is not less than the set value
- **Minimum Duration**: The duration of the trajectory automatically segmented is not less than the set value

Segment Table

Click the *Segment Table* button in the *Trajectory* tag, and the segment result table will pop up at the lower left corner of the software. In the table, it records the detailed information of the trajectory segments divided in the above method (including the visibility of the trajectory segments, start and end time, color). Click the corresponding button in the toolbar above the table to realize the functions of opening, saving, deleting, clearing, and hiding unsegmented areas.



Save

Click the *Save* button, the save dialog will pop up and the trajectory will be saved to the specified path, and the file format is xml.

Open

Click the *Open* button, and the open dialog will pop up. The file to be opened should be in xml format.

Delete

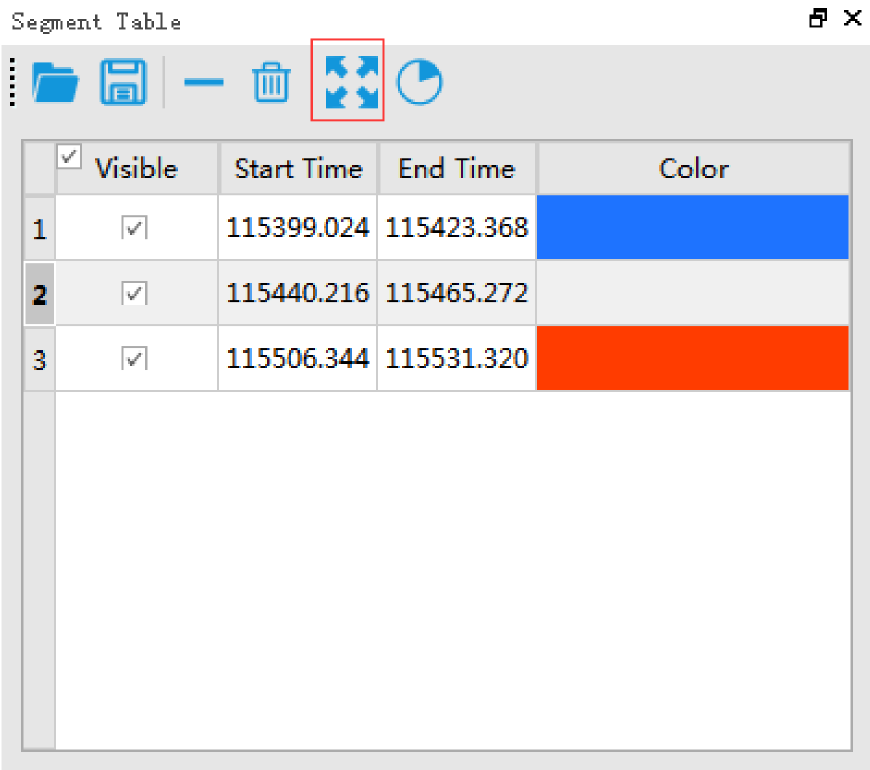
Click the *Delete* button, and the selected trajectory segment will be deleted.

Clear

Click the *Clear* button to delete all the trajectory segments in the table.

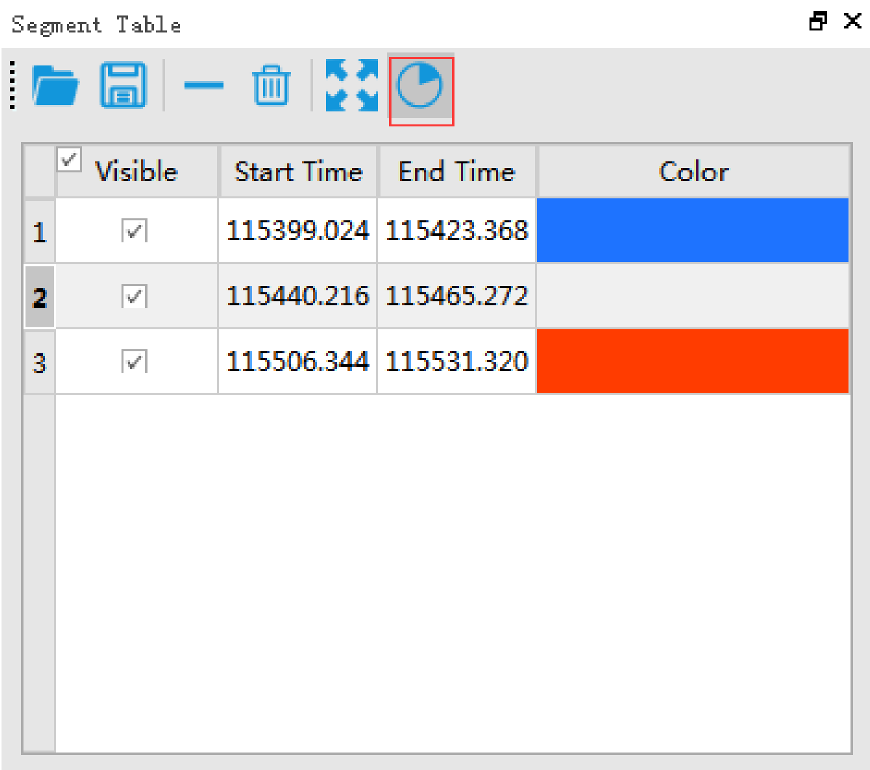
Extend

First select the row with the trajectory segment, and then click the *Display by Segment Range* button, and then the 3D window will zoom to the currently selected segment.



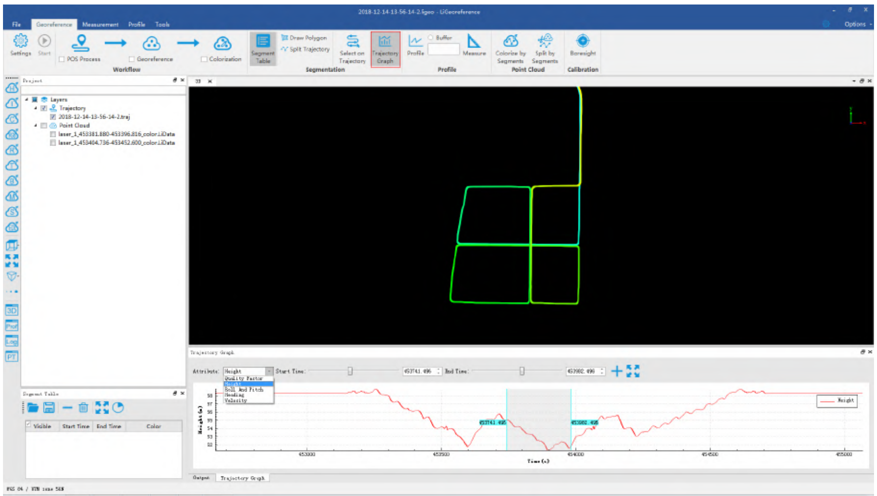
Hide

Click the *Hide Rest Part*  button, and the unsegmented trajectory will be hidden, that is, only the segments and their related point cloud will be displayed in the 3D window.



Trajectory Graph

Click the *Trajectory Graph* button in the *Trajectory Segment* tag. A graph will be displayed at the bottom of the user interface to display the trajectory map, and the trajectory map displays the trajectory segmentation information at each time. Through the trajectory graph menu bar, users can adjust the display properties, add trajectory segments, and change the trajectory display range.



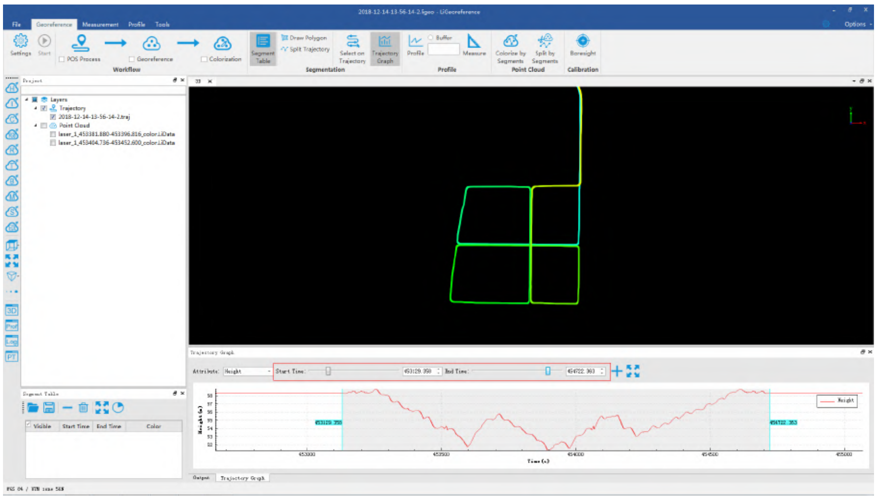
Adjust Display Properties

Click the *Properties* tag to adjust the information displayed in the segment status diagram. Users can choose to display by altitude, by quality factor, by roll angle and pitch angle, by azimuth angle and by speed.

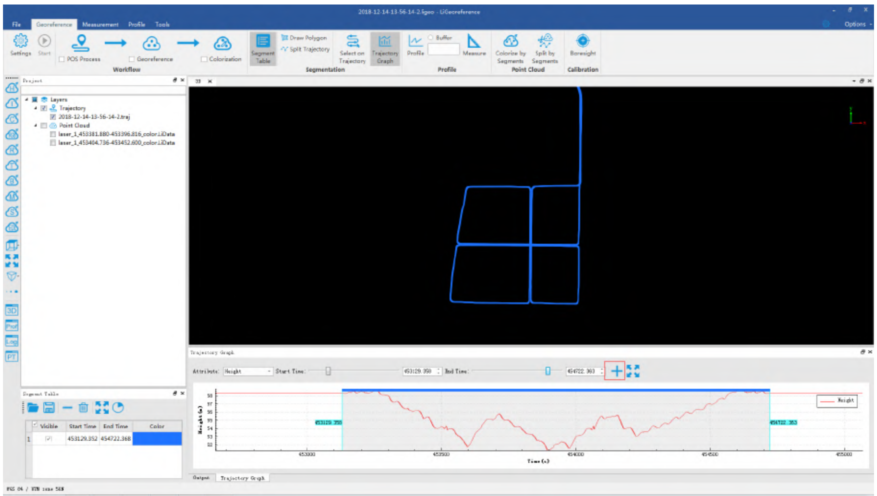
Add Segments

First click the scroll bar after *start time* to select the start time of the trajectory segment, then click the scroll bar after *end time* to select the end time of the trajectory segment, and finally click the *add segment* button to finish the adding of the new segment.

Select the starting and ending time:



Add trajectory segment:

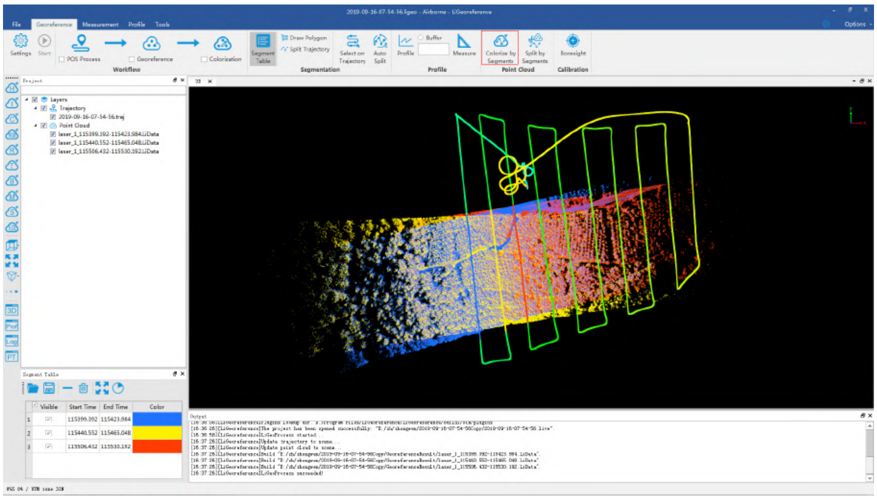


Change Trajectory Display Range

The trajectory graph displays trajectory segmentation information at all times by default. Use the mouse wheel to slide up and down on the track graph to zoom in and out the trajectory graph display range. Click the *Full Range*  button to restore the default display.

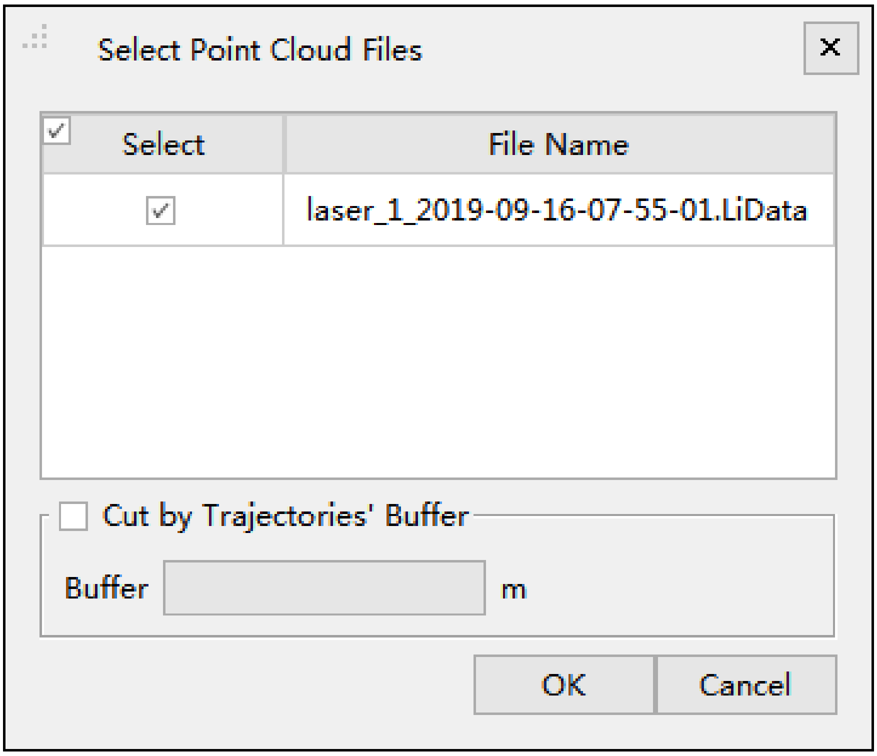
Colorize by Segments

Click the *Colorize by Segments* button in the *Point Cloud* tag . The point cloud in the display window will be colored according to the segment of the trajectory, that is, the point cloud is colored with a specific color according to the segment, and the point cloud without segment is displayed in gray.



Split by Segments

Click the *Split by Segments* button in the *Trajectory* tag. And click the *OK* button in the pop up window to segment the point cloud into different parts according to the range of different trajectory segments. By checking the *Segment by Trajectory Buffer* option and set the *Buffer* value, users can limit the range of segmentation. Click the *Cancel* button to cancel the segmentation process.

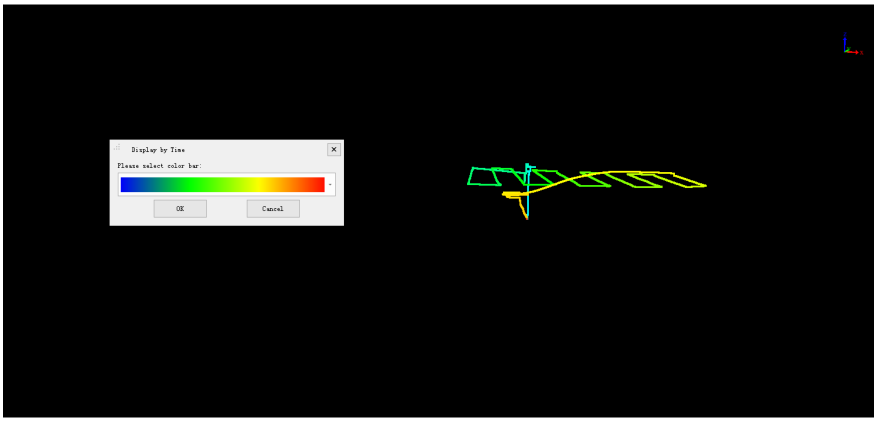


Trajectory Display

The software supports multiple trajectory display methods, as follows:

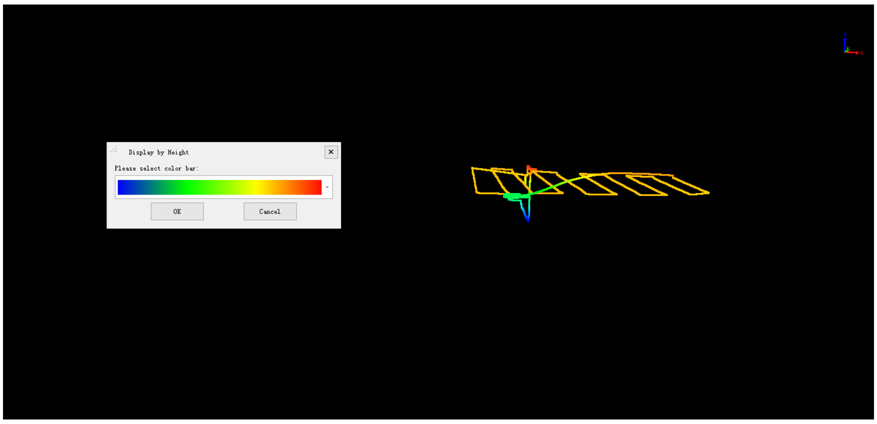
Display by Time (default)

Click the *Display by Time* button in the *Trajectory Display* tag. The trajectory will be displayed by data collection time and the color bar can be selected in the pop up window.



Display by Height

Click the *Display by Height* button in the *Trajectory Display* tag. The trajectory will be displayed by height of the trajectory and the color bar can be selected in the pop up window corresponds to different height level.

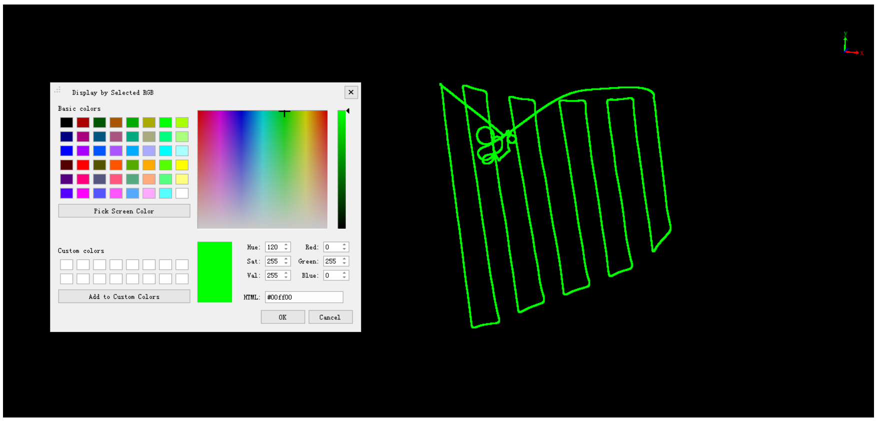


Display by Quality

Click the *Display by Quality* button in the *Trajectory Display* tag. The trajectory will be displayed by quality of the trajectory and the color bar can be selected in the pop up window corresponds to different quality level.

Display by Selected RGB

Click the *Display by Selected RGB* button in the *Trajectory Display* tag. The trajectory will be displayed by specified color and the color can be selected in the pop up window.

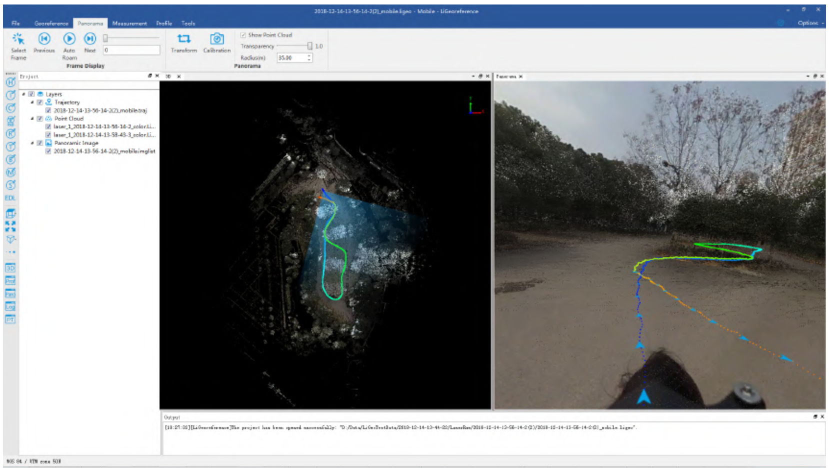


Point cloud and panorama roaming (only support mobile platform)

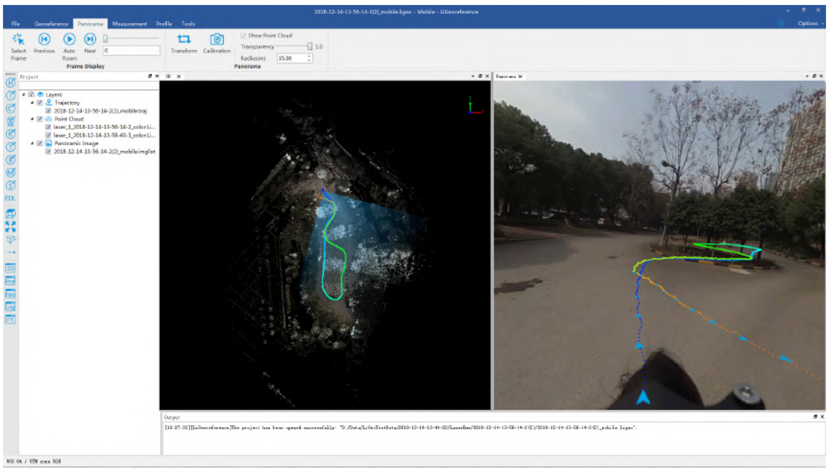
After georeferencing process is done, the software supports point cloud and panorama roaming. Camera file is necessary for panorama roaming. See Configure camera raw data for detailed information.

Panorama roaming operations:

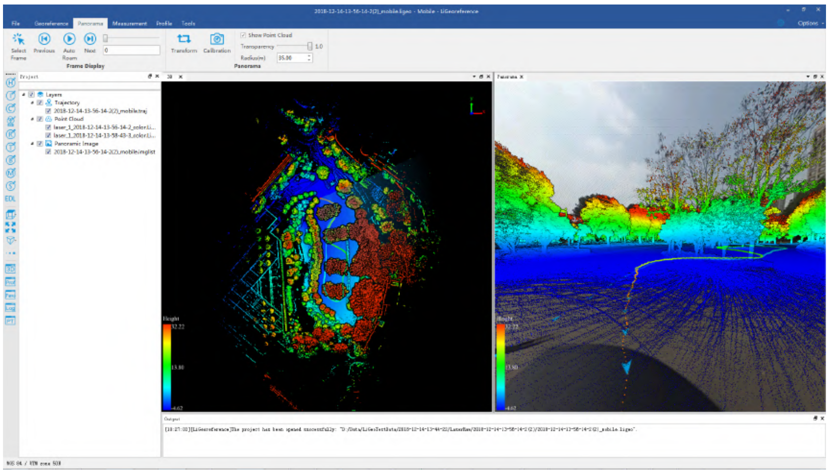
1. Create a new project and georeference, or open a project.
2. When georeferencing is done, a 3D viewer and panorama viewer will open, where point cloud data is shown in both window, while panorama image is shown in panorama viewer. Users can choose to show or hide the corresponding data through the check box in front of the data name in the project management window.



3. Uncheck ☐ Show Point Cloud to only show panorama image in panorama viewer.

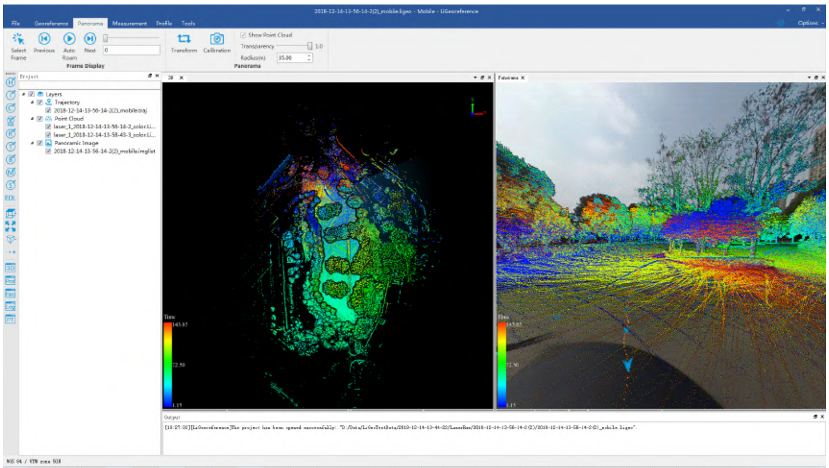


4. Click the color bar tool on the left side window to change display methods, including by height, intensity, class, RGB, return numbers, time, mix etc. EDL can be used in conjunction with other display methods, to enhance outline feature information of point cloud features. For example:

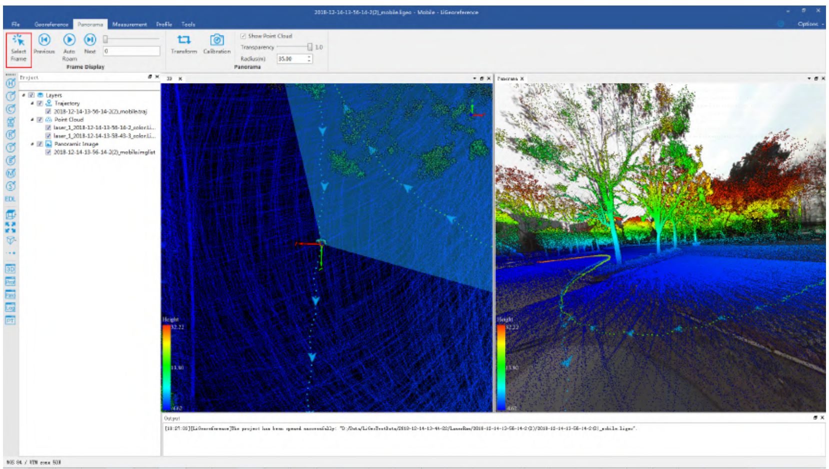


> Note: The display methods in toolbar apply to all data. If users only want to apply display method to a certain data, right click the data and change it.

5. Right click on the trajectory file name to switch the display method of the trajectory file. The following figure shows the effect displayed by time.



6. Click *Select frame* at *Panorama* page, select image exposure location in 3D or panorama viewer(blue triangle arrow, turning into orange by default) and switch to the selection position.



7. Click *Previous* or *Next* to switch to previous or next frame.

8. Drag the bar 

to switch frame number.

9. Click *Auto roam*  In the panoramic window, roam the point cloud and image from your perspective. Click the button again to stop the automatic roaming. If the perspective of the panoramic window changes, you can click the space bar on the keyboard to restore the default direction.

Point Cloud Process

The point cloud process functions supported in the software include:

Cut Overlap

Colorize Point Cloud

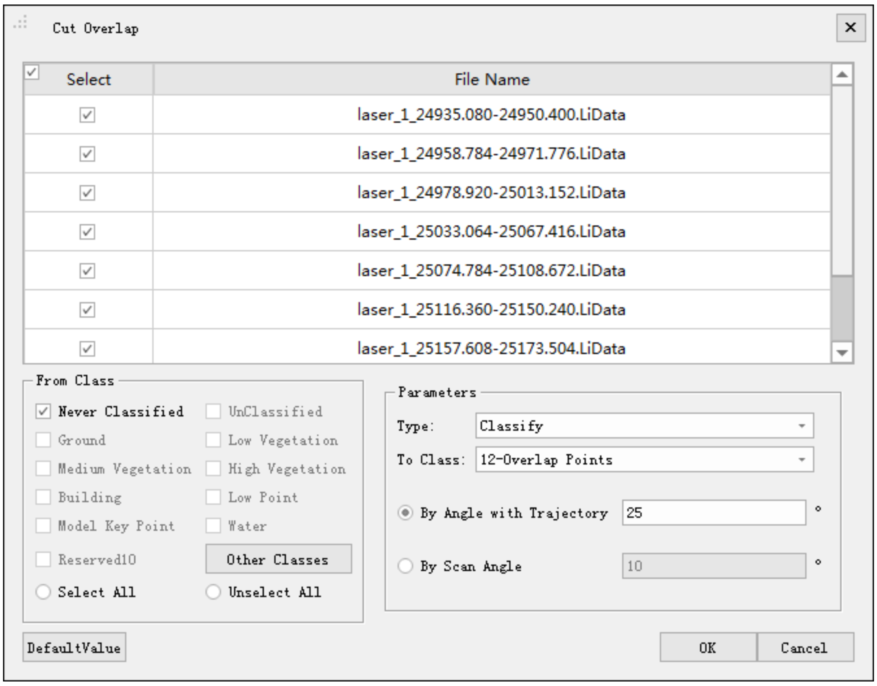
Transformation

Precision Check

Remove Outliers

Cut Overlap

Cut Overlap: Click this button, and the following interface will pop up. Set the cut overlap parameters, and click "OK" button to cup the overlap points in the overlap areas of different strips by classifying or deleting the points.



Settings

Cut overlap interface Parameters:

- **Type**:
  - **Classify**: Classify the overlap points to the target class and keep the points in the original point cloud file;
  - **Delete**: Classify the overlap points to the target class and delete the points from the point cloud file (Note: if there already have been points in the target class, they will be deleted at the same time as well).
- **To Class**: The target class of classifying.
- **By Angle with Trajectory**: The angle between the point and the trajectory. If the angle between the point and the trajectory is larger than the input value, that point will be classified as an overlap point. Note: This function can only be used when there is a trajectory file and the point cloud can be matched with the trajectory by GPS time.
- **By Scan Angle**: If the scanning angle of the point is larger than the input value, that point will be classified as an overlap point. Note: This function can only be used when the scanning angle is stored as an attribute of the point cloud.

> Note:
> To use the cut overlap function, there should be at least two point cloud files loaded in the software.

Colorize Point Cloud

Summary

Users can choose a colorization method from two based on their needs to colorize the point cloud data.

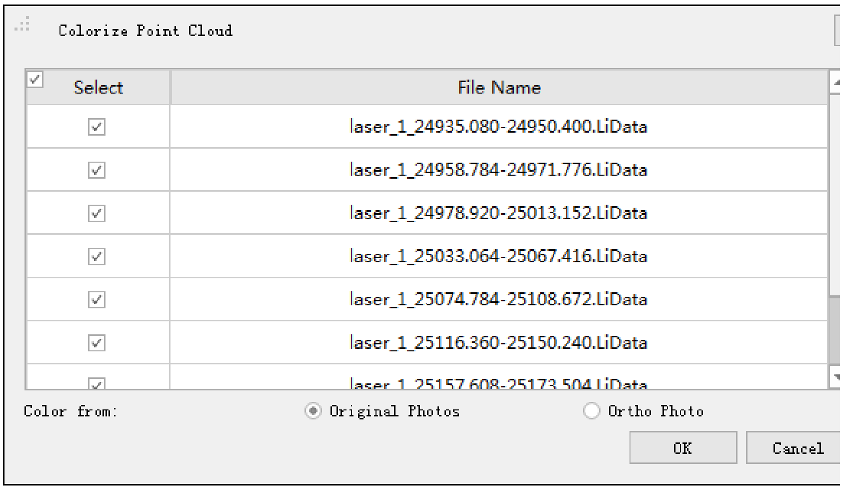
Two color information resources include:

- Original Photo
- Ortho Photo

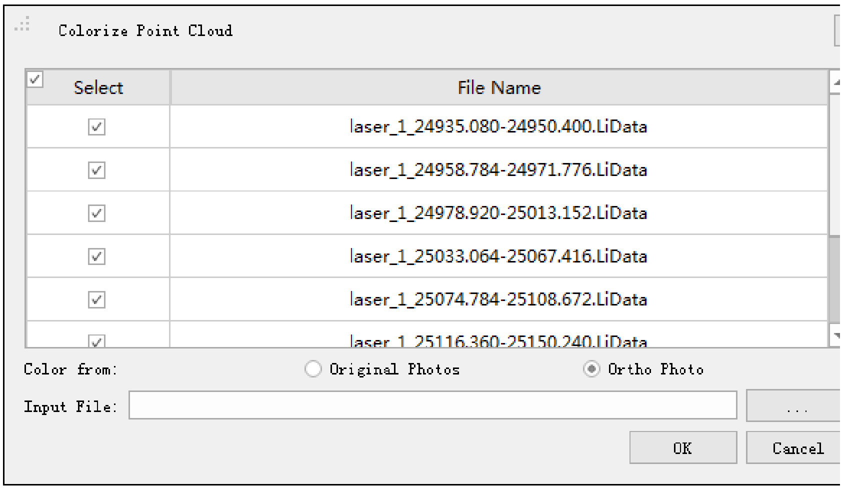
Usage

Click the button, and the dialog will pop up.

Original Photo: Use the original images in the project folder to colorize the point cloud data.



Ortho Photo: Map the RGB information in the multi-band image data to the color attribute of the point cloud data. Users are required to input multi-band image data that has an intersection with the point cloud data range.



Settings

- **Original Point Cloud Data**: Select one or more point cloud files. The point cloud should be in LiData format.
- **Input File**: Users need to input the multi-band image data at the same geographic location as the point cloud data. The image data should be in tif format.

Transformation

Summary

The users can select a conversion type to perform point cloud data conversion as required.

Four coordinate transformation methods are supported:

- **Linear Transformation**
- **XY Multiply**
- **Translation and Rotation**
- **3D Affine Transformation**

Steps

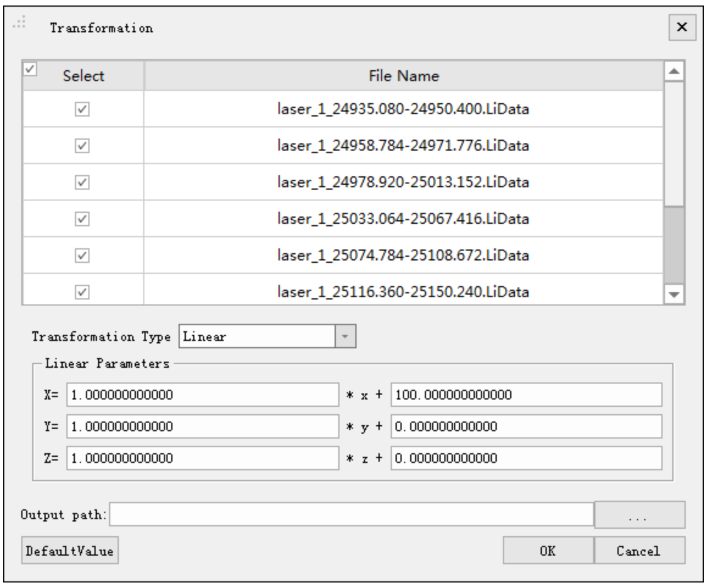
1. **Input Point Cloud Data**: Input one or more point cloud data. The data should be in LiData format.
2. Choose **Transformation**. Select the transformation methods in the dropdown menu and set the relevant parameters.
3. **Output Path**: The output path for the result. After the execution of this function, a new transformed point cloud file will be generated in this path.

Usage

Click the  button and the dialog will pop up.

Settings

Linear Transformation

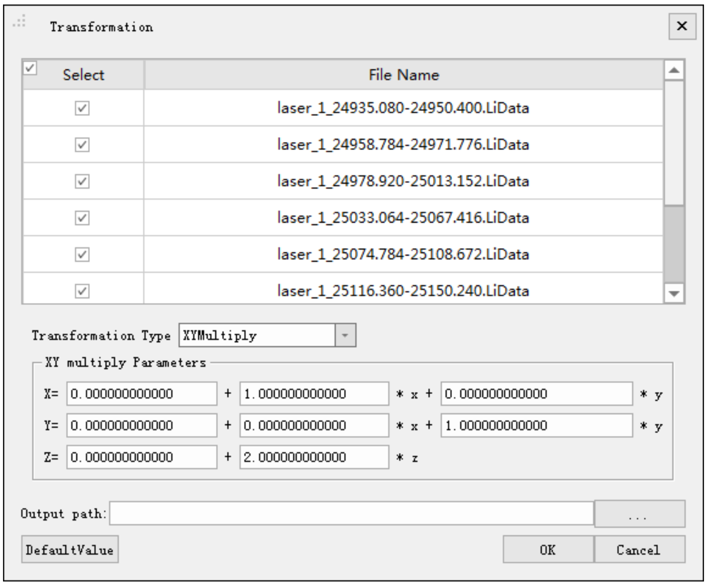


The linear transformation is used to translate and scale the point cloud data. The users can enter a set of translation and zoom parameters for the X, Y, and Z coordinates, respectively. The target coordinates are calculated with the following formula:

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

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

XYMultiply

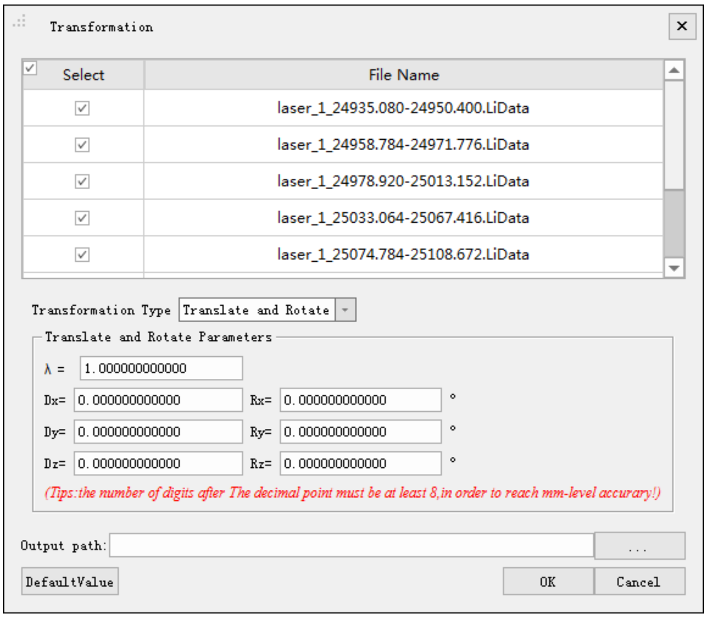


The target coordinates are calculated using the following formula:

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

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

Translation and Rotation



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 = 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)

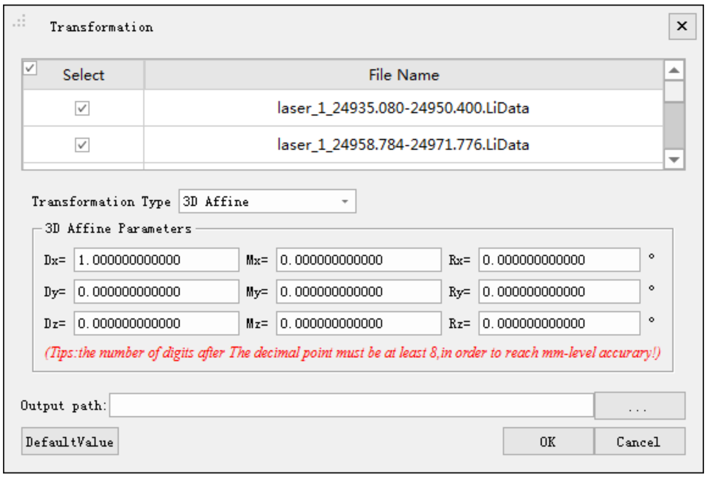
R23 = cos(Rx) *sin(Ry)* sin(Rz) - sin(Rx) * cos(Rz)

R33 = cos(Rx)* cos(Ry)

- **λ (default is "0")**: scale factor applied to X, Y, Z.
- **Dx, Dy, Dz (default is "0")**: value added to X, Y, Z (translation amount).
- **Rx, Ry, Rz (default is "0")**: The angle of rotation around X, Y, Z axis, expressed in degrees.

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

3D Affine Transformation



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 is "0")**: value added to X, Y, Z (translation amount).
- **Mx, My, Mz (default is "0")**: scale factor applied to the X, Y, and Z axes.
- **Rx, Ry, Rz (default is "0")**: The angle of rotation around X, Y, Z axis, expressed in degrees.

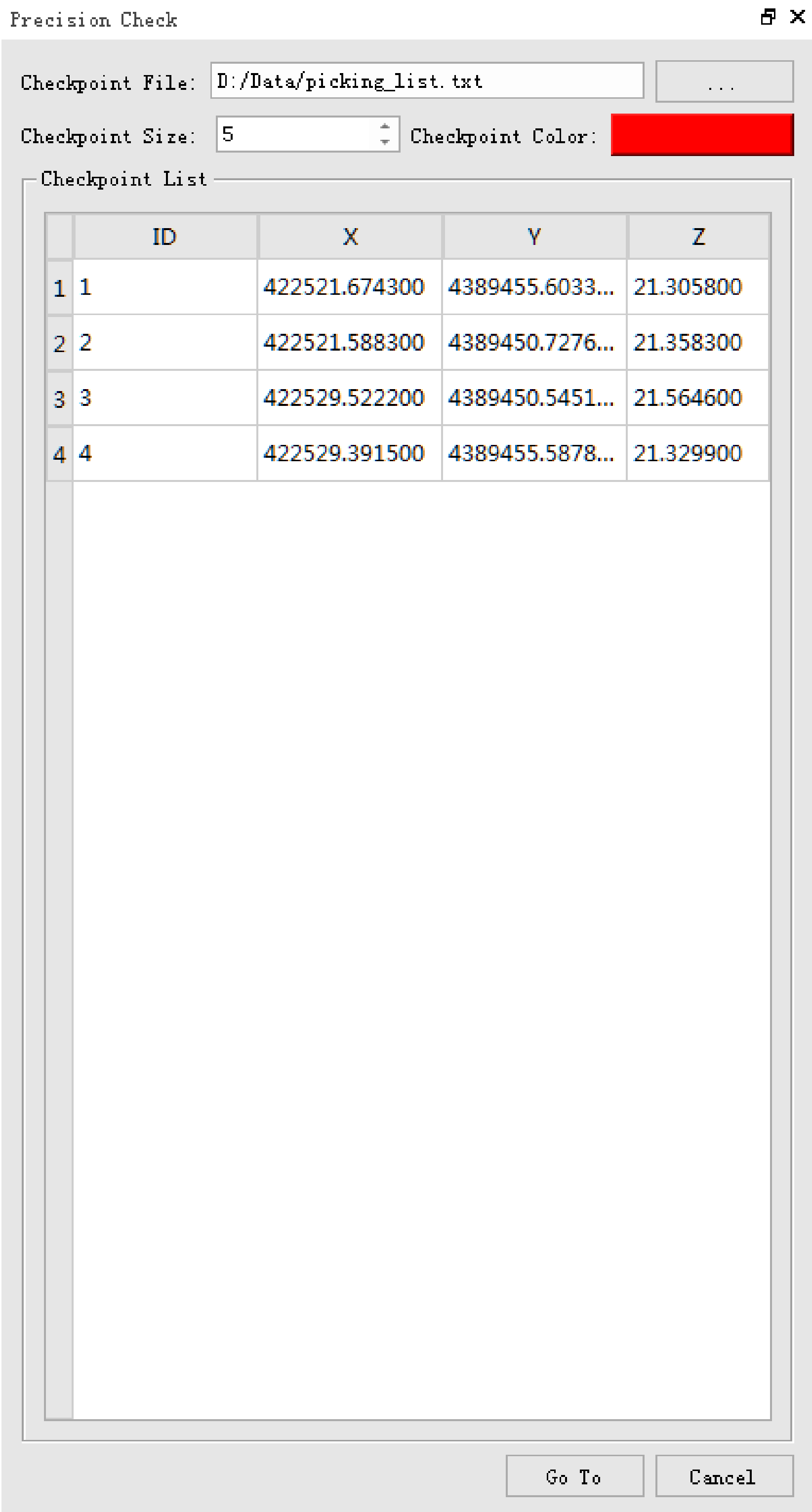
> Note: To achieve accuracy in millimeter level, at least eight decimal places should be retained after the decimal point.

Precision Check

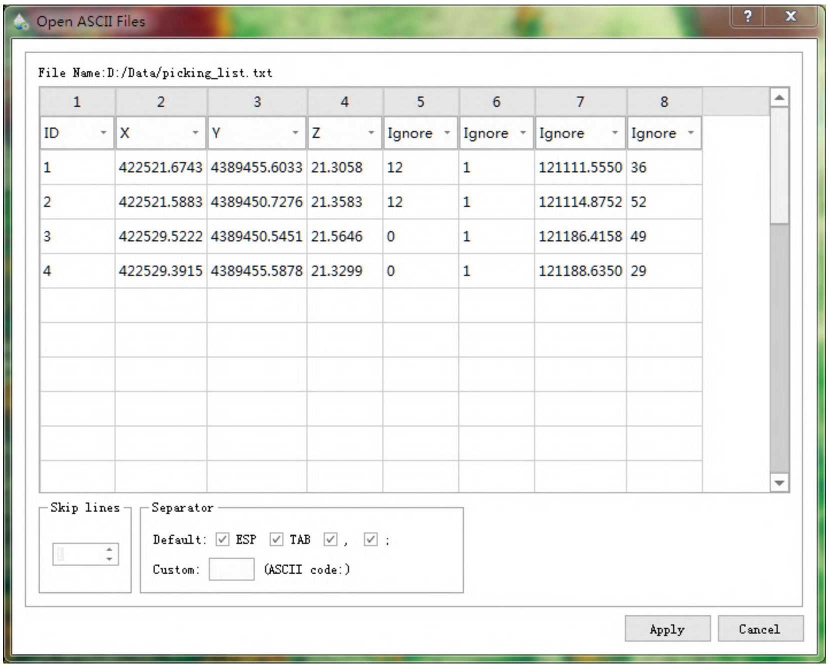
Click the *Precision Check* button in the *Tools* tag. The Precision Check interface will pop up on the right side of the software interface. This function is used to check the accuracy of point cloud data based on external checkpoints.

Step

1. Click the "Precision Check" button, and the interface of this function will pop up, as shown below:



2. Click the "Browse" button and the "Open file" dialog will pop up. Select the checkpoint file need to be loaded and click the "Go To" button, as shown below:



3. The "Open ASCII file" dialog box pops up. Select the X, Y, Z data column (required) and the ID column (optional), as well as the number of jumps and separators for the opened file, and click the "Apply" button.
4. The "Checkpoint List" table displays all checkpoint information, and the the point numbers and positions of all checkpoints are displayed in the 3D window. Double-click a row of the table or select a row of the table and click the "Jump" button, the point of view will jump to the selected checkpoint.
5. Modify the "Checkpoint Size" and "Checkpoint Color" to change the checkpoint size and color displayed in the window.

Settings

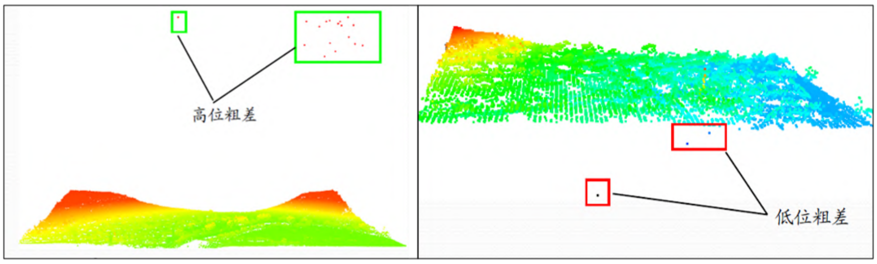
- **Checkpoint Size**(The default value is "5"): Adjust the point size of the checkpoint in the scene.
- **Checkpoint Color**: Adjust the color of the checkpoints in the scene.

> Note: This function can be used in conjunction with the profile tool.

Remove Outliers

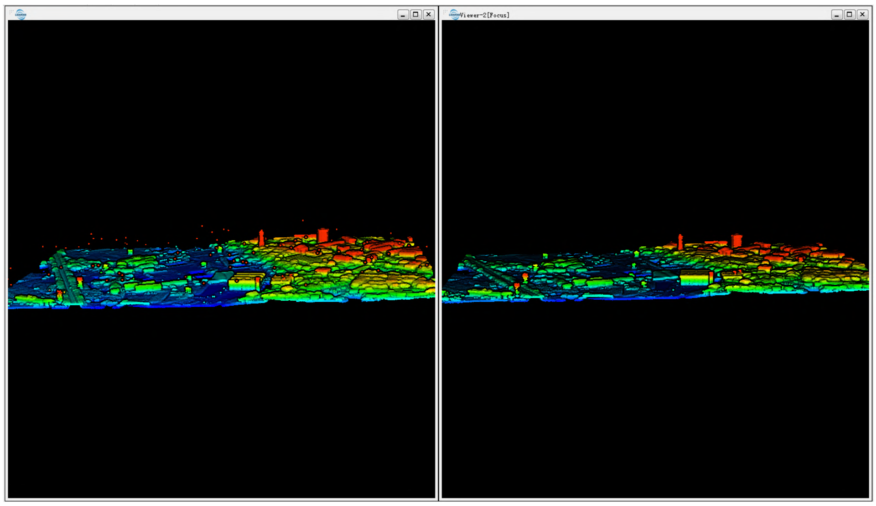
Summary

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



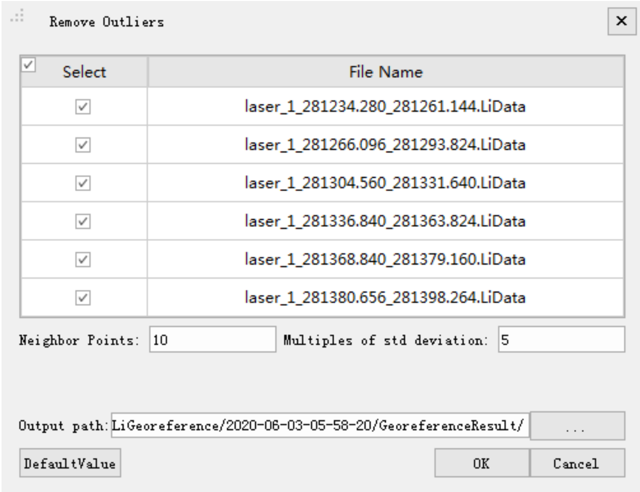
The algorithm will first search for each point's neighboring points within a user-defined area and calculate the average distance from the point to its neighboring points. Then, the mean and standard deviation of these average distances for all points are calculated. If the average distance of a point 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 button and the interface shows below：



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.
- **Output path**: Path of the output file. After the function being executed, a new file will be generated. When more than one files are entered, the path needs to be set to a folder.

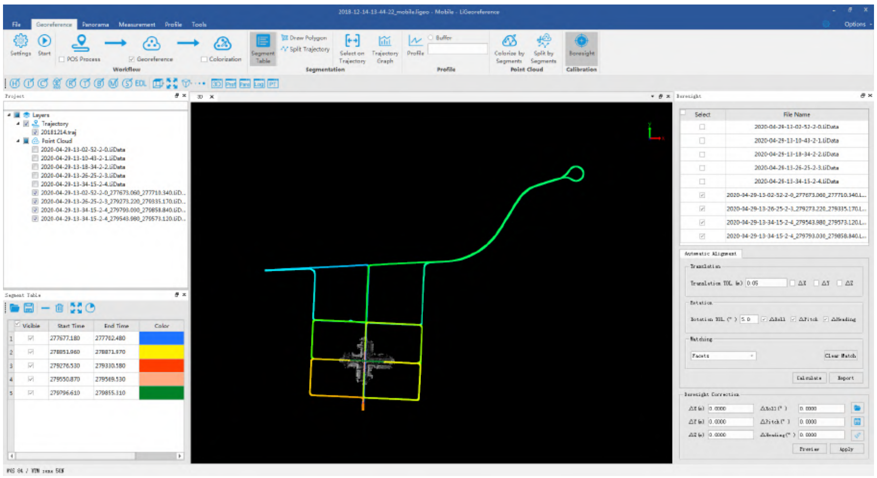
> Note: The algorithm of this function can be performed repeatedly to improve the denoising results. The outlier removal results is limited if the noises are to dense.

Calibration

- Laser Calibration
- Panoramic Camera Calibration

Laser Calibration

Click the *Boresight* button in *Calibration*, the boresight interface will pop up on the right side. This function is mainly used to correct the boresight error of the laser. The point cloud data will be converted accordingly according to the correction value. To obtain high-quality point cloud data, the selection of laser boresight error correction values is particularly important. This software provides two methods of automatic boresight error correction and manual boresight error correction.



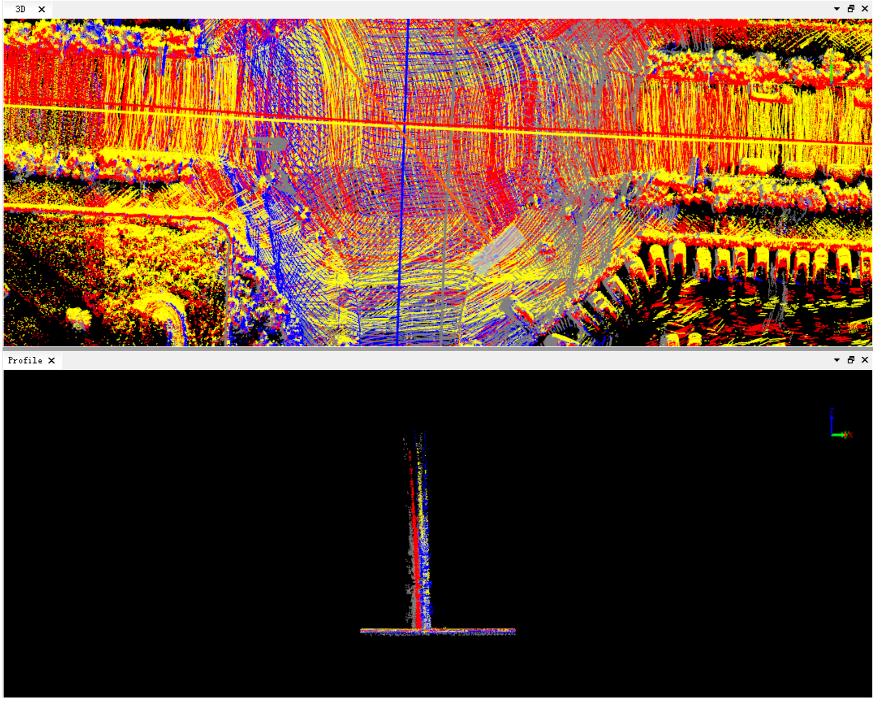
automatic boresight error correction:

Check the boresight error to be calculated on the boresight interface, and enter translation tolerance and rotation tolerance And after matching method, click Calculate and the software will automatically calculate the boresight error and display the result in the boresight error correction parameter box.

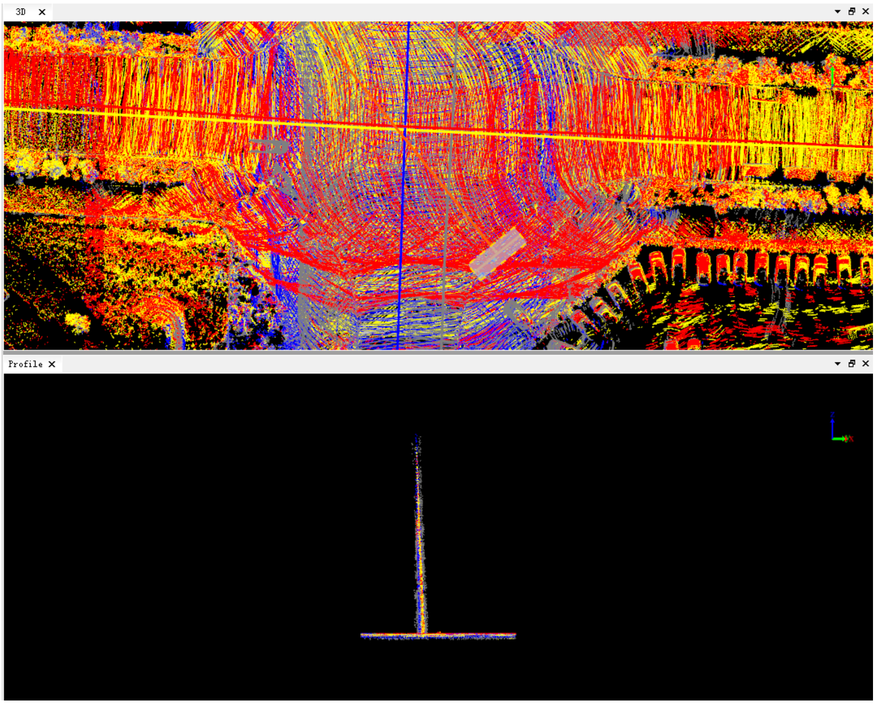
After calculating the boresight error in the automatic boresight error correction mode, the software will calculate the alignment quality and generate an HTML report. Click the report to open the generated HTML report. Please refer to Automatic calculation of boresight error for the relevant principles of automatic boresight error correction.

Manual boresight error correction:

Users can also input the boresight error correction parameters by themselves. For manual calculation of boresight error, please refer to manual calculation of boresight error. Click the "Preview" button, the error correction value will be temporarily applied to the selected point cloud, but the point cloud file on the disk is not modified. If the preview effect is good, you can click the "Apply" button to apply the error correction value to the point cloud file on the disk. No matter it is automatic mode or manual mode, in the process of correction, you can use the profile tool to view the correction results, as shown in the picture.

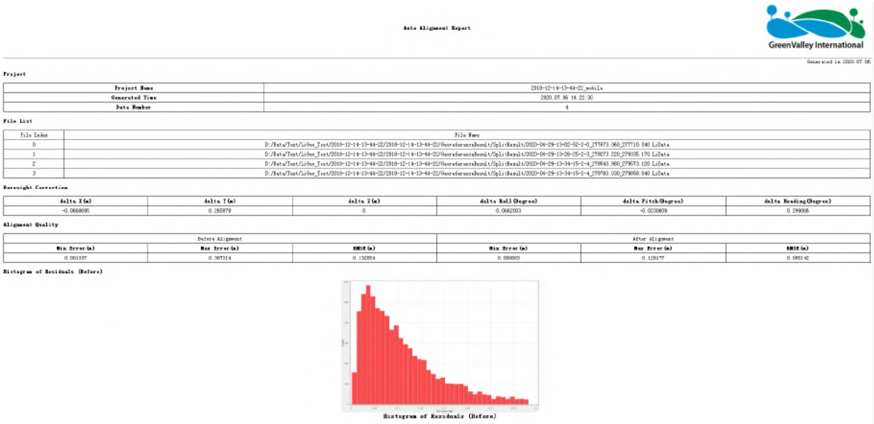


Before modification



After modification

Click the "Report" button to view the boresight error correction quality report, as shown in the picture.



Auto Alignment Report

Generated in 2020.07.06

Project

Project Name	2018-12-14-13-44-22_mobile
Generated Time	2020.07.06 14:22:30
Data Number	4

File List

File Index	File Name
0	D:/Data/Test/LiGeo_Test/2018-12-14-13-44-22/2018-12-14-13-44-22/GeoreferenceResult/SplitResult/2020-04-29-13-02-52-2-0_277673.060_277710.340.LiData
1	D:/Data/Test/LiGeo_Test/2018-12-14-13-44-22/2018-12-14-13-44-22/GeoreferenceResult/SplitResult/2020-04-29-13-26-25-2-3_278273.220_279335.170.LiData
2	D:/Data/Test/LiGeo_Test/2018-12-14-13-44-22/2018-12-14-13-44-22/GeoreferenceResult/SplitResult/2020-04-29-13-34-15-2-4_278543.980_279573.120.LiData
3	D:/Data/Test/LiGeo_Test/2018-12-14-13-44-22/2018-12-14-13-44-22/GeoreferenceResult/SplitResult/2020-04-29-13-34-15-2-4_279793.030_279858.840.LiData

Boresight Correction

delta X (m)	delta Y (m)	delta Z (m)	delta Roll (Degree)	delta Pitch (Degree)	delta Heading (Degree)
-0.0668695	0.265879	0	0.0662003	-0.0230609	0.299066

Alignment Quality

Before Alignment			After Alignment		
Min Error (m)	Max Error (m)	RMSE (m)	Min Error (m)	Max Error (m)	RMSE (m)
0.001337	0.387314	0.132854	0.000603	0.128177	0.085142

Histogram of Residuals (Before)

Histogram of Residuals (Before)

Click the "Clear" button to delete the matching information and calculate again after changing the relevant parameters.

You can load the error correction file in sequence through the three buttons on the right, save the current parameters as an error correction file, or clear the currently set correction value.

Parameter settings

- **boresight error calibration**
  - **ΔX/ΔY/ΔZ**: boresight offsets error calibration values.
  - **ΔRoll/ΔPitch/ΔHeading**: boresight atitudes error calibration values.
- **Automatic alignment**: The software automatically matches the relevant points of the segmented point cloud, and calculates the optimal correction value of the boresight error through adjustment.
  - **Translation tolerance**: The adjustment range of the maximum translation amount corresponds to ΔX, ΔY, ΔZ, and the program default setting is 0.05 meters.
  - **Rotation tolerance**: The maximum rotation adjustment range corresponds to ΔRoll, ΔPitch, ΔHeading, and the program default setting is 5°.
  - **Optional**: You can freely decide whether the three translation amounts and three rotation amounts participate in the adjustment and calculate the correction value. It is not recommended to modify ΔZ when processing aerial look-down data. By default, all rotations are checked, and all translations are not checked. Use the default value to get better results.
  - **Match**: You can select two matching methods: patch matching and sampling point matching.
    - **patch**: Evenly extract high-order patch groups in the overlapping areas of the data to be matched (compare robustness on data with this feature)。
    - **sampling point**: Sampling points are extracted by analyzing the significance on the data to be matched, and then matching is performed based on the sampling points and their normal vectors.

Boresight Error Calculation

The boresight error between **laser scanning reference coordinate system** and **inertial navigation platform reference coordinate system** is the largest system error source in airborne lidar. The impact of these errors on the coordinates of the ground laser point also depends on the flying height and the scanning angle.

LiGeo provides two methods to calibrate the errors:

1. Manual measurement and calibration
2. Automatic adjustment correction

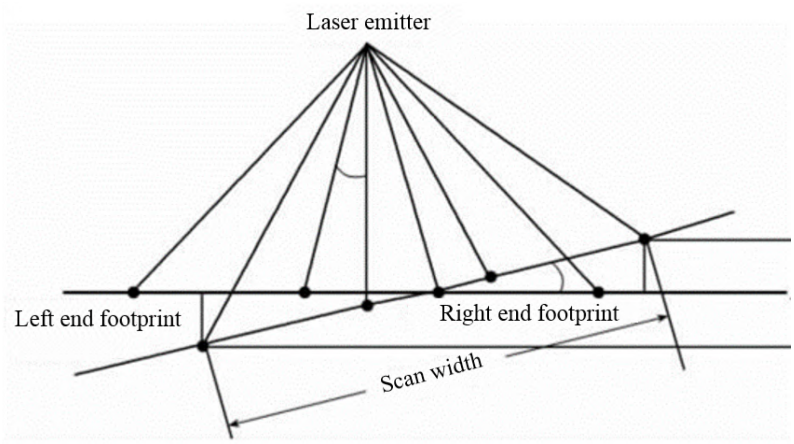
The principles are explained in detail below.

Manual measurement and calibration

First, you need to prepare the calibration data, usually flying in four directions that are perpendicular to each other. After the flight, the ground feature points (such as playgrounds, regular houses, etc.) are measured. Based on the overlapping laser foot data, *geometry step method* can be used.(Zhang et al. , 2010)
The restored value of the installation angle error (ie, the amount of rotation) is calculated. The boresight offset error (that is, translation amount) has little effect, and manual measurement and calibration will not correct it.

Estimated roll angle error (ΔRoll)

The roll angle error will cause the plane scan line to tilt (as shown below), and will cause the plane position of the scanned object to shift along the scan direction (perpendicular to the flight direction).



In the two flight strip data for round-trip flight at the same flight altitude,

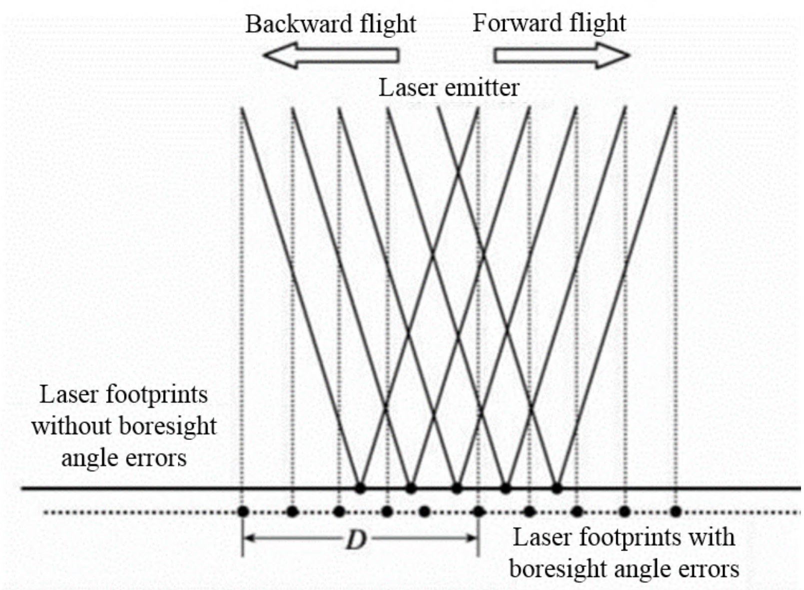
- Draw the profile perpendicular to the flight direction and measure the height difference of the ground features with the same name Δh.
- Measure the horizontal distance r of the feature with the same name and the centerline of the two zoning strips in the 2D view.

Then the estimated roll angle error can be calculated as:

$$\Delta Roll \approx arctan\left(\frac{\Delta h}{2r}\right)$$

Estimated pitch angle error（ΔPitch）

In the line scanning mode, the positioning error of the pitch direction mainly causes the true position of the scanned object to deviate along the direction perpendicular to the scanning line. The following shows the schematic diagram of the effect of pitching positioning error on the scanning laser foot.



In the two flight strip data of the round-trip flight:

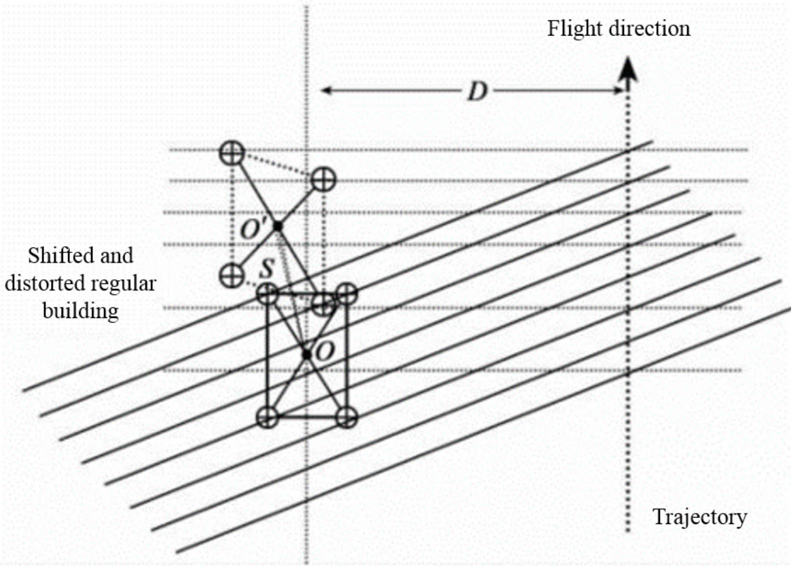
- Draw the profile parallel to the flight direction and measure the distance difference D of the center position of the same feature along the flight direction.
- Calculate the average flight height H according to the trajectory (flight height should be as consistent as possible).

Then the estimated pitch angle error can be calculated as:

$$\Delta Pitch \approx arctan\left(\frac{D}{2H}\right)$$

Estimated heading angle error（ΔPitch）

The heading angle setting error will change the center position of the scanned object and deform the object at the same time, as shown in the following figure.



Open the 2D view in the two flight strip data of forward and backward flight.

- Measure the distance S between the average center positions of the laser foot points of the ground features twice.
- Measure the distance D between two flight strips.

Then the estimated pitch angle error can be calculated as:

$$\Delta Heading \approx arctan\left(\frac{S}{D}\right)$$

Automatic adjustment correction

Manual measurement and estimation requires relevant professional knowledge and proficient operation of the software, and automatic calculation can greatly reduce the workload of the operator. In the data with obvious features, automatic calculation can completely replace manual calculation to achieve the same or even higher accuracy.

The automatic algorithm can not only correct the installation angle error (that is, the amount of rotation), but also correct the installation offset error (that is, the amount of translation). You can freely select the value that needs to be corrected. It is recommended to correct only the installation angle error, because they have the greatest influence. The principle of the algorithm is as follows:

1. Extract the **feature points** and normal vectors in the adjacent flight strips, refer to the algorithm (Glira et al., 2015)
2. Match the feature points extracted from adjacent flight belts to obtain **relevant point pairs**.
3. Establish a correction model of boresight error and calculate the distance of relevant point pairs **along the normal vector**
4. The least square method is used to minimize the relevant distance **, and at the same time obtain the optimal solution of the correction value.

```
@inproceedings{
    author={Zhang Xiaohong, Forsberg Rene},
    title={Retrieval of Airborne Lidar Misalignments Based on the Stepwise Geometr
    booktitle={Survey Review 42(316):176-192 April 2010},
    year={2010},
}
```

```
@inproceedings{
    author={Philipp Glira, Norbert Pfeifer, Christan Briese and Camillo Ressl},
    title={A Correspondence Framework for ALS Strip Adjustments based on Variants
    booktitle={PFG Photogrammetrie, Fernerkundung, Geoinformation Jahrgang 2015 He
    year={2015},
}
```

Panoramic Camera Calibration

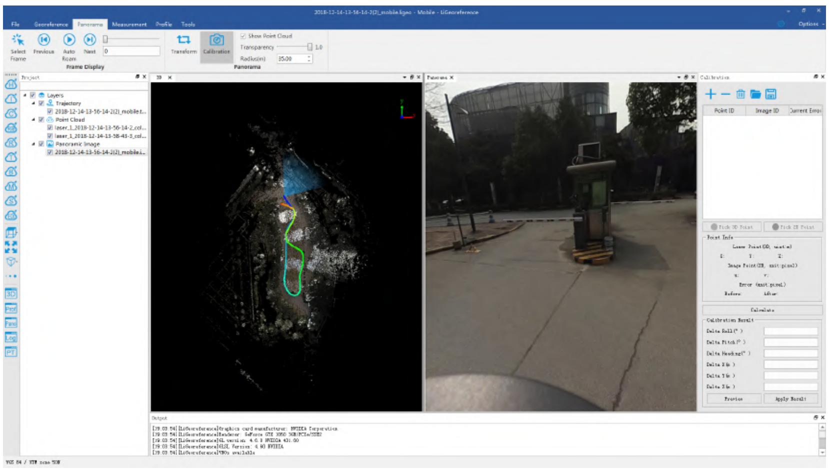
After completing High-performance point cloud georeference, due to the placement error between the panoramic camera and the laser, there is still a certain deviation between the panoramic image and the point cloud data, which cannot be perfectly overlapped, as shown below.

LiGeoreference provides a panoramic calibration module to estimate the placement error between the panoramic camera and the laser, thereby improving data deviation and accuracy.

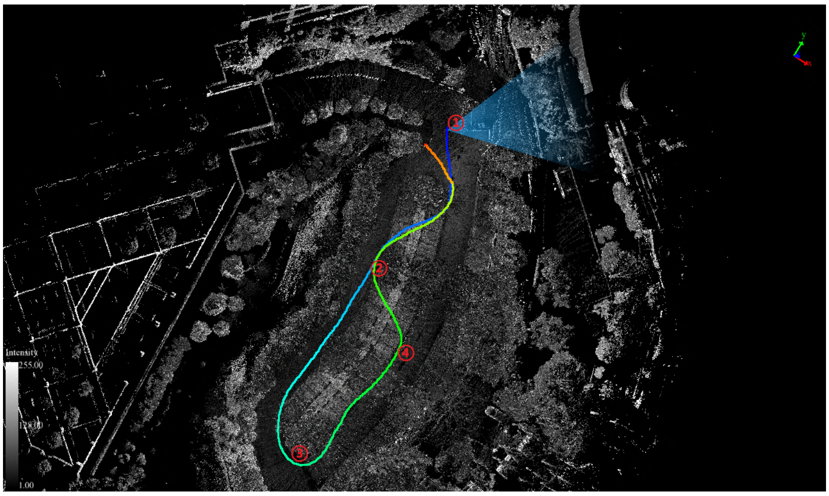
> Note: Set the display depth of the point cloud by adjusting the menu bar **Panorama**->**Radius**, so as to hide the point cloud in the distance and facilitate the observation of the area of interest. This trick can also be used in the calibration point selection process below.

Operating procedures

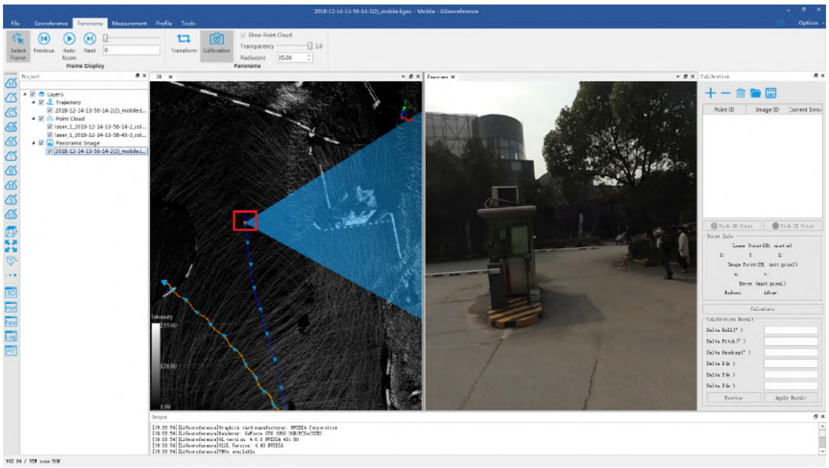
1. Switch to *Panorama* tab, click *calibration*, and a calibration window will pop up on right side.



2. Add calibration points. It is recommended to select the camera exposure point in multiple directions of the scene, and then select multiple point pairs at each exposure point, at least 4 point pairs need to be added (for example, 4 point pairs are selected at four exposure times in southeast, northwest, ie. 16 point pairs in total)



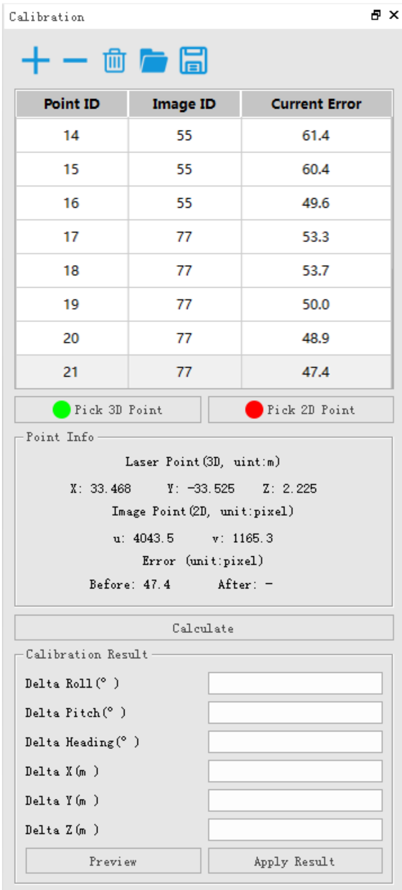
3. Click *Select frame*, and select triangle arrow in 3D viewer. The panorama viewer will automatically switch to corresponding frame.



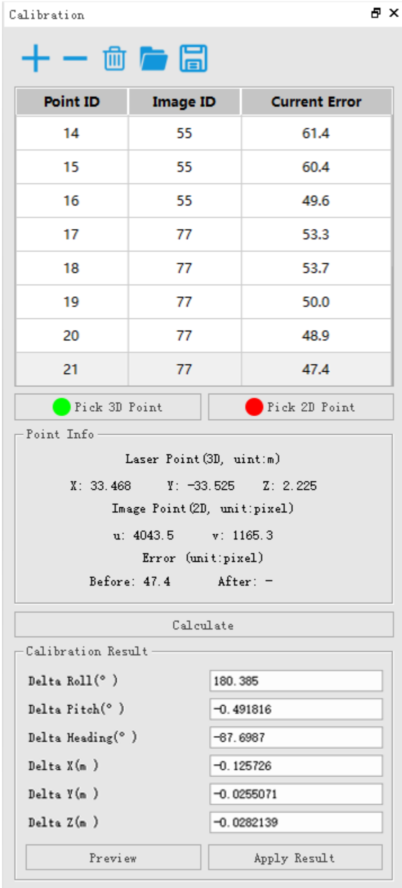
   - Click *Select 2D point* and select image point in panorama viewer. You can use magnifier above to zoom in.

4. Click *Select 3D point* and select corresponding point cloud in panorama viewer.

5. Repeat the above steps until enough point pairs are selected.
6. Select the corresponding image frames in the other three orientations and repeat the above steps until all points are selected.



7. Click *Calculate* to start calibration.



8. Click *Preview* to preview the calibration result. Before calibration:

After calibration:

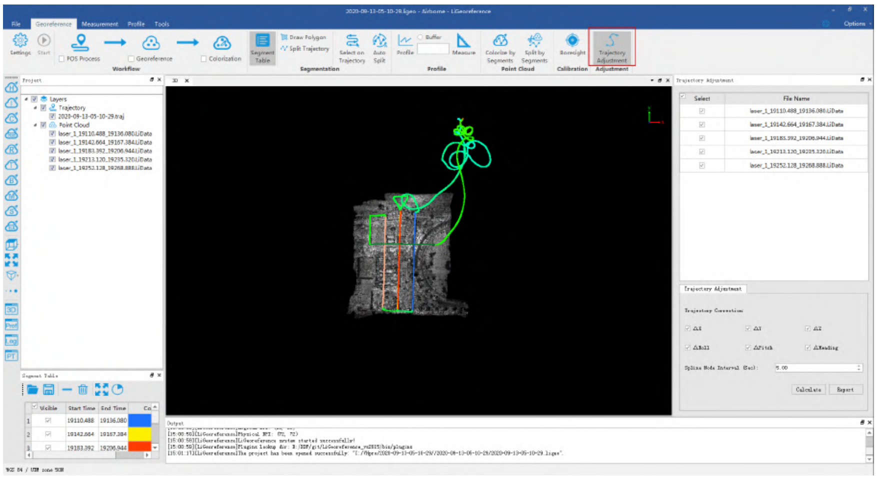
9. Apply the calibration to the data by clicking *Apply* button.

> Note:
>
> 1. There are two ways to control show/hide point cloud data: You can either click *show/hide point cloud* button in the toolbar, or adjust transparancy by draging the bar.
> 2. Generally, display by intensity is recommended for picking points.

Trajectory Adjustment

If point clouds discrepancies are still obvious after point cloud georeference and boresight correction, the misalignment may be caused by trajectory errors. With this tool, trajectories and related point clouds can be post-processed and refined.

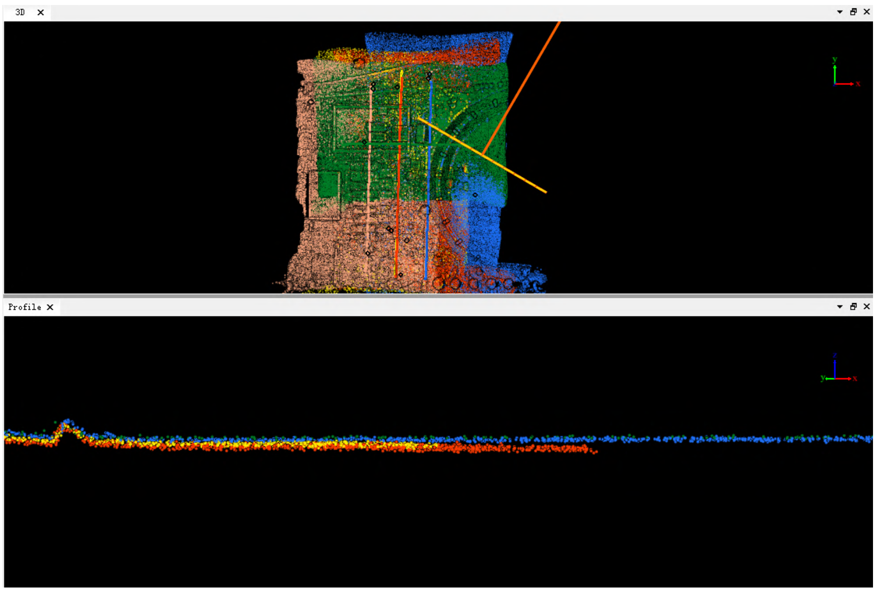
Click the button *Trajectory Adjustment* , the interface will pop up on the right side. This function estimates fluctuating errors of trajectory, then updates point clouds based on correction values.



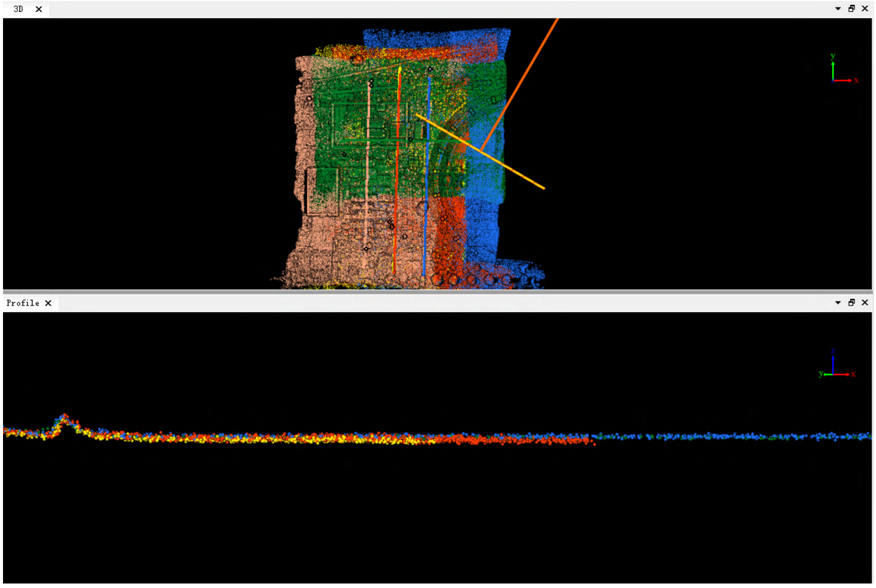
Check trajectory correction components on the interface, set spline node interval for trajectory fluctuation, click Calculate button, then the software runs automatically. Point cloud data will be corrected accordingly.

A quality report in HTML format will be generated after correction. Click Report button to view it.

You can use profile tool to view the correction results, as shown below.



Before correction



After correction

Click the "Report" button to view correction quality, as shown below.

Trajectory Adjustment Report

Generated in 2020.11.19

Project

Generated Time	2020.11.19 11:57:38
Data Number	5

File List

File Index	File Name
0	C:/VHpro/2020-09-13-05-10-29/2020-09-13-05-10-29/GeoreferenceResult/laser_1_19110.488_19136.080.LiData
1	C:/VHpro/2020-09-13-05-10-29/2020-09-13-05-10-29/GeoreferenceResult/laser_1_19142.664_19167.384.LiData
2	C:/VHpro/2020-09-13-05-10-29/2020-09-13-05-10-29/GeoreferenceResult/laser_1_19183.392_19206.944.LiData
3	C:/VHpro/2020-09-13-05-10-29/2020-09-13-05-10-29/GeoreferenceResult/laser_1_19213.120_19235.320.LiData
4	C:/VHpro/2020-09-13-05-10-29/2020-09-13-05-10-29/GeoreferenceResult/laser_1_19252.128_19268.888.LiData

Alignment Quality

Before Alignment			After Alignment		
Min Error(m)	Max Error(m)	RMSE(m)	Min Error(m)	Max Error(m)	RMSE(m)
0.000000	0.359000	0.049171	0.000000	0.051000	0.025454

Parameter settings

- **Trajectory Correction**
  - **ΔX/ΔY/ΔZ**: position components of trajectory correction.
  - **ΔRoll/ΔPitch/ΔHeading**: angular components of trajectory correction.
- **Spline Node Interval (Sec)**: Fluctuating corrections for trajectory are calculated based on spline nodes. The smaller the interval, the higher the fluctuation's frequency. A smaller interval is preferred if trajectory errors vary a lot in local region. Default value is valid for most data.

Report

Elevation Difference Check

Density Analysis

Control Point Report

Adjust Elevation

Trajectory Plot

Trajectory Report

Image Overlap Report

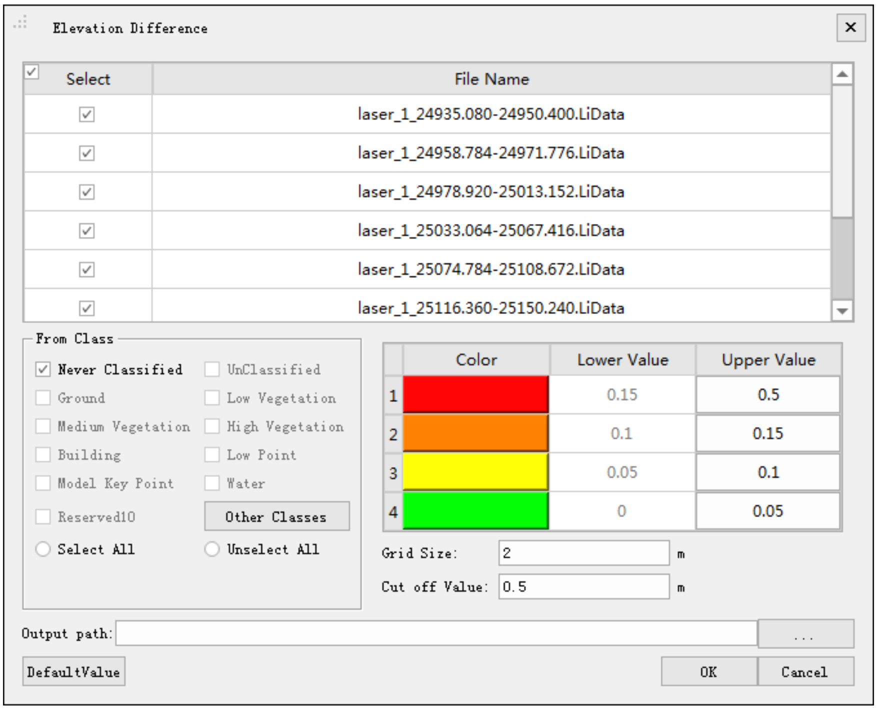
Elevation Difference Check

Summary

Use the elevation difference check report tool to analyze the difference in elevation between point cloud data.

Usage

Click the  button to pop up the dialog.



Settings

- **Input data**: Enter at least two point cloud data.
- **From Class**: The class of point cloud that participates in height difference quality check.
- **Grid Size (m) (default is "2")**: The size of the grid side length in the gridding of point cloud.
- **Cut off Value (m) (default is "0.5")**: If the difference is larger than this threshold, the result will not be recorded. The reason for setting this threshold is to remove the influence of moving objects.
- **Output path**: The results of the height difference quality inspection will be exported to a folder, which contains the results of the height difference quality inspection of each route and the complete html format report.

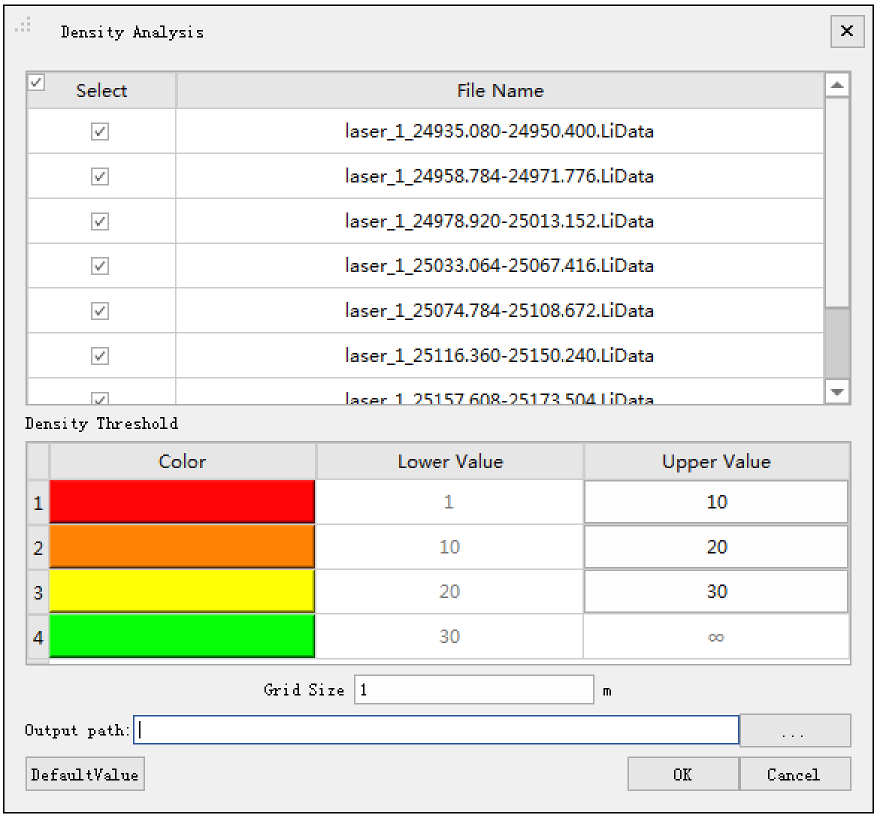
Density Analysis

Summary

Use density analysis tools to analyze the density of point cloud data.

Usage

Click the button and the dialog will pop up.



Settings

- **Input Data**: The input file can be a single point cloud data file or a point cloud data set.
- **Density Threshold**: The density of dots between adjacent thresholds will be displayed in the corresponding color.
- **Grid Size (m) (default is "1")**: The size of the grid side length in the gridding of point cloud.
- **Output Path**: The output path of the density analysis results. The results of the density analysis of each route and the complete html format report are stored in the corresponding folder.

Control Point Report

Summary

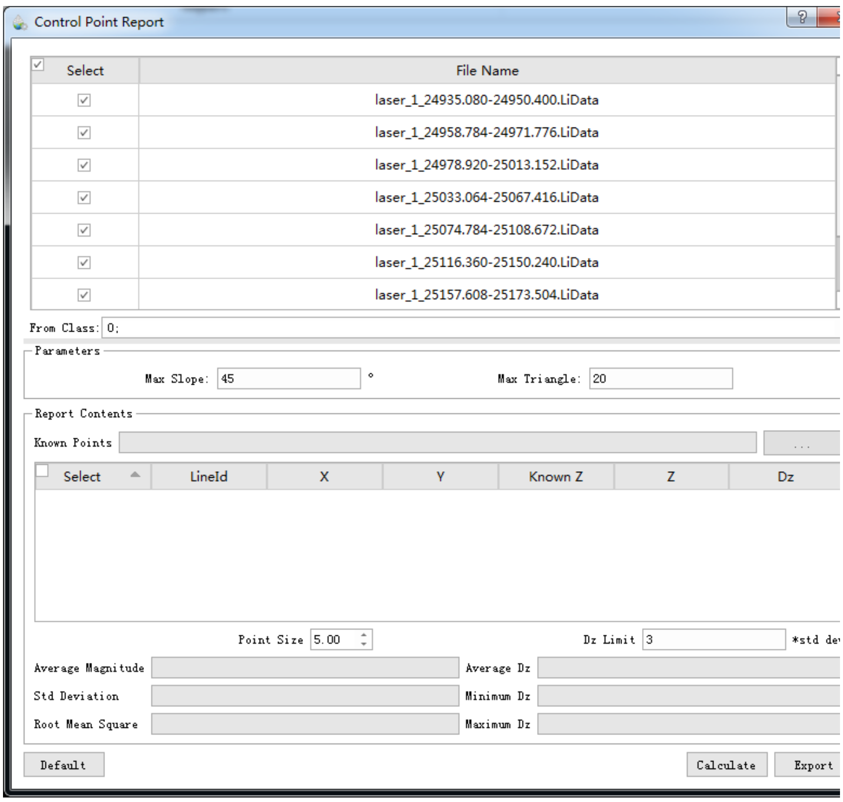
The control point report tool will create an elevation difference report between the point cloud and the ground control point, which can be used to check the elevation accuracy of the point cloud and use the calculated correction values to improve the elevation accuracy of the point cloud data.

The control point file is a text file separated by commas. Each row must consist of 3 columns, namely X, Y, and Z. The first row is the header. For the format, see Control Point File Format. At least three control points are required to successfully create a control point report.

The output report shows the information of the elevation difference between the point cloud loaded and the ground control point. The statistical information of the elevation difference such as the average magnitude of elevation difference, standard deviation, mean square error, average elevation difference, and maximum and minimum elevation difference values.

Usage

Click the  button, and the dialog will pop up.



After the calculation is complete, if users want to view the location of each control point, users can double-click the left mouse button anywhere in the row of the control point to jump to the location of the control point. Through Profile Tools, users can view the relative positional relationship between the control point and the point cloud more intuitively.

Settings

- **Input Point Cloud Data**: The input file can be a single point cloud data file or a point cloud data set.
- **From Class (the default is "all available classes")**: Users need to select a point cloud class that uses control points to check elevation accuracy. Generally, a hard surface point cloud such as ground points, building points, etc. is selected.
- **Z Tolerance（m）（default is "0.15")**:The height difference tolerance between the three nearest points. Since the triangle length constructed by the nearest point may be small, a small distance may cause the calculated slope value to be larger and exceeding the maximum slope value. In this case, if the height difference of the nearest point is within the tolerance range, so we decide the current result is valid. Generally, this value can be adjusted according to the point cloud thickness.
- **Max Slope (degrees) (default is "45")**: Maximum terrain slope tolerance. If the slope is greater than this value, the height difference will not be calculated. Generally, the control point will choose a relatively smooth terrain, so if the slope is too large, it is easy to be affected by the wrong information.
- **Max Triangle (m) (default is "20")**: The maximum TIN side length is used to avoid large deviations caused by elevation interpolation. The side length of the triangle is too large, indicating that the **initial class** points of the point cloud area corresponding to the control point are too few, and the calculated elevation difference error is large.
- **Known Points**: Input control point file.
- **Point Size (default is "5")**: The data in the control point report list can be double-clicked to locate the corresponding control point in the window, and the point size sets the size of the control point displayed in the window.
- **Dz Limit (default is "3")**: Set the tolerance of Dz. If the Dz is not within the tolerance range, it will be displayed in red to indicate the height difference between the point cloud and the control point is unusually large. Maximum tolerance = mean high difference + Dz limit × standard deviation; minimum tolerance = mean high difference - Dz limit × standard deviation.
- **Calculate**: After setting the parameters, the users can click this button to calculate the height difference.
- **Export**: Export the control point report file in txt format, the file contains the elevation error information of the point cloud data and the statistical information of Dz.

Adjust Elevation

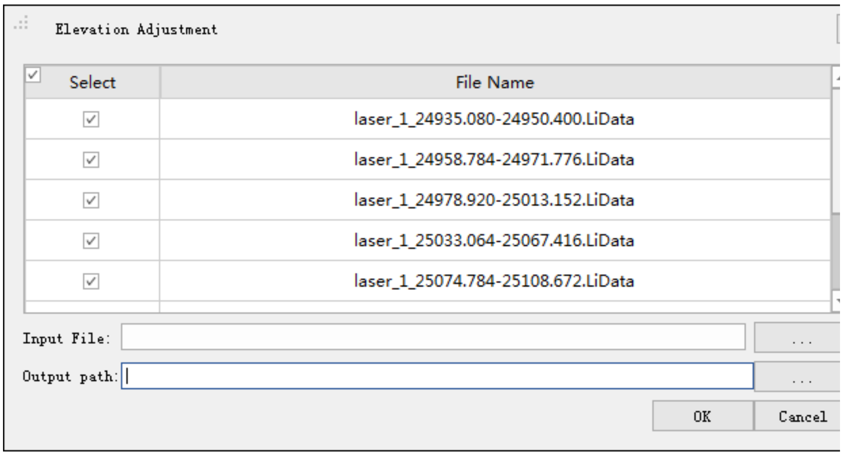
Summary

The elevation of the original point cloud data is usually in ellipsoid height. Usually, these values need to be converted to local elevation system or local elevation system values. For larger areas, the adjustment of the elevation value cannot be defined as a mathematical formula. Therefore, the elevation adjustment model needs to be defined by constructing a triangulated network model of known control point data and using local elevation interpolation values to correct local point interpolation. The transformed data can be checked by Control Point Report tool.

It is recommended to use the control point network data covering the complete project area to adjust the model to gain more accurate elevation information for the edge area of the project.

Usage

Click the  button, the dialog will pop up.



Settings

- **Input Point Cloud Data**: The input file can be a single point cloud data file or a point cloud data set.
- **Input File**: Users need to input adjustment model file of control points, and the file can be generated by the Control Point Report tool.
- **Output Path**: Output path of the adjusted point cloud data.

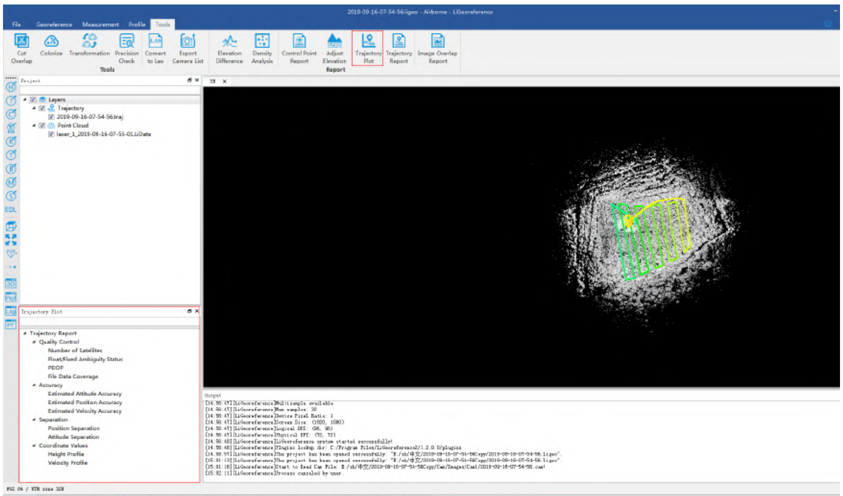
Trajectory Plot

Summary

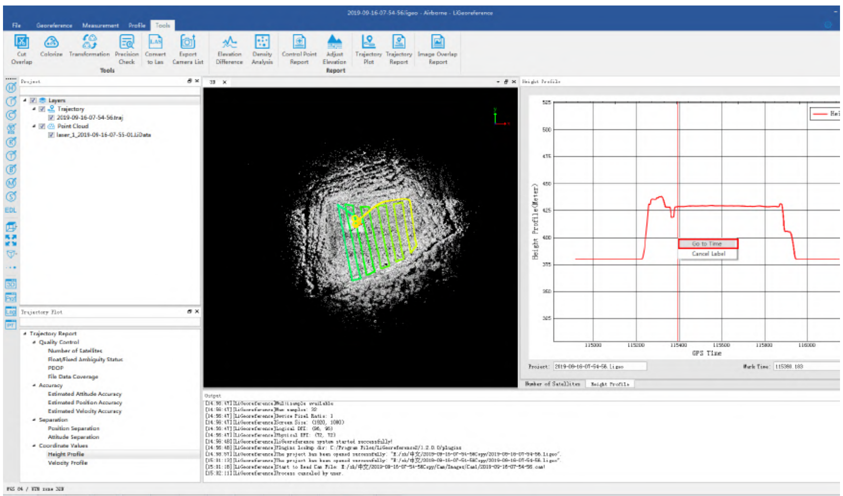
Create a docking window that shows various quality reports of the Trajectory. These quality reports mainly include the number of satellites, data coverage, attitude accuracy, position accuracy and PDOP value. Users can double-click one of the items to view the specific quality report chart.

Usage

Click *Report* > *Trajectory Plot*



After the trajectory plot generated in the dock window, users can click on one of the items to view the details of the report. Click on the directory tree and double-click on a specific report to pop up a chart of the item selected. Users can zoom and drag on the chart. Clicking the left button in the chart will display the specific time of the clicked point, and then right-clicking will show the "jump to" and "cancel the display" button. Click "Jump to" button, the display will zoom to the the corresponding time point on the trajectory and show the trajectory information at that time.



Trajectory Report

Summary

Generate a trajectory quality report in HTML format to view the quality of the generated trajectory file. The content of the report mainly includes the number of satellites, data coverage, attitude accuracy, position accuracy and PDOP value.

Usage

Click the *Report* > *Trajectory Report* button.

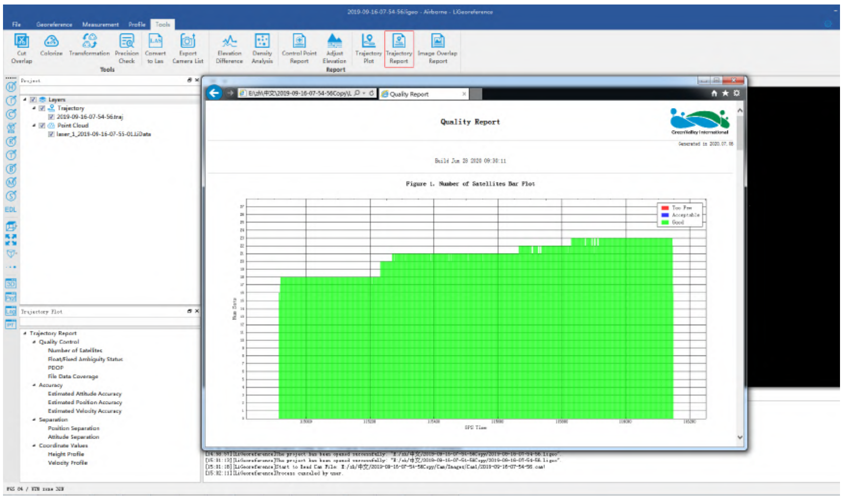


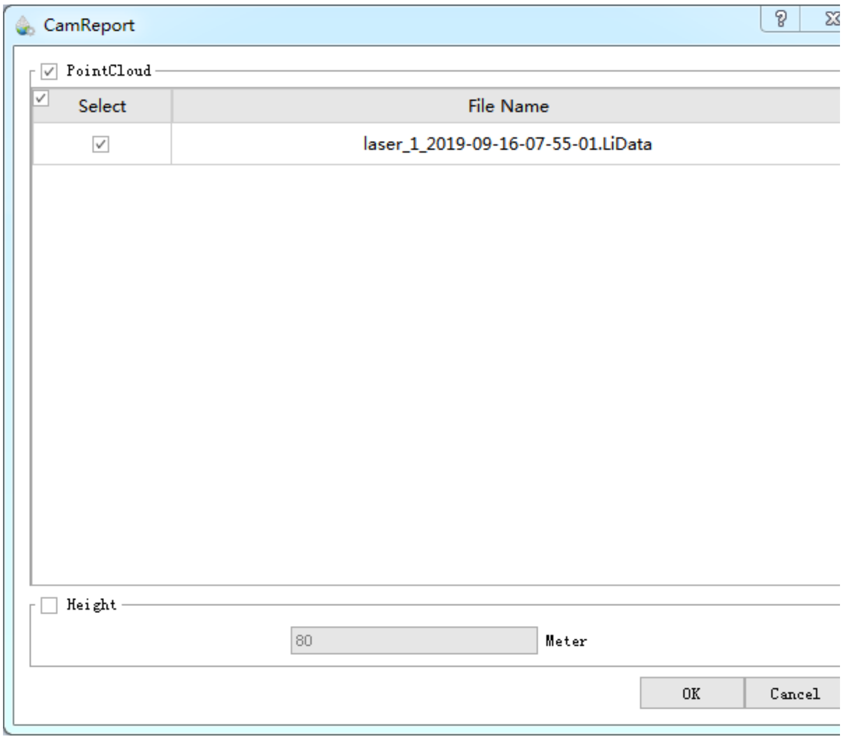
Image Overlap Report

Summary

Generate an HTML format image overlap report to check the overlap rate of images and whether there are missing images.

Usage

Click the *Report* > *Image Overlap Report* button.



After setting the parameter points, it will generate the image overlap ratio report in HTML format.

Settings

- **Input Point Cloud**: Check the point cloud when the point cloud has been georeferenced, and use the selected point cloud to generate DEM to generate the image overlap rate report.
- **Height**: Enter the altitude of the flight. The flight altitude can be used to calculate the image overlap report more quickly, but the accuracy will be lower.

Project Management

Project management includes two parts: layer management and window management.

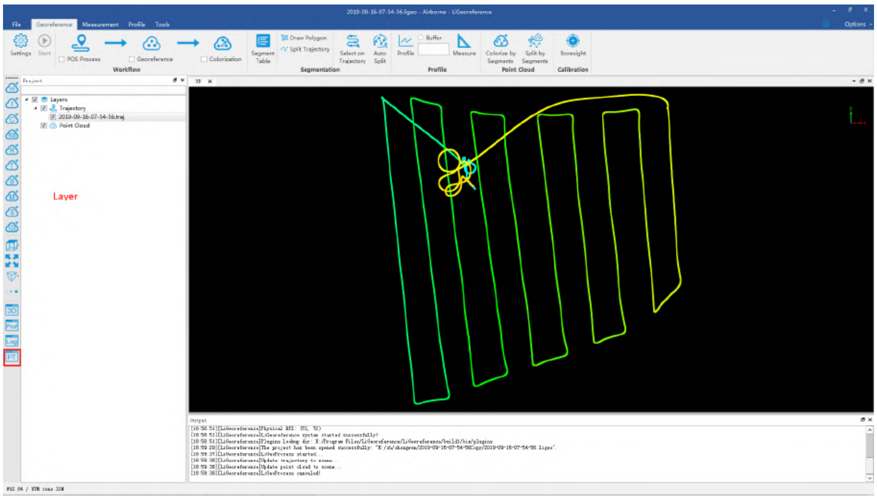
- Layer Management
- Window Management

Layer Management

Summary

In the project layers the users can show/hide data in all windows by checking/unchecking the box before data node. The context menu (i.e. right-click menu) of data node, which differs depending on data types, is mainly used for data query, display, statistics, export, and removal, etc.

Click the  button (in the red box) to show project layers as follows:



The following right-click menu needs to be explained:

- Point Cloud
- Trajectory
- Image List

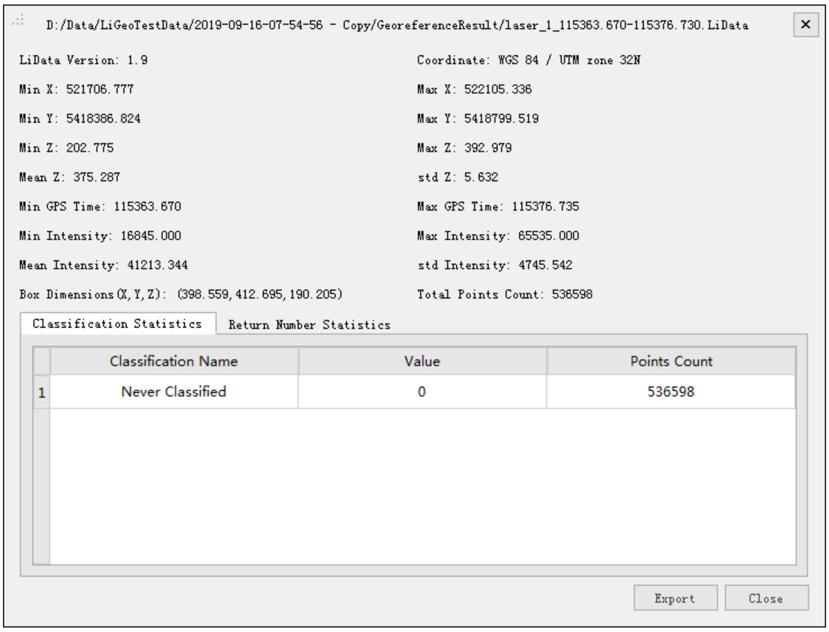
Point Cloud Data Right-click Menu

Summary

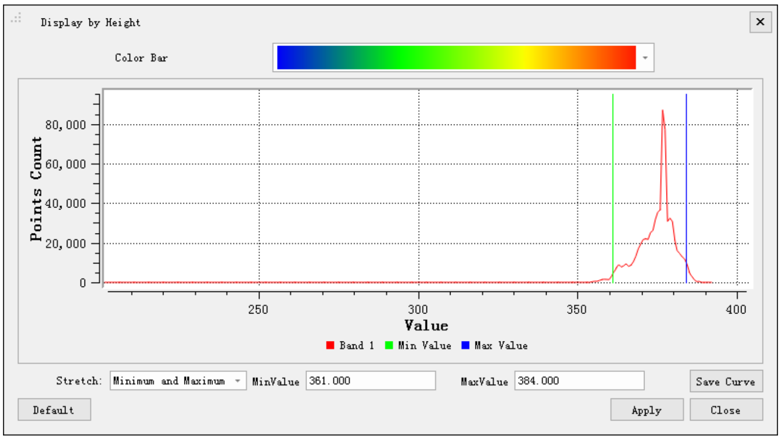
The right-click menu of the point cloud data in the result data layer management tree mainly includes the query, display, statistics, and export of point cloud data.

Data Right-click Menu

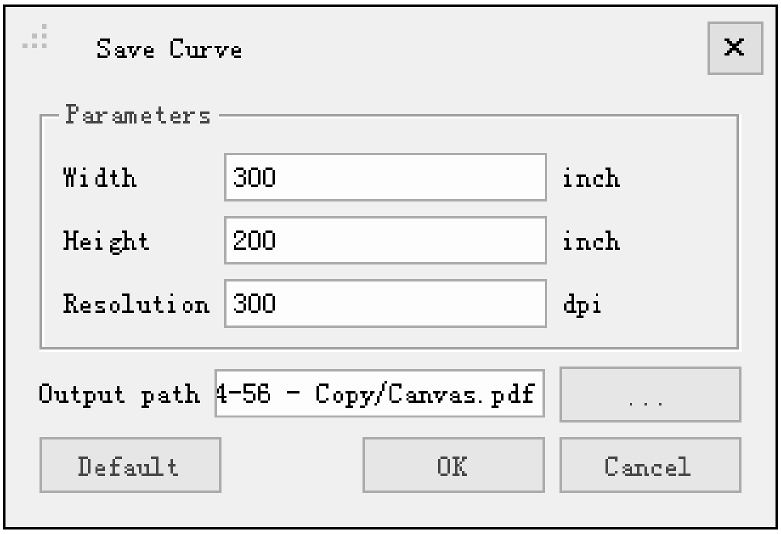
- **Info**: Check the point cloud information including data path, coordinate information (minimum, maximum and mean value), GPS Time, intensity, the bounding box, total amounts of point cloud, classification and return number information. Click "Export" button to save as txt formatted file.



- **View Mode**: Set display mode of point cloud including the following types.
  - **Display by Height**: Change the minimum, maximum or standard deviation value to enhance the display effect.

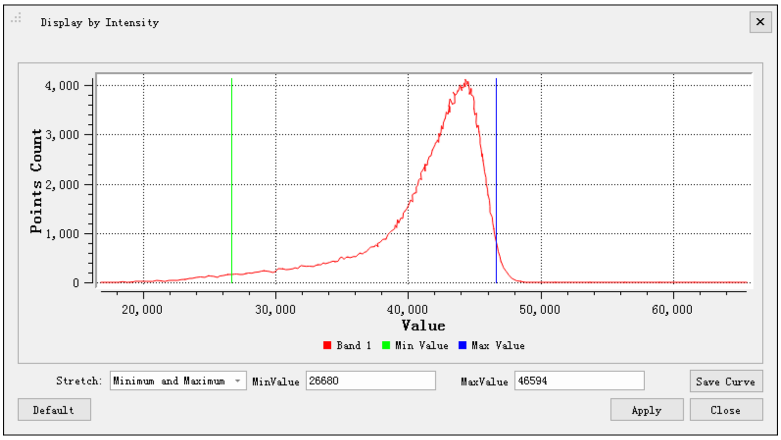


The histogram displayed on the interface can be exported in pdf format. Click the "Save Curve" button to pop up the "Save Curve" dialog box. As shown in the figure, set the width, height and resolution of the exported curve figure, select the output path, and click OK button to save the curve.

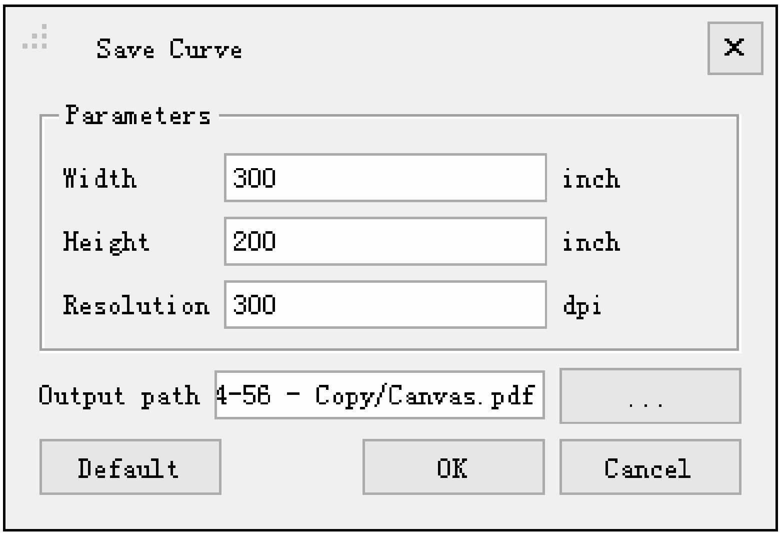


For more details please refer to Display by Height.

- **Display by Intensity**: The interface pops up as shown and can be stretched by the minimum maximum or standard deviation value to improve the display.

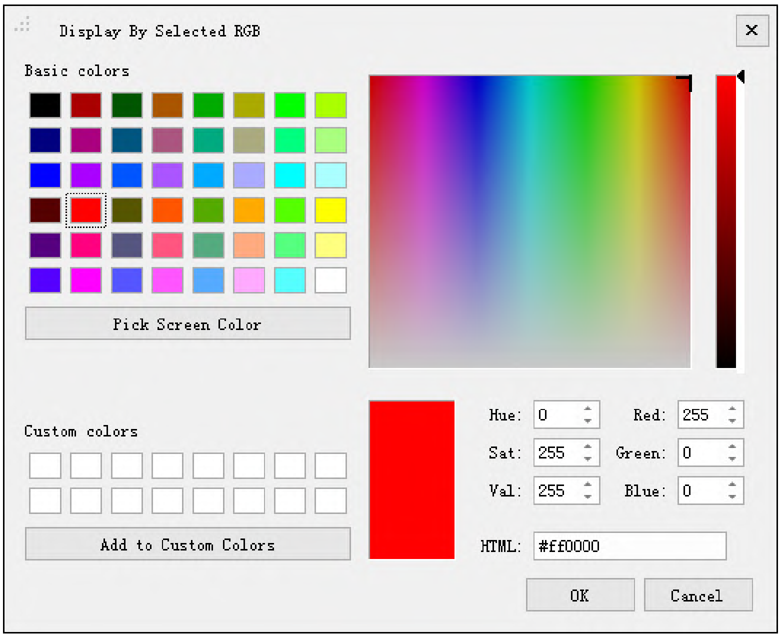


The histogram displayed on the interface can be exported in pdf format. Click the "Save Curve" button to pop up the "Save Curve" dialog box. As shown in the figure, select the width, height and resolution of the exported curve, select the output path, and click OK button to save the curve.



For more details please refer to Display by Intensity.

- **Display by Classification**: For more details please refer to Display by Classification.
- **Display by RGB**: For more details please refer to Display by RGB.
- **Display by Return**: For more details please refer to Display by Return Number.
- **Display by Time**: For more details please refer to Display by Time.
- **Display by Selected RGB**: Select user-defined color to display the point cloud data. For more details please refer to Display by Selected.



- **Display by Blend**: For more details please refer to Display by Blend.
- **Display by Mix**: For more details please refer to Display by Mix.

- **Zoom to Layer**: Calculate the bounding box of the current point cloud data, and display all opened point cloud data in global view in the current viewer with this bounding box range.
- **Export**: Export the data into LAS (.las or .laz) format.
- **Replace Data**: Replace current point cloud data.

Settings

- **Display by Height**:
  - **Color Bar**: The color bar is used to reflect the elevation properties of the point cloud.
  - **Stretch**: Set the stretch of histogram.
    - **Min, Max (default)**: The method uses the minimum and maximum pixel values as the endpoints of the histogram. For example, set the minimum and maximum values of the image to 2488 and 2656 respectively, and set the linear stretch pixel value sits between 0-255. It improves the brightness and contrast of the image by distributing the pixel values across the entire histogram range, and makes the features in the image easy to distinguish.
    - **Standard Deviation**: This method is used between the values defined by the standard deviation n. For example, the minimum and maximum values of an image are 2488 and 2656 respectively. If n is 2, the value above the 2nd standard deviation will become 0 or 255, and the other values are stretched between 0-255.
- **Display by Intensity**
  - **Stretch**
    - **Min, Max (default)**: The method uses the minimum and maximum pixel values as the endpoints of the histogram. For example, the minimum and maximum values of an image are 2488 and 2656 respectively, and set the linear stretch pixel value sits between 0-255. By distributing pixel values across the entire histogram range, you can make the features in the image easily distinguish by increasing the brightness and contrast of the image.
    - **Standard Deviation**: This method is used between the values defined by the standard deviation n. For example, the minimum and maximum values of an image are 2488 and 2656 respectively. If n is 2, the value above the 2nd standard deviation will become 0 or 255, and the other values are stretched between 0-255.
- **Save Curve**: Set the stretch of histogram.
  - **Width**: Save the pixel width of the curve.
  - **Height**: Save the pixel height of the curve.
  - **Resolution**: Save the resolution of the curve.
  - **Output Path**: Save the output path of the curve.

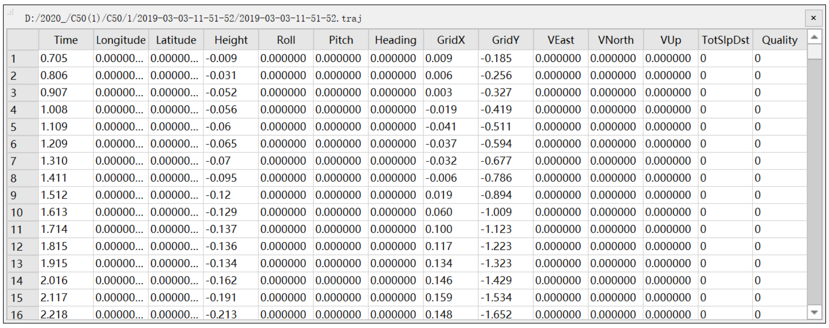
Trajectory Right-click Menu

Summary

The right-click menu of the trajectory data in the data layer management tree mainly includes the query and display of trajectory data.

Data Right-click Menu

- **Info**: View the basic information of trajectory data, including GPS time, latitude, longitude, altitude, Roll, Pitch, Heading angle, etc., as shown in the figure.



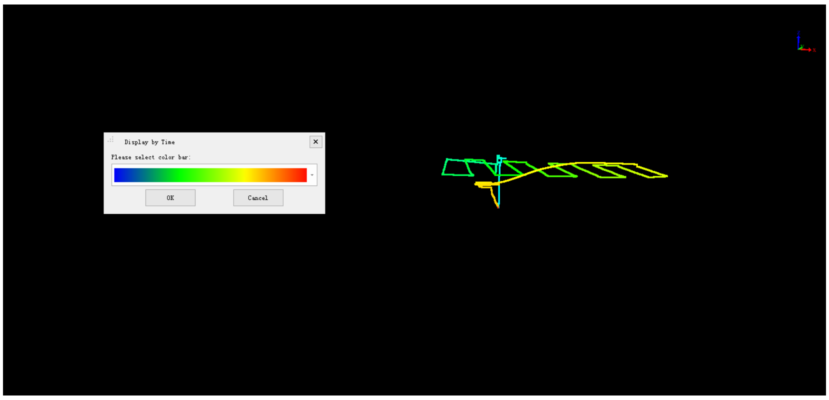
D:/2020_/C50(1)/C50/1/2019-03-03-11-51-52/2019-03-03-11-51-52.traj

	Time	Longitude	Latitude	Height	Roll	Pitch	Heading	GridX	GridY	VEast	VNorth	VUp	TotSlpDst	Quality
1	0.705	0.00000...	0.00000...	-0.009	0.000000	0.000000	0.000000	0.009	-0.185	0.000000	0.000000	0.000000	0	0
2	0.806	0.00000...	0.00000...	-0.031	0.000000	0.000000	0.000000	0.006	-0.256	0.000000	0.000000	0.000000	0	0
3	0.907	0.00000...	0.00000...	-0.052	0.000000	0.000000	0.000000	0.003	-0.327	0.000000	0.000000	0.000000	0	0
4	1.008	0.00000...	0.00000...	-0.056	0.000000	0.000000	0.000000	-0.019	-0.419	0.000000	0.000000	0.000000	0	0
5	1.109	0.00000...	0.00000...	-0.06	0.000000	0.000000	0.000000	-0.041	-0.511	0.000000	0.000000	0.000000	0	0
6	1.209	0.00000...	0.00000...	-0.065	0.000000	0.000000	0.000000	-0.037	-0.594	0.000000	0.000000	0.000000	0	0
7	1.310	0.00000...	0.00000...	-0.07	0.000000	0.000000	0.000000	-0.032	-0.677	0.000000	0.000000	0.000000	0	0
8	1.411	0.00000...	0.00000...	-0.095	0.000000	0.000000	0.000000	-0.006	-0.786	0.000000	0.000000	0.000000	0	0
9	1.512	0.00000...	0.00000...	-0.12	0.000000	0.000000	0.000000	0.019	-0.894	0.000000	0.000000	0.000000	0	0
10	1.613	0.00000...	0.00000...	-0.129	0.000000	0.000000	0.000000	0.060	-1.009	0.000000	0.000000	0.000000	0	0
11	1.714	0.00000...	0.00000...	-0.137	0.000000	0.000000	0.000000	0.100	-1.123	0.000000	0.000000	0.000000	0	0
12	1.815	0.00000...	0.00000...	-0.136	0.000000	0.000000	0.000000	0.117	-1.223	0.000000	0.000000	0.000000	0	0
13	1.915	0.00000...	0.00000...	-0.134	0.000000	0.000000	0.000000	0.134	-1.323	0.000000	0.000000	0.000000	0	0
14	2.016	0.00000...	0.00000...	-0.162	0.000000	0.000000	0.000000	0.146	-1.429	0.000000	0.000000	0.000000	0	0
15	2.117	0.00000...	0.00000...	-0.191	0.000000	0.000000	0.000000	0.159	-1.534	0.000000	0.000000	0.000000	0	0
16	2.218	0.00000...	0.00000...	-0.213	0.000000	0.000000	0.000000	0.148	-1.652	0.000000	0.000000	0.000000	0	0

- **View Mode**: Set the display mode of trajectory data, including the following types:

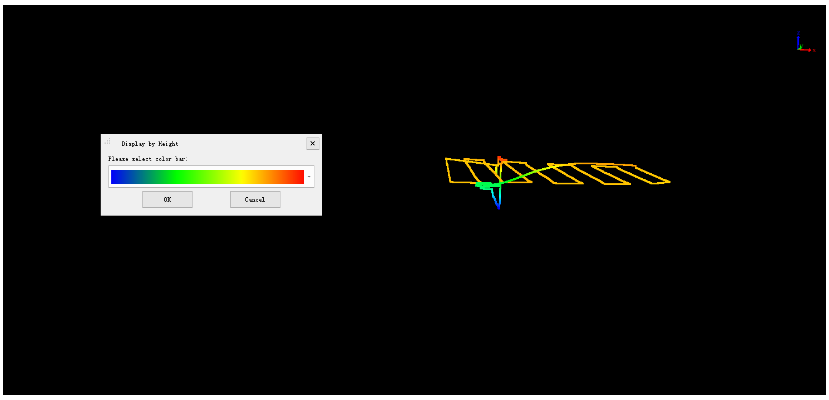
- Display by Time (default)

  Click the *Display by Time*  button in the *Trajectory Display* tag. The trajectory will be displayed by data collection time and the color bar can be selected in the pop up window.



- Display by Height

  Click the *Display by Height*  button in the *Trajectory Display* tag. The trajectory will be displayed by height of the trajectory and the color bar can be selected in the pop up window corresponds to different height level.

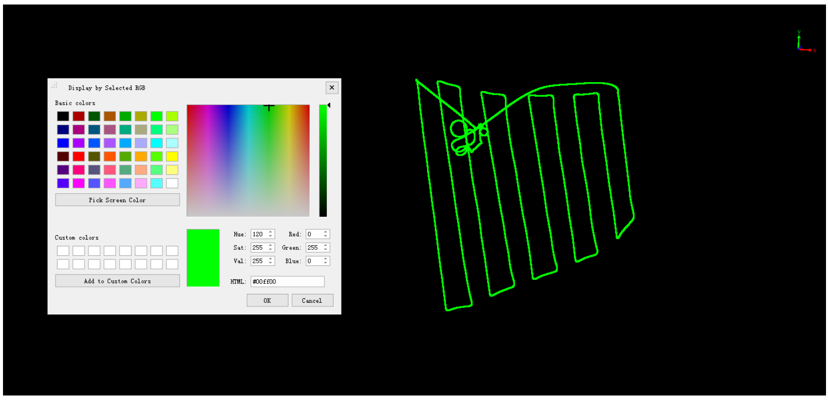


- Display by Quality

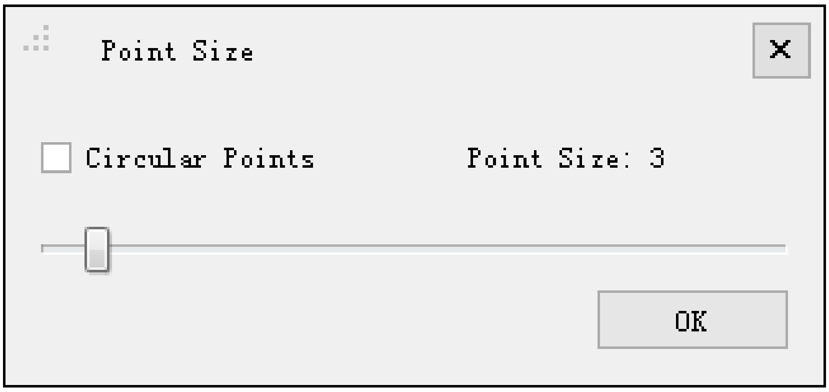
  Click the *Display by Quality* button in the *Trajectory Display* tag. The trajectory will be displayed by quality of the trajectory and the color bar can be selected in the pop up window corresponds to different quality level.

- Display by Selected RGB

  Click the *Display by Selected RGB* button in the *Trajectory Display* tag. The trajectory will be displayed by specified color and the color can be selected in the pop up window.



- **Zoom to Layer**: Calculate the bounding box of the current trajectory data, and display all opened trajectory data in global view in the current viewer with this bounding box range.
- **Point Size**: The size of the displayed point of the trajectory data can be adjusted through the scroll bar. The shape of the point can be selected from circle and square points, as shown in the figure.



Parameters Setting

- **Point Size**:
  - **Circular Points (optional)**: Set the shape of the displayed point of the trajectory data to be circle or square.
  - **Point Size**: Set the displayed point size of the trajectory data.

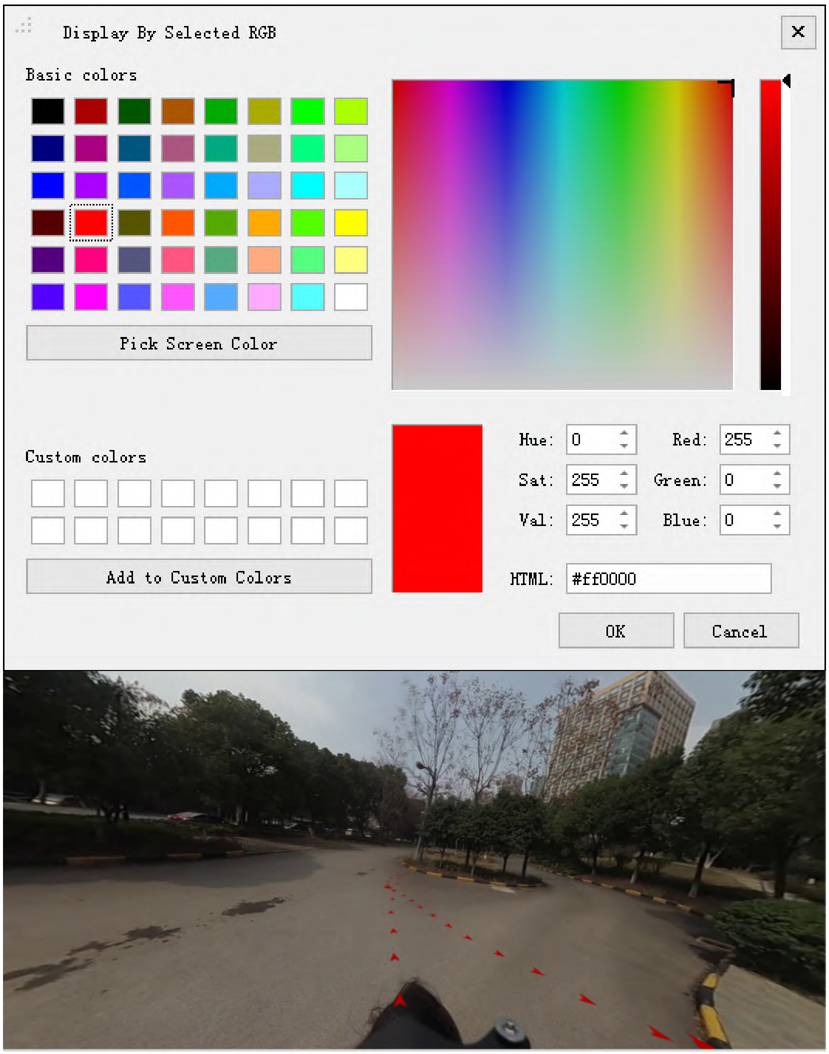
Image List Right-click Menu (only applicable to Mobile Vehicle Device)

Summary

The right-click menu of the image list data in the result data layer management tree mainly contains the function of management of the display of the exposure points of the panoramic data (arrow-shaped objects in the panoramic window).

Right-click Menu

- **Select RGB**: Click in the pop-up window to select the specified color to display the exposure point, as shown below (select red).



Window Management

Summary

The window management tool controls the display of the project window.

Detailed Introduction

Display 3D window.

Display profile window.

Display panorama window.

Display log window.

Display layer (project tree) window.

Measure Tools

The measure tools are used to measure geometric information about the data. The measurement tools in the software consist of two main types: 3D measure tools and panoramic measure tools. 3D measurements are for point cloud data in a 3D window, and panoramic measurements are for panoramic image data in a panoramic window.

3D Measure Tools

Panorama Measure Tools

3D Measure Tools

The measure tools are used to measure geometric information about the data.

- Pick point
- Multi Pick point
- Length Measurement
- Area Measurement
- Angle Measurement
- Height Measurement
- Volume Measurement
- Density Measurement

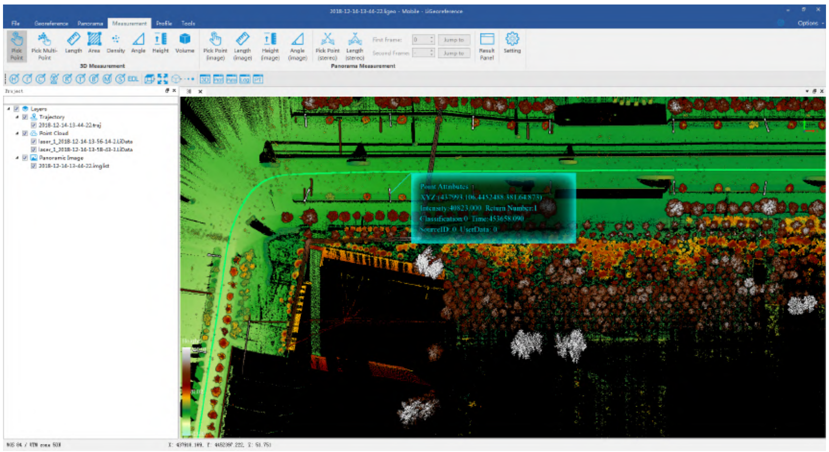
Pick Point

Description: This tool is applicable to point cloud data, the attributes that can be queried contain position, intensity, return number, classification and GPS time.

Steps

1. Click *Pick Point*  button via *3D Measurement* tag.
2. Click a valid point in the scene and a label that displays the point attributes will pop up.

   The label will show the position, intensity, return number, classification and GPS time.

   
3. Right-click to go back to the previous point during the measurement.

> Note: The tool is only available in the 3D window.

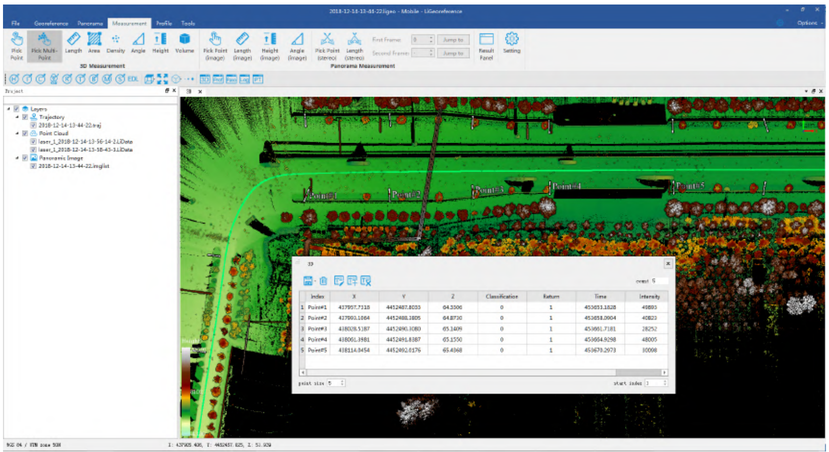
Multi Pick Point

Description: For point cloud data, the attributes that can be queried contain position, intensity, return number, classification and GPS time. Different from the pick point tool, this tool allows querying multiple points at the same time, and the selection set can be exported in txt, asc, neu, xyz, pts, or csv file.

Steps

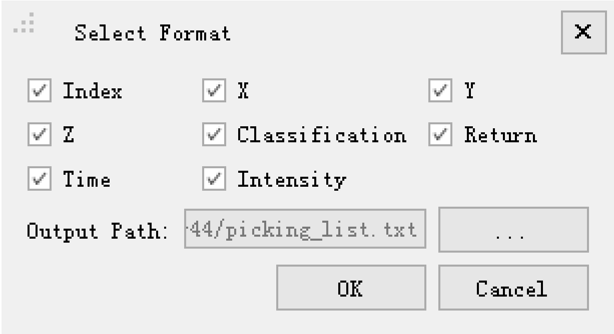
1. Click the *Pick Multi-Point*  button via *3D Measurement* tag. Left-click the points in the scene and the selection results are marked by labels. At the same time, a table that contains the attributes of the selection points will pop up, shown as follows.

   The attributes of point cloud data shown in the table contain index, position (XYZ), classification, return number, GPS time and intensity. The total number of the points is updated real-time above the table.

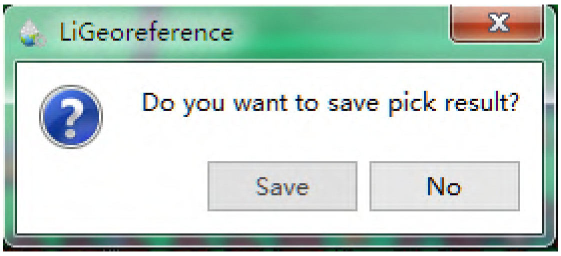
   

2. The "marker size" is used to set the point size of the marker in the scene. The "start index" is used to set the start index of the selected points.
3. Select a row of the table by left-clicking and click the button  to delete the point.
4. After clicking the "Start Editing" button , the attribute values can be changed by double-clicking the cells in the added attribute columns, and typing in the new values.
5. After clicking the "Add Attribute" button , the following dialog will pop-up. Currently, it is supported for the following types of custom attributes: integer, float, text, date, and enum. After click "ok" button, the added field will be displayed in the attributes table.
6. The "Remove Attribute" button  is not available when there is no custom attributes added. After adding custom attributes, the custom attributes can be removed by clicking "Remove Attribute" button (only the custom attributes can be removed).

7. The selection set can be exported as txt, asc, neu, xyz, pts, or csv file. Click the drop-down menu  to pop up "Select Format" dialog, as shown below. The menu "Save 3D points" is available. The coordinates information and other attribute information can be saved as .txt format.



8. Click ... to pop up the export dialog. Input the output path, and check the attributes that need to be exported. Click "OK" to complete the export. Click "Cancel" to cancel the export.
9. If the selected points have not been saved before quiting this tool, a message box will pop up as follows. Click "Save" to save the points. Click "No" to cancel the selections.



Settings

- **X**: X component of the coordinate.
- **Y**: Y component of the coordinate.
- **Z**: Z component of the coordinate.
- **Classification**: The class attribute of point cloud data.
- **Return**: The return number attribute of point cloud data.
- **Time**: The GPS time attribute of point cloud data.
- **Intensity**: The intensity attribute of point cloud data.
- **Index**: The index of select point
- **Output Path**: The path of the output file.

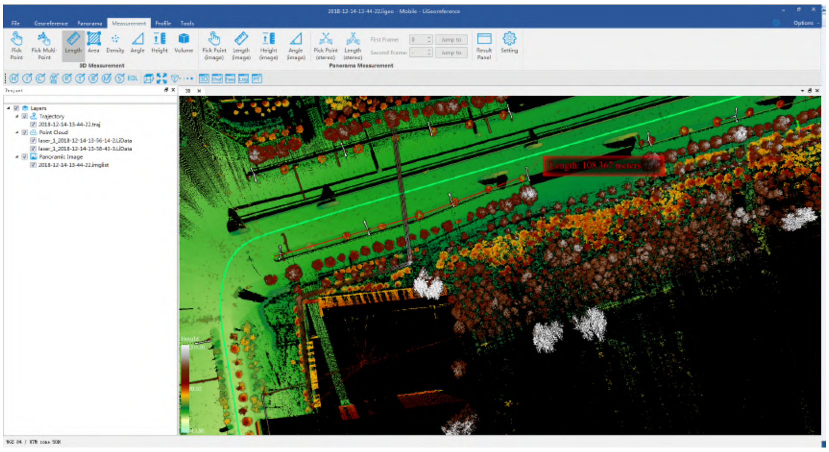
> Note: The tool is only available in the 3D window. If the center of rotation needs to be changed, hold down the the Ctrl key and select the center of rotation with the left mouse button.

Length Measurement

Description: This tool is applicable to point cloud data, which calculates the distance between two consecutive points.

Steps

1. Click the *Length*  button via *3D Measurement* tag.
2. Left-click at least two points in the scene and the corresponding polyline will be rendered real-time. The measurement result is displayed in a label as follows. Double-clicking the last point will stop the measurement process, and the distance value will continue to be displayed in the label.
3. Right-click to go back to the previous point during the measurement.



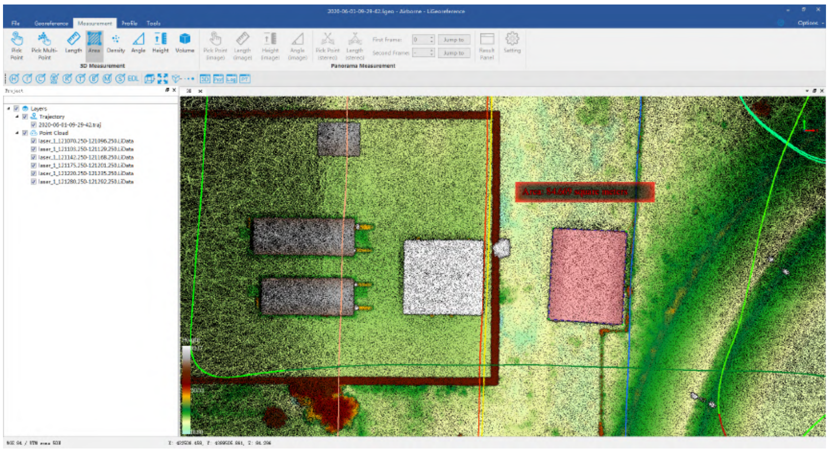
> Note: The tool is only available in the 3D window.

Area Measurement

Description: This tool is applicable to point cloud data which calculates the projected area within the polygon region. Current window will switch to Orthogonal Projection automatically for 3D data.

Steps

1. Click the *Area*  button via *3D Measurement* tag.
2. Left-click at least three points in the scene and the corresponding polygon area will be rendered real-time. The measurement result is displayed in a label as follows.
3. Double-clicking the last point will stop the measurement process, and the measurement result will continue to be displayed in the label.
4. Right-click to go back to the previous point during the measurement.



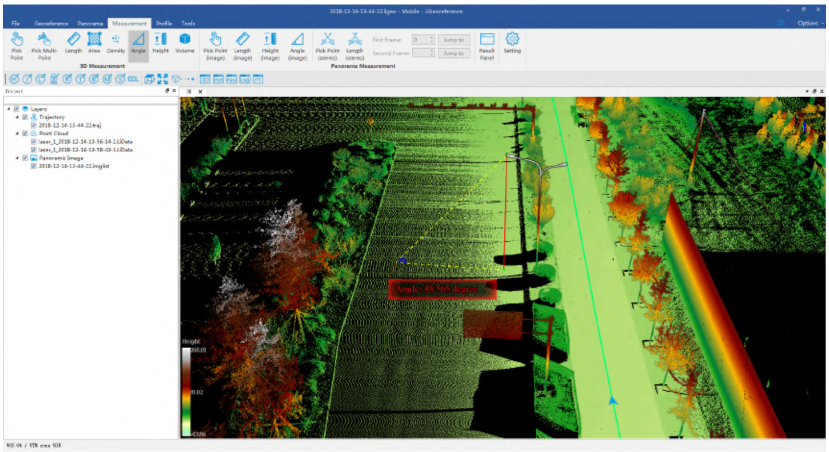
> Note: This tool only works under orthogonal projection. And also the tool is only available in the 3D window.

Angle Measurement

Description: This tool is applicable to point cloud data which calculates the angle of pitch between two points in 3D view.

Steps

1. Click the *Angle*  button via *3D Measurement* tag.
2. Select the reference point of angle measurement by left-clicking.
3. Select the measurement point by double-clicking. The pitch angle between the reference point and the measurement point will be rendered in the scene and the measurement result is displayed in a label as follows.



4. Click the right mouse button to go back to the previous step.

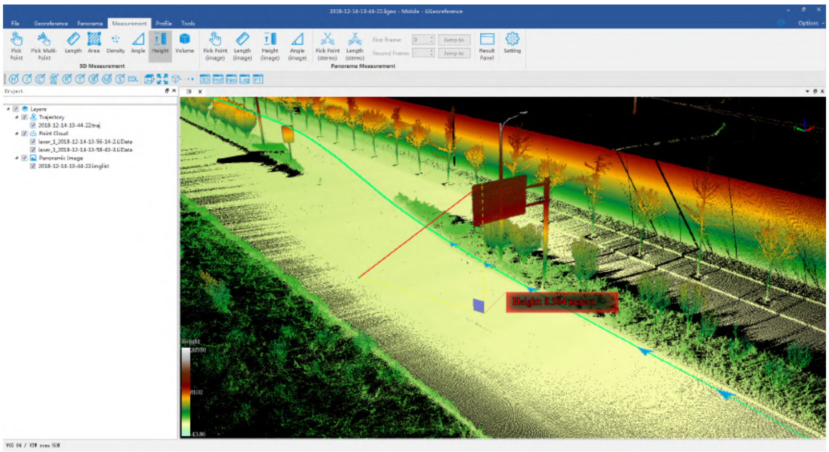
> Note: The tool is only available in the 3D window.

Height Measurement

Description: This tool is applicable to point cloud data which calculates the relative height difference between two points.

Steps

1. Click the *Height*  button via *3D Measurement* tag.
2. Select the reference point of height measurement by left-clicking.
3. Select the measurement point by double-clicking. The relative height difference between the reference point and the measurement point will be rendered in the scene and the measurement result is displayed in a label as follows.



4. Right-click to go back to the previous point during the measurement.

> Note: The tool is only available in the 3D window.

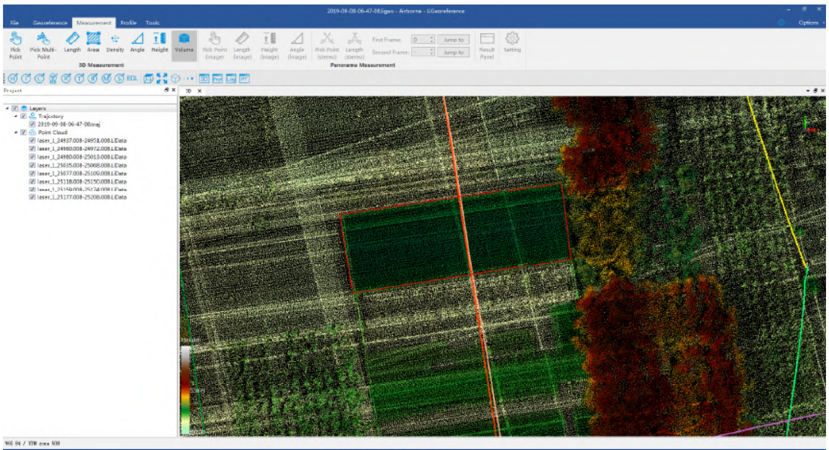
Volume Measurement

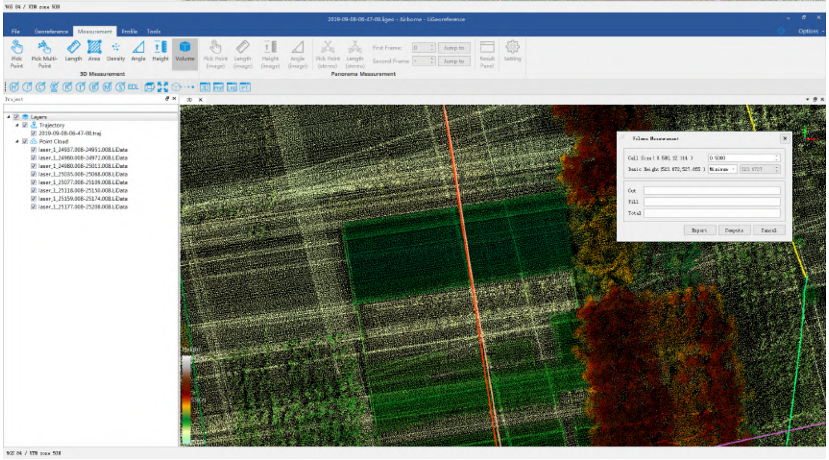
Description: This tool is applicable to point cloud data which calculates filling, cutting and total amount relative to a reference height. It's commonly used in volume measurement of coal pile and hull.

Step

1. Click *Volume*  button via *3D Measurement* tag.

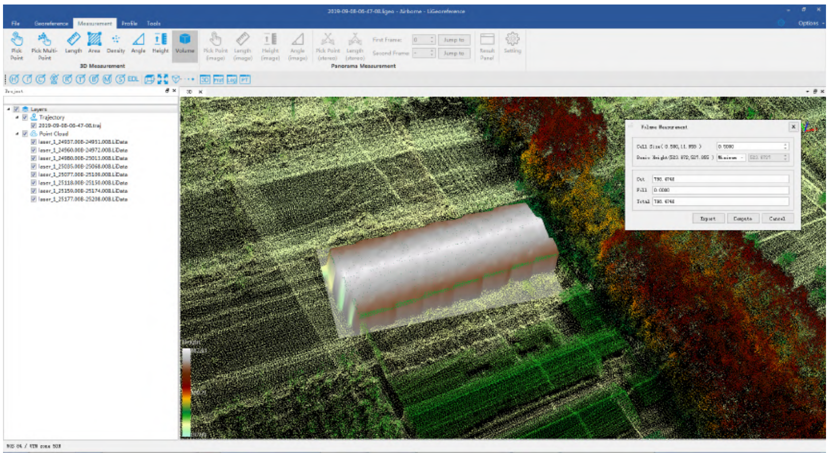
2. It is suggested to adjust the window to top view before the tool is used. Select at least three points to generate the reference plane for volume calculation by left-clicking. Select the last point by double-clicking. The border of the selected region will be rendered in red and the dialog "Volume Measure" will pop up.





3. Set the cell size.

4. Set the reference plane of volume measurement. The options include minimum value, fit plane, and customizing.
5. Click the "Compute" button to generate the measurement result, including cut volume, fill volume and total volume. The corresponding volume will be rendered in the scene, as shown below.



6. Click the "Export" button to export the result in *.pdf format.

Parameters Setting

- **Cell Size**: It defines the smallest unit size for calculation. The smaller the value is, the more accurate the calculation is.
- **Basic Height**: It defines the reference plane to calculate filling and cutting.
  - **Minimum (Default)**: Use the minimum height of the selected points as the height of the reference plane.
  - **Fitted Plane (Mean)**: Fit the best plane according to the selected points.
  - **Customize**: This value is specified by the user.

> Note: This tool only works with point cloud data in 3D view.

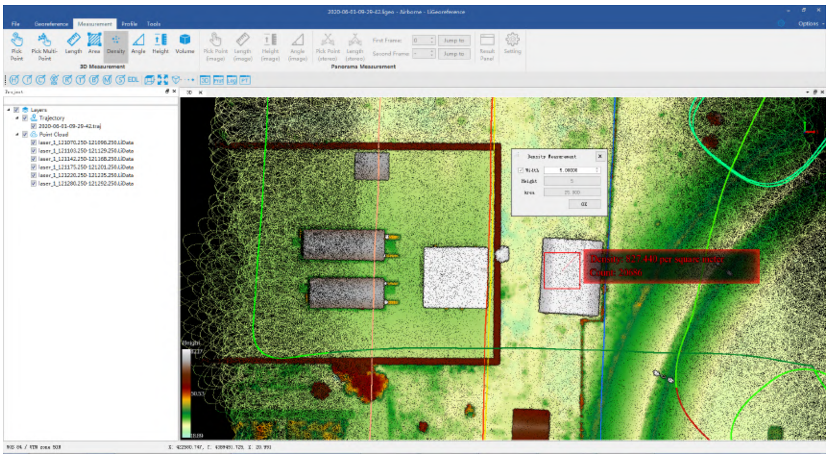
Density Measurement

Description: Point density is an important metric to measure the quality of point cloud data. The average number of points per square meter can be counted with this tool.

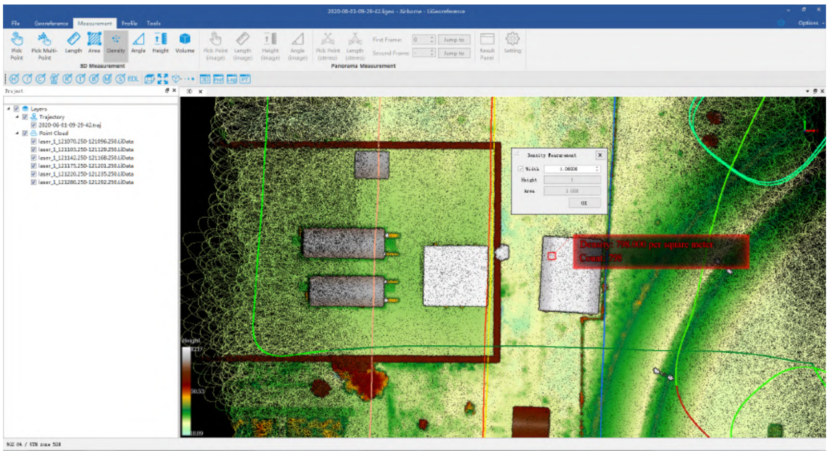
Steps

1. Click the *Density*  button via *3D Measurement* tag. Active window is adjusted to orthogonal projection automatically when this tool is started.
2. Then the dialog "Density" pops up.
3. If the option "Width" is checked, the width value can be manually input, and the height value will be set to the same as the width value, then the area value will be decided by "Width" and "Height". The measurement region can be selected by left-clicking. If the option "Width" is unchecked, the width value and the height value will be decided by the size of the rectangle that is drawn interactively by left-clicking the upper left corner and the lower right corner. The area value will be decided by "Width" and "Height". The rectangle will be rendered in the scene and the measurement result (number of total points and point density) is displayed in a label as follows.

   Default Width (the Width value is five)

   Reset Width (the Width value is one)



Parameters Setting

- **Width**: It defines the width of the reference rectangle.
- **Height**: It defines the height of the reference rectangle.
- **Area**: It defines the area of the reference rectangle.

> Note: This tool only works with point cloud data under orthogonal projection.

Panorama Measure Tools

Panorama measurements consist of two methods: one is based on Point Cloud Depth Interpolation and the other is based on Forward Intersection.

Switch the software top menu to the Measurement mode before the measurement begins.

Panorama Measurements based on Point Cloud Depth Interpolation

Panorama Measurements based on Forward Intersection

Result Panel

Setting Dialog

Panorama Measurements based on Point Cloud Depth Interpolation

The principle of estimating the location information of measuring points is based on the point cloud data depth value and interpolation algorithm within a certain range around the measuring point.

The main functions are listed below:

Pick Point

Length Measurement

Height Measurement

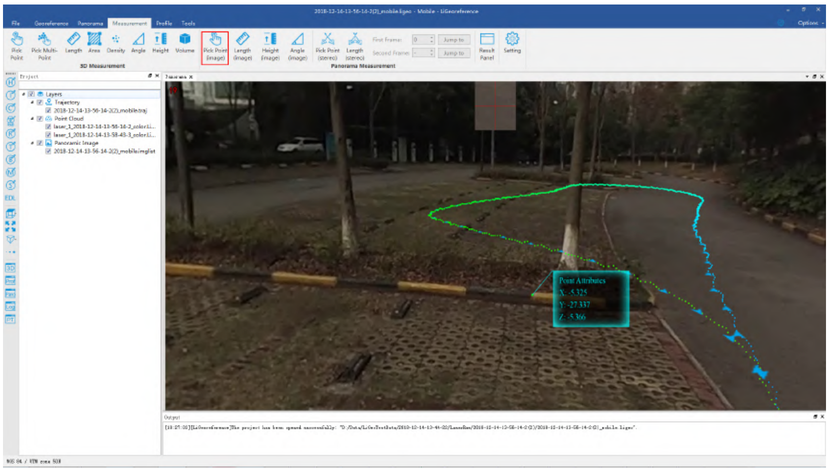
Angle Measurement

Pick Point (Depth Interpolation)

Description: This tool is applicable to panoramic data, the attributes that can be queried contain position information.

Steps

1. Click the *Pick Point*  button via *Panorama Measurement* tag.
2. Select a point by left-clicking and the measurement result is displayed in a label as follows.



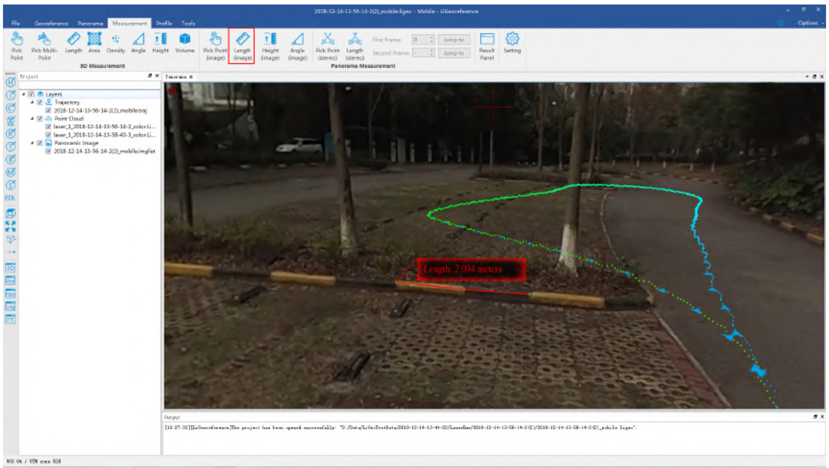
3. Right-click to go back to the previous point during the measurement.

Length Measurement (Depth Interpolation)

Description: This tool is applicable to panoramic data, which calculates the distance between two consecutive points.

Steps

1. Click the *Length*  button via *Panorama Measurement* tag.
2. Left-click at least two points in the scene and the corresponding polyline will be rendered real-time.
3. The measurement result is displayed in a label.
4. Double-clicking the last point will stop the measurement process, and the distance value will continue to be displayed in the label.



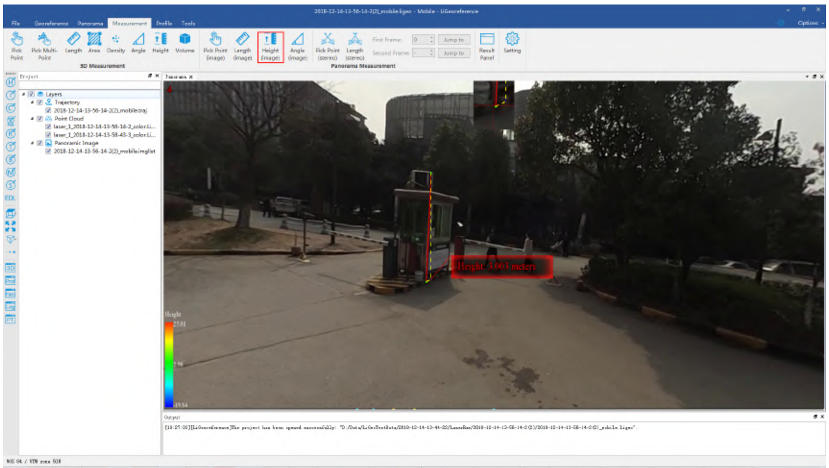
5. Right-click to go back to the previous point during the measurement.

Height Measurement (Depth Interpolation)

Description: This tool is applicable to panoramic data which calculates the relative height difference between two points in panorama window.

Steps

1. Click the *Height*  button via *Panorama Measurement* tag.
2. Select the reference point of height measurement by left-clicking in panorama window.
3. Double-click to select the end point of height measurement to complete the measurement. The interface pop-up box displays height information.



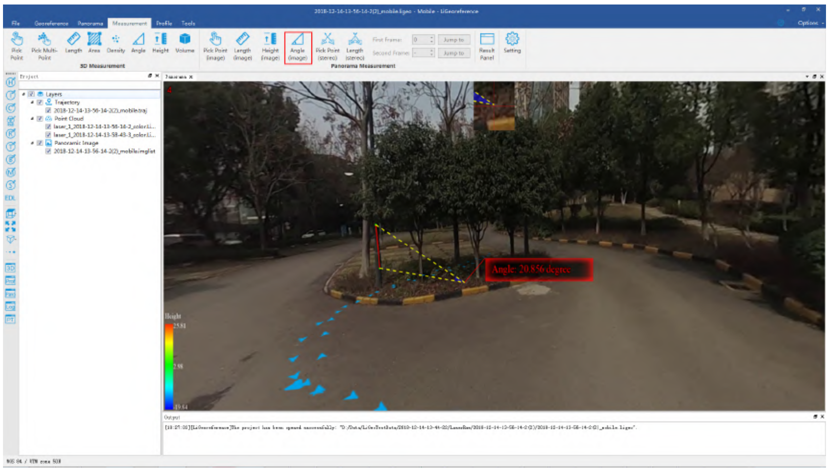
4. Right-click to go back to the previous point during the measurement.

Angle Measurement (Depth Interpolation)

Description: This tool is applicable to panoramic data which calculates the angle of pitch between two points in Panorama view.

Steps

1. Click the *Angle*  button via *Panorama Measurement* tag.
2. Select the reference point of angle measurement by left-clicking in (*Panorama*) view.
3. Select the measurement point by double-clicking. The pitch angle between the reference point and the measurement point will be rendered in the scene and the measurement result is displayed in a label as follows.



Panorama Measurements based on Forward Intersection

Using the measuring point to select the tie-points on the two-frame image, and combined with the forward intersection algorithm, the measurement point position information is obtained.

The main functions are listed below:

Pick Point

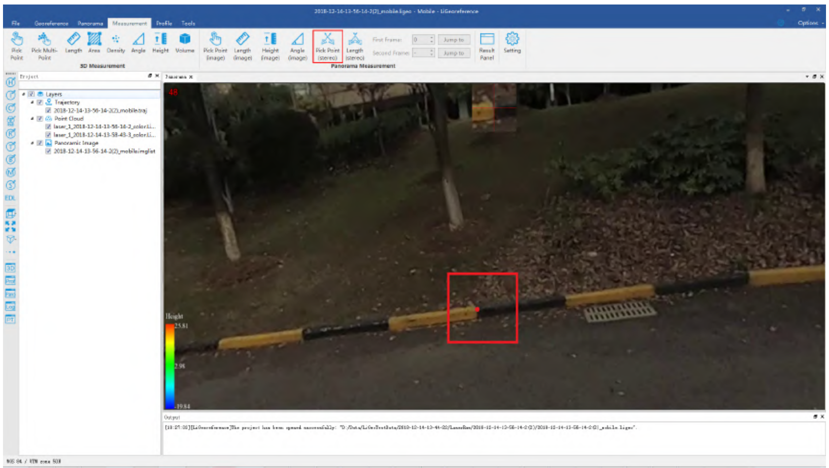
Length Measurement

Pick Point (Forward Intersection)

Description: This tool is applicable to panoramic data, the attributes that can be queried contain position information.

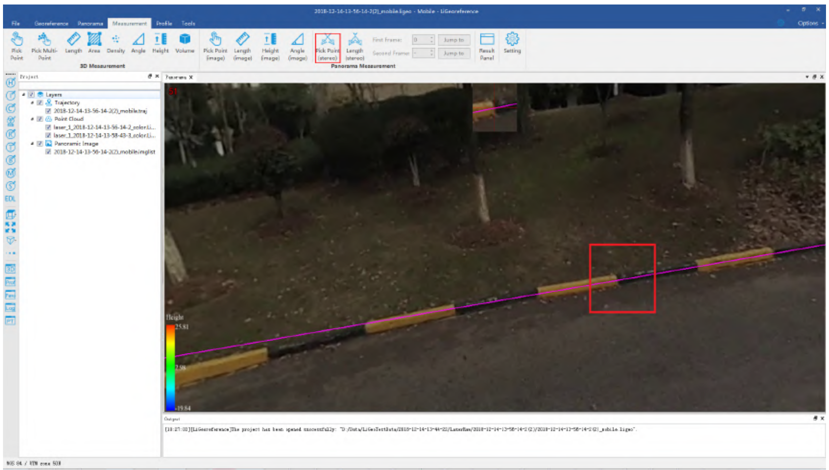
Steps

1. Click the *Pick Point(stereo)*  button via *Panorama Measurement* tag.
2. Select the first corresponding point by left-clicking in panorama window.

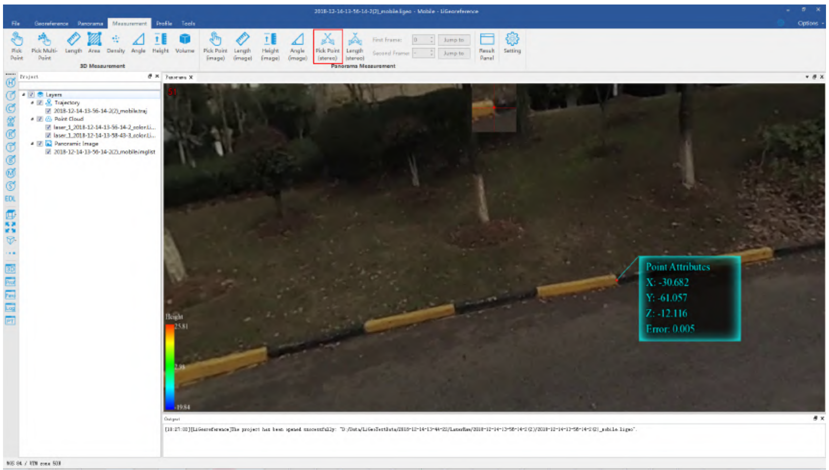


3. The image will update automatically in panorama window.Select the second corresponding point by left-clicking, and the auxiliary line shown on the image helps to select the point.

   The panorama window will switch to the second frame image automatically and the auxiliary line will display：



   Select the corresponding point on the second frame image:



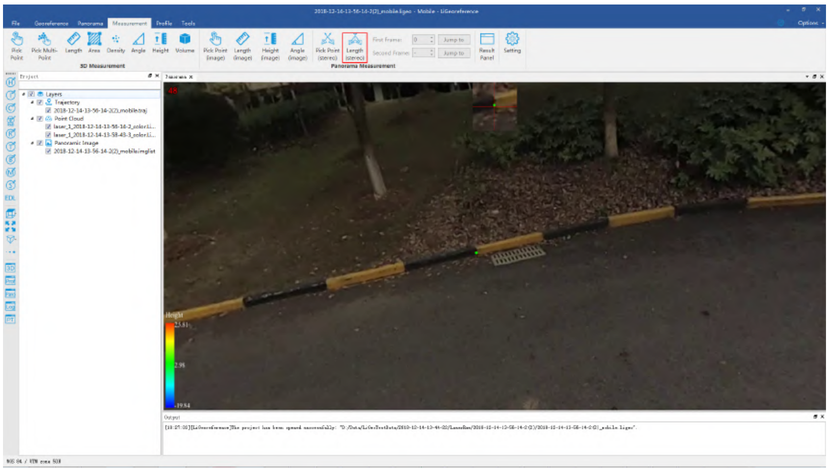
> Note:
>
> 1. In step 3, the auxiliary line is actually the epipolar line generated by the intersection of the epipolar plane with the image plane. If the installation errors between the panorama camera and lidar have been calibrated (The attitude of image is accurate under this condition). In theory, the second corresponding point we select is close by the epipolar line. So the auxiliary line is useful to locate the corresponding point.
>   2. Switch to the first frame image which needs to be measured before selecting the first corresponding point. After selecting the first corresponding point, switch to the second frame image that needs to be measured. The specific switch method is to edit the frame number of *First Frame* and *Second Frame*. And click *Jump to* button or press the button of *Enter*.

Length Measurement (Forward Intersection)

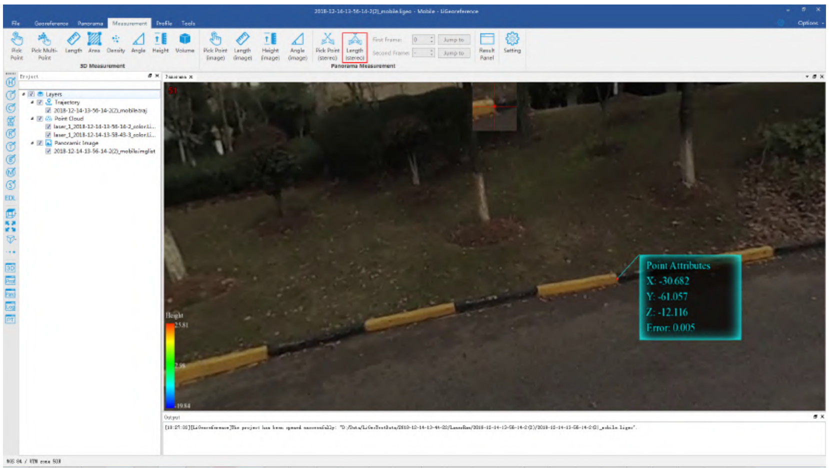
Description: This tool is applicable to panoramic data, which calculates the distance between two consecutive points.

Steps

1. Click the *Length(stereo)*  button via *Panorama Measurement* tag.
2. Left-click to select the starting point in the scene, the operation is the same as Pick Point step.



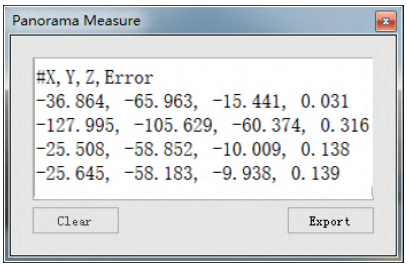
3. Select the end point, the operation is the same as Pick Point。



4. Right-click to go back to the previous point during the measurement.

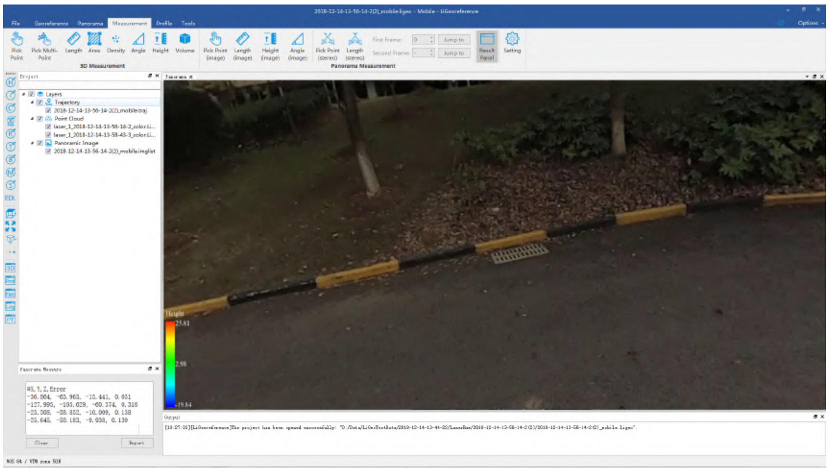
Result Panel

The result of panorama measurements can be recorded in Result Panel. And it is supported to export measured points list.



Steps

1. Click the *Result Panel* button via *Panorama Measurement* tag. The Result Panel will pop up from the left corner.

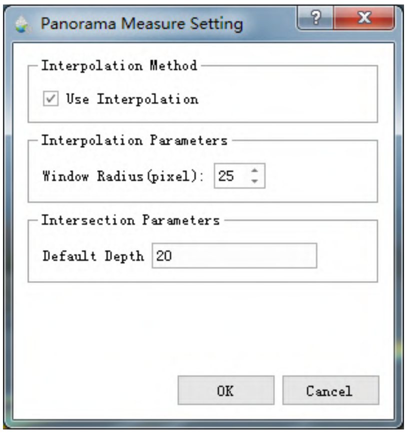


2. Click *Clear* button to clear Result Panel.

3. Click *Export* button to export measured points list.

Dialog Setting

Dialog Setting is used to set parameters for running the function of panorama measurements.



Settings

- **Use Interpolation** : This option is checked by default. It is available to choose whether select the complex interpolation algorithm or not when using the function of Panorama Measurements based on Depth Interpolation. If unselect this function, nearest neighbor algorithm is used to calculate the point location information.
- **Windows Radius (pixel)**: It is the windows radius to be used when running interpolation algorithm. For example, when the windows radius is N, all the depth value around the measured points in the square area whose length value is 2N + 1 (the unit is pixel) will be read. If the point density is not high and measurements can not perform with default windows radius, users can increase the value of windows radius.
- **Default Depth**: It is the assumed depth of measured points. And it is recommended in the second frame image when using the function of Panorama Measurements based on Forward Intersection

Profile Tools

Profile editing tool allows users to view the profile of the point cloud data in the selected rectangle area. Users can view, measure, and edit the data in the profile window.If users want to produce the topographic production with high accuracy, it is necessary to manually check and modify the classification results。

- Switch View
- Select Profile Region
    - Fixed Buffer
    - Move
    - Rotate
    - Expand
- Measure Tools
- Manual Classify

Profile and Measuring Tool

It is supported to use all the 3D measurements tools in the *Measurement* tag in the main viewer. It is only supported to use the measurement tools in the *Profile* tag in the profile sub-window.

> Note: If users switch the profile window to measurement tools interface, the measurement tools will activate. And to reuse the profile tools, it is necessary to restart the profile tools.

Profile and Select Tool

All the select tools (Cut tools included) are supported to use in the main profile window. Only the selection tool in the *Profile* tag are supported in the profile sub-window.

> Note: If users switch the profile window to select tools interface, the measurement tools will activate. And to reuse the profile tools, it is necessary to restart the profile tools.

Switch View

Description: Unlike common 3D scene viewing, by default, the profile does not support rotation operation, we provide four point of views, which are front view, rear view, left view and right view:

Steps

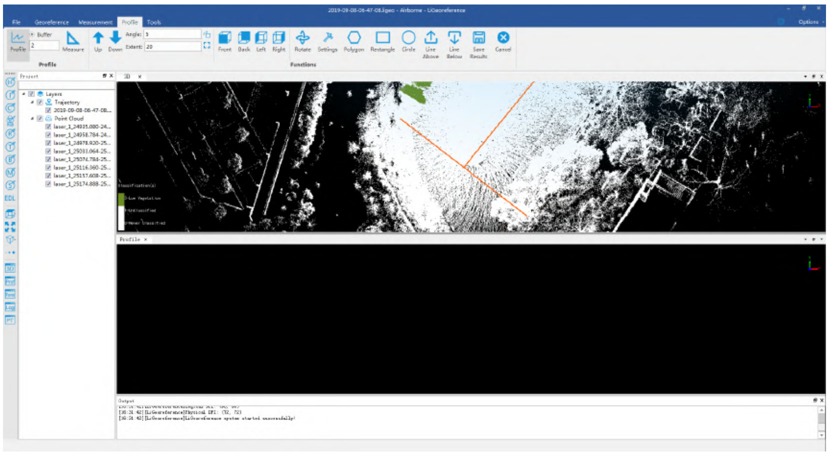
1. By default, profile view shows the front view.
2. **optional** Click the button to switch to front view.
3. **optional** Click the button to switch to rear view.
4. **optional** Click the button to switch to left view.
5. **optional** Click the button to switch to right view.

> Note: It is also supported to start rotate mode under non-default settings.

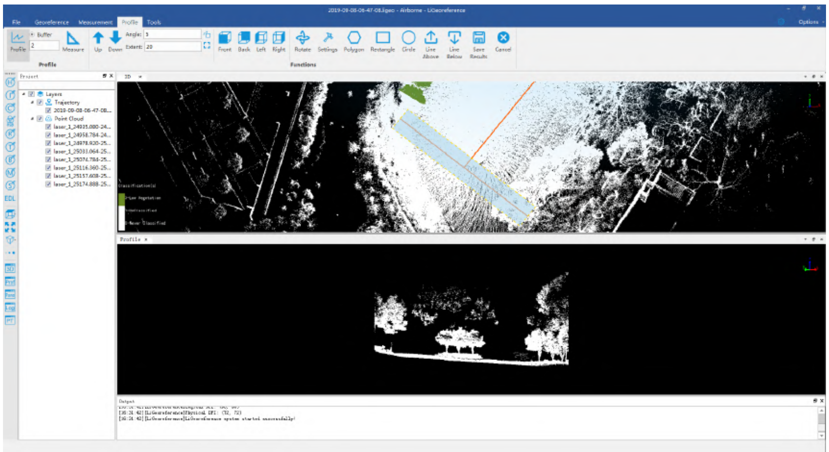
Select Profile Region

Step

1. Move the mouse to 3D window to zoom to interested area.
2. Select the first point by left-clicking, move the mouse to select the second point. The profile direction is done.



3. Move the mouse to select the profile width, double left-clicking to finish selecting profile area. In the profile window, the selected area will be displayed.



After selecting the section area, the selection area may need to be adjusted according to different application scenarios. This software provides a variety of flexible selection area adjustment methods.

Fixed Buffer

Move

Rotate

Expand

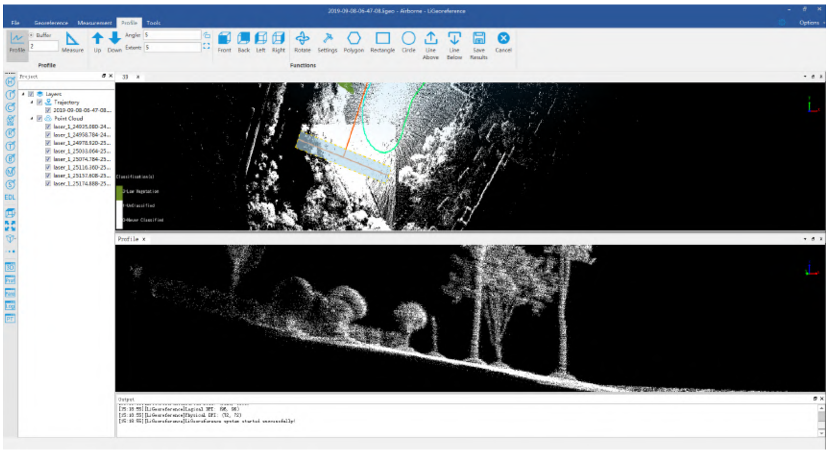
> Note: It is supported to mixed use of tools mentioned above.

Fixed Buffer

Profile buffer width can be fixed to an input value.

Steps

1. Set the *Buffer* in the toolbar, i.e., set the width of the buffer as 2 meters:



2. Check the radio button before *Buffer* value to fix it.
3. Add the first endpoint of the profile by clicking a position. Move the cursor and add the second endpoint in the same way. The two endpoints determine the profile direction.
4. Finished.

Move

Move the current selected area.

Steps

1. Move and zoom to the target area in the main window. Add the first endpoint of the profile by clicking a position. Move the cursor and add the second endpoint in the same way. The two endpoints determine the profile direction.
2. Move the cursor perpendicularly to the profile direction to change the profile width. Then double click to confirm the width.
3. **(Optional)** Click  to move the current selected area forward.
4. **(Optional)** Click  to move the current selected area backward.

Rotate

Description: Rotate the current section area.

Steps

1. Move and zoom to the target area in the main window. Add the first endpoint of the profile by clicking a position. Move the cursor and add the second endpoint in the same way. The two endpoints determine the profile direction.
2. Move the cursor perpendicularly to the profile direction to change the profile width. Then double click to confirm the width.
3. Set the rotation angle (unit: degree, -360~360) in the *Angle* box.
4. Click to rotate.

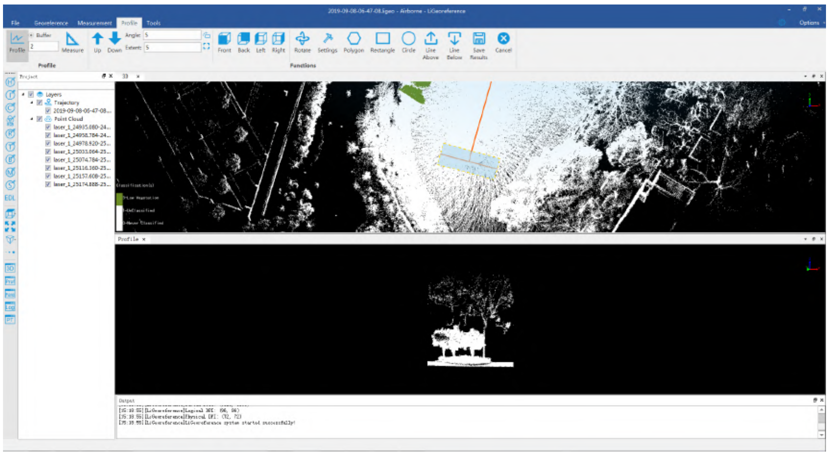
Expand

Description: Expand the selected area to the left and right.

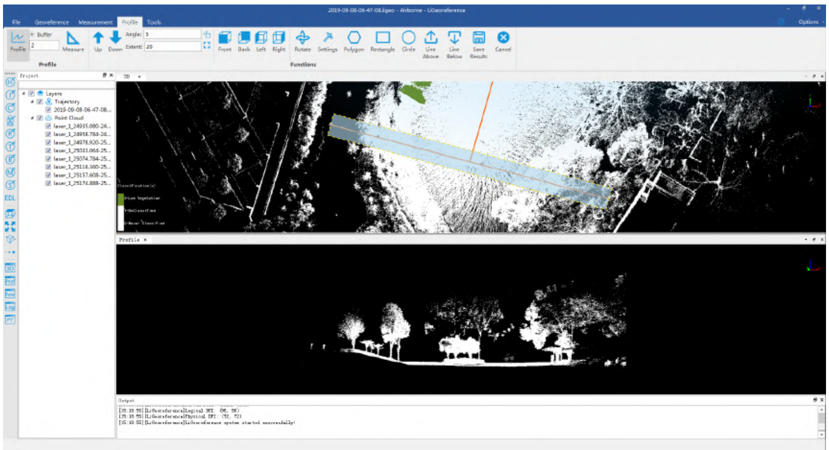
Steps

1. Click the *Expand* button to expand the selected area in the profile.

   Before expanding

   After expanding

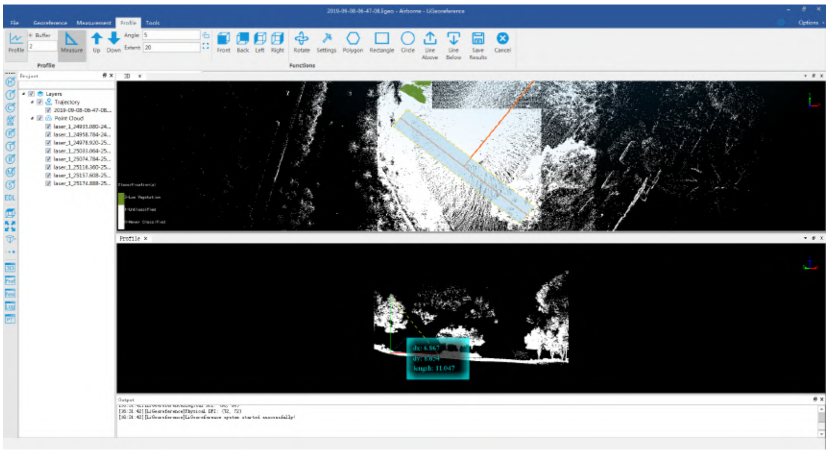
2. Adjust the value in the input box left to the *Expand* button to change the length of expanding each time.

Measure Tool

Description: Unlike general measurements, the orthogonal projection is the default setting in the profile window. After picking two points, their horizontal distance and vertical distance are displayed. When the profile scene rotation function is not turned on, the frustum axis is always perpendicular to the Z axis and parallel to the horizontal plane. Under these conditions, the vertical distance and horizontal distance are useful in certain scenarios. For example, users can use this information to check points cloud data accuracy.

Steps

1. Click the *Measure*  button *profile* tag to start the measurement.
2. Left-click to select the first point.
3. Move the mouse, select the second point by double-clicking, and finalizing the calculating of the distance between the two selected points.

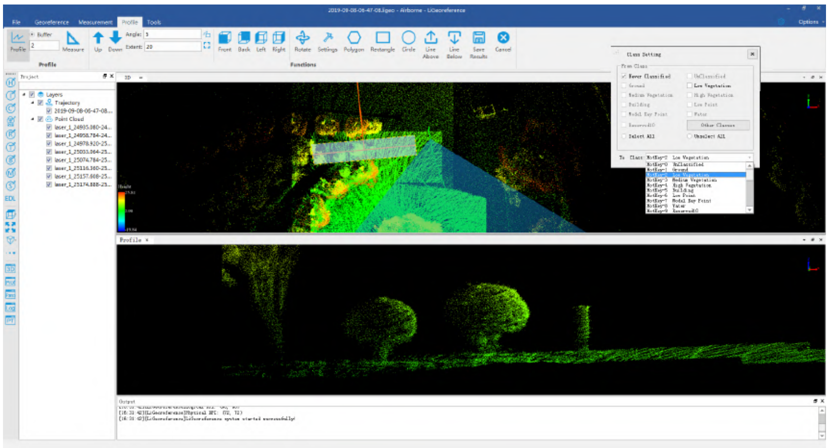


Manual Classify

Description: Most of the tools provided by the profile window are integrated on the toolbar, and these tools can be used for manual classification.

Steps

1. Click the button to set the From and To classes.

   Select the classes need to be modified to confirm the changing classes. And then, if the points with the selected classes are selected by the selection tool, they will be changed to the "To Class". For example, if users only want to change the unclassified points into vegetation points, they only need to check the unclassified points and leave the other classes unchecked in "From Classes", and then set the "To Class" to low vegetation points in the drop-down menu. In this way, in the next selection operation, all the selected unclassified points will automatically become vegetation points until the next time users re-check the "From Classes" or re-select the "To Class".

2. Choose a suitable selection tool and modify the point cloud classes:

   Polygon selection: It is supported using Odd Even Rule to judge if the arbitrary polygons and/or complex concave polygons are selected. Polygon selection is often used to select objects with complex contours, such as a tree, a building, etc.

   Rectangular selection: When the targets are some shapes that are relatively simple, or the requirements are not particularly strict, users can use the rectangular selection directly. Compared with polygon selection, the side of the selection rectangle can only be parallel to the corresponding side of the window. In other words, only the rectangle aligned with the coordinate axis of the window is supported.

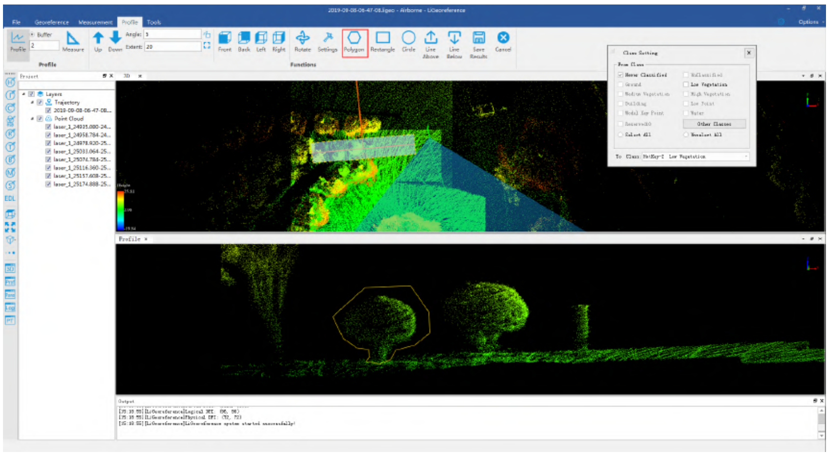
   Circle selection: In some cases, circular selection is also very convenient, such as choosing a circular pool or a parterre.

   Line above selection: select the points above the drawn polyline in the window.

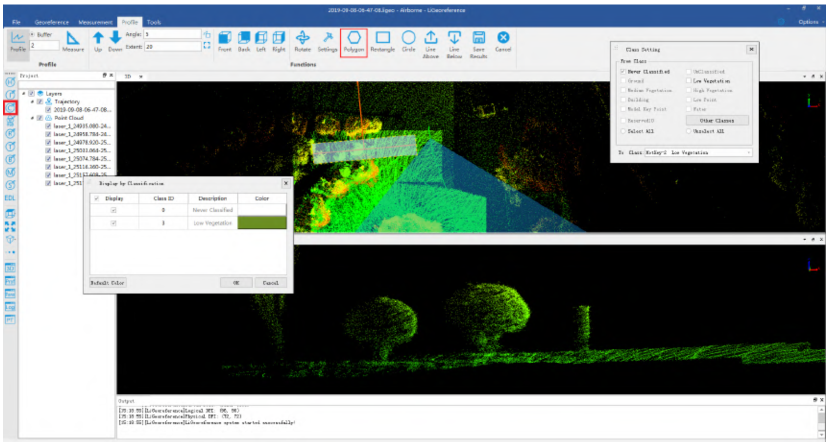
Line below selection: select the points below the drawn polyline in the window.

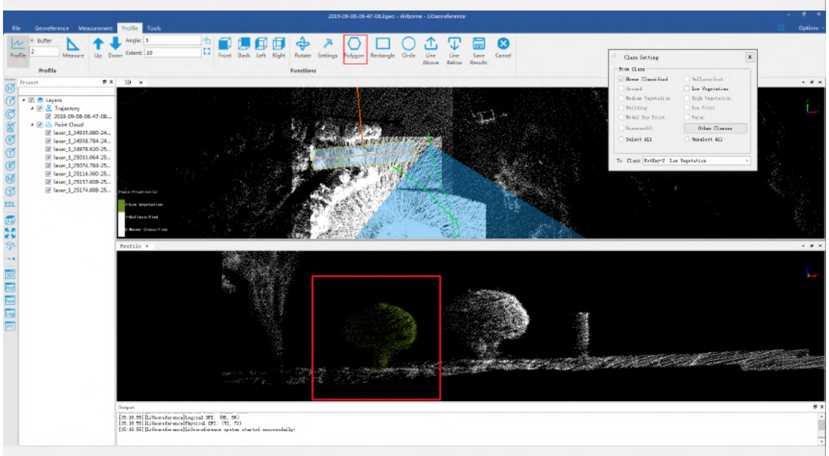
Example (use the polygon selection tool to modify the point cloud class):

Draw polygon (double-click the left mouse button to end the selection)



3. Adjust the display mode to display by class, users can clearly see the point cloud selected in the previous step (click the button in the red box below).





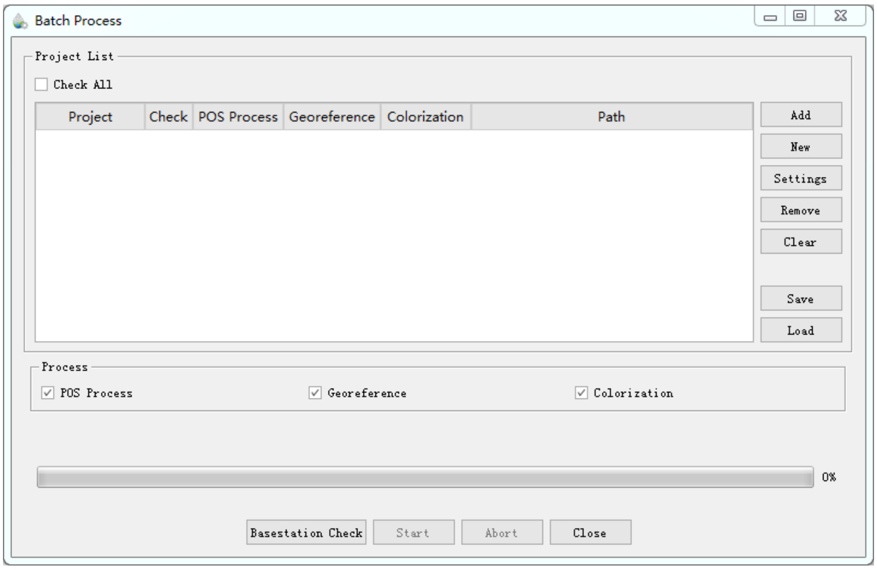
4. **(Optional)** Use Hotkey **Ctrl+Z** to undo the last operation. Or click the button to undo all the temporary operation.

5. After the modification of the point cloud classes in the current area, and confirming all the modification are correct, click the button to save the result permanently.

> All the operations of manual point classification are kept in RAM, please don't forget to save the changes to file.

Batch process

Launch LiGeoreference, and select *Batch Process* to open the page.



Batch Process Page

Add project to batch process list

There are two ways of adding project to batch process list: to add an existing project and to create a new project:

- Add project
  Click *Add* and import project file.

- New project
  Click New to create new project, and it will be imported into the batch process list automatically.

Change georeference process steps

Users can set the georeference procedure on their demands by checking the box for each steps. Please see georeference process for detailed introduction.

Basestation check

Click *Basestation Check* to start checking the validity of the base station file. If there is an invalid base station file, it will prompt whether to download from the greenvalley licloud (the download operation needs to consume points), click to confirm and start to download the base station file, after the download is complete, you can view the project list *Check* column to determine the status of the corresponding project base station.

Start batch process

Click *Start* to start batch process (You need to process *base station check* before batch process).

Abort batch process

Click *abort* to end batch process.

Close batch process

Click *Close* to close batch process. Please note that you cannot close batch process while processing, you need to end processing first.

Save batch process list

Click *Save* to save batch process list.

Load batch process list

Click *Load* to load batch process list saved before.

Remove batch process list

Click *Remove* to remove a specific batch process list row.

Clear batch process list

Click *Clear* to clear all items in batch process list.

Viewing Tools

Set current active window to some view.

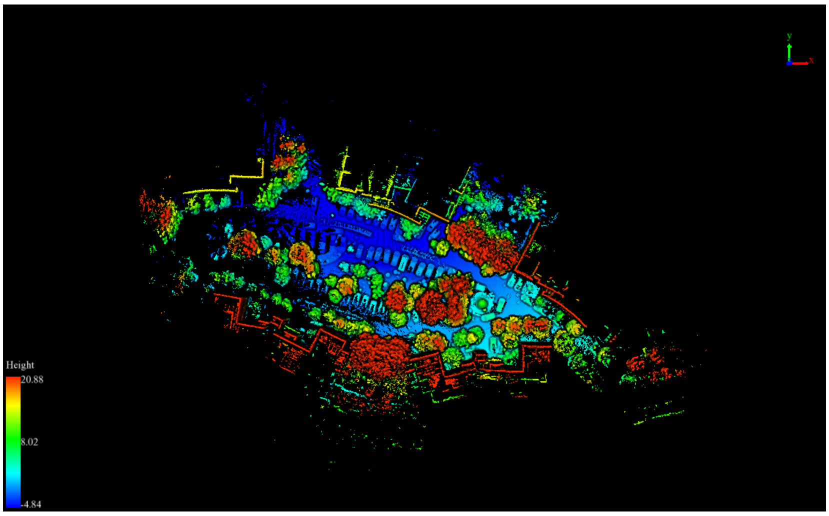
- Top View
- Bottom View
- Left View
- Right View
- Front View
- Back View
- Front Isometric View
- Back Isometric View
- Set View Mode
- Full Extent
- Configure Point Size and Type

Top View

Description: Set camera to top view. View data from +z to -z direction. View plane: x-y plane.

Steps

1. After clicking this button, current active window will be shown:



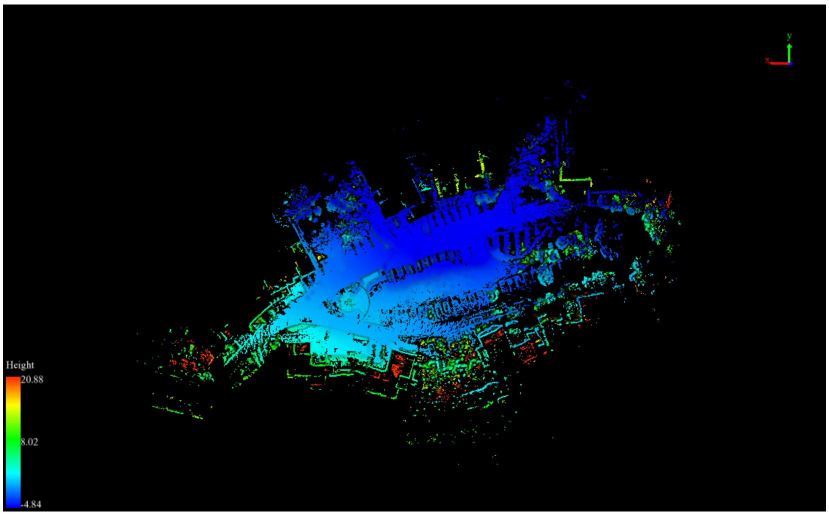
> Note: This tool is only for viewer in 3D mode, and it does not reset the center position of the viewer. If you need to reset to the default view, please click Full Extent。

Bottom View

Description：Set camera to bottom view. View data from -z to +z direction. View plane: x-y plane.

Steps

1. After clicking this button, current active window will be shown:

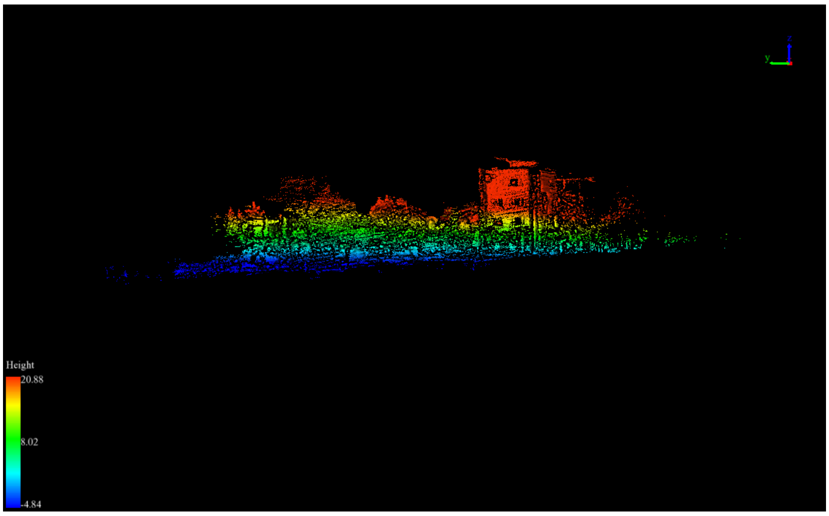


Left View

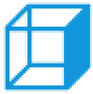
Description: Set camera to left view. View data from -x to +x direction. View plane: y-z plane.

Steps

1. After clicking this button, current active window will be shown:



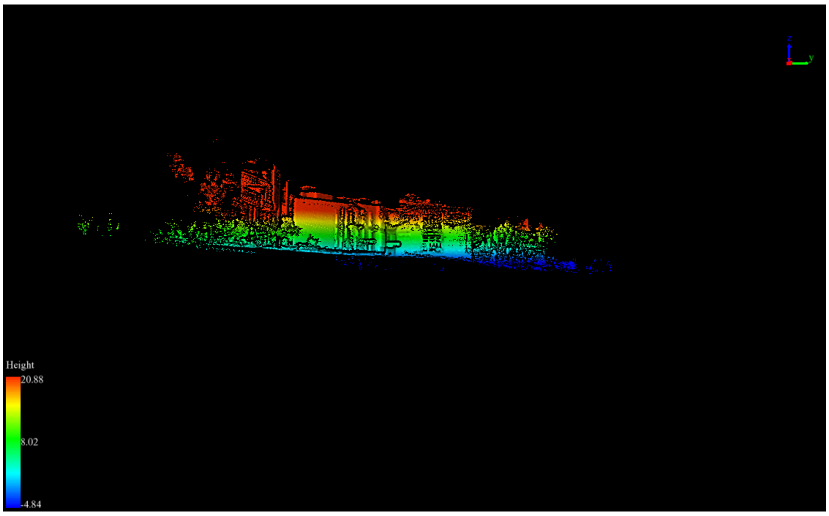
Right View



Description: Set camera to right view. View data from +x to -x directior
View plane: y-z plane.

Steps

1. After clicking this button, current active window will be shown:

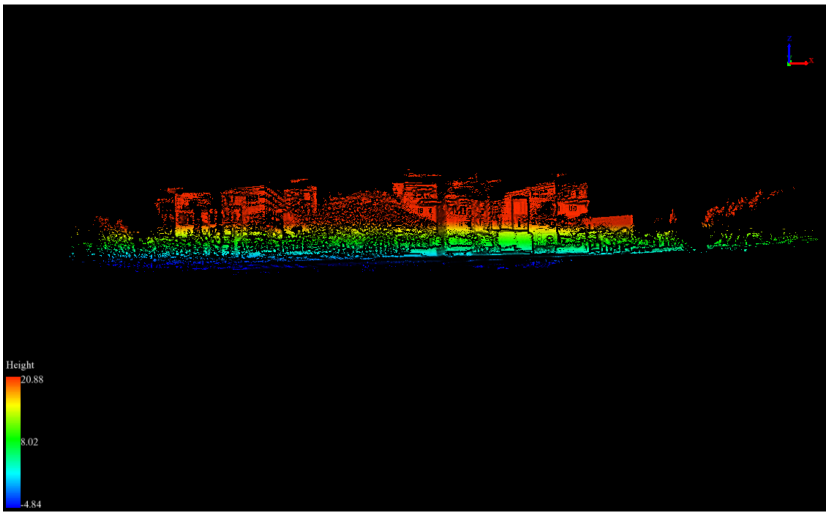


Front View

Description: Set camera to front view. View data from -y to +y directior
View plane: x-z plane.

Steps

1. After clicking this button, current active window will be shown:

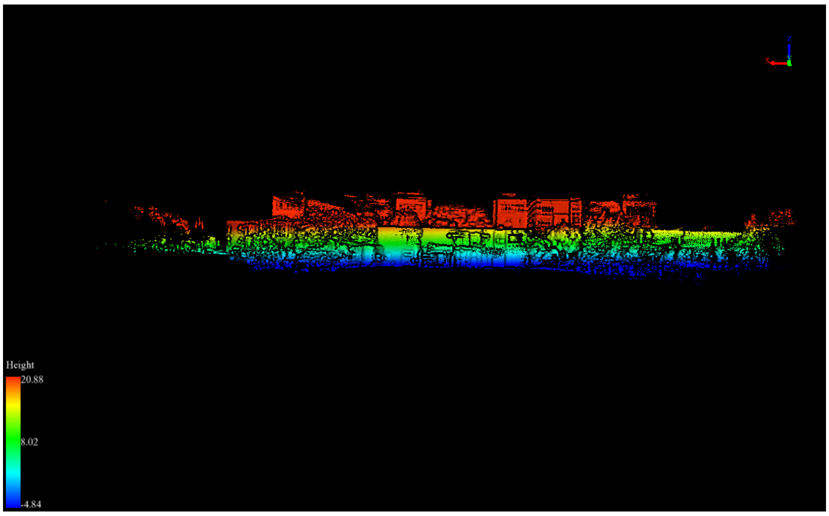


Back View

Description: Set camera to back view. View data from +y to -y directio
View plane is x-z plane.

Steps

1. After clicking this button, current active window will be shown:

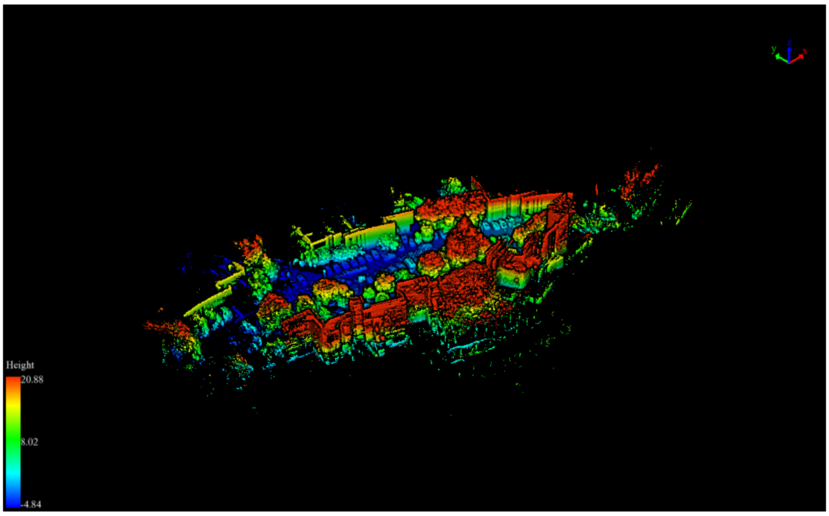


Front Isometric View

Description: Set camera position to front 45 degrees of X-Y plane.

Steps

1. After clicking this button, current active window will be shown:

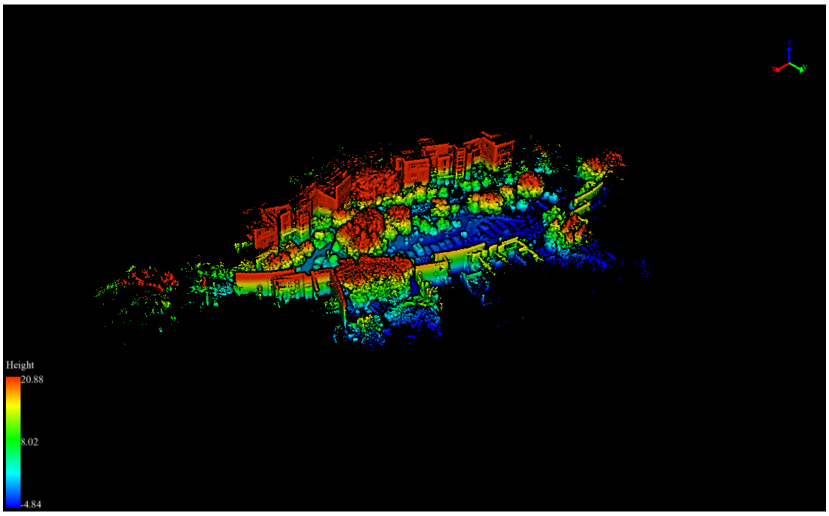


Back Isometric View

Description: Set camera position to back 45 degrees of X-Y plane.

Steps

1. After clicking this button, current active window will be shown:

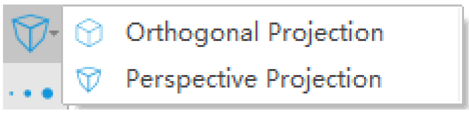


Set View Mode

Description: Select projection mode (orthographic/perspective).

Steps

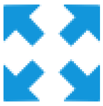
1. After clicking this button, the option of projection mode is popped up. If Orthogonal Projection is selected, current active window will be set in orthogonal projection. If Perspective Projection is selected, current active window will be set in perspective projection.



Setting

- **Shortcut Key**：F3

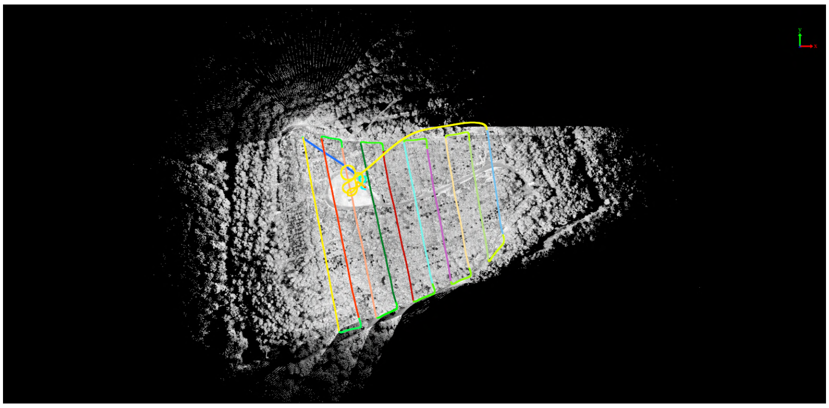
Full Extent



Description: Full extent function is applicable to the 3D viewer, which i used to make all the data in the 3D viewer will fill the entire window in a view, so as to achieve the purpose of global view of the data.

Steps

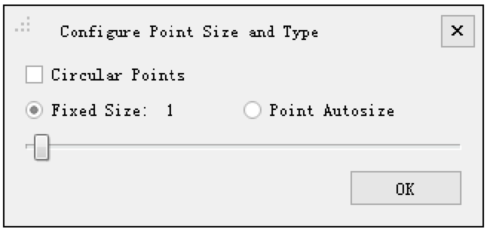
1. Click the  button on the toolbar. And the data in the 3D viewer will automatically zoom to cover the entire window, as shown in the figure.



Configure Point Size and Type

Description: Configure point size and type.

Steps

1. Click this button to open the dialog shown as below:


2. Configure point size and type.

Settings

- **Circular Points**: Determine point type. If checked, point will be rendered as circle, otherwise, point will be rendered as square.
- **Fixed Size**: If checked, point size would be fixed. User can adjust point size using the slider below (range 0-50 pixels).
- **Point Autosize**: If checked, point size is auto changing based on the depth of the viewer.

Color Tools

With tools in this section, LiGeoreference allows you to visualize vast amounts of point cloud using the best data representations for your analysis. You can change the coloration of the point cloud displaying by classification (or intensity, GPS time, return number etc.). You can also enhance the render effect using visualization tools such as EDL, which is intuitive and helpful for quality check.

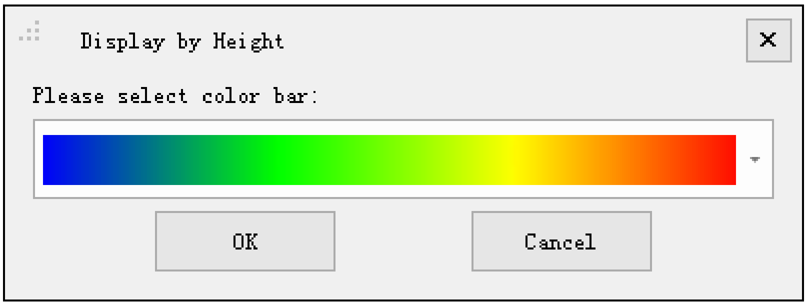
- Display by Height
- Display by Intensity
- Display by Class
- Display by RGB
- Display by Return
- Display by Time
- Display by Blend
- Display by Mix
- Display by Selected
- Display by EDL

Display by Height

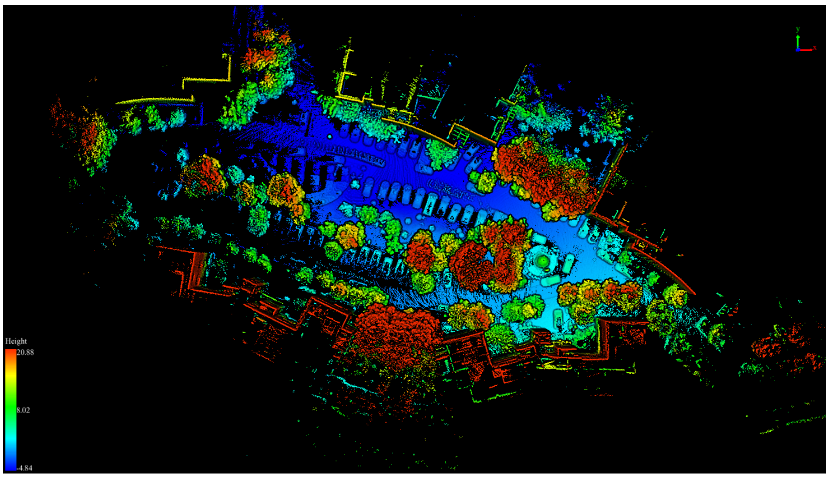
Description: This tool is used for displaying point cloud data. The elev
values of point cloud data are mapped to several uniformly varying colo
intervals, so as to display the variation of elevation values more intuitiv

Steps

1. Click the button on the toolbar to pop up the dialog "Display by Height", as shown below.



2. Select the appropriate color bar in the combo box and click the "OK" button. The color indicator of the window will generate the corresponding color bar according to the elevation range of the point cloud data. At the same time, the data is displayed by elevation in the scene. The visual effects are better with EDL mode, as shown below.



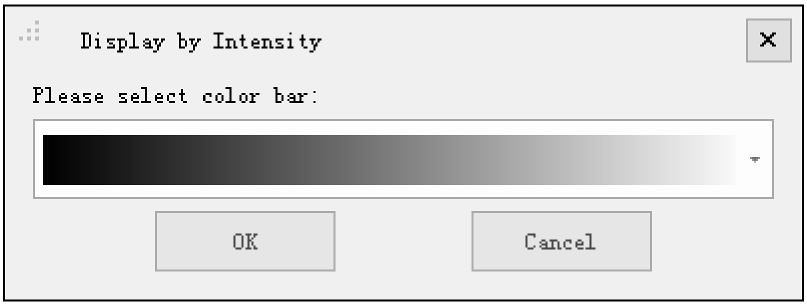
> Note: This tool only works with point cloud data.

Display by Intensity

Description: This tool is used for displaying point cloud data. The inter
values of point cloud data are mapped to several uniformly varying colc
intervals, so as to display the variation of intensity values more intuitive

Steps

1. Click the button  on the toolbar to pop up the dialog "Display by Intensity", as shown below:



2. Select the appropriate color bar in the combo box and click the "OK" button. The color indicator of the window will generate the corresponding color bar according to the intensity range of the point cloud data. At the same time, the data is displayed by intensity in the scene. The visual effects are better with EDL mode, as shown below.

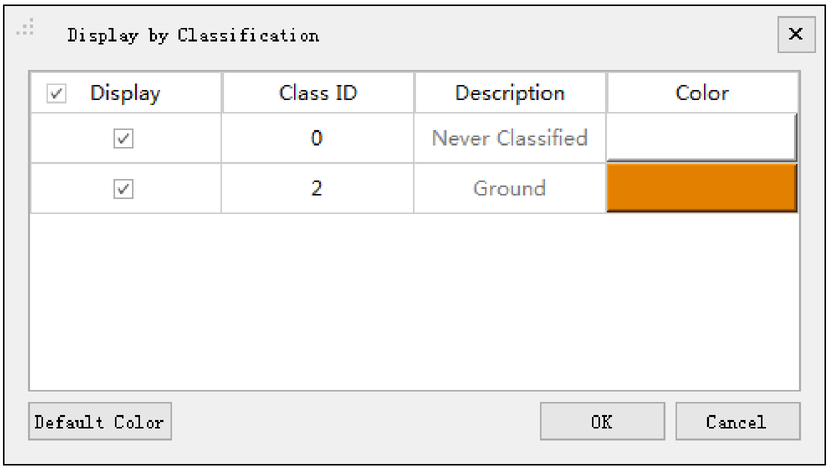
> Note: This tool only works with point cloud data.

Display by Class

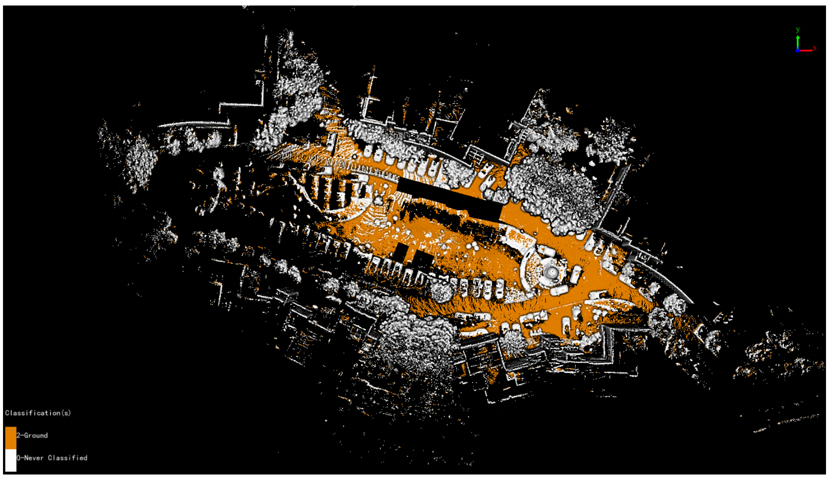
Description: This tool is used for displaying point cloud data. The class of point cloud data are mapped to discrete color values, so as to disting different classes of point cloud data more intuitively.

Steps

1. Click the button  on the toolbar to pop up the dialog "Display by Classification", as shown below:



2. Select the appropriate color for each class and click the "OK" button. The color indicator of the window will generate the corresponding color bar according to the class attribute of the point cloud data. At the same time, the data is displayed by classification in the scene. The visual effects are better with EDL mode, as shown below.



> Note: This tool only works with point cloud data.

Display by RGB

Description: This tool is used for displaying point cloud data. The poin cloud data is displayed according to its own color value.

Steps

1. Click the button on the toolbar. The data is displayed according to its own RGB values in the scene, as shown below:

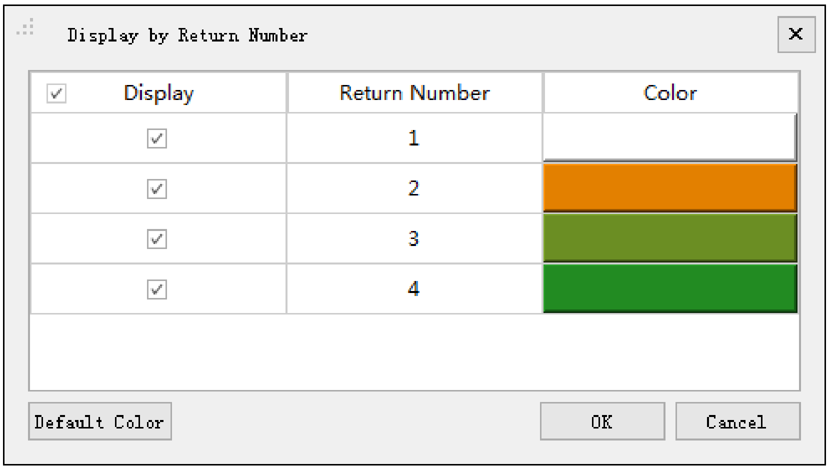
> Note: This tool only works with point cloud data contains RGB attributes.

Display by Return

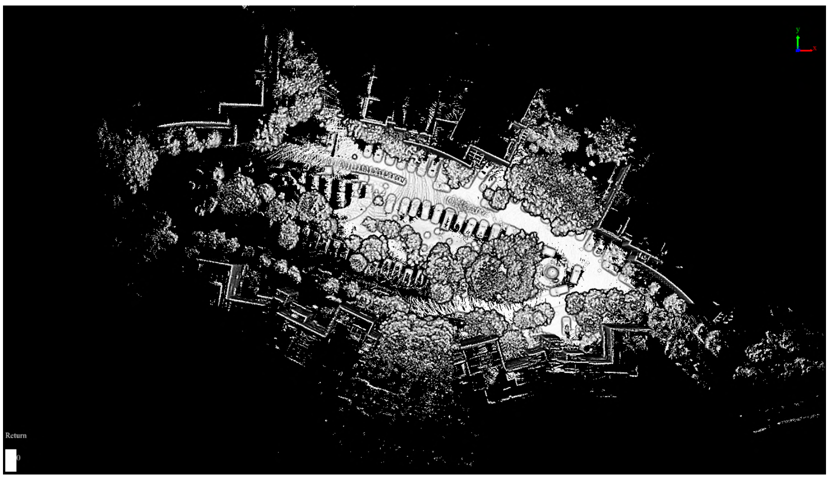
Description: This tool is used for displaying point cloud data. The retur numbers of point cloud data are mapped to discrete color values, so as distinguish different return numbers of point cloud data more intuitively.

Steps

1. Click the button on the toolbar to pop up the dialog "Display by Return Number", as shown below:



2. Select the appropriate color bar for each return number and click the "OK" button. The color indicator of the window will generate the corresponding color bar according to the return number attribute of the point cloud data. At the same time, the data is displayed by return number in the scene. The visual effects are better with EDL mode, as shown below:



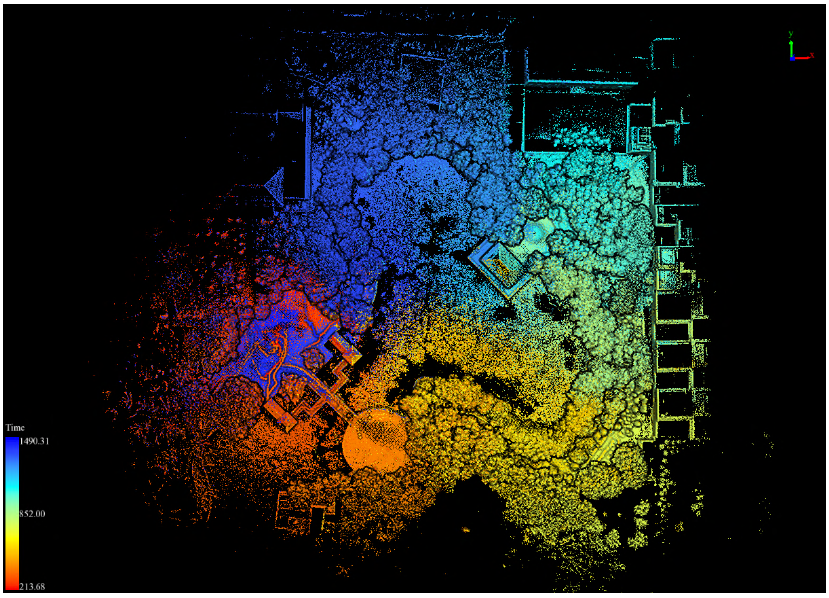
> Note: This tool only works with point cloud data.

Display by Time

Description: This tool is used for displaying point cloud data. The GPS time values of point cloud data are mapped to several uniformly varying color intervals, so as to display the variation of GPS time values more intuitively.

Steps

1. Click the button on the toolbar to pop up the dialog "Display by Time".
2. Select the appropriate color bar in the combo box and click the "OK" button. The color indicator of the window will generate the corresponding color bar according to the GPS time range of the point cloud data. At the same time, the data is displayed by time in the scene. The visual effects are better with EDL mode, as shown below.



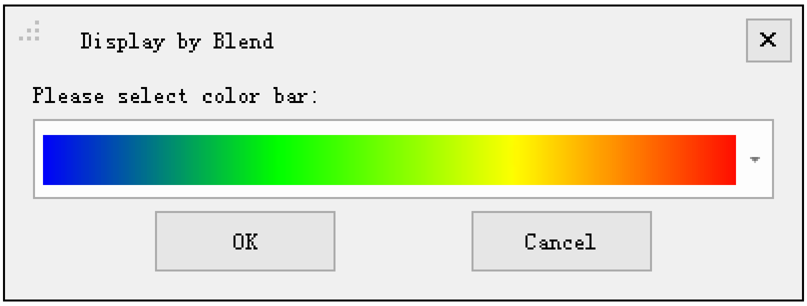
> Note: This tool only works with point cloud data.

Display by Blend

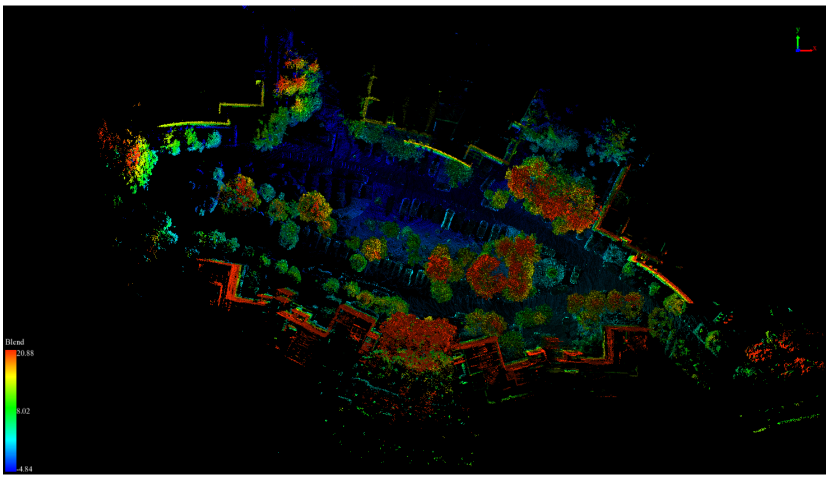
Description: This tool is used for displaying point cloud data. Consider elevation attribute and intensity attribute, the point cloud data is mappe several uniformly varying color intervals, so as to reflect the compreher variation of elevation/intensity more intuitively, and display the feature c and boundary more explicitly.

Steps

1. Click the button on the toolbar to pop up the dialog "Display by Blend", as shown below.



2. Select the appropriate color bar in the combo box and click the "OK" button. The color indicator of the window will generate the corresponding color bar according to the elevation range of the point cloud data. At the same time, the data is displayed in the scene according to the elevation values and intensity values. The visual effects are better with EDL mode, as shown below.



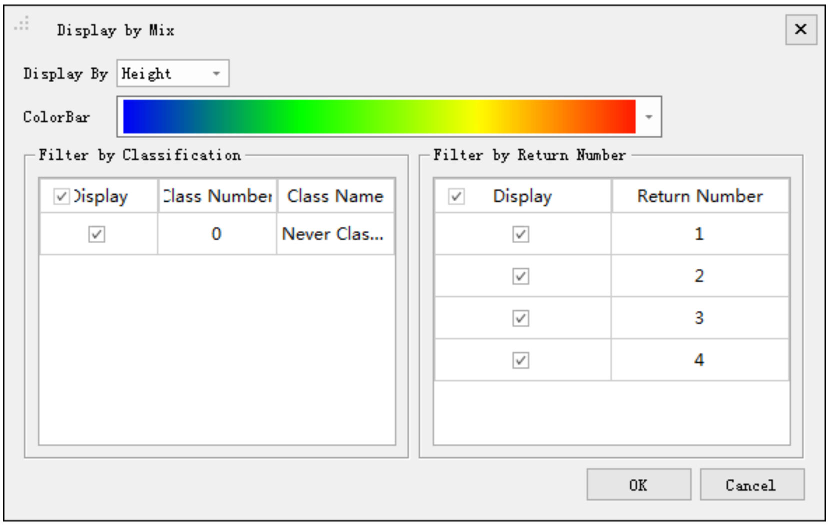
> Note: This tool only works with point cloud data. The visual effects will be better after PCV process for the point cloud data.

Display by Mix

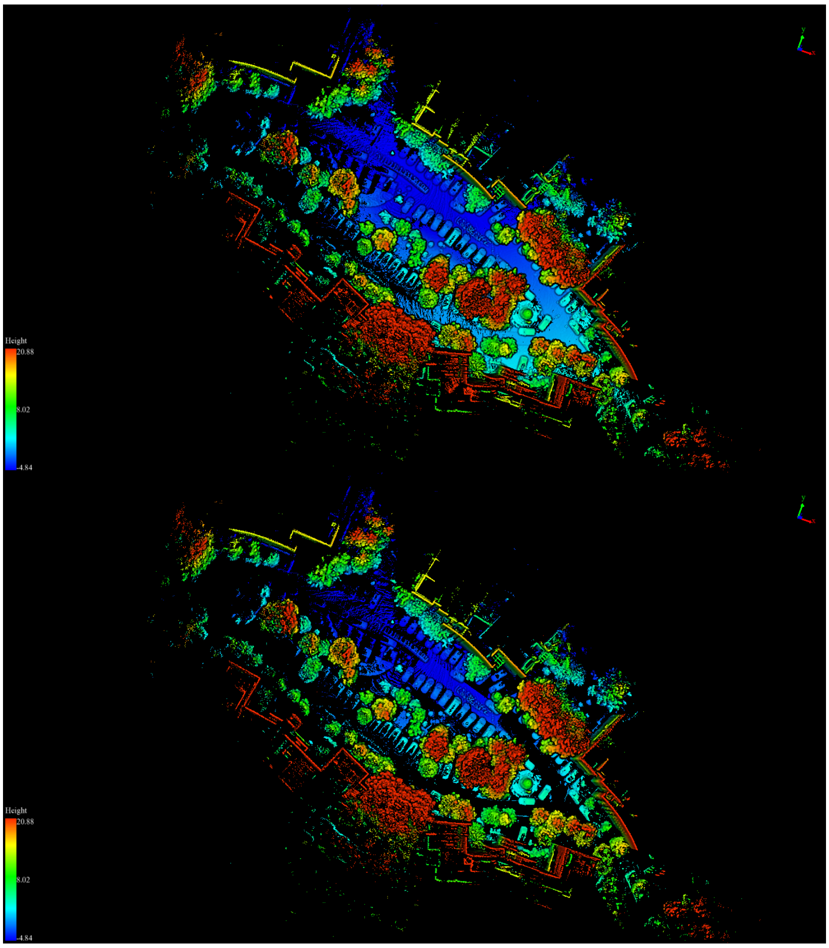
Description:This tool is used for displaying point cloud data. Different attributes of point cloud data are mapped to several uniformly varying c intervals, at the same time different ways of attribute filtering are suppo so as to display the variation of a certain attribute of the filtered point cl data more intuitively.

Steps

1. Click the button on the toolbar to pop up the dialog "Display by Mix", as shown below.



2. Select the attribute for display.
3. Select the appropriate color bar in the combo box.
4. Check the classes and return numbers for filtering.
5. Click the "OK" button. Then the color indicator of the window will generate the corresponding color bar according to the selected attribute range the point cloud data. The data will be filtered by the specified attributes first and then be displayed by the specified attributes in the scene. The visual effects are better with EDL mode, as shown below.



Settings

- **Display By**: The selected attribute will be mapped to specified color range.
  - **Height(Default)**: The elevation attribute of the point cloud data.
  - **Intensity**: The intensity attribute of the point cloud data.
  - **Time**: The GPS Time attribute of the point cloud data.
- **ColorBar**: The color bar supports several uniformly varying color intervals for color mapping.
- **Filter by Classification**: List all the classes users can choose to filter the point cloud data.
- **Filter by Return Number**: List all the return numbers users can choose to filter the point cloud data.

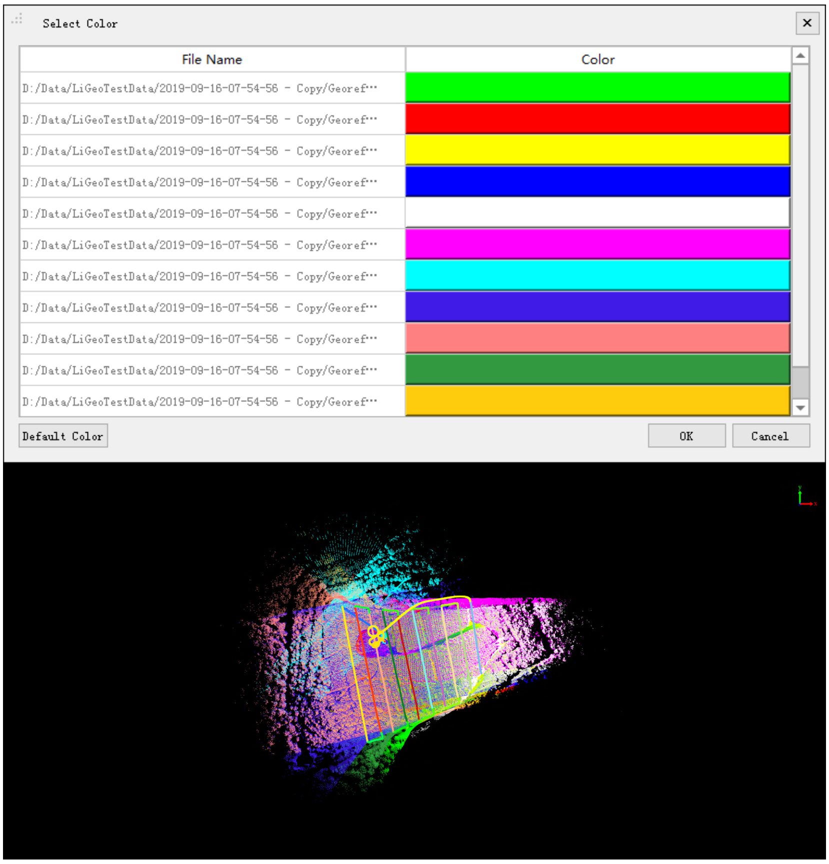
> Note: This tool only works with point cloud data.

Display by Selected

Description: Display each different point cloud data in different colors.

Steps

1. Click the button on the toolbar. Each point cloud data is displayed according to the specified color, as shown below:



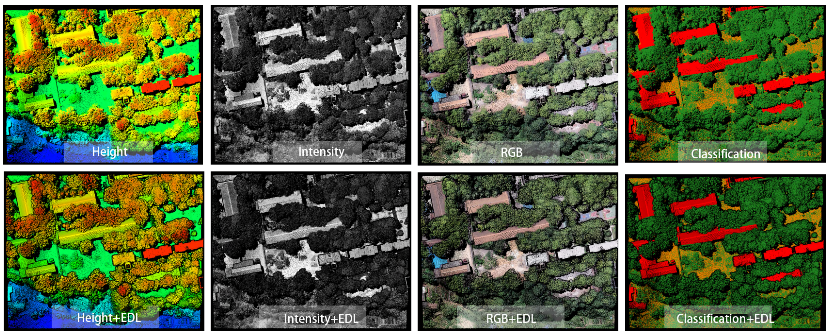
Display by EDL

EDL

Description: This tool is used to display the point cloud data and enha the visual effects of the contour features using the Eye Dome Lighting (EDL) mode. EDL is a shading technique that works with other display mode (e.g. display by height, display by intensity) to improve the depth perception in 3D point cloud visualization.

Steps

1. Click the button EDL on the toolbar. The visual effects of the point cloud data in the scene will be improved with EDL mode. The following picture shows the comparison before and after using EDL display mode.



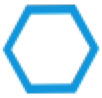
> Note: This tool only works with point cloud data.

Selection Tools

Tools to select the point cloud data, and save or classify the points in the selected area. Including polygon selection, rectangle selection, sphere selection, circle selection, line above selection, line below selection, plane selection, subtract selection, and cancel selection.

- Polygon Selection
- Rectangle Selection
- Sphere Selection
- Circle Selection
- Line above Selection
- Line below Selection
- Plane Selection
- Subtract Selection
- Cancel Selection

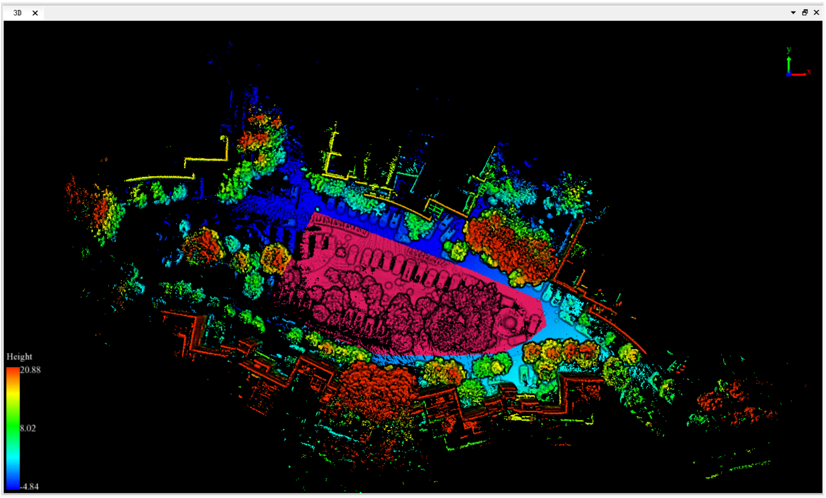
Polygon Selection



Description: Select point cloud data in the drawn polygon area.

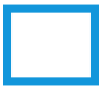
Step

1. Click the button  to activate this function.
2. Add polygon vertices by left click. At least 3 vertices are needed to form a closed polygon.
3. (Optional) Delete added vertices in reverse order by right-clicking, if some of them are unwanted.
4. Left double click to add the last vertex. The selected points in the polygon area are highlighted in red.



5. After the first selection, users can make another selection and combine the results of two selections.

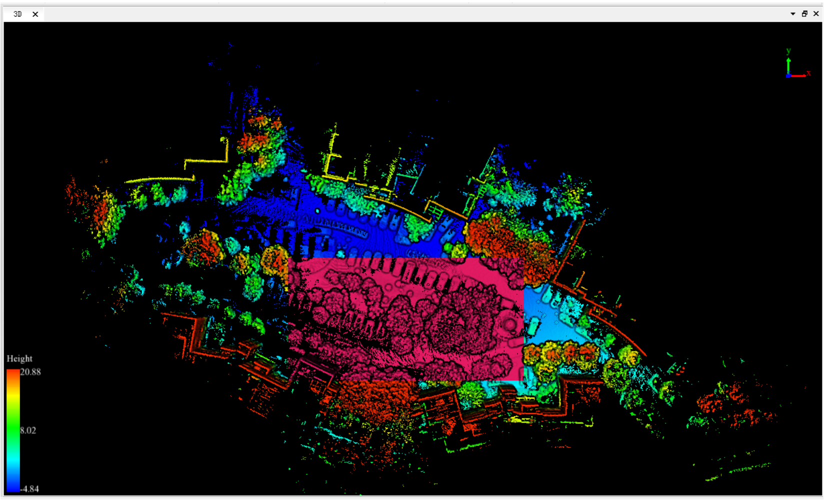
Rectangle Selection



Description: Select point cloud data in the drawn rectangle area.

Step

1. Click the button  to activate this function.
2. Add the first vertex by left click. Then move cursor to adjust rectangle size.
3. (Optional) Delete the first vertex by right-clicking, if it's unwanted.
4. Left double click to add the second diagonal vertex. The selected points in the rectangle area are highlighted in red.

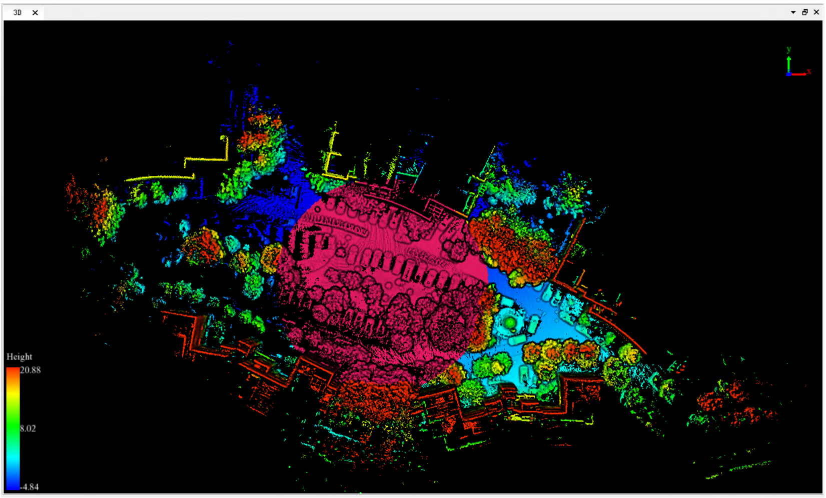


5. After the first selection, users can make another selection and combine the results of two selections.

Sphere Selection

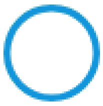
Description: Select point cloud data in the drawn sphere.

Step

1. Click the button  to activate this function.
2. Add the center point of sphere by left click. Then move cursor to adjust radius.
3. (Optional) Delete the center point by right-clicking, if it's unwanted.
4. Left double click to confirm the radius. The selected points in the sphere are highlighted.


5. After the first selection, users can make another selection and combine the results of two selections.

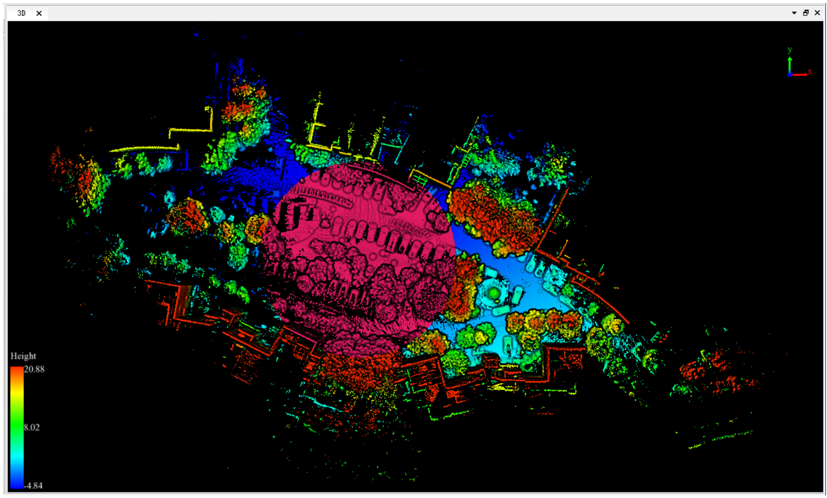
Circle Selection



Description: Select point cloud data in a circle area.

Steps

1. Click the button  to activate this function.
2. Click to select the center of the circle. Move the mouse, and the position of mouse will be recognized as the boundary of the circle.
3. Right-click to cancel the circle center selection. Go back to the second step and choose the circle center again.
4. Double-click to define the boundary of the circle. The selected points in the circle area will be highlighted in red.



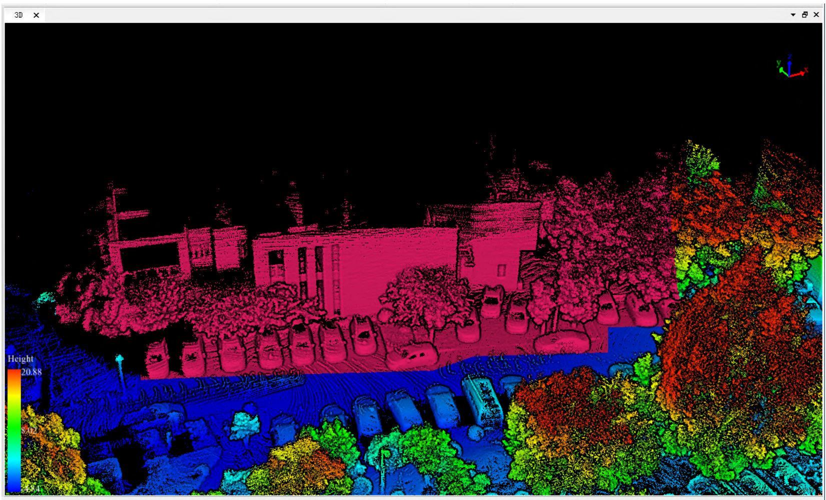
5. After the first selection, users can make another selection and combine the results of two selections.

Line above Selection

Description: Select point cloud data above the drawn line.

Step

1. Click the button to activate this function.
2. Add the first vertex by left click. Move the mouse, the mouse position is determined to be the boundary point of the area above the line.
3. Right-click to cancel the first vertex selection. Go back to the second step and choose the vertex again.
4. Left double click to finish selection. The selected area above the polylines are highlighted in red.



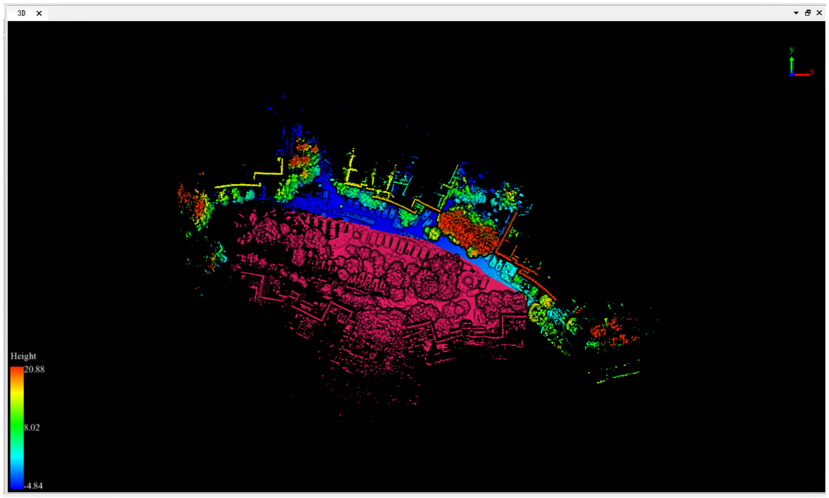
5. After the first selection, users can make another selection and combine the results of two selections.

Line below Selection

Description: Select point cloud data above the drawn line.

Step

1. Click the button  to activate this function.
2. Add the first vertex by left click. Move the mouse, the mouse position is determined to be the boundary point of the area below the line.
3. Right-click to cancel the first vertex selection. Go back to the second step and choose the vertex again.
4. Left double click to finish selection. The selected area below the polylines are highlighted in red.



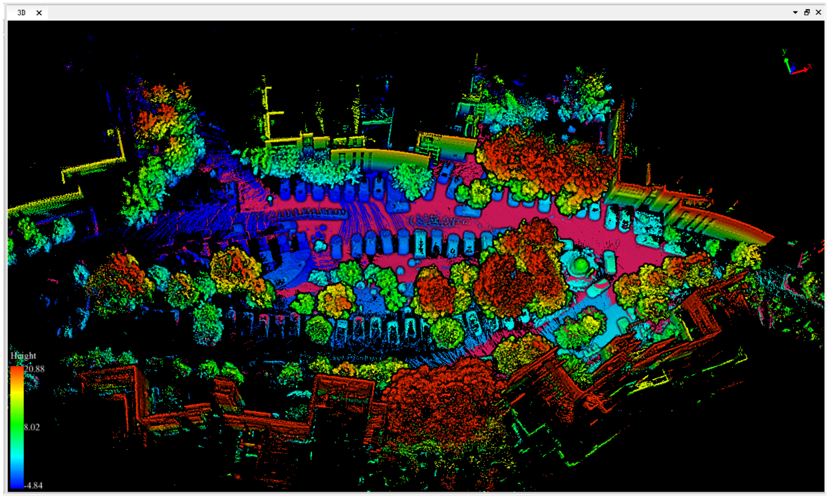
5. After the first selection, users can make another selection and combine the results of two selections.

Plane Selection

Description: Select point cloud data automatically in specific area.

Step

1. Click the button to activate this function.
2. In the window, select a polygon area and all the points in this selected plane, which the polygon is in, will be generated automatically.
3. Right-click to cancel the last point selection. Go back to the previous step and choose the point again.
4. Left double click to finish selection. The selected plane are highlighted in red.



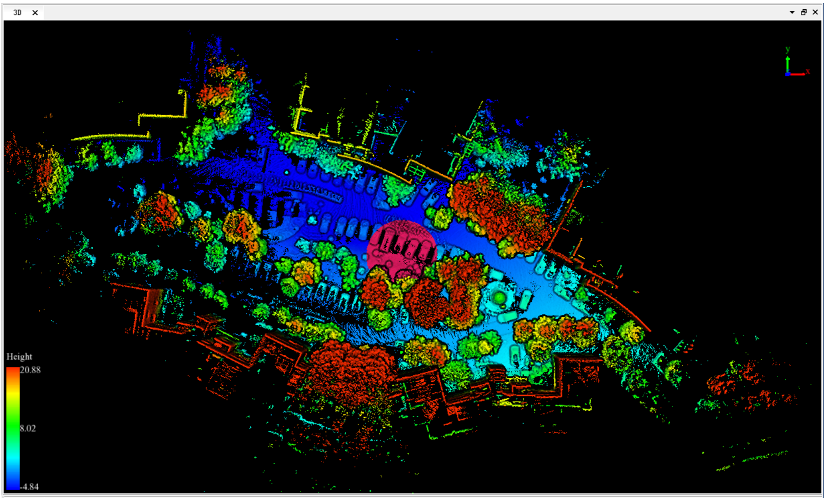
5. After the first selection, users can make another selection and combine the results of two selections.

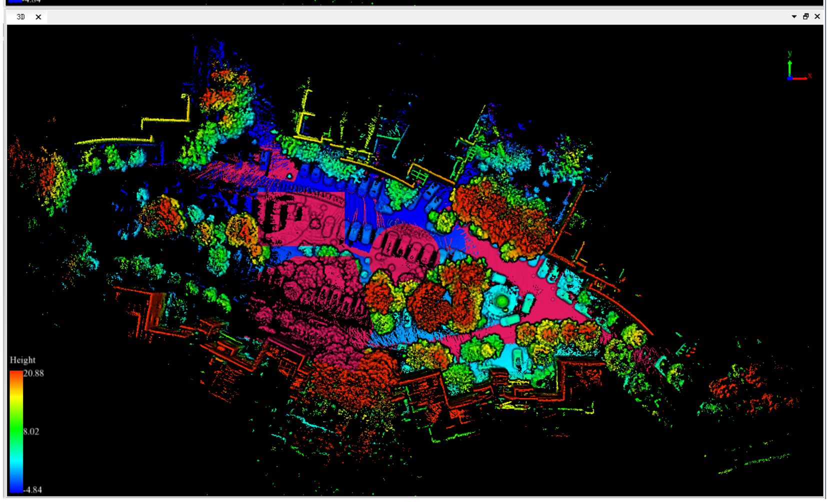
Subtract Selection

Function Description: If Subtract Selection is inactive, more points ca added to the currently selected. If active, unwanted points can be remo from the currently selected. This function is effective on one of the geometric selection tools including Polygon Selection, Rectangle Selec Sphere Selection, Circle Selection, Line above Selection, Line below Selection, Panel Selection

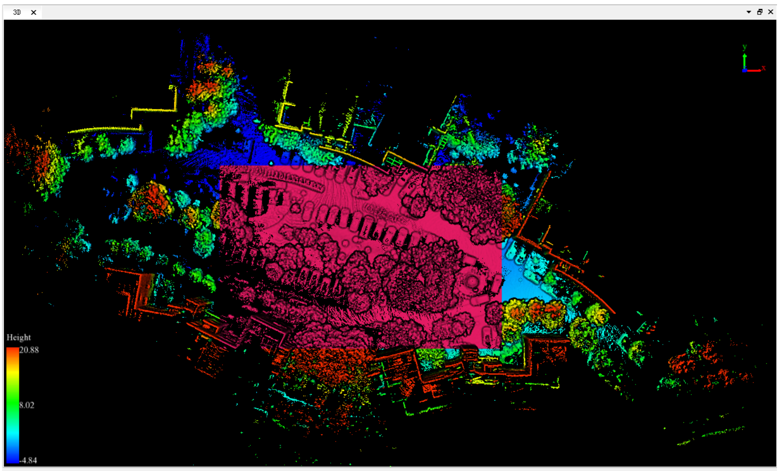
Step

1. Activate one of the geometric selection tools (Polygon Selection, Rectangle Selection, Sphere Selection, Circle Selection, Line above Selection, Line below Selection, Panel Selection) before using Subtract Selection. Then please activate/deactivate Subtract Selection by left click.
2. (Optional) If Subtract Selection is inactive, multiple selections can be combined.

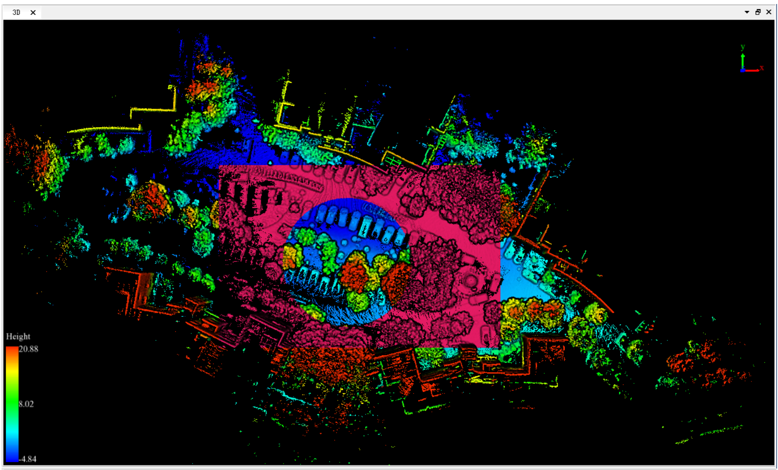


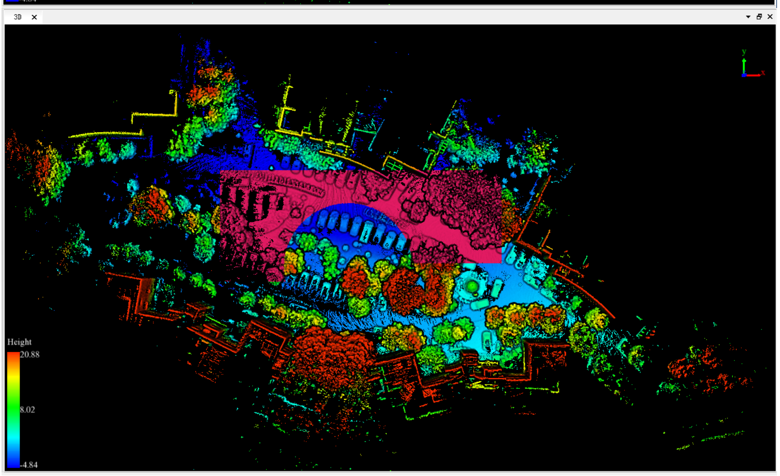


3. (Optional) If Subtract Selection is active , unwanted points can be removed from the currently selected.
    - 3.1 Select an initial selection area.



    - 3.2 Activate Subtract Selection, choose polygon selection and circle selection to delete the area.





Cancel Selection

Description: Cancel all the selections and cut operations.

Step

1. Click this button after selections (Polygon Selection, Rectangle Selection, Sphere Selection, etc.) or cut operations (In Cut, Out Cut).
2. Click the button . All the selections and cut operations will be canceled.

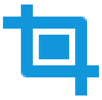
> Note: This function is only applicable to point cloud data.

Cut Tools

To clip the point cloud data, the area selected by the Select Tool can be in cut and out cut. The cut result can be saved, and cancel the selection.

- In Cut
- Out Cut
- Save Cut Result
- Cancel Selection

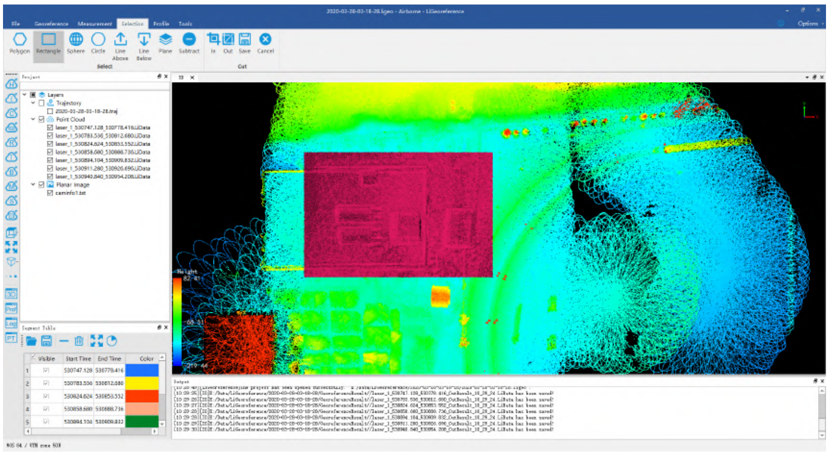
In Cut



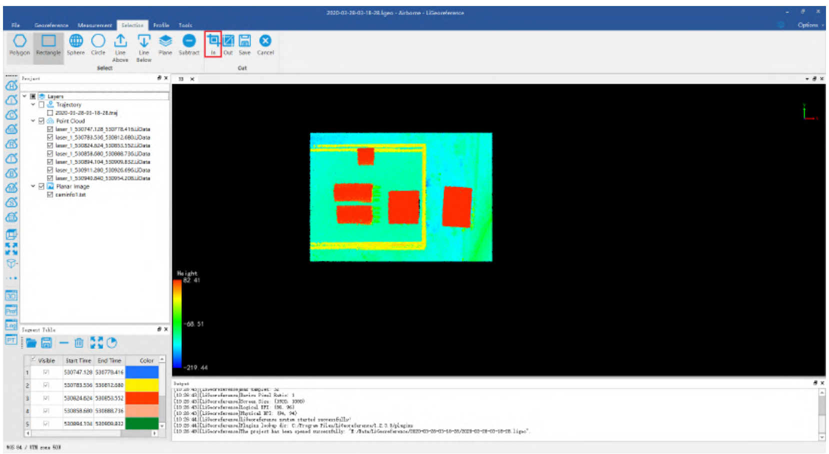
Description: Based on the currently selected area, clip all the point clo data in the window, retain the point cloud in the selected area, and the point cloud outside the selected area is hidden.

Steps

1. Select the area to be cut first. Please use the selecting tools, (Polygon Selection, Rectangle Selection, Sphere Selection, Circle Selection, Line Above Selection, Line Below Selection, Plane Selection), to pick the area of interests, as shown below:



2. Click this tool icon to keep the area inside the selected area, as shown below:



3. After the cut, users can select the points and cut again.

Settings

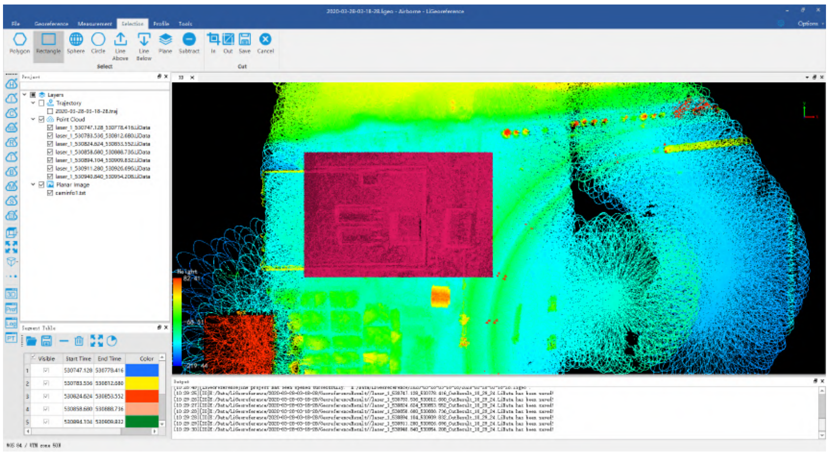
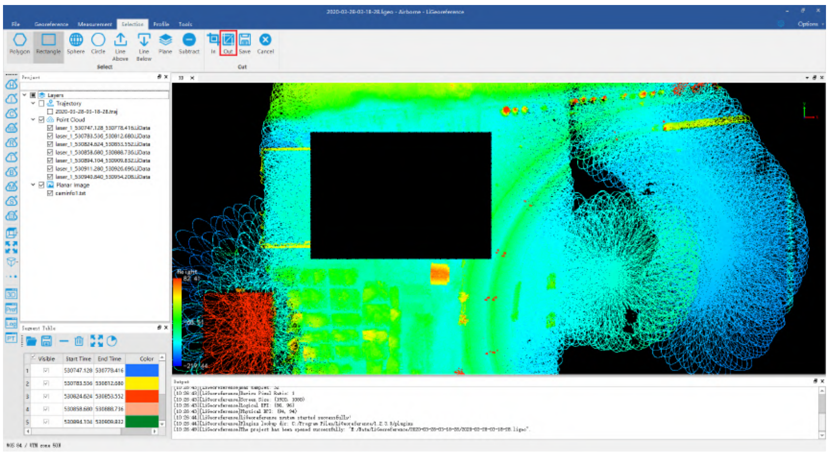
- **Hot Key**：**Ctrl + Z** Cancel the last cut effect. The selected area will be canceled as well.

> Note: This tool only works with point cloud data.

Out Cut

Description: Based on the currently selected area, clip all the point clo data in the window, retain the point cloud outside the selected area, an the point cloud inside the selected area is hidden.

Steps

1. Select the area to be cut first. Please use the selecting tools, (Polygon Selection, Rectangle Selection, Sphere Selection, Circle Selection, Line Above Selection, Line Below Selection, Plane Selection, Subtract Selection), to pick the area of interests, as shown below:

2. Click this tool icon to keep the area outside the selected area, as shown below:

3. After the cut, users can select the points and cut again。

Settings

- **Hot Key**：**Ctrl + Z** Cancel the last cut effect. The selected area will be canceled as well.

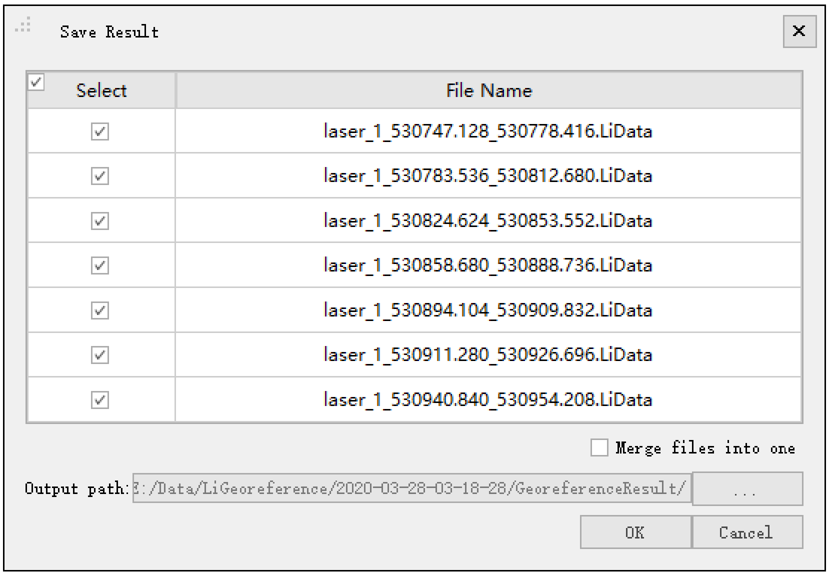
> Note: This tool only works with point cloud data.

Save Cut Result

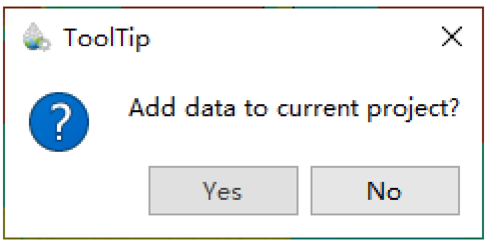
Description: Save the result of point cloud after cutting as a new point cloud file.

Steps

1. First, cut the point cloud and get the cut result. Please refer to In Cut and Out Cut。
2. When there is a cutting result, this function is activated. Click this function to pop up the save settings window, as shown in the figure.



3. Select the original point cloud data to participate in the cutting and saving function.
4. Choose whether to merge all the cut point clouds into one point cloud file based on users' needs.
5. Select the output path of the cut file, the system will form a new cut file name based on the original file name and the current system time, and the naming rule is "Original file name_CutResult_Time information.LiData".
6. After saving, it will automatically cancel the original selection and cutting effects in the window, and ask the user whether to add the cut data to the current project, as shown in the figure.



7. Users can select whether to load the result to the current viewer based on needs. If yes, the corresponding cut and saved file will be loaded to the current project.

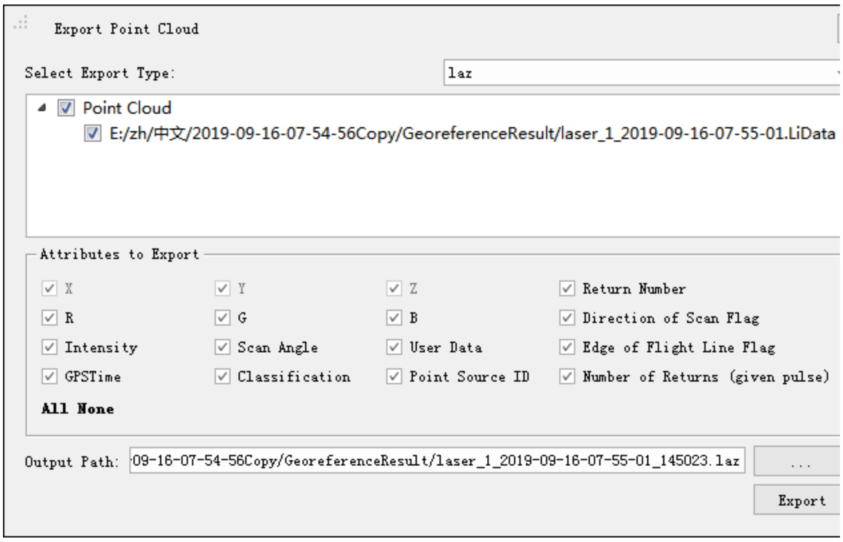
Export Tools

- Export LAS File
- Export Camera Information

Export LAS File

The LiData data result can be converted into Las/Laz format data, used as input of third-party software, and used for data display or further data processing.

Click the *Export LAS File*  button to export the high-accuracy point cloud data in LAS/LAZ format.



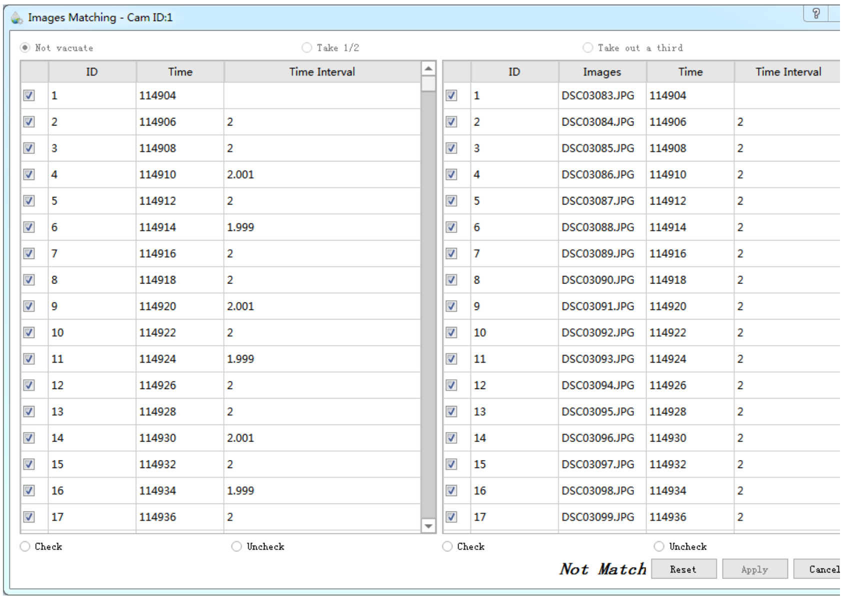
Export Camera Information

Summary

Generic camera files can be generated based on the imported trajectory files and original camera files for point cloud coloring.

Usage

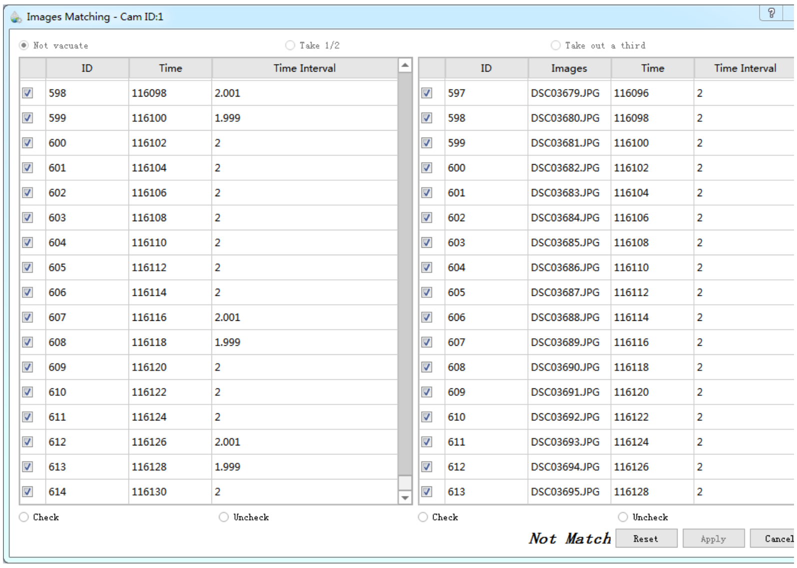
Click the *Export Camera Info* button to generate the generic camera files



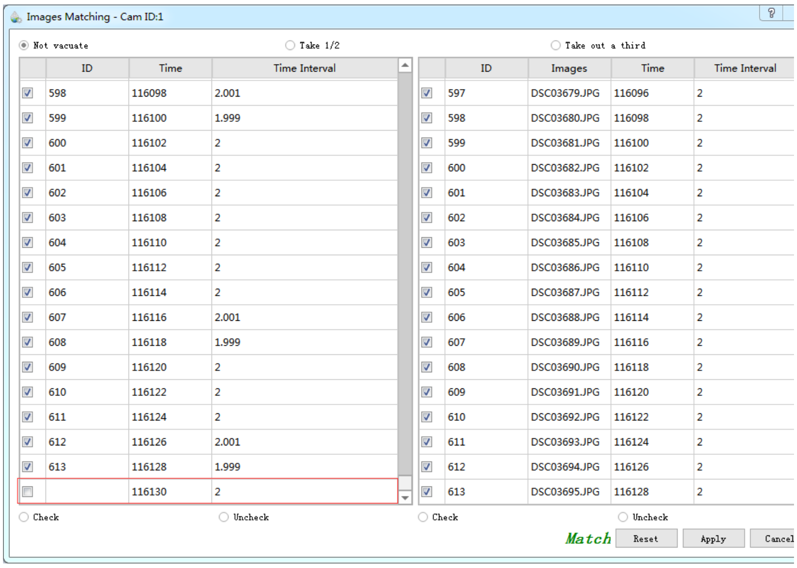
This dialog box will pop up when the number of images in the image folder is inconsistent with the number of data in the Cam file. The left side of the dialog box is a list of cam file information, the first column is the serial number, and the second column is the recorded exposure time (second of the day), and the third column is the time difference between the current data and the previous row of data; the right side of the dialog box is the information list of the image data in the image folder, the first column is the image name, the second column is the image acquisition time, and the time is synchronized with the time in the left side of the window (cam file information), and the third column is the difference between the current time and the time on the previous row.

When the image matching dialog box pops up, manual registration is required, such as the following steps:

1. As shown in the following figure: scroll down the matching dialog box to view, there are 614 rows on the left and 613 rows on the right, users can know that there are 1 more records in the cam file or 1 less image,



1. In this example, there is more data record on the left, users can cancel the checking of the last row on the left, at this time, the dialog box becomes the "Match" state shown in the following figure:



2. Choose one of the following options in the radio box at the top： "Keep all data": Keep all the image data; "Keep 1/2 of data": Retain half of the data. Keep a photo in each two photos; "Keep 1/3 of data": Retain one-third of the data. Keep a photo in each three photos.

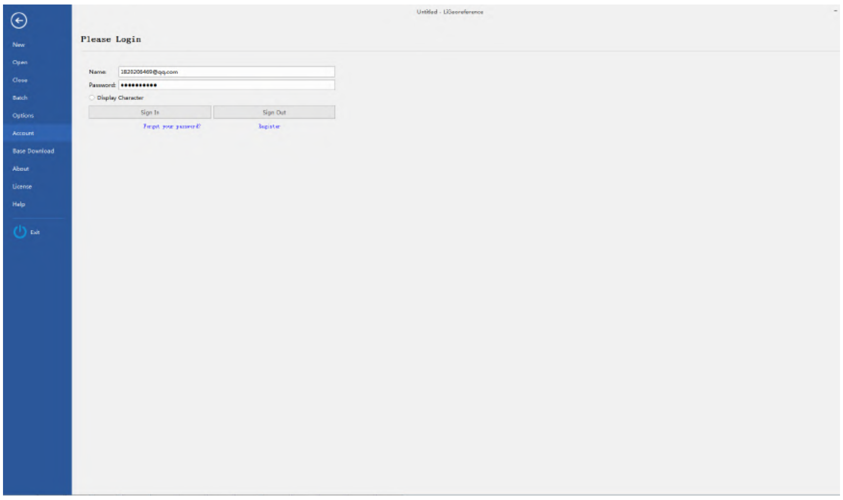
Account

Summary

Login licloud to enable the usage of the FindMM Virtual Base Station service.

Usage

Click *Account* to input the account user name and password, and then click *Login* to login to the account. If users do not have a LiCloud account, please click the *Sign Up* button to register a new account on LiCloud Website. If users forget the password, please click the *Forget Password?* button to jump to the LiCloud Website to recover the password.



Settings

- **User Name**: Enter the LiCloud account user name here.
- **Password**：Enter the LiCloud account password here.

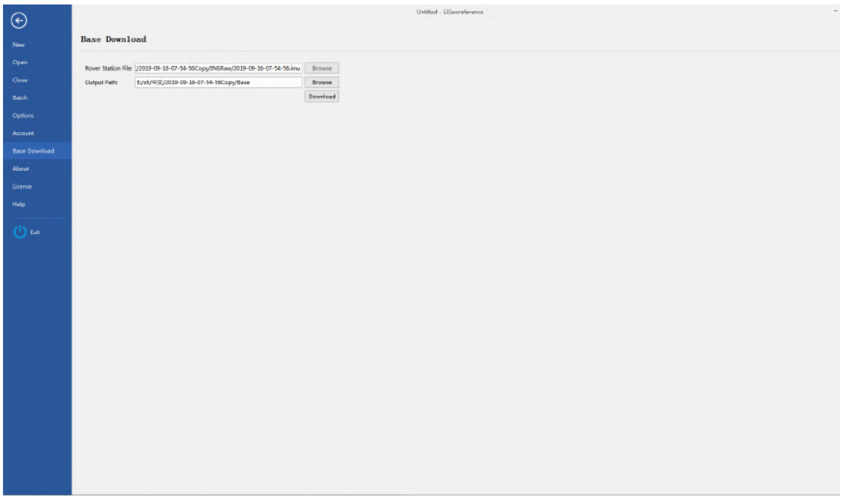
Download Base Station File

Summary

Download the base station file corresponding to the mobile station file (IMU data) to the selected output path.

Usage

After logging in on the account interface, set the mobile station path and output path, and click the Download button to download the base station. If the users do not log in before downloading the base station file, a login interface will pop up for the user to log in.



Settings

- **Remote Station File**: Select the remote station file.
- **Output Path**: Enter the path where to store the base station file.

Coordinate Conversion

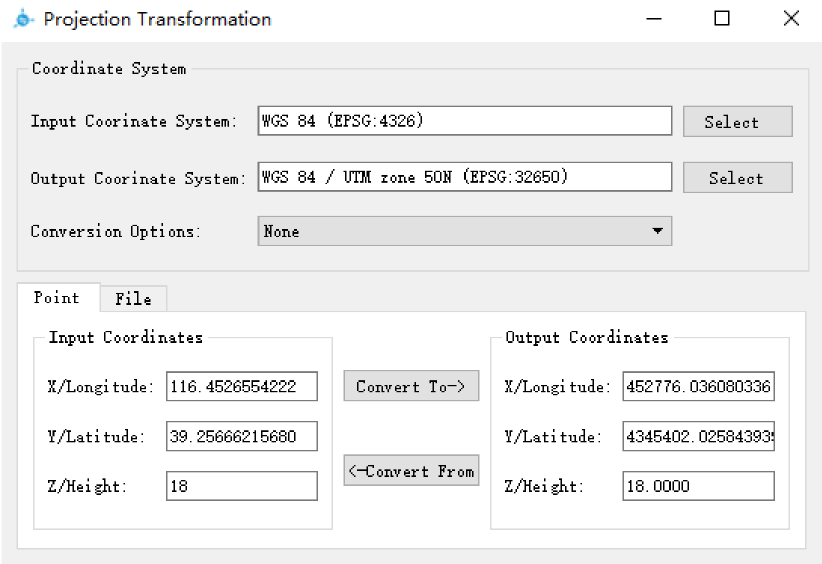
The coordinate conversion tool can convert the coordinate of a single point or file based on a specified coordinate system. The coordinate system includes geographic coordinate system, projected coordinate system, user-defined coordinate system, etc. Switch the top menu to the *processing* page, click the *projection conversion* button, and the coordinate conversion dialog box will pop up. When transforming the vertical coordinate, responding vertical datums should be download, please refer to vertical datums for detail.

Steps

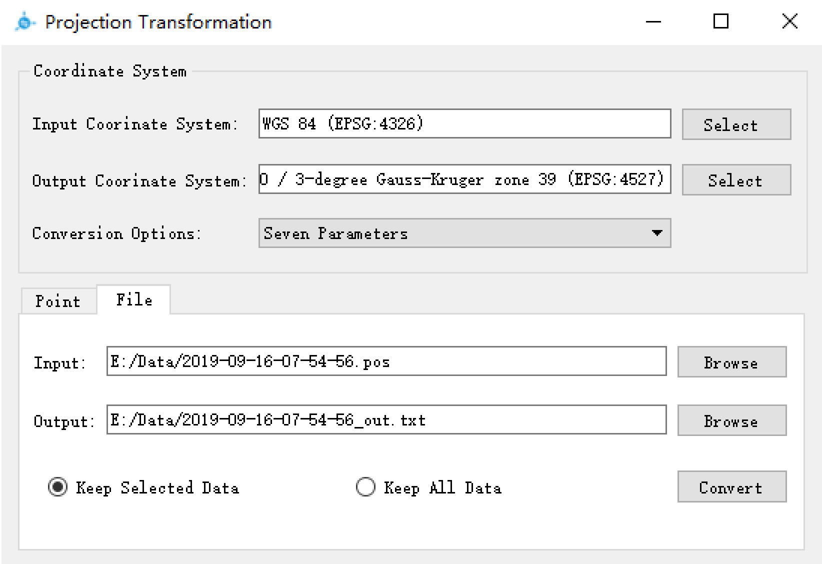
1. **Set Coordinate System**: Select Input Coordinate System and Output Coordinate System accordingly.

2. **Set Conversion Option**: Conversion options include Bursa seven-parameter and plane four-parameter models, and the default setting is None. When performing seven-parameter conversion, the seven parameters are only valid when the input and output coordinate system ellipsoid parameters are inconsistent, otherwise it is invalid. When performing four-parameter conversion, the set coordinate system should include at least one projection coordinate system, otherwise the coordinate system setting is invalid. There are three situations for four-parameter conversion: 1. Non-projected coordinate system -> projected coordinate system, the system first converts the input coordinate to the projected coordinate system, and then performs 4-parameter conversion; 2. projected coordinate system -> projected coordinate system, the system first perform 4-parameter conversion and then converted to the output projected coordinate system; 3. projected coordinate system -> non-projected coordinate system, the system first performs 4-parameter conversion on the input coordinates, and then converts to the target coordinate system.

3. **Point Conversion**: Enter the X/Longtitude, Y/Latitude, and Z/Height on *Input Coordinates*, then click *Convert To* to calculate the output coordinates.

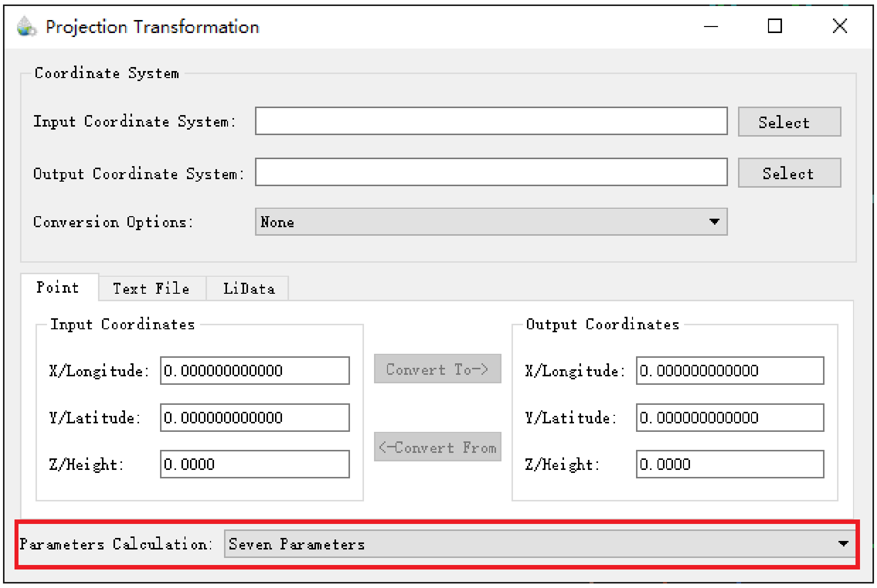


4. **File Conversion**: Set *Input* and *Output* on *File* tab. Currently, only text file is supported. After selecting the input file, the file header is availible for modification, and the user can choose according to the actual coordinate order correspondence. After completing the file header modification and selecting the retained data option, click the *Convert* button to complete the file coordinate conversion. *Keep selected data* option means that only the coordinate sequence in the file is saved, and *Keep all data* option means that the other columns of the file are also saved, only original coordinate is replaced.



Parameter Calculation

The coordinate conversion tool provides a parameter calculation function. In the **parameter calculation** column, select the type of parameter to be calculated, which are **seven parameters**, **four parameters**, and **three parameters**, as shown in the figure below. See Parameter Calculation for details.


Projection Transformation
Coordinate System
Input Coordinate System:
Select
Output Coordinate System:
Select
Conversion Options:
None
Point
Text File
LiData
Input Coordinates
X/Longitude:
0.000000000000
Y/Latitude:
0.000000000000
Z/Height:
0.0000
Convert To->
<-Convert From
Output Coordinates
X/Longitude:
0.000000000000
Y/Latitude:
0.000000000000
Z/Height:
0.0000
Parameters Calculation:
Seven Parameters

Parameter Calculation

The parameter calculation tool can realize the calculation of seven parameters, four parameters and three parameters. Switch the top menu to the *Tools* page, click the *Projection Conversion* button, and the coordinate conversion dialog box will pop up with corresponding parameter calculation options.

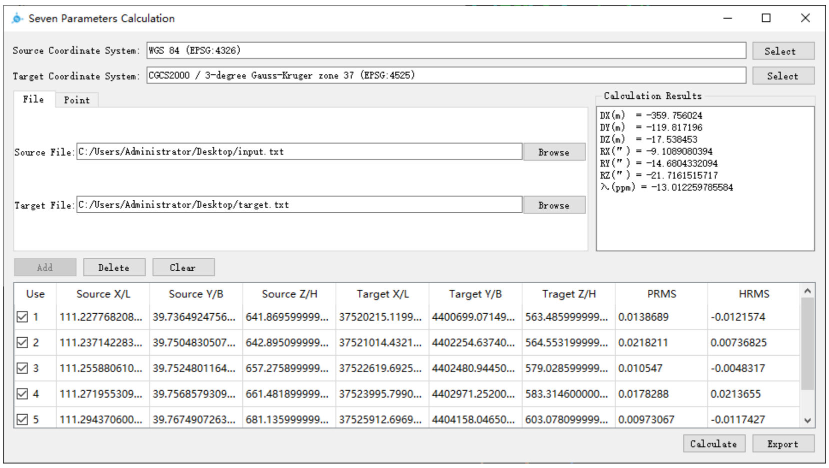
Seven Parameters Calculation

Summary

According to the input corresponding three or more control point pairs, the point pair format is spatial rectangular coordinates (X, Y, Z) or geographic coordinates (B, L, H), and the Bursa model is used to calculate the seven parameters for conversion between coordinate systems , Namely three translation parameters DX, DY, DZ, three rotation parameters RX, RY, RZ and a scale difference λ. The control point pairs should be distributed as evenly as possible and not collinear, otherwise the calculation result will be inaccurate.

Steps

1. **Parameter calculation**: select seven parameters from the drop-down box, and a dialog box for seven-parameter calculation will pop up



2. **Set the coordinate system**: Click the *Select* button to select the desired source coordinate system and the desired target coordinate system.

3. **Point Conversion**: On the point page, enter the coordinates of the point pairs and click *Add* to add the point pairs to the calculation list.

4. **File Conversion**: On the file page, select the source coordinate file path and the target coordinate file path, and the point pairs recorded in the file will be added to the calculation list.

5. **Delete**: After selecting a row in the list, click *Delete* to delete this row of point pair.

6. **Clear**: Delete all the point pairs.
7. **Calculation**: Calculate the seven parameters according to the used point pairs, and display the results in the *calculation result*.
8. **Export**: The calculation result will be saved as a TXT file.

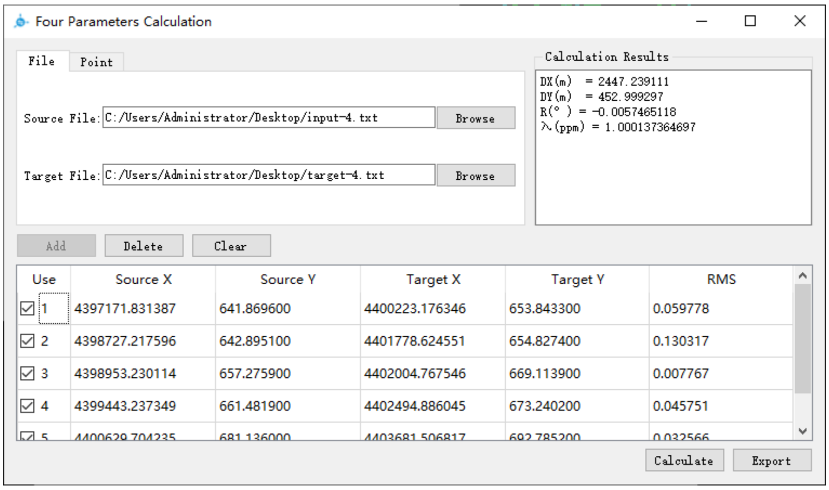
Four Parameters Calculation

Summary

According to two or more control point pairs corresponding to the input, the point pair format is spatial rectangular coordinates (X, Y), four parameters for conversion between coordinate systems are calculated, including two translation parameters DX and DY, one rotation parameter R and one Scaling ratio λ.

Steps

1. **Parameter calculation**: select four parameters in the drop-down box, and a dialog box for four-parameter calculation will pop up.



2. **Set the coordinate system**: Click the *Select* button to select the desired source coordinate system and the desired target coordinate system.
3. **Point Conversion**: On the point page, enter the coordinates of the point pairs and click *Add* to add the point pairs to the calculation list.
4. **File Conversion**: On the file page, select the source coordinate file path and the target coordinate file path, and the point pairs recorded in the file will be added to the calculation list.
5. **Delete**: After selecting a row in the list, click *Delete* to delete this row of point pair.
6. **Clear**: Delete all the point pairs.
7. **Calculation**: Calculate the seven parameters according to the used point pairs, and display the results in the *calculation result*.
8. **Export**: The calculation result will be saved as a TXT file.

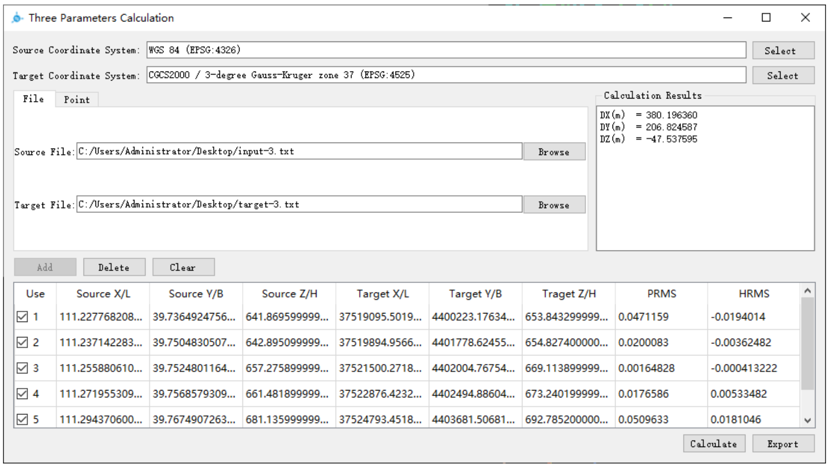
Three Parameters Calculation

Summary

According to the input corresponding one or more control point pairs, calculate the three parameters of the conversion between coordinate systems, including translation parameters DX, DY, DZ, the point pair format is spatial rectangular coordinates (X, Y, Z) or geographic coordinates (B, L, H).

Steps

1. **Parameter calculation**: select three parameters from the drop-down box, and a dialog box for three-parameter calculation will pop up.



2. **Set the coordinate system**: Click the *Select* button to select the desired source coordinate system and the desired target coordinate system.

3. **Point Conversion**: On the point page, enter the coordinates of the point pairs and click *Add* to add the point pairs to the calculation list.

4. **File Conversion**: On the file page, select the source coordinate file path and the target coordinate file path, and the point pairs recorded in the file will be added to the calculation list.

5. **Delete**: After selecting a row in the list, click *Delete* to delete this row of point pair.

6. **Clear**: Delete all the point pairs.

7. **Calculation**: Calculate the seven parameters according to the used point pairs, and display the results in the *calculation result*.

8. **Export**: The calculation result will be saved as a TXT file.

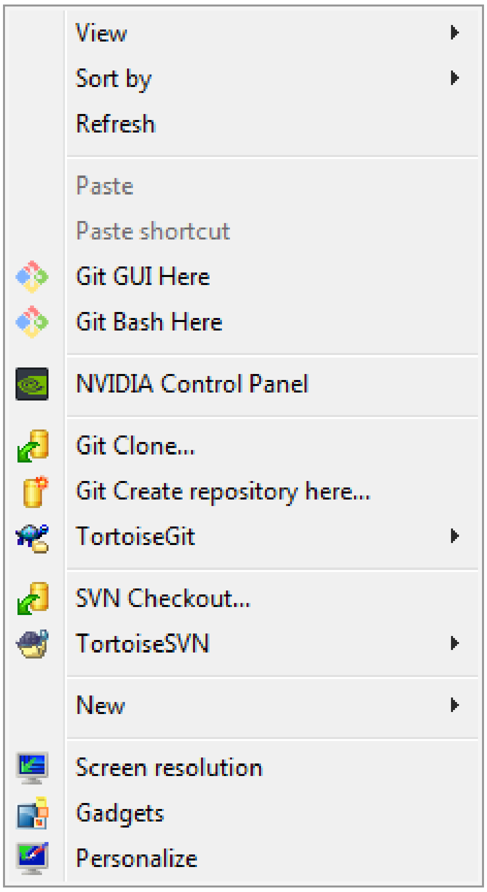
Appendix

- High-performance graphics mode adjustment
- Abbreviations
- Control point file format
- SDC
- OUT
- POF
- POS
- Vertical Datum
- Release note

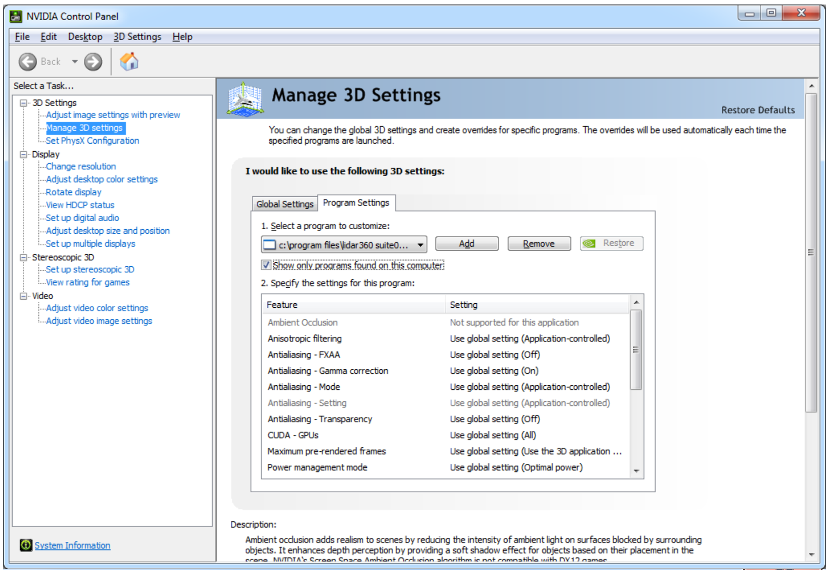
High-performance graphics mode adjustment

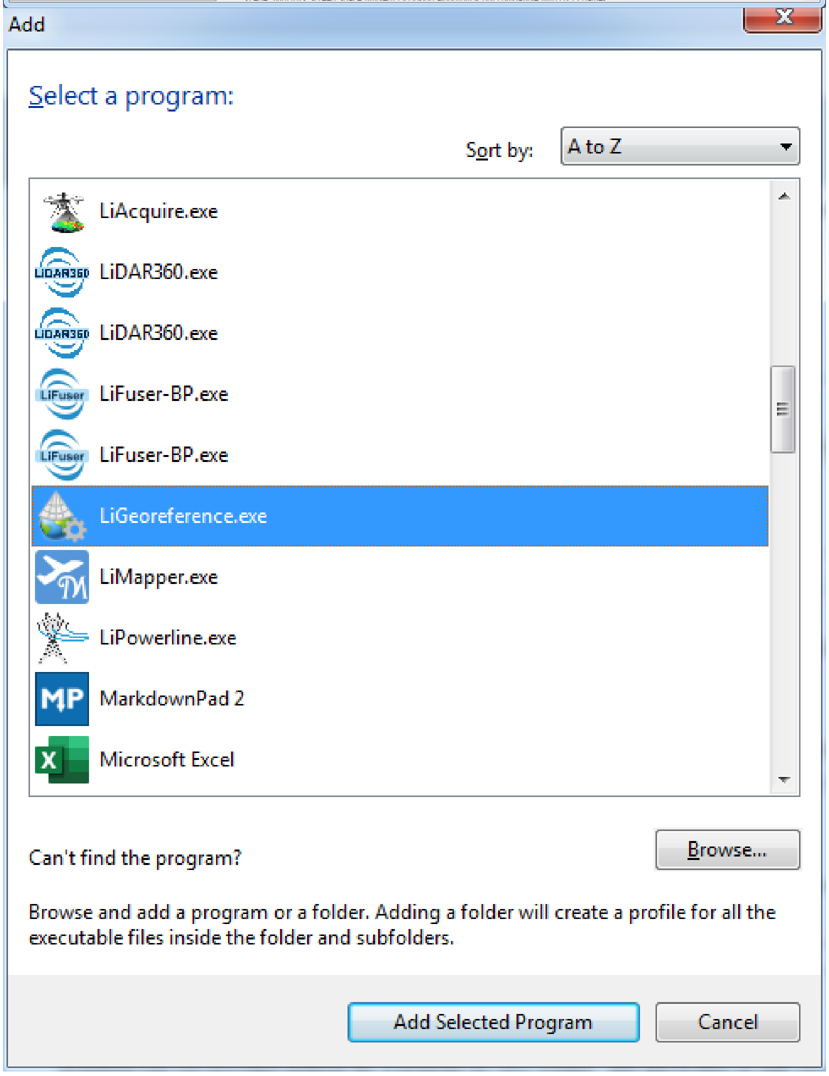
Please adjust to high-performance graphics mode of LiGeoreference:

1. Right-click on the desktop and select NVIDIA Control Panel.



2. Select Manage 3D Settings -> Program Settings -> Add "LiGeoreference.exe" to the list of high-performance graphics modes and click "Apply".


NVIDIA Control Panel
File Edit Desktop 3D Settings Help
Back
Select a Task...
3D Settings
Adjust image settings with preview
Manage 3D settings
Set PhysX Configuration
Display
Change resolution
Adjust desktop color settings
Rotate display
View HDCP status
Set up digital audio
Adjust desktop size and position
Set up multiple displays
Stereoscopic 3D
Set up stereoscopic 3D
View rating for games
Video
Adjust video color settings
Adjust video image settings
System Information
Manage 3D Settings
Restore Defaults
You can change the global 3D settings and create overrides for specific programs. The overrides will be used automatically each time the specified programs are launched.
I would like to use the following 3D settings:
Global Settings
Program Settings
1. Select a program to customize:
c:\program files\lidar360 suite0...
Add
Remove
Restore
Show only programs found on this computer
2. Specify the settings for this program:
Feature
Setting
Ambient Occlusion
Not supported for this application
Anisotropic filtering
Use global setting (Application-controlled)
Antialiasing - FXAA
Use global setting (Off)
Antialiasing - Gamma correction
Use global setting (On)
Antialiasing - Mode
Use global setting (Application-controlled)
Antialiasing - Setting
Use global setting (Application-controlled)
Antialiasing - Transparency
Use global setting (Off)
CUDA - GPUs
Use global setting (All)
Maximum pre-rendered frames
Use global setting (Use the 3D application ...
Power management mode
Use global setting (Optimal power)
Description:
Ambient occlusion adds realism to scenes by reducing the intensity of ambient light on surfaces blocked by surrounding objects. It enhances depth perception by providing a soft shadow effect for objects based on their placement in the


Add
Select a program:
Sort by:
A to Z
LiAcquire.exe
LiDAR360.exe
LiDAR360.exe
LiFuser-BP.exe
LiFuser-BP.exe
LiGeoreference.exe
LiMapper.exe
LiPowerline.exe
MarkdownPad 2
Microsoft Excel
Can't find the program?
Browse...
Browse and add a program or a folder. Adding a folder will create a profile for all the executable files inside the folder and subfolders.
Add Selected Program
Cancel

Abbreviations/Glossary

Body coordinate system

This term refers to the Cartesian Coordinate System attached to the aircraft. The most commonly used is the NED(North-East-Down) where the x-axis points from tail to nose, the y-axis to the right wing, and the z-axis downwards. Applying the roll, pitch, and yaw angles of the POS data file to this body coordinate system brings the system axes parallel to north, east, and down, respectively.

SOCS

The laser scanner's own coordinate system, denoted in the laser scanners manual.

UTC

Coordinated Universal Time is the primary standard by which the world regulates time.

WGS84

World Geodetic System 1984. Reference system for the Global Positioning System(GPS) since 1987. It defines a reference frame for the Earth, a Geodetic Datum as well as an Earth reference ellipsoid. In the context of this guide, it is in some cases used as synonym for any geocentered GD.

SOW

Within each week, GPS time is usually denoted as the second of the week(SOW) or a number between 0 and 604,800 (60 seconds/minute x 60 minutes/hour x 24 hours/day x 7 days/week).

Timestamp

A highly accurate time descriptor, that specifies output by the GNSS receiver and is derived from the GNSS's own atomic clock time base. In the Riegl ALS system timestamp data is added to every laser measurement.

GPS

Global Positioning System. Currently the only fully functional Global Navigation Satellite System(GNSS). It utilized a constellation of at least 24 medium Earth orbit satellites that transmit precise microwave signals. The system enables users to determine their position, velocity, and time anywhere in the world.

MTA

Multi-Time-Around, this indicates a phenomenon that return signals fall behind the subsequent transmission pulse in the time domain.

PDOP

To indicate the position accuracy is strong or weak. In general, the better the satellite distribution, the smaller the PDOP value, and generally less than 3 is the ideal state.

File format

- Control point file format
- SDC
- OUT
- POF
- POS

Control point file format

The control point file is a comma-separated text file format (extension *.txt). Each line contains three columns consisting of X, Y, and Z coordinates. The first line is the table header. The following table shows some examples of control point files:

```
X, Y, Z
473575.563, 291005.332, 127.244
473576.899, 291004.245, 126.328
473576.899, 291004.243, 126.317
473576.899, 291004.245, 126.328
473576.899, 291004.243, 126.317
```

SDC

The extracted data file (*.SDC) contains data records for each target detected. The data format of the binary record is different for different file types. The following references the SDC data format provided in [Riegl] (http://www.riegl.com/products/software-packages/riprocess/).

SDC data format

- version 5.4

Data	Meaning	Type
TIME	seconds of the day or of the week	double
RANGE	measured range value(m)	float
THETA	measured theta value(degree)	float
X	x coordinate(m)	float
Y	y coordinate(m)	float
Z	z coordinate(m)	float
AMPLITUDE	Amplitude	unsigned short
WIDTH	Width of target return	unsigned short
TARGETTYPE	0(COG),1(PAR),2(GPF), 3 TO 5(GPE)	unsigned char
TARGET	index of target	unsigned char
NUMTARGET	total number of targets	unsigned char
RGINDEX	range gate index of measurement	unsigned short
CHANNELDESC	channel descriptor	unsigned char
CLASSID	class identifier	unsigned char
RHO	tile mount angle(degree)	float
REFLECTANCE	reflectance	short int

OUT

As a format of track files, *.OUT is a binary file. The following table provides the format of the POSPac SBET file provided by Applanix. For details, please refer to the POSPac Getting Started Manual.

The track information structure of its file storage is as follows:

Data	Units	Type
time	seconds	double
latitude	radians	double
longitude	radians	double
altitude	meters	double
x velocity	meters/second	double
y velocity	meters/second	double
z velocity	meters/second	double
roll	radians	double
pitch	radians	double
platform heading	radians	double
wander angle	radians	double
x body acceleration	meters/second^2	double
y body acceleration	meters/second^2	double
z body acceleration	meters/second^2	double
x body angular rate	radians/second	double
y body angular rate	radians/second	double
z body angular rate	radians/second	double

POF

Description of POF file format. The following quotes the POF data format provided in [Riegl] (http://www.riegl.com/products/software-packages/riprocess/).

Introduction

Use POF files in binary format instead of POS files to search for timestamps faster. The time stamp in the POF file is stored in standard seconds. There is only difference between this time format and UTC weekly seconds: the first day is determined by the file header, and UTC weekly seconds always start on Sunday.

You can use the following formula to convert standard seconds to UTC weekly seconds:

int Days = Floor(NormSecs/86400.0);

double Secs = NormSecs - (Days*86400.0);

double WeekSecs = Secs + (DayOfWeek(Date)+Days mod 7) * 86400.0;

> Note: DayofWeek(Date) = 0(Sun), 1(Mon),...,6(Sat)

Header structure

The file starts with the string "RIEGL POSITION&ORIENTATION" and is separated by <0x00>:

- **RIEGL POSITION&ORIENTATION<0x00>**

Next is the major and minor version information (binary, small byte, each is an unsigned integer of 2 bytes):

- **(MAJOR:u2)(MINOR:u2)**

The definition of 1.0 and 1.1 version

Data	Meaning	Type
DATAOFFSET	data offset	u4
YEAR	The creation year of the trajectory	u2
MONTH	The creation month of the trajectory	u2
DAY	The creation day of the trajectory	u2
ENTRIES	Number of entries(data records)	n8
MINLON	Minimum longitude(degree)	d8
MAXLON	Maximum longitude(degree)	d8
MINLAT	Minimum latitude(degree)	d8
MAXLAT	Maximum latitude(degree)	d8
MINALT	Minimum altitude(m)	d8
MAXALT	Maximum altitude(m)	d8
AVGINT	Average time interval(sec)	d8
MAXINT	Maximum time interval(sec)	d8
DEVINT	Standard deviation of jumps(sec)	d8
TIMEUNIT	0(normsecs),1(daysecs),2(weeksecs)	u1
TIMEINFO	0(GPS),1(UTC),2(unknown)	u1
TIMEZONE	Time zone	16
LOCATION	Location	32
DEVICE	Navigation device	32
RESERVED	Reserved	32
PROJECT	Project name	32
COMPANY	Company name	32
RESERVED	Reserved	101

Note: The Timeunit field only stores the time format of the original data input(e.g. using our POF import software). This field is used for information only or when exporting the data (ASCII format,...)

In the data records time stamps are always stored as norm seconds.

1.0 version of data records

Every data record represents a measurement from the IMU/GPS unit:

Data	Units	Type
TIME	second	double
LON	degree	double
LAT	degree	double
ALT	m	double
ROLL	degree	double
PITCH	degree	double
YAW	degree	double

56 bytes records size.

1.1 version of data records

Every data record represents a measurement from the IMU/GPS unit:

Data	Units	Type
TIME	second	double
LON	degree	double
LAT	degree	double
ALT	m	double
ROLL	degree	double
PITCH	degree	double
YAW	degree	double
DIST	m	double

64 bytes records size.

Note:u = unsigned integer (little endian), n = signed integer (little endian), d8 = double precision floating point (little endian)

Each line of the POS file is in order of GPS time, longitude, latitude, altitude, roll angle (Roll), pitch angle (Pitch), yaw angle (Heading), GridX, GridY. Among them, GPS time, longitude, latitude, altitude, roll angle (Roll), pitch angle (Pitch), yaw angle (Heading) are mandatory items, GridX, GridY are optional.

The trajectory information structure of its file storage is as follows:

Data	Units	Type
GPS time	seconds	double
longitude	degree	double
latitude	degree	double
height	meters	double
roll	degree	double
pitch	degree	double
heading	degree	double
GridX(Optional)	meters	double
GridY(Optional)	meters	double

Here are some examples:

Example1 (GridX，GridY not included):

```
380954.000,112.5311950876, 26.8969520123,378.543,  7.1701230000,  3.0890110000,-39.40
380954.008,112.5311938923, 26.8969533249,378.537,  7.2001860000,  3.0914780000,-39.40
380954.016,112.5311926975, 26.8969546376,378.531,  7.2368710000,  3.0936380000,-39.40
380954.024,112.5311915034, 26.8969559507,378.525,  7.2683090000,  3.1015050000,-39.39
380954.032,112.5311903098, 26.8969572641,378.518,  7.3007560000,  3.1115160000,-39.39
380954.040,112.5311891169, 26.8969585779,378.512,  7.3269790000,  3.1179720000,-39.38
380954.048,112.5311879247, 26.8969598920,378.506,  7.3525870000,  3.1180460000,-39.38
380954.056,112.5311867331, 26.8969612065,378.500,  7.3745730000,  3.1151630000,-39.37
```

Example 2 (GridX，GridY included):

```
383207.336,112.5421590662,26.9034172036,313.865,3.538615,2.660518,-67.848653,653147.09
383207.344,112.5421572108,26.9034177865,313.861,3.533299,2.659177,-67.840828,653146.91
383207.352,112.5421553554,26.9034183697,313.857,3.522385,2.658042,-67.828619,653146.72
383207.36,112.5421535001,26.9034189529,313.854,3.512757,2.659231,-67.816251,653146.544
383207.368,112.5421516447,26.9034195363,313.85,3.502656,2.662677,-67.807435,653146.359
383207.376,112.5421497892,26.9034201198,313.846,3.502243,2.664987,-67.803265,653146.17
383207.384,112.5421479336,26.9034207035,313.843,3.500293,2.668456,-67.80232,653145.989
383207.392,112.5421460783,26.9034212874,313.839,3.501546,2.671267,-67.797563,653145.80
383207.4,112.5421442231,26.9034218713,313.835,3.496569,2.674773,-67.789195,653145.6191
383207.408,112.542142368,26.9034224554,313.832,3.483849,2.676885,-67.774991,653145.434
383207.416,112.5421405129,26.9034230395,313.828,3.471533,2.676137,-67.765536,653145.24
383207.424,112.5421386577,26.9034236237,313.824,3.47028,2.675779,-67.760612,653145.064
383207.432,112.5421368024,26.9034242079,313.82,3.475101,2.677064,-67.761833,653144.878
383207.44,112.5421349471,26.9034247923,313.817,3.476053,2.681571,-67.761664,653144.693
```

Vertical Datums

When performing coordinate conversion in the projection library, vertical datum is needed for coordinate system conversion. The software provides EGM2008 geoid model elevation conversion by default. If other geoid models need to be supported, you could download the corresponding grid datum files. Grid files are provided by the official PROJ library.You can download proj-data-1.2here, or go to https://proj.org/download.html for latest version. After downloading the file, copy all files in the folder to the *geoid* folder, under the software installation directory(C:\Program Files\LiGeoreference\1.2.1.0\geoid). "1.2.1.0" refers to software version.

> Note: Do not modify the tif file name and put the file directly in the geoid folder. Or the file will be unrecognizable.If the same file name exists, it can be replaced directly. If you cannot download the file or encounter difficulties, you can contact us via info@lidar360.com.

LiGeoreference release notes

LiGeoreference v1.2.1

This version is a major revised version. The interface has been redesigned and a lot of new functions have been added to improve the point cloud pre-processing workflow.

1. More user-friendly interactive interface.
2. Support third-party hardware, and create project in wizard-style.
3. Support batch processing, to process multiple projects at a time.
4. Support multi-camera, multi-laser scanner data processing.
5. Support vehicle-mounted data processing, panoramic roaming and panoramic measurement.
6. Add boresight calibration.
7. Add control point report and elevation adjustment.
8. Add cut overlap function, to remove redundant point clouds between strips.
9. Add coordinate transformation of point cloud, including linear transformation, affine transformation, translation and rotation.
10. Add strip elevation difference analysis，density analysis and accuracy check.
11. Support automatic splitting of trajectory and support user preference setting.
12. Support seperate base station file downloading.
13. Support the latest geographic and projected coordinate system setting, and support vertical coordinate system conversion.
14. Support triple-returned point cloud data of Livox laser scanner.
15. Add real-time hover tool, which can be used with other measurement tools, to detect surface, edge and corner.

LiGeoreference v1.2.2

The main updates of current version are listed below:

1. Add trajectory adjustment.
2. Add point cloud denoising.
3. Support LAS/LAZ format when georeferencing and only LAS1.2/LAZ1.2 version supported.
4. Support spliting point cloud by number of points and by time interval.
5. Support thin points when georeferencing.
6. Support pandarXT-32 laser data georeferencing.
7. Add progress bar and exception handling for decompressing files.
8. Optimize point cloud colorization and efficiency improved greatly.
9. Fix the image POS interpolation problem in certain situations.
10. Fix the issue that buffer is not refreshed in time when querying WKT.
11. Fix the issue that the latest WKT can't be recognized in LiDAR360.
12. Fix the problem that georeferencing fails when the target coordinate system contains a vertical coordinate system.
13. Fix generating traj format files when opening the project and progress bar added.

14. Fix the problem that project tree node is not updated after importing external POS.
15. Fix the problem that requires re-georeferencing when cloud colorization with seven-parameters coordinate conversion.
16. Fix the issue georeferencing extremely slow when the POS with unequal interval.

LiGeoreference v1.2.3

New features of this version:

1. Support data collect by Ouster LiDAR sensors.
2. Support data collect by PandarQT LiDAR sensors.
3. Add seven-parameter, four-parameter, and three-parameter calculation functions to the Target Coordinate System settings.
4. Add a selection page to provide the function of manually selecting and cutting point clouds.
5. Add angle filtering and filtering by velocity.
6. The "uniform color" function is turned on by default and the color enhancement function is added to improve the contrast, brightness, and overall color saturation.
7. Fix the computer freezes problem in reading INS from StarNeto.
8. When exporting the camera file, write the geodetic coordinates in the image metadata file "caminfo.txt".
9. Fix the LiDAR file decompression fails problem.
10. Fix the problem that certain areas (with photos) displayed in black after colorization.

LiGeoreference v1.2.4

New features of this version:

1. Fix the georeference failed problem in the batch process tool.
2. Fix the failed to load projects problem in the batch process tool.
3. Fix the colorization freeze and progress bar stuck problems, and improve the calculation efficiency.
4. Fix the crash problem when using the "Export Camera List" tool and the loss of accuracy problem when writing pos into photos.