LixelStudio 3.0

User Manual

V3.2.0.0

I. LixelStudio Software

LixelStudio is a 3D processing software independently developed by XGRIDS, providing project post-processing, point cloud and other data viewing, editing, processing services and industry applications for Lixel series handheld scanner, bringing breakthrough 3D data productivity.

Specifically, LixelStudio V3.2.0.0 mainly includes the following modules:

- Project processing module: mainly used to process the data obtained by Lixel series handheld scanner. Including project processing, map fusion, and accuracy check.
- Tool Module: mainly used for point cloud data post-processing, including basic point cloud denoising, resampling, measuring, etc.
- Applications module: mainly include applications such as volume calculation and Mesh reconstruction.

II. Version and Copyright

(1) Version

Software version: LixelStudio V3.2.0.0

Release date: March 24, 2025

This manual is based on LixelStudio V3.2.0.0 version. Operations may be different for other versions. Please verify the software version before use.

(2) New Features

This update mainly includes: tunnel mode, enclosed area volume calculation, fisheye image EXIF information added, authorization activation optimization, robust mode optimization, processing efficiency optimization, control point conversion result report optimization, Mesh optimization, coloring optimization, etc. The following is a brief description of the changes in the function list:

1. Narrow scene

Project processing → advanced setting, narrow scene is added to special mode. This mode is limited to narrow and long straight scenes such as tunnels, mines, and long straight corridors. If checked in other regular scenes, SLAM mapping may fail.

2. Enclosed area volume calculation

- Application module, a new enclosed area volume calculation function is added, which is mainly used to support the volume calculation of enclosed areas.

3. Image EXIF information

- Added image EXIF information to the exported fisheye image.

4. Activation

- Added detailed authorization information, and added the function of updating authorization in settings.

5. Mesh import

- Support import and browse of mesh models in .ply, .obj, and .osgb formats.

6. Coloring

- For L2 Pro, a new "Optimize visual pose" option has been added to improve the coloring effect in texture-rich areas.

7. Optimization of SLAM mapping

- Robust mode: After checking, it will be processed directly in robust mode.

- Optimize SLAM mapping efficiency thus improve project processing speed.

8. Control point transformation report optimization

- Optimize the control point accuracy report. For the control points that are checked for coordinate transformation a conversion point accuracy report is output, and for the control points that are not checked but matched successfully a checkpoint accuracy report is output.

9. Mesh optimization

- Supports Mesh construction of las point cloud within 50G and improves construction stability.

10. Coloring optimization

- Optimize some coloring black blocks and hole problems in previous version.

11. Other optimizations

- Optimize some interactions in coordinate transformation. Add software version and unit information to the output report

(5) Trademark

(6) Copyright

you with data post-processing services for the Lixel series hardware. We welcome your comments and suggestions on improvements concerning our hardware, software, training, and documentation. For inquiries, please contact us via email at enterprise@xgrids.com or reach out to our XGRIDS SNS. Thank you.

Document update date: September 23, 2024

III. Software Installation

(1) Software Installer Download

Please use the official download link provided for the software installer.

(2) Recommended Computer Configuration

Operating System Support: Windows 10 /11 Professional, Home

Hardware basic configuration:

CPU: i7 11th generation

GPU: Graphics card 3060 and above

Memory: 64G

Hard disk: 1T

Recommended configuration:

CPU: i9 12th generation

GPU: Graphics card 3070 included and above

Memory: 64G

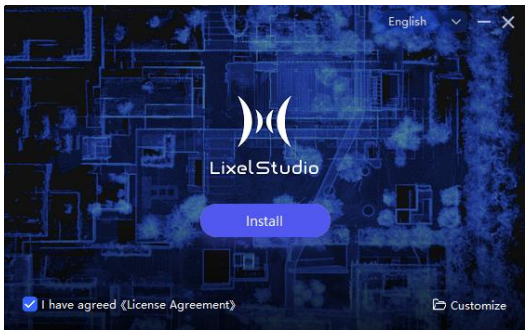
Hard disk: 1T（SSD）

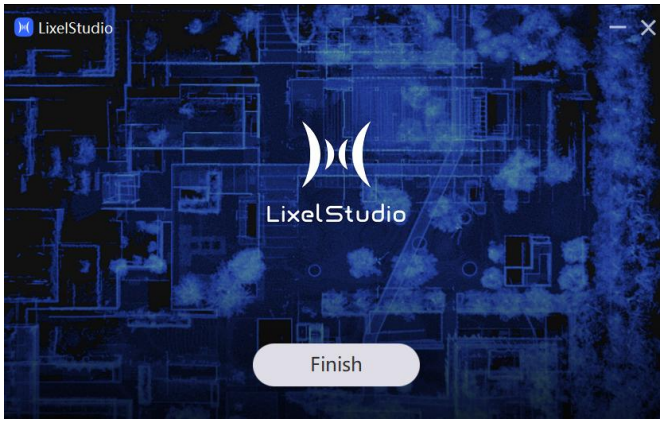
(3) Installation Procedures

After downloading the installation package, please double-click the application to begin the installation process. Follow the prompts step by step. Please check your language at this step. The specific operations are as follows:

1. Quick Installation

◦ After clicking Install, the program will create the installation path in the default C drive and directly install the program. Once the installation is complete, clicking "Open" will immediately launch the software.

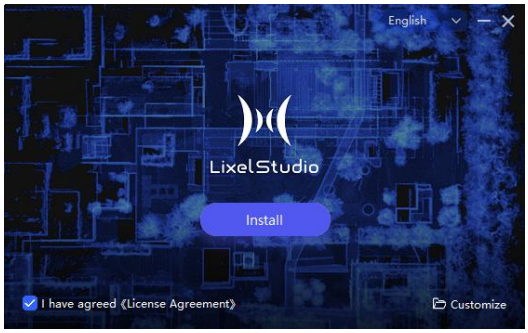


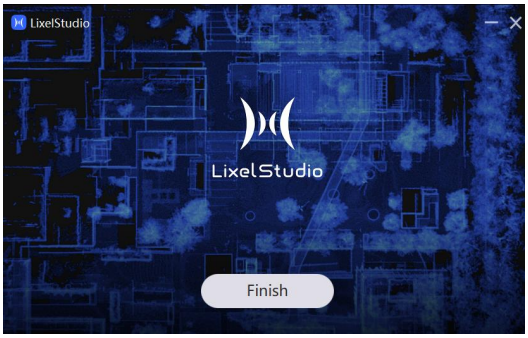


2. Customize Installation

◦ You can click "Customize" in the bottom right corner of the installation interface to select the installation path and choose whether to add a

desktop shortcut. Click "Install" to automatically proceed with the installation. Once the installation is complete, you can click "Open" to immediately launch the software.





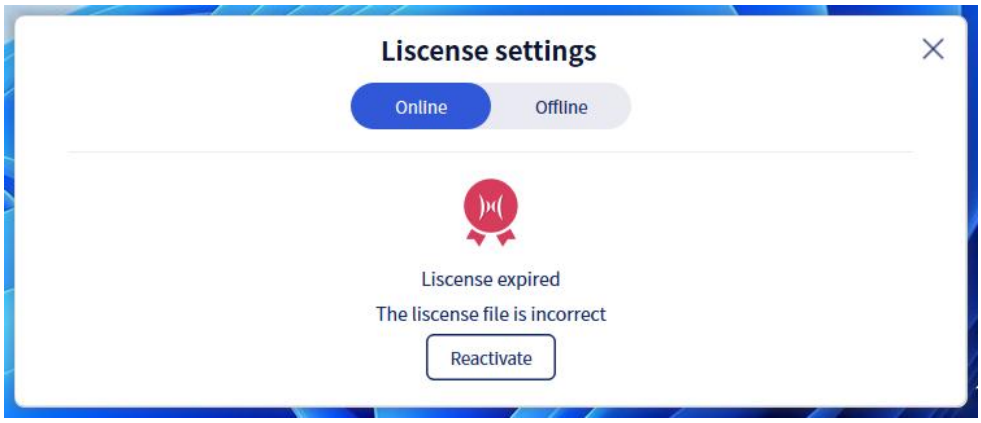
(4) Authorization and Activation

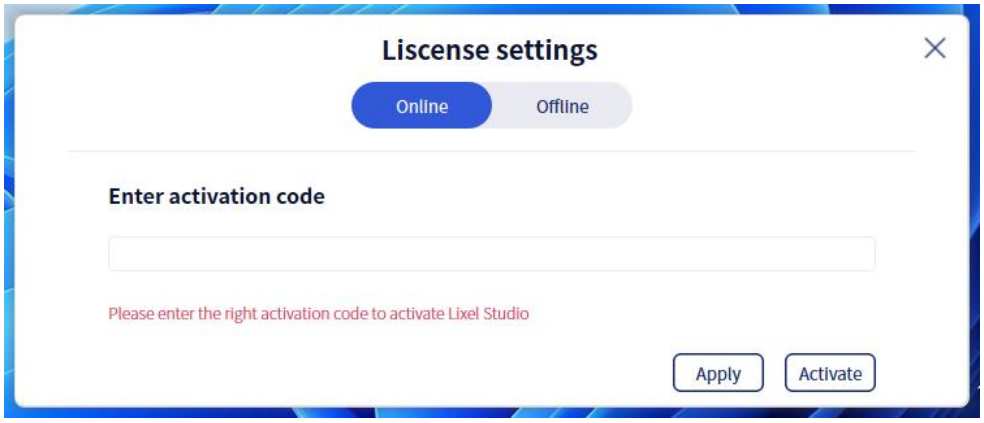
Currently, two methods of authorization and activation are supported: online and offline. The LixelStudio software must be authorized and activated before it can run.

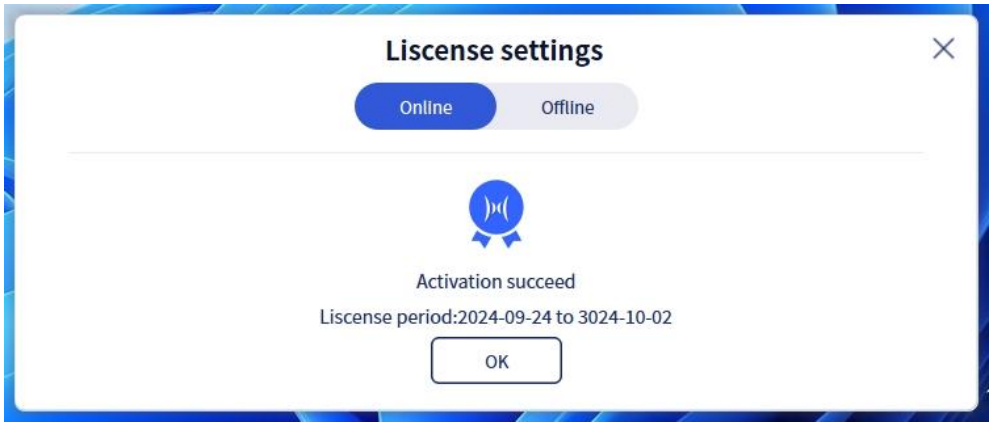
After installing the software for the first time and opening it, the software will display "Authorization Expired/Incorrect Authorization File." If the computer is connected to the internet, you can perform online activation; if the computer cannot connect to the internet, you can perform offline activation.

1. Online

Click on "Online" and select "Reactivate." A window titled "Enter Activation Code" will pop up. Enter the correct activation code and click the "Activate" button. Once activation is successful, you can normally enter the software.





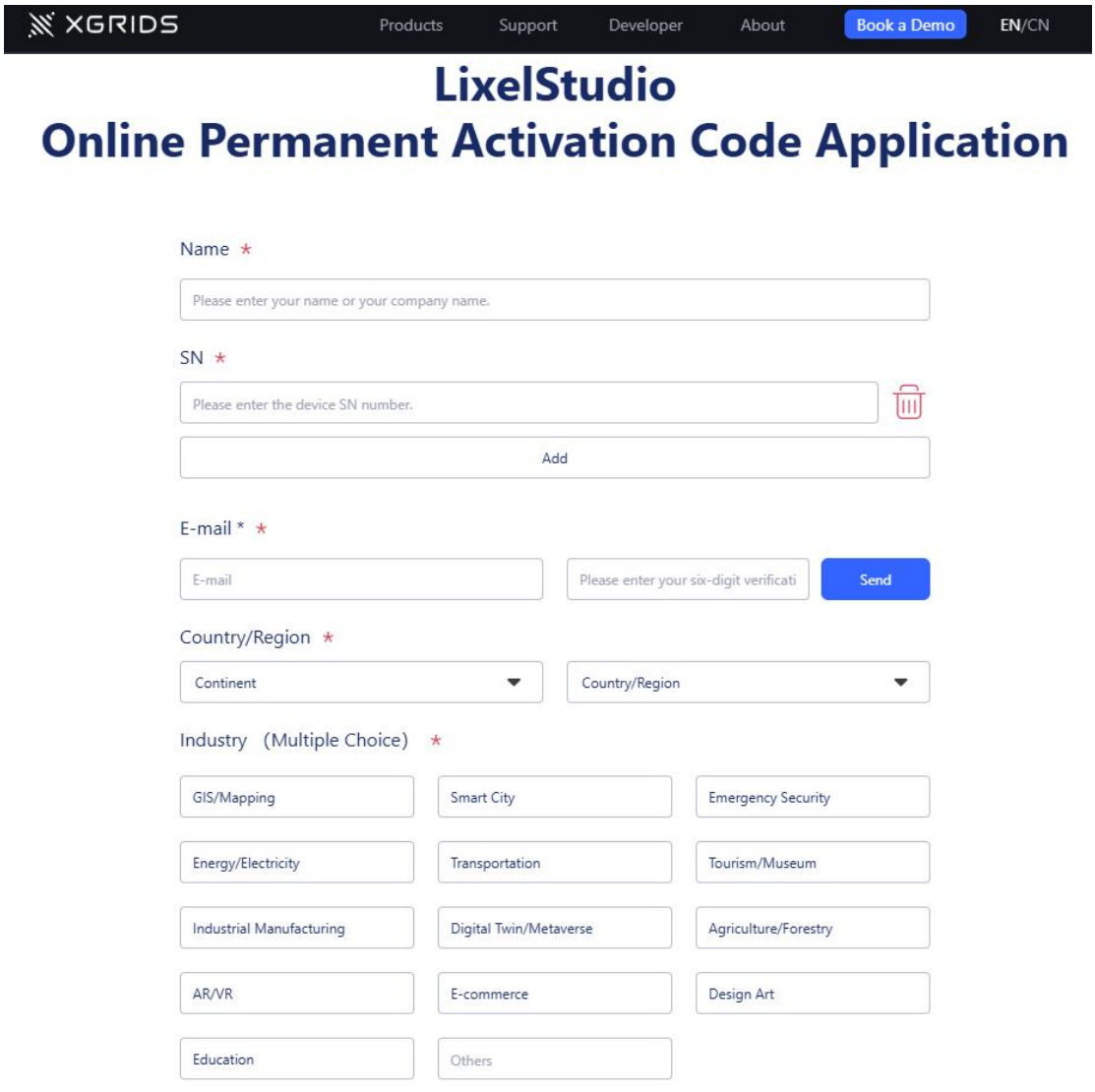


For trial users, you can enter the corresponding trial activation code to activate the software. The trial activation code can be obtained by contacting the respective sales manager or distributor. After entering the code, click "Activate" to successfully activate the LixelStudio software. Once activation is successful, click "Confirm" to enter the main program.

For customers who have purchased the XGRIDS handheld scanning device, you can click the "Apply" button, which will redirect you to the official application link. After correctly filling in the corresponding application information, the system will send a permanent activation code to the application email.

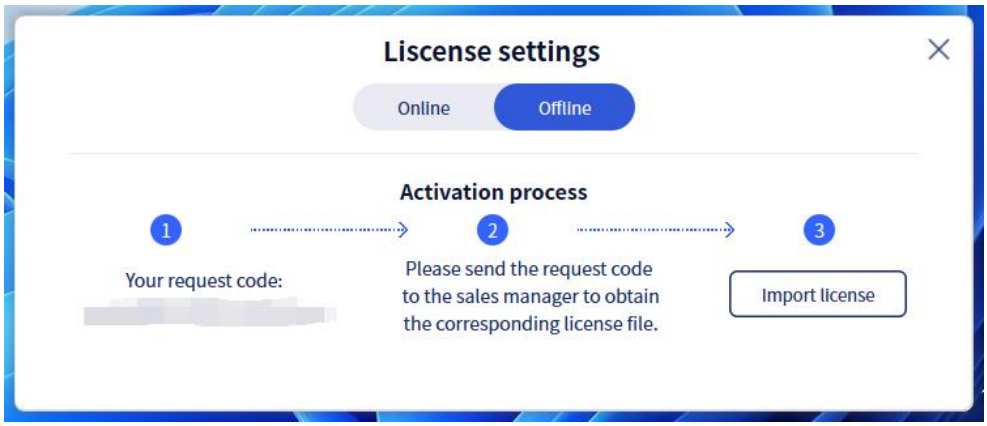
Note: Each device will be equipped with 3 permanent activation codes. You can apply for up to 50 devices at a time. After applying, please save the activation code information to prevent loss. If you unfortunately lose it, you can reapply by logging in to the application website: https://xgrids.com/activationrequest

Please make sure to fill in the correct SN number and use the same email address as the previous application to apply again. The system will resend the previously obtained activation codes to that email.



2. Offline

Click on "Offline," and the software will generate a request code corresponding to this computer. Please copy the request code completely and send it to the respective sales manager or distributor. They will help generate the license file corresponding to this computer. Make sure the request code is copied correctly. After receiving the license file, click "Import License" and select the correct license file to successfully activate LixelStudio. Once activation is successful, click "Confirm" to enter the main program.



IV. Software Interface

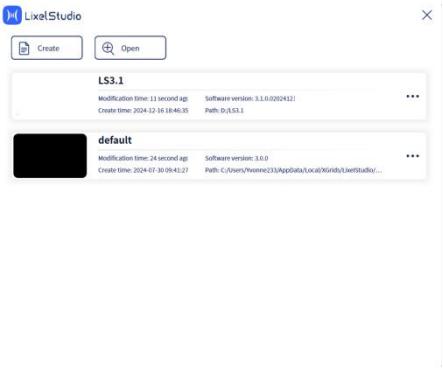
(1) Overall Description of the Interface

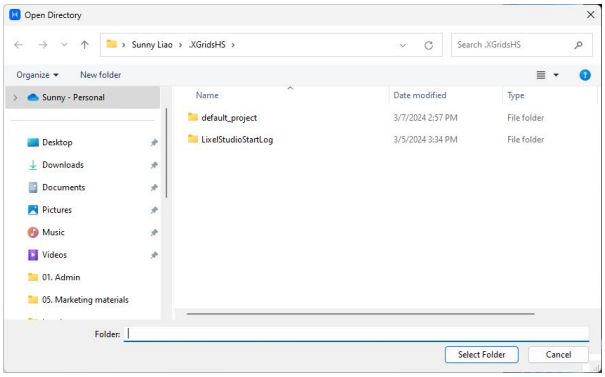
1. Welcome Interface

Double-click the software to open the software. After the software launches successfully, the LixelStudio welcome page is displayed first. After a moment, you will be directed to the software usage page.

2. **Project Panel**

LixelStudio 3.2.0.0 uses a project-based structure to manage data. Before entering the software's main operation interface, you first need to create a project. Click "Create" to select the project path, create a new folder, enter the corresponding file name, and select it.



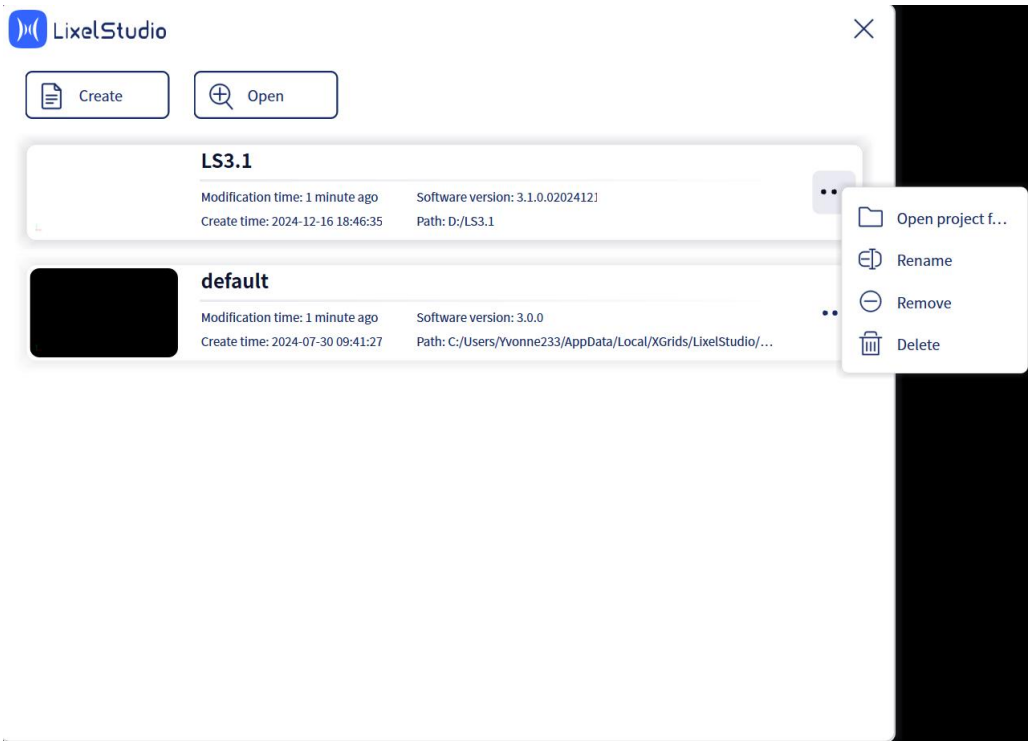


If there are existing projects, the project interface will display the corresponding projects. Projects are sorted by modification time, with the most recently modified projects displayed at the top. You can directly click on the corresponding project to enter the software operation interface.

Clicking the "···" to the right of a project allows you to manage the project, including opening the project path, renaming the project, removing the project, and deleting the project.

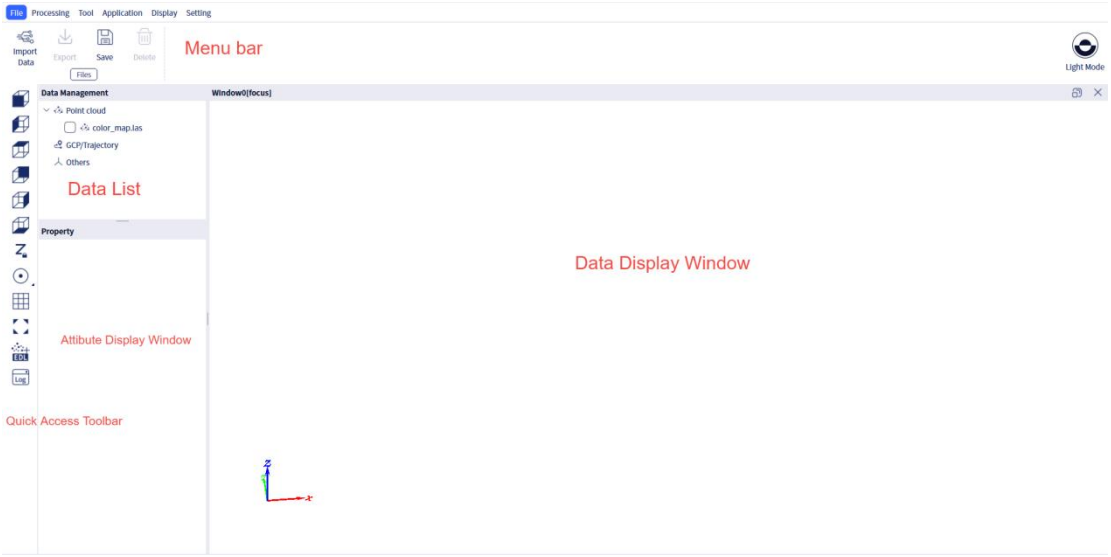
Note: Removing a project will delete the project from the LixelStudio

startup project list, but the project's data will still be retained on the corresponding disk. Deleting a project will remove the project from the LixelStudio startup project list and also delete the data from the corresponding disk. Please choose carefully.



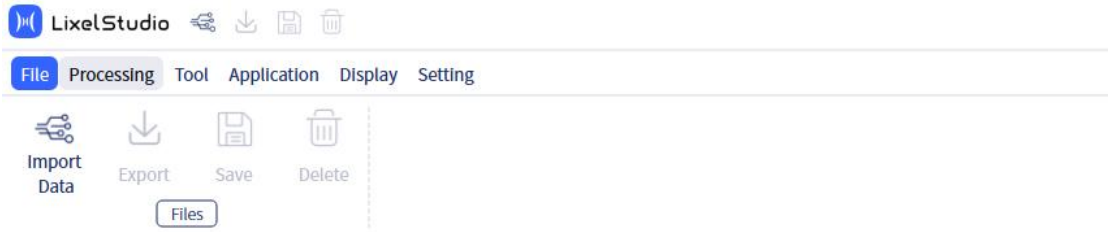
3. **Overall Interface**

The figure below shows the overall interface of the LixelStudio 3.2.0.0 software, including the menu bar, data list, attribute properties information bar, data display area, and quick operation bar.



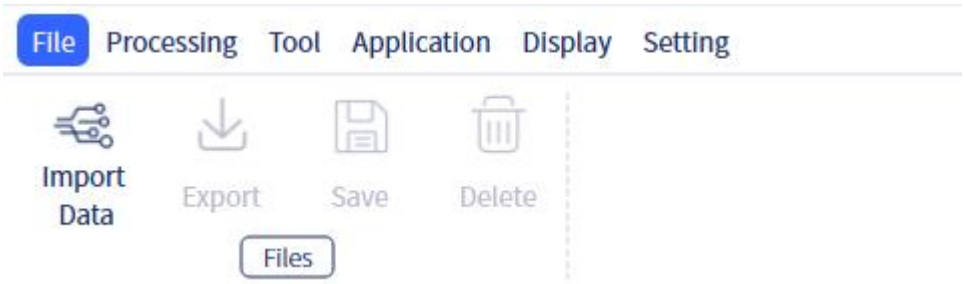
(2) Menu Bar

The menu bar includes File, Processing, Tool, Application, Display, and Setting.



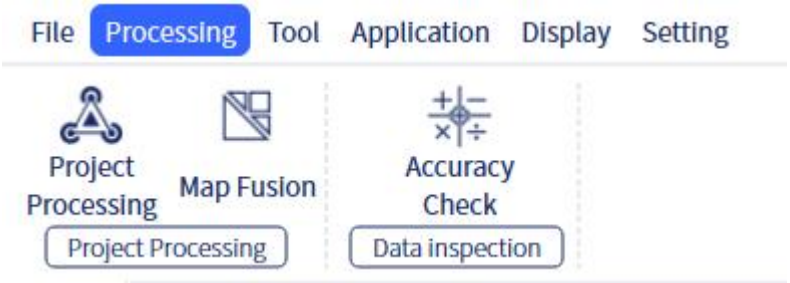
1. File

Files include import data, export data, save, and delete.



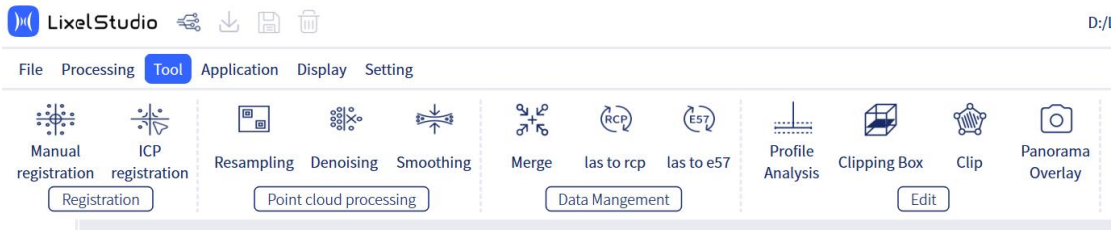
2. Processing

Processing includes project processing, map fusion, and accuracy check.



3. Tools

Tools include Manual Registration, ICP Registration, Resampling, Denoising, Smoothing, Merge, las to rcp, las to e57, Profile Analysis, Clipping Box, Clip, and Panorama Overlay.

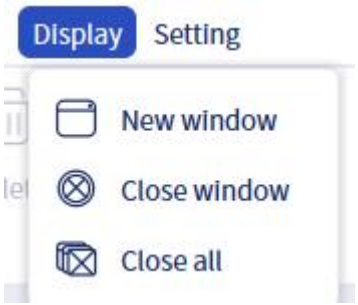


4. Application

Applications include volume calculation, volume comparison, enclosed volume calculation, and Mesh.

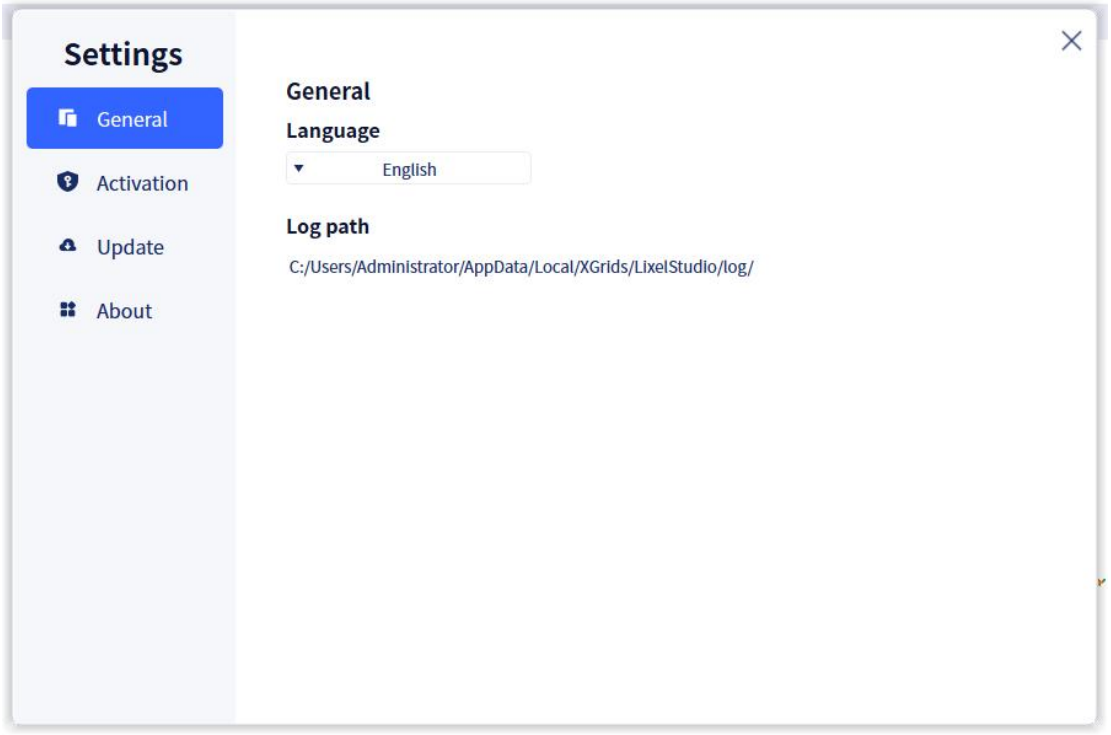
5. Display

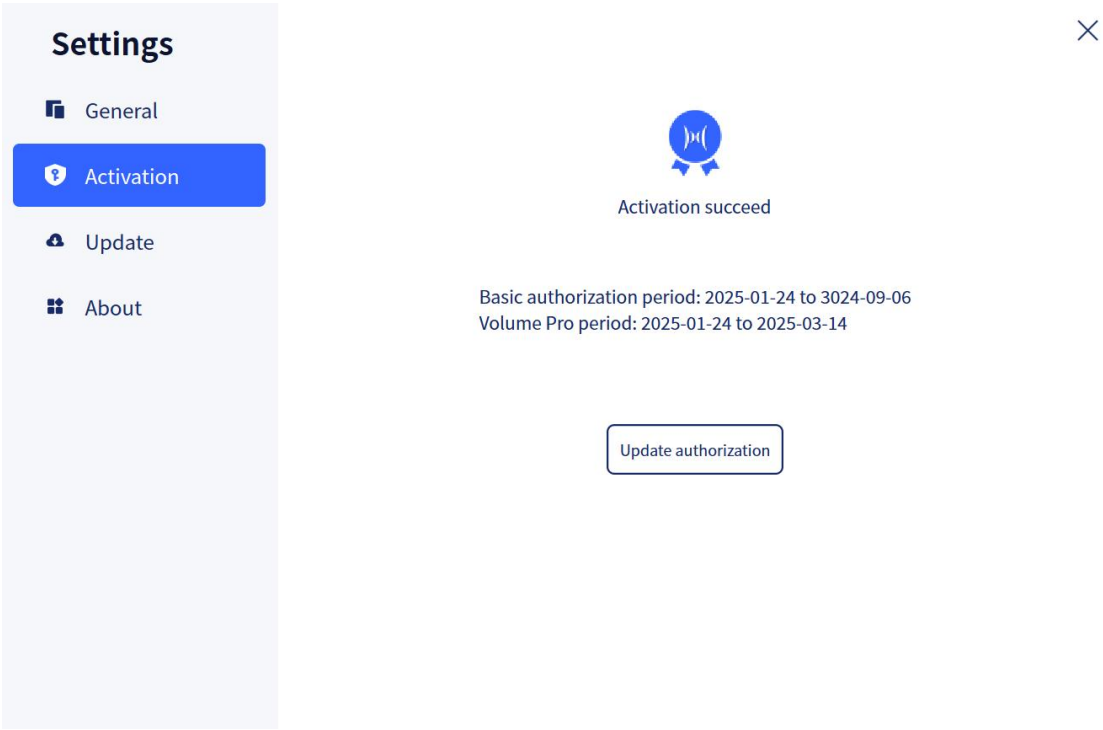
Display includes new window, close window, and close all.

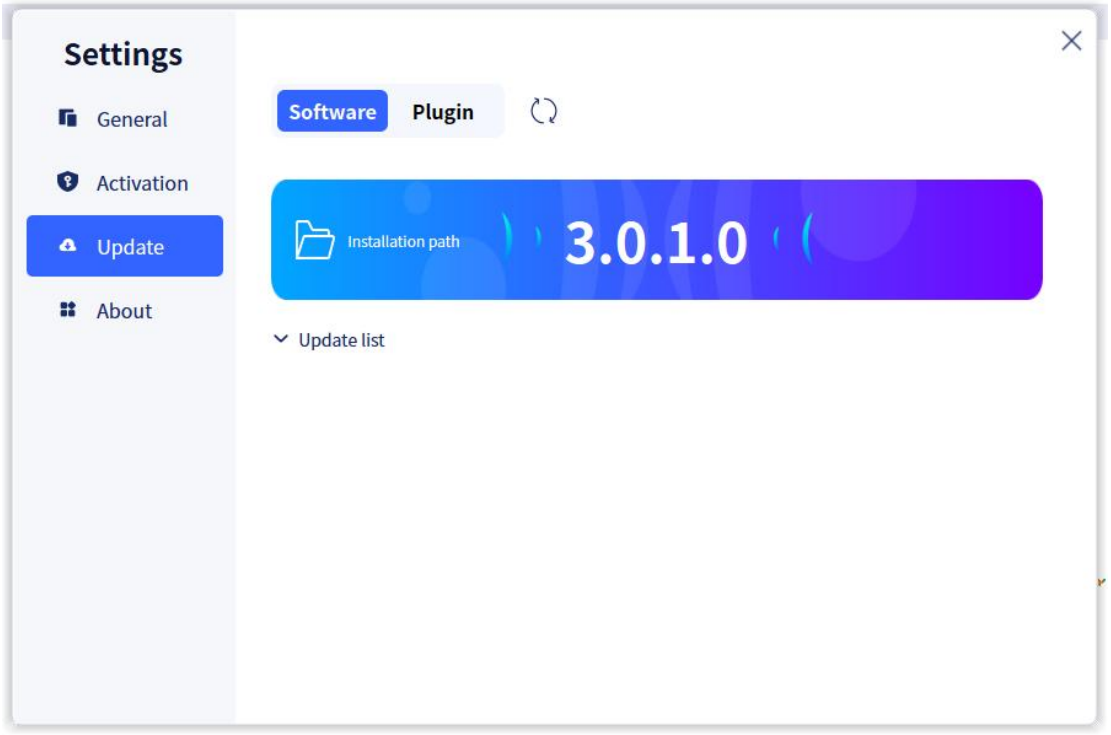


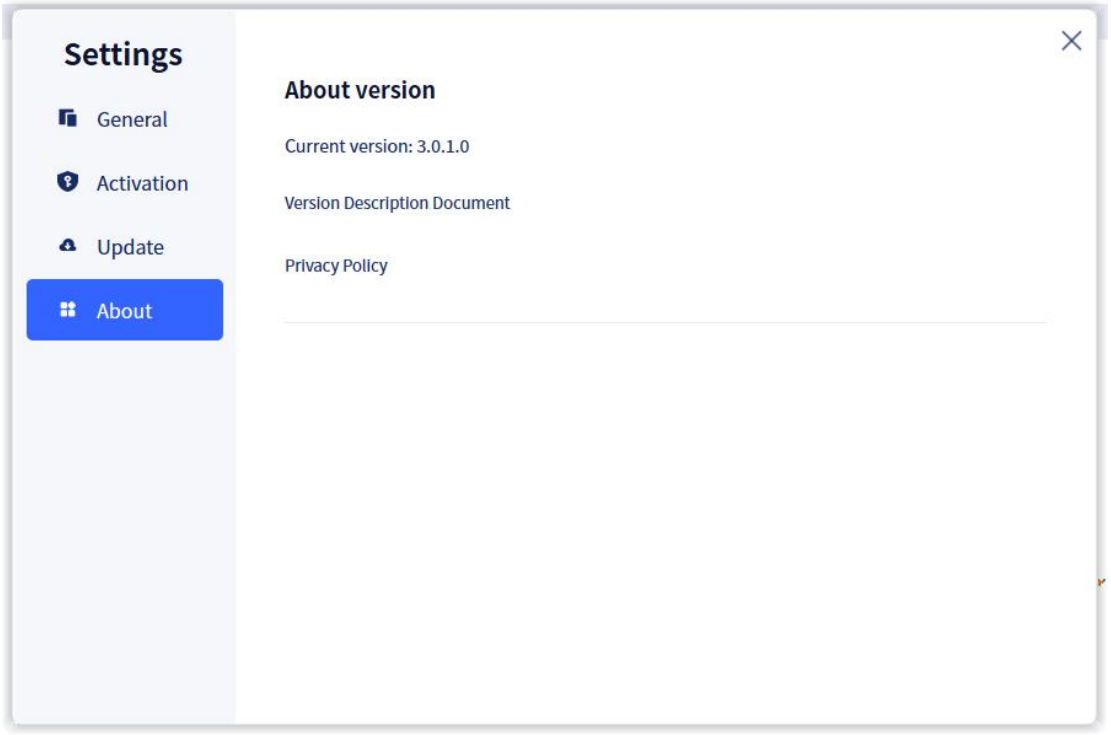
6. Setting

Settings include General, License, Update, and About.


Settings
General
Activation
Update
About
General
Language
English
Log path
C:/Users/Administrator/AppData/Local/XGrids/LixelStudio/log/


Settings
General
Activation
Update
About
Activation succeed
Basic authorization period: 2025-01-24 to 3024-09-06
Volume Pro period: 2025-01-24 to 2025-03-14
Update authorization





(3) Data List

The data list is located in the upper left area of the software and is used to manage the imported data files in the project.

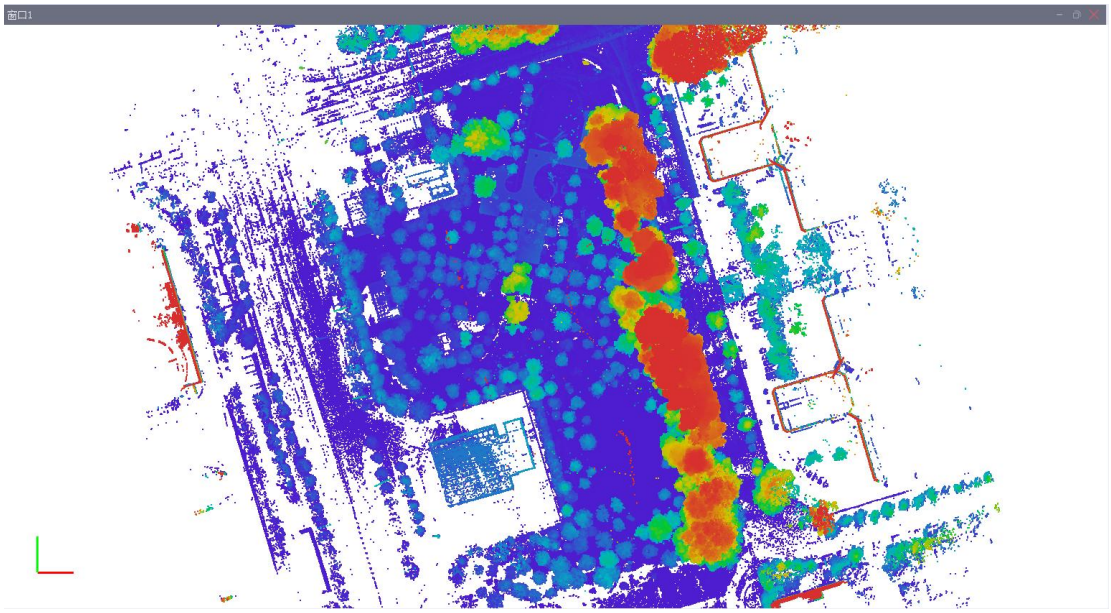
(4) Attribute Information Window

The attribute information window is located in the middle area on the left side of the software, used to manage the attribute information of the opened point cloud data and adjust the point size, rendering method, and transparency.

(5) Data Display Window

The data display window is located in the central area of the software and is used to display the data that the user has opened. Users can

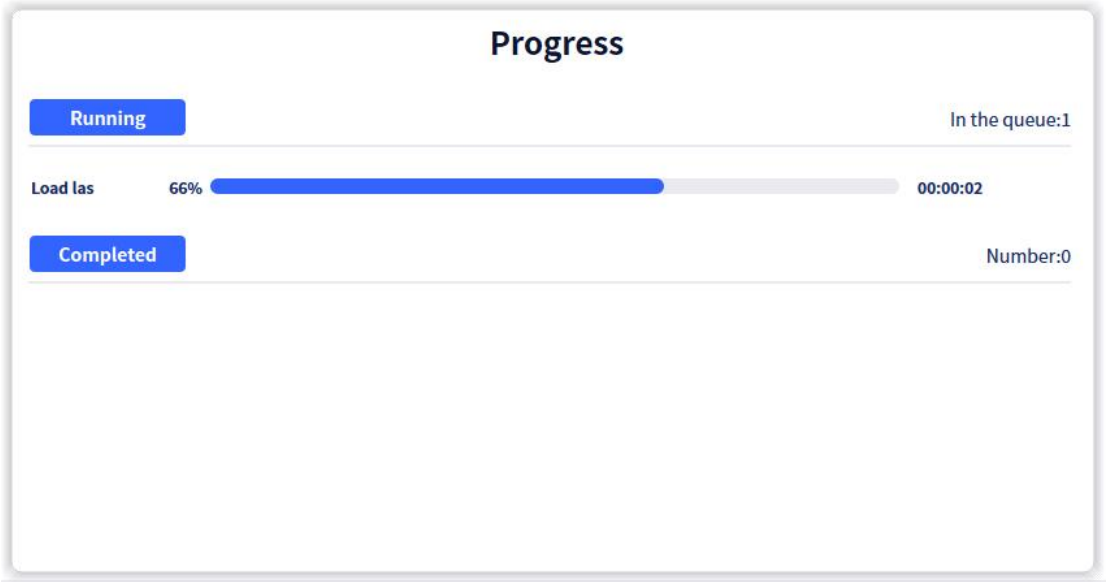
process data such as point clouds and images in the window.



(6) Process display toolbar

The progress display area is located at the bottom of the software and is used to show the progress of data operations performed by the user. When the program is running, moving the mouse over the progress bar will display the complete progress list.

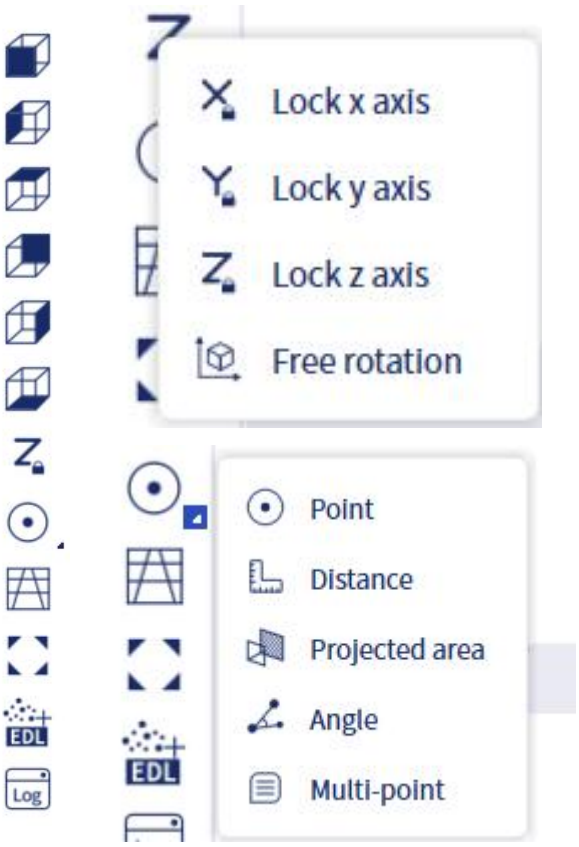
For processing results, they will be displayed in the task queue. Clicking the button on the right can open the result folder. Clicking delete will remove the completed task from the completed queue.



(7) Quick access toolbar

The quick operation bar is located on the far-left side of the software and mainly includes:

- **Six Views**: Front, Left, Top, Back, Right, Bottom
- **Coordinate Axis Locking**: Includes X-axis, Y-axis, Z-axis locking, and free rotation
- **Measurement**: Includes point, distance, area, angle, and multi-point measurement
- **Camera Mode**: Perspective mode, orthographic mode
- **Adaptive Mode**
- **EDL Display**
- **Workbench Display Switching**

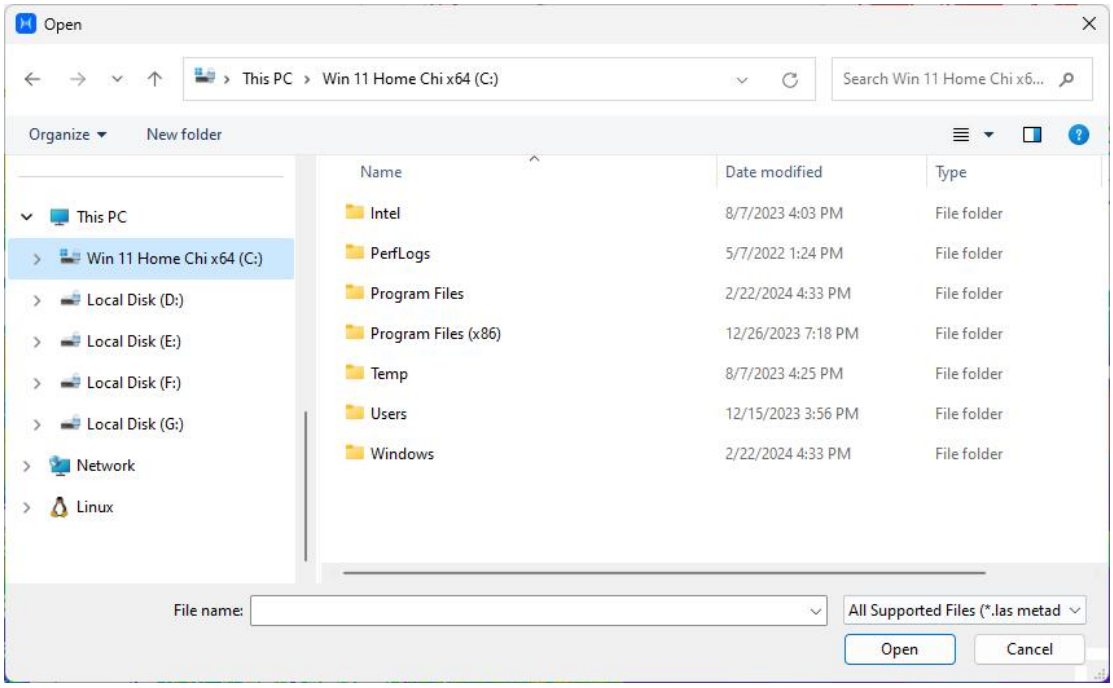


V. Basic Operations

(1) File

1. Import data

Click on "Import Data" to select the data you need to import. Click "Open," and the software will import the data and open it in the current window. Currently, it supports the import of point cloud data, including formats such as LAS (versions 1.1-1.4), LAZ, e57 and PLY. It also supports the import of control points and trajectory data in CSV and TXT formats and mesh in ply, obj and osgb formats.

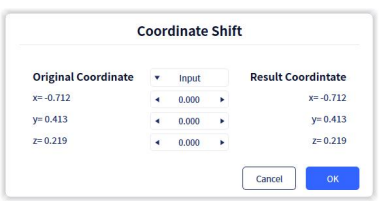


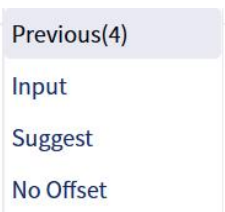
1.1 Import .las data

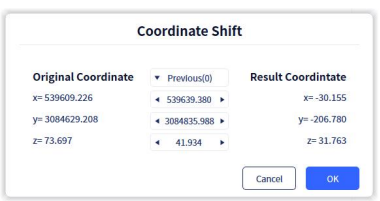
After selecting the .las file to import, the software will prompt you to choose the coordinate offset for rendering display (this offset will only affect the display of the point cloud in the window and will not affect the coordinates of the point cloud data itself).

Currently, the following offset options are provided: Input, Suggested, No Offset, Previous (0/1/...). Input refers to the offset value included in the LAS header file; Suggested refers to the recommended offset calculated by the software; No Offset means displaying directly in the software without any offset; Previous (0/1/...) refers to using the same offset as the previously imported point cloud.

For multiple-point cloud data within the same project in an absolute coordinate system, choosing "Input" for the first import is recommended. For subsequent point clouds in the same coordinate system, you can choose "Previous (0)." This way, the point clouds will be rendered and displayed in the same coordinate system.

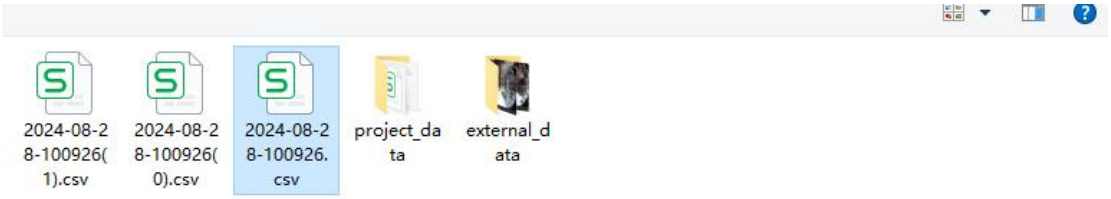




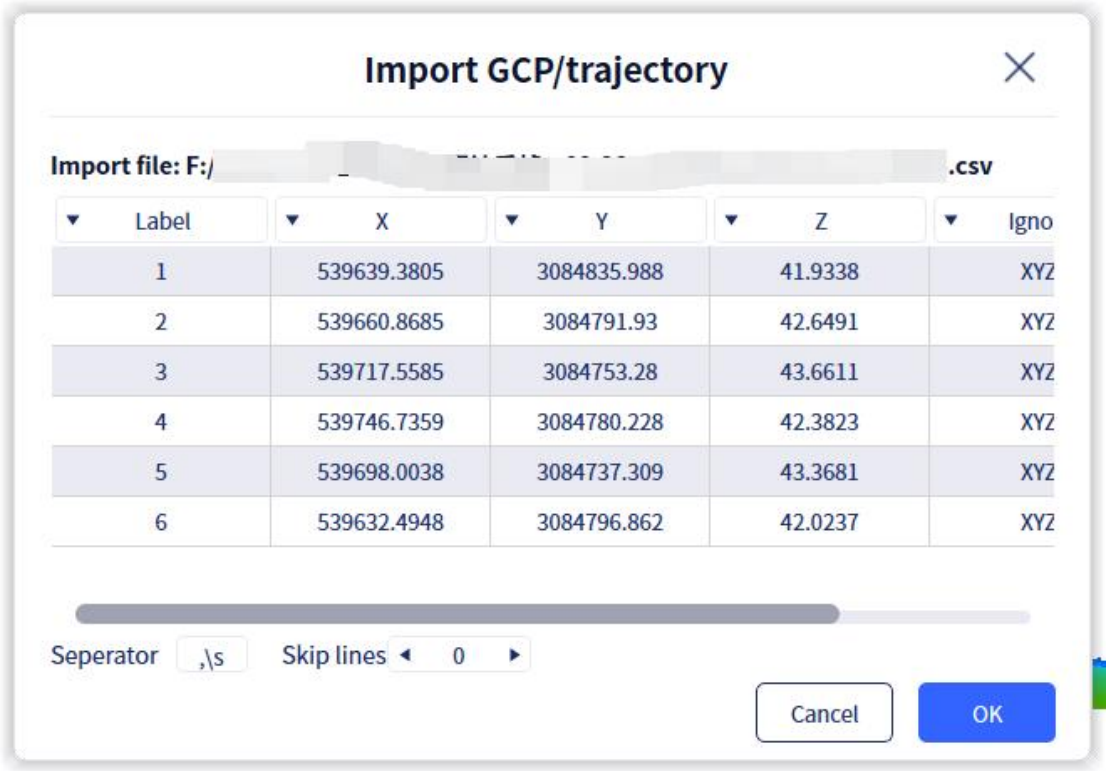


1.2 Import Control Points and Trajectory TXT/CSV Data

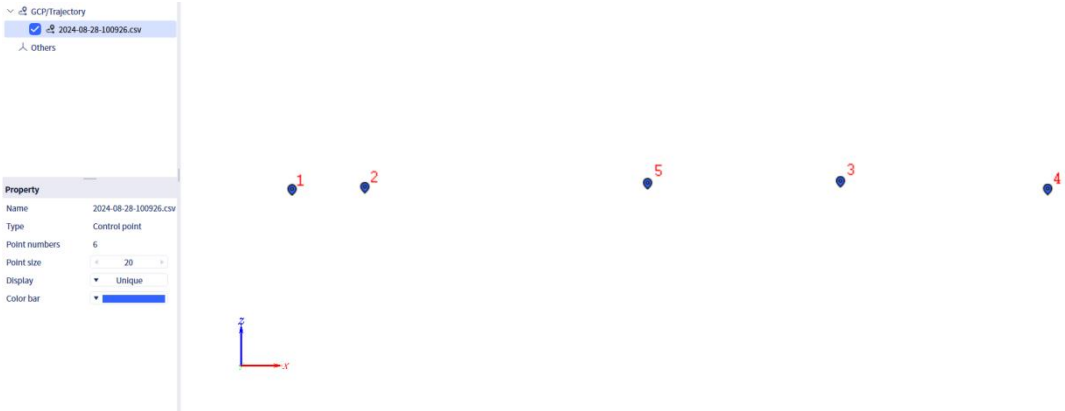
After selecting the .txt/.csv file to import, a dialog box will appear where you can freely choose the delimiter based on the data format and specify whether to skip rows when reading the data.



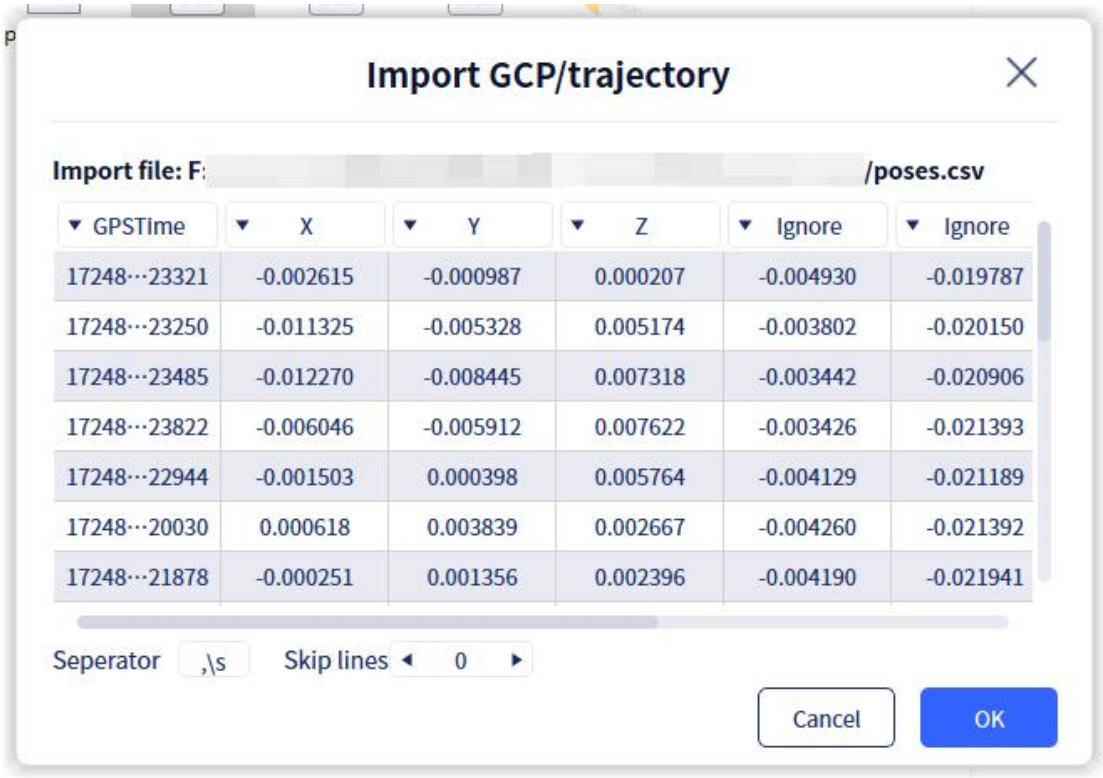
The software will automatically assign information such as X coordinate, Y coordinate, Z coordinate, intensity, and label to each column of data. You can select the appropriate assignment for each column according to your actual needs.

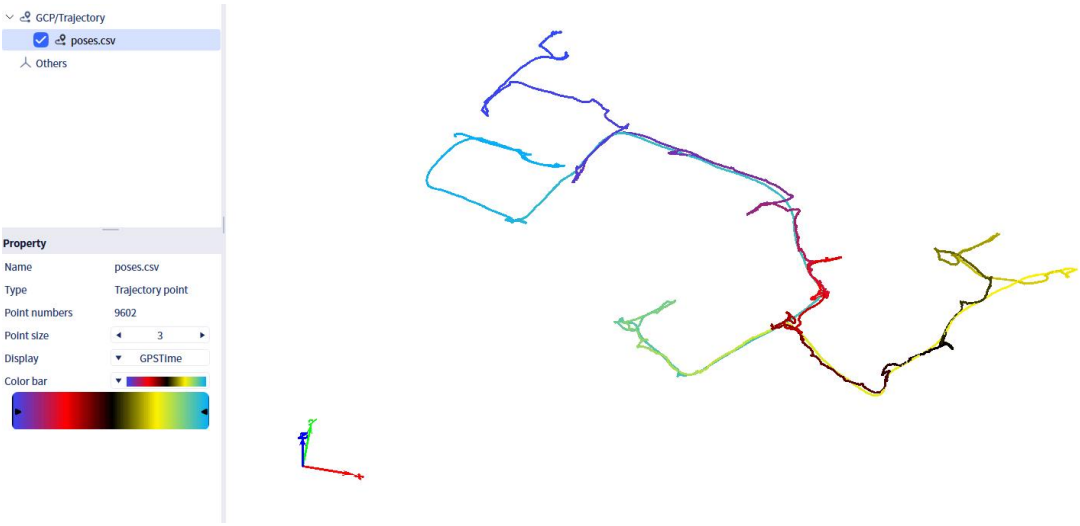


After making your selections, click "Confirm" to import the data. If you are importing control point data and the data includes label information, the imported data points will be displayed with special symbols in the data display box.



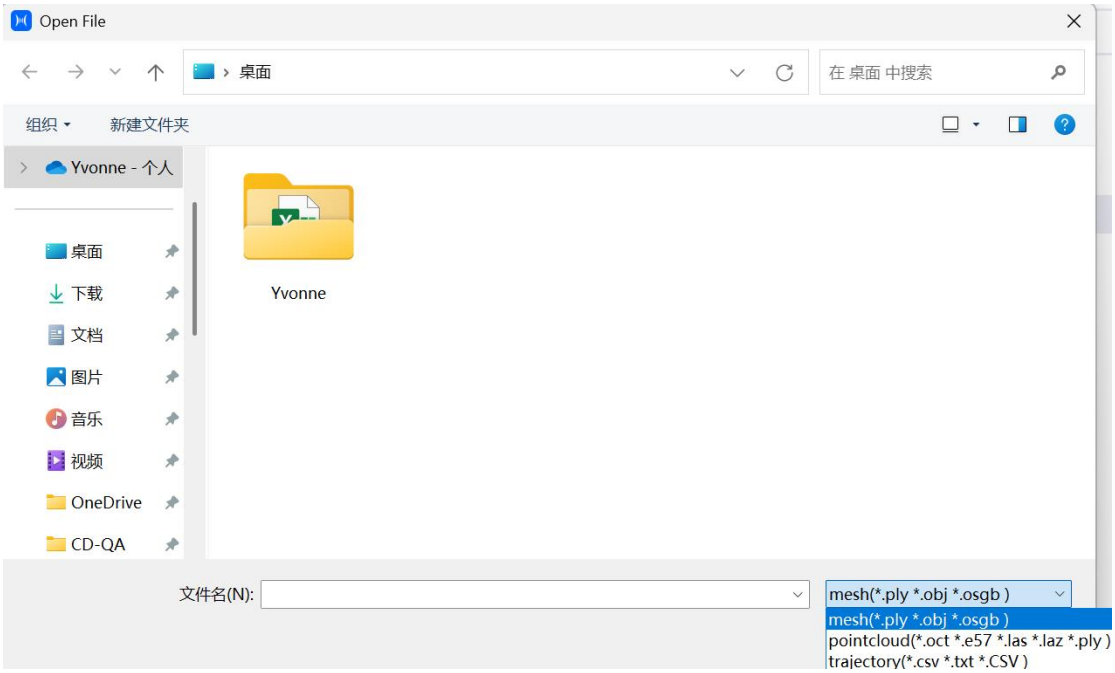
If the imported data is regular trajectory data, it will be displayed similarly to point cloud data. As shown in the figure below, the imported trajectory data is rendered and displayed using GPS time.

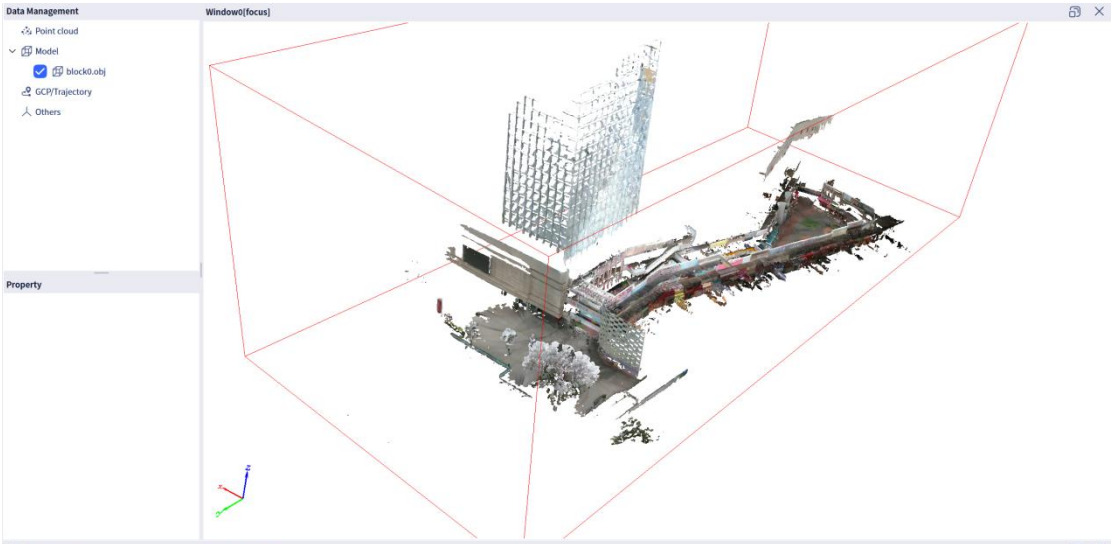




1.2 Import Mesh

Select the .ply/.obj/.osgb file to import, the mesh will display in the data window. Similar to point cloud browsing, the rotation center can be selected by double-clicking.


Open File
桌面
在 桌面 中搜索
组织
新建文件夹
Yvonne - 个人
桌面
下载
文档
图片
音乐
视频
OneDrive
CD-QA
Yvonne
文件名(N):
mesh(*.ply *.obj *.osgb)
mesh(*.ply *.obj *.osgb)
pointcloud(*.oct *.e57 *.las *.laz *.ply)
trajectory(*.csv *.txt *.CSV)


Data Management
Point cloud
Model
block0.obj
GCP/Trajectory
Others
Property
Window0(focus)


Data Management
Point cloud
Model
block0.obj
GCP/Trajectory
Others
Property
Window0(focus)
牛小席
一粉道
加盟热线：400-168-9586

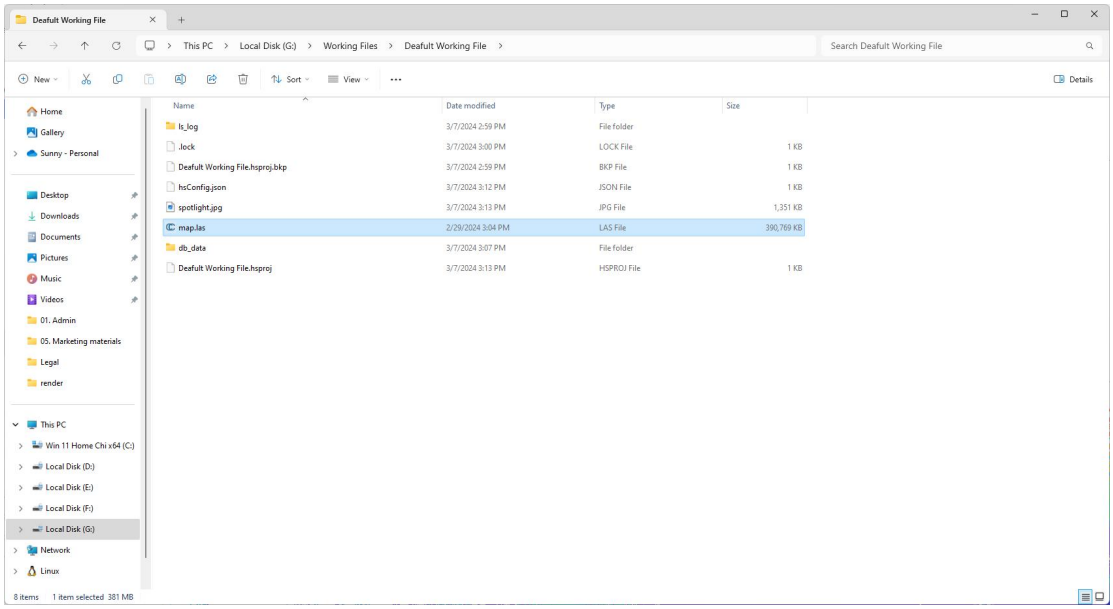
2. Save project

Click "Save" to save the files within the project.

3. Export data

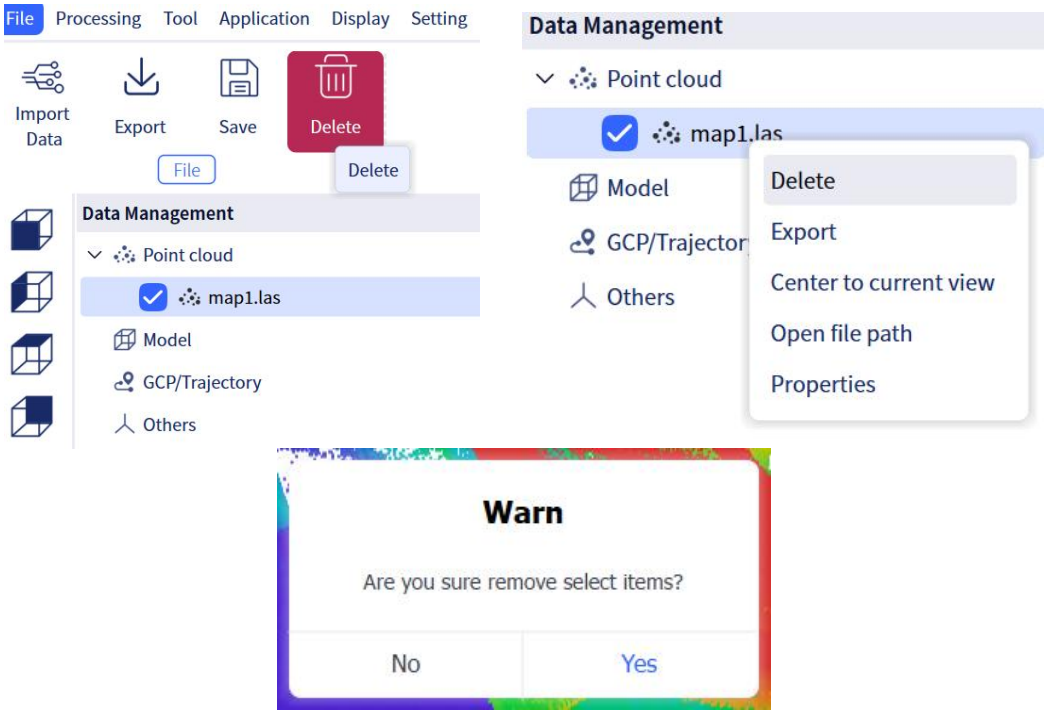
Select the data you need to export and click "Export Data" to export the corresponding point cloud data files to the selected path. Currently, the software supports exporting point cloud data in LAS, LAZ, PLY and unstructured e57 formats.

To export structured e57 data, please refer to the "las to e57" function in the "VI. Main Functions (II) Tools 3. Data Management" section.



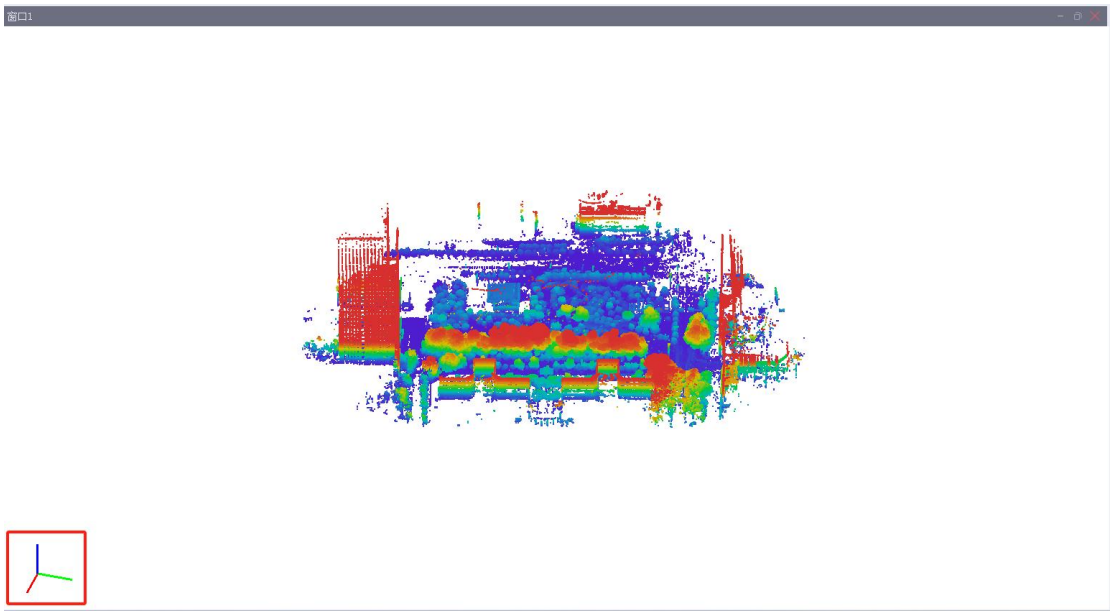
4. Delete data

Click on the data file in the corresponding data list, then click "Delete" or right-click, select “Delete” and confirm to delete the corresponding data.



(2) Data Operation and Viewing

You can use mouse operations to zoom, pan, and rotate the data. In the lower-left corner of the data display window, the coordinate axis system of the current point cloud data is shown, with the X-axis in red, the Y-axis in green, and the Z-axis in blue.



1. Zoom

Point cloud data can be zoomed in and out by controlling the mouse wheel. The scroll wheel can be zoomed in forward and out backward.

2. Translation/Pan

You can translate and drag point cloud data by right-clicking the mouse.

3. Rotation

You can rotate point cloud by holding down the left mouse button and dragging the mouse. The rotation center of point cloud can be selected by double-clicking. When rotating, the data can now be translated to the center of the window for easier rotation. If you need to fix the Z-axis for rotation, you can click the quick access Z-axis lock button to lock the Z-axis for rotation.

(3) Data list

The data list can manage the imported data files in the project. The data can be displayed or hidden. Select the point cloud and right-click to open the right-click menu to delete, export, center to the current view, open the file path, and open the property settings.

1. Point cloud display and hiding

After importing the point cloud, the display point cloud will be checked by default. Unchecking it will hide the point cloud.

2. Right-click menu for a single data

After selecting a single data, right-clicking will open the right-click menu bar of the point cloud.

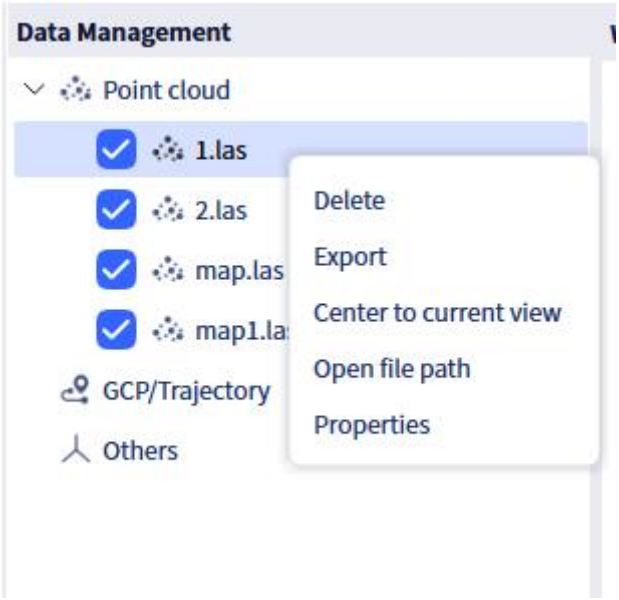
Delete: Confirm deletion in the pop-up window to delete the point cloud.

Export: Select the data to be exported and click Export Data to export the corresponding point cloud data file to the selected path. Currently, the software supports exporting point cloud data in las, ply, and unstructured e57 formats.

Center to current view: The viewing angle will be readjusted to restore the point cloud data to the original top view and display it in the center of the window.

Open file path: You can open the directory of this point cloud in the computer.

Properties: You can set the point size, transparency and rendering mode of the point cloud.



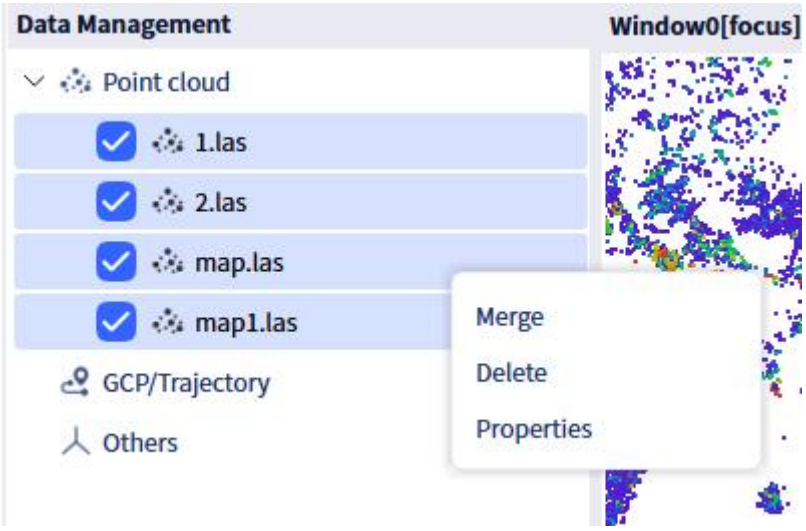
2. Right-click menu for multiple data

After selecting multiple data, right-clicking will open the right-click menu bar of multiple data.

Merge: The Merge function supports the selection of multiple point clouds, which can be merged into one point cloud. For details, please refer to the "3. Data Management 3.1 Merge" section.

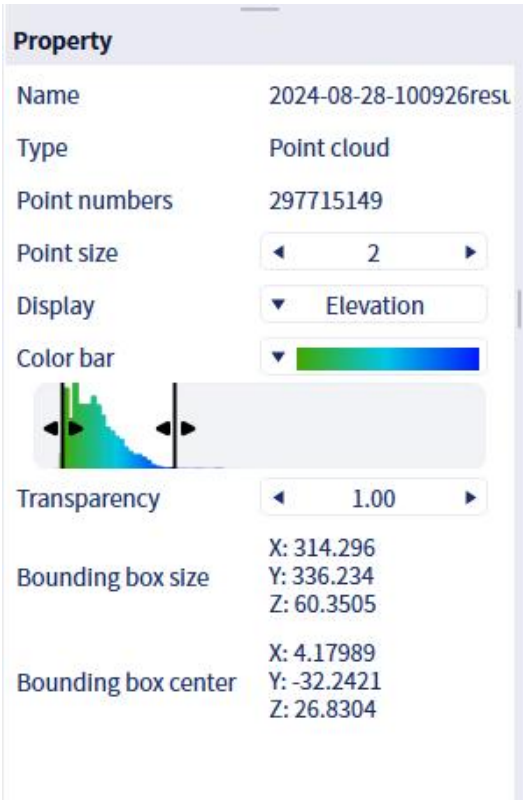
Delete: Confirm deletion in the pop-up window to delete all the selected point clouds.

Properties: You can set the point size, transparency and rendering mode of all the selected point cloud.



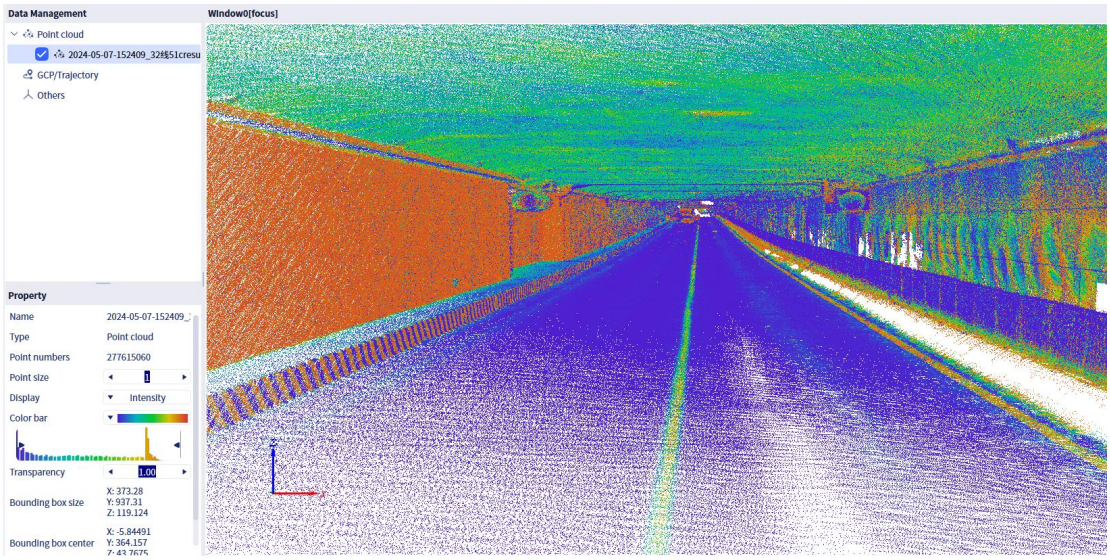
(4) Attribute Information

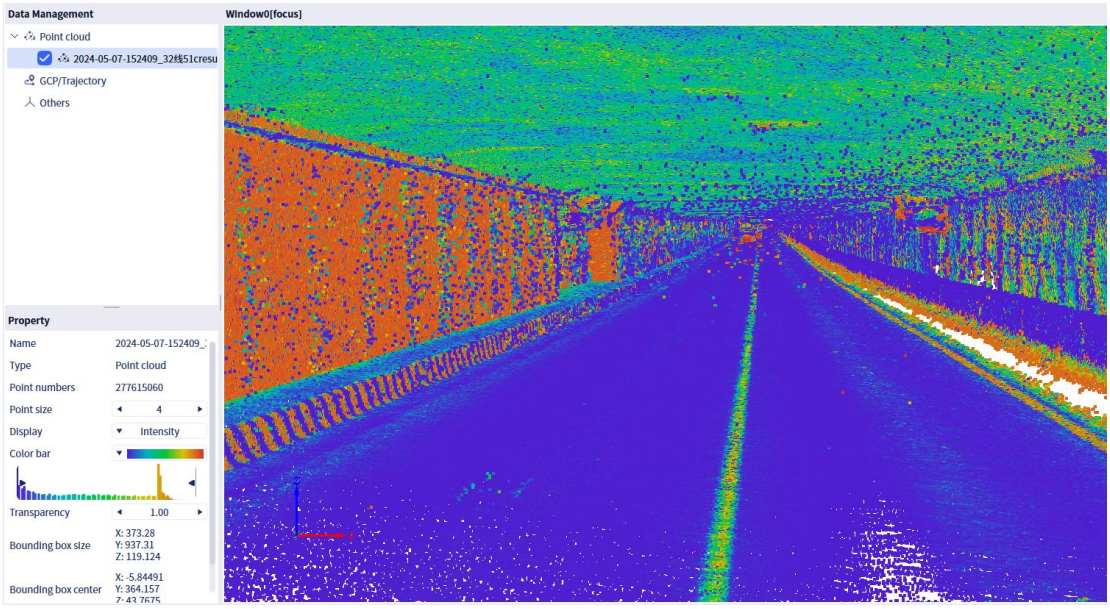
By selecting an individual point cloud data, you can view its basic information, such as point number, in the property information bar. You can also adjust the display mode, transparency, and other settings of the point cloud.



1. **Point size**

Adjusting the "Point Size" allows you to change the size of the points in the point cloud data displayed in the current window. The size ranges from 1 (smallest) to 10 (largest). The different point size display effects are shown in the figure below (the point cloud is displayed in intensity).



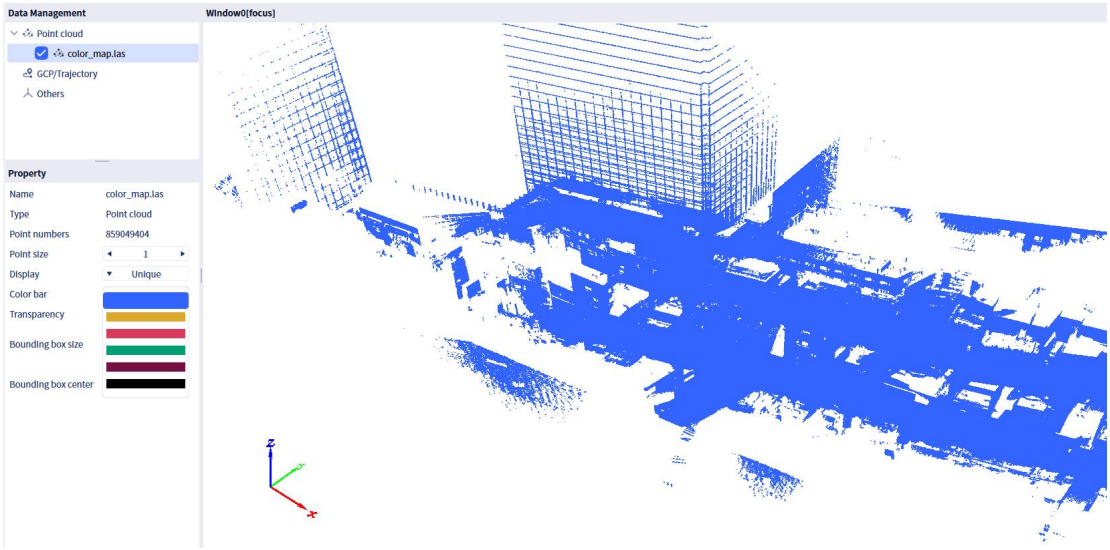


2. **Display mode**

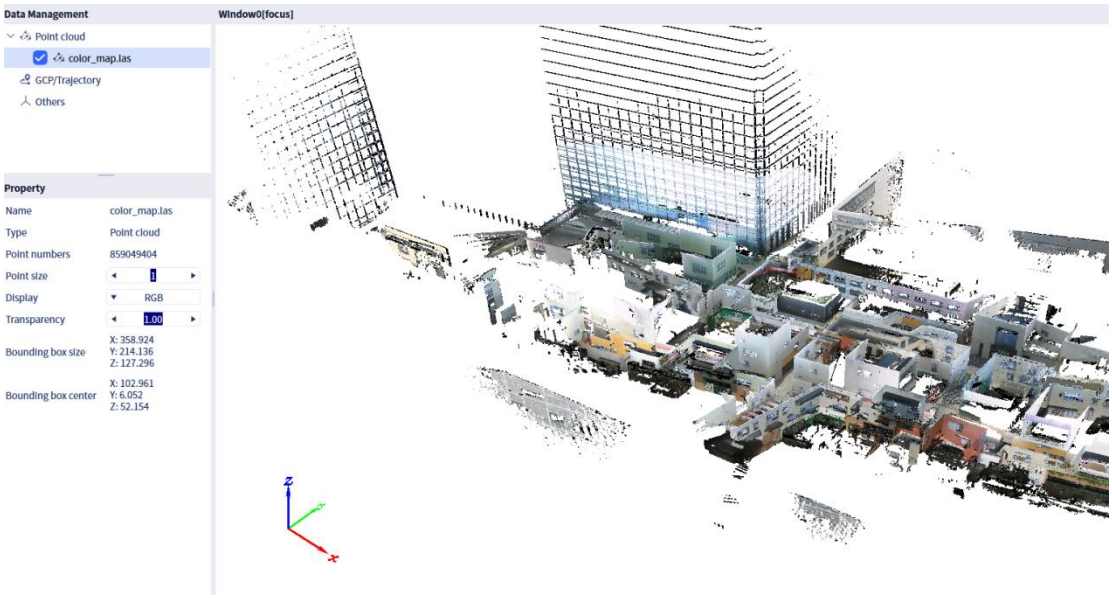
Adjusting the display mode allows you to change the rendering display of the point cloud. Currently, the software provides five different display types: "RGB," "Elevation," "Intensity," "GPS Time," and "Unique." Users can adjust the

display mode according to their needs.

Selecting "Unique" will display the point cloud in a fixed color. In light mode, it will be displayed in black; in dark mode, it will be displayed in white. If the user needs to specify a color for display, select the point cloud data, go to the properties window, choose "Set Color," select the desired color, and confirm. The point cloud will then be displayed in the selected color.

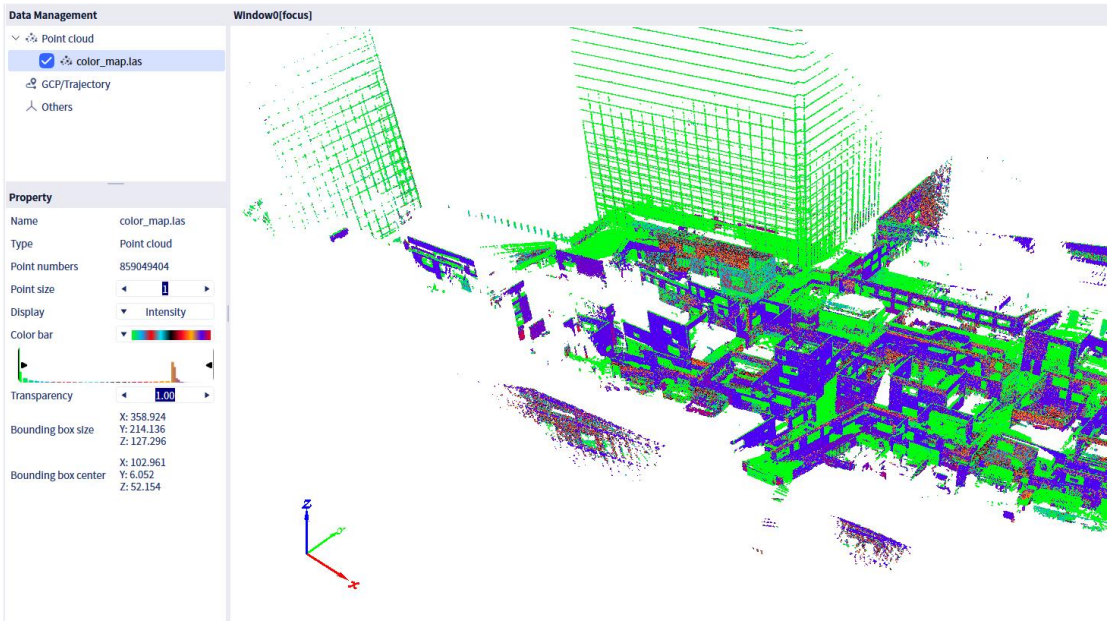


Selecting "RGB" will display the point cloud in its actual colors. The RGB color display effect is as follows:

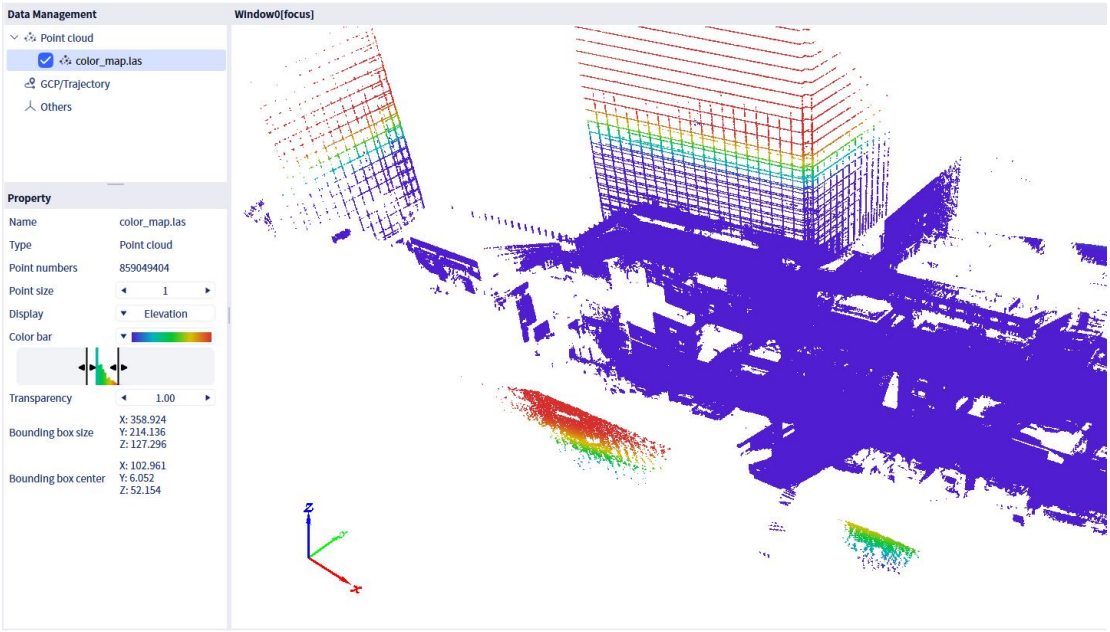


Selecting "Intensity," "Elevation," or "GPS Time" will display the point cloud using different color bands. The software provides various color bands for these display modes, and users can choose the color band according to their needs.

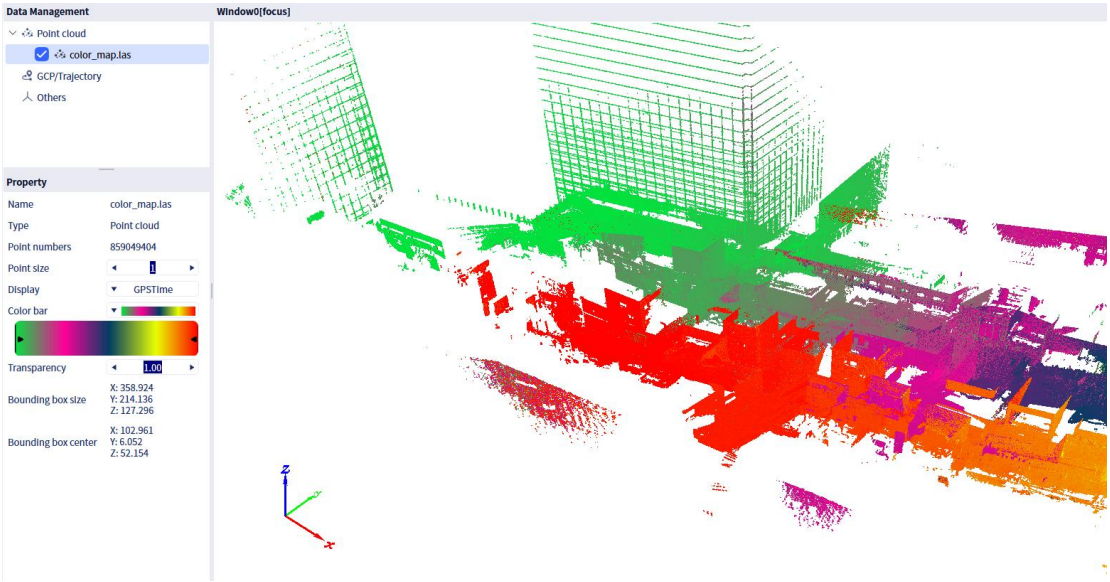
The intensity display effect is as follows:



Elevation display effect:

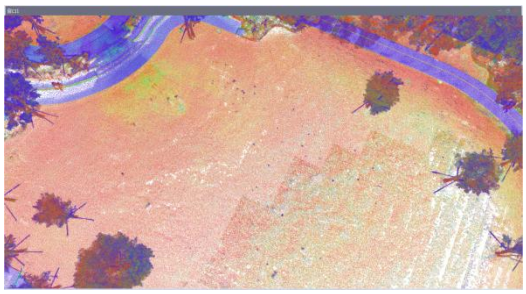


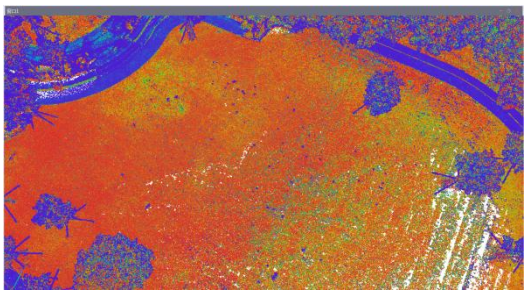
GPS Time display effect:



3. **Transparency**

Adjust "transparency" to adjust the transparency of the point cloud data displayed in the current window. 0 is the minimum and 1 is the maximum. The smaller the value, the more transparent the point cloud will appear. The following picture shows the comparison effect (left: transparency 0.1, right transparency 1).



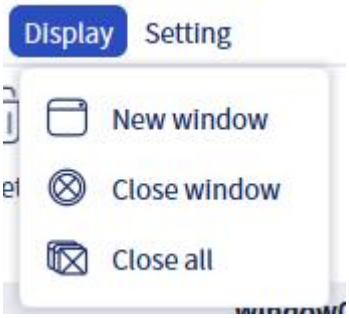


4. Open file path

Select the point cloud, right-click and select "Open File Path" to automatically open the directory of this point cloud in the computer.

(5) Display

Display menu allows for multi-window management. Click "Display" to bring up a drop-down menu.



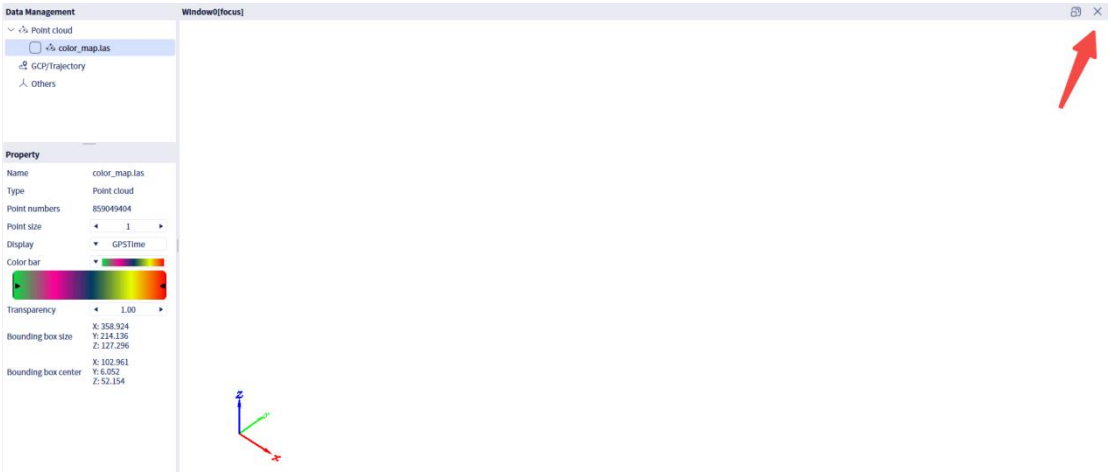
1. New window

Click "New window" to add a blank window in the software display area. The software defaults to this window as the activation window. If you need to display the imported data in this window, click "File" - "Import Data", and the newly imported data will be displayed in this window. You can also click on the imported data and drag it into the window that needs to be displayed.

After the software is opened, there is an automatic default window in the interface. If the user accidentally closes the window, they can directly click the "New window" button in the center of the screen to create a new window. They can also click "Display" - "New window" in the menu bar to create a new window.

2. Close the window

Click "Close Window" and the software will close the currently active window. You can also click the close key " X " in the upper right corner of the window to close the window.



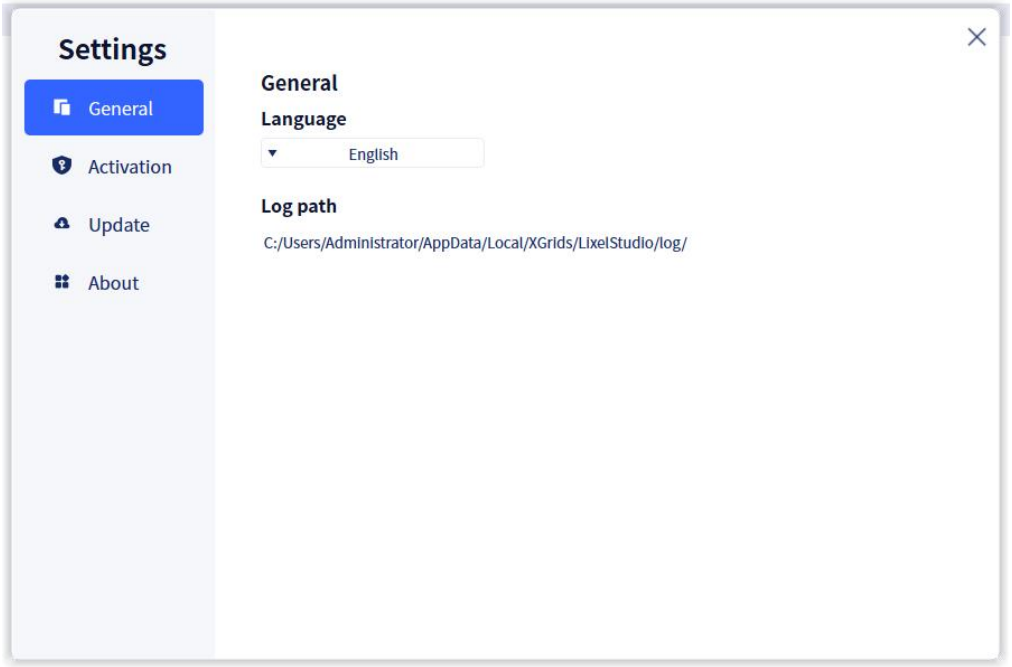
3. Close all windows

Click "Close All", and the software will close all open windows.

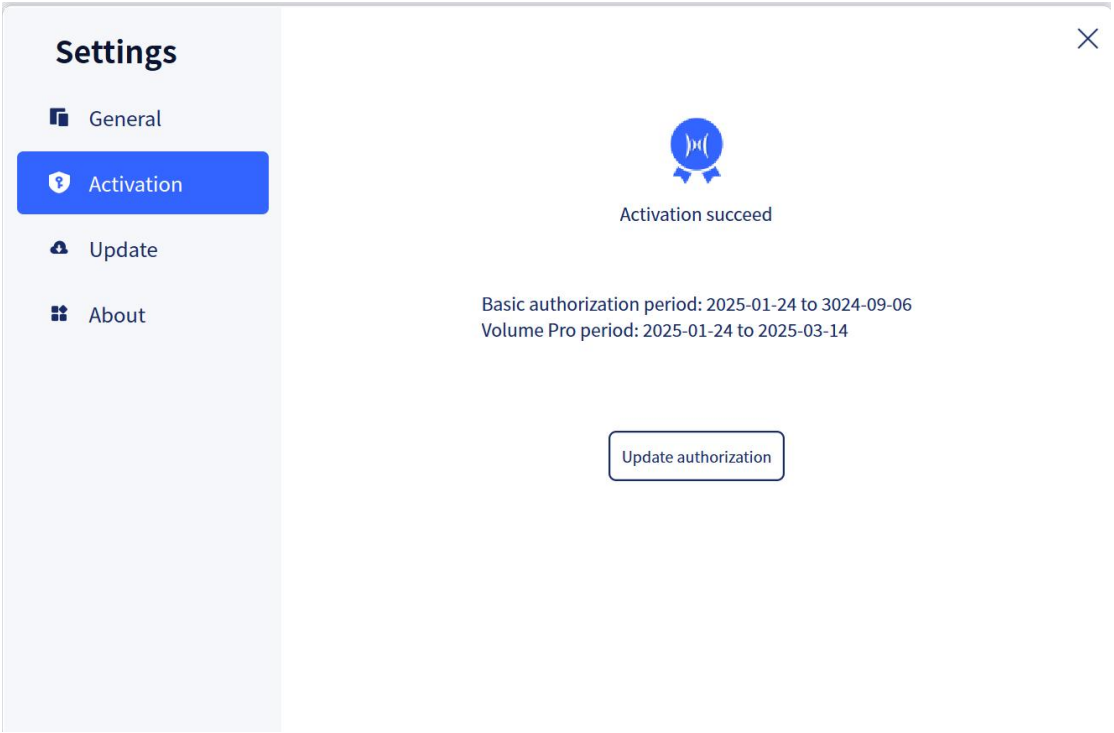
(6) Setting

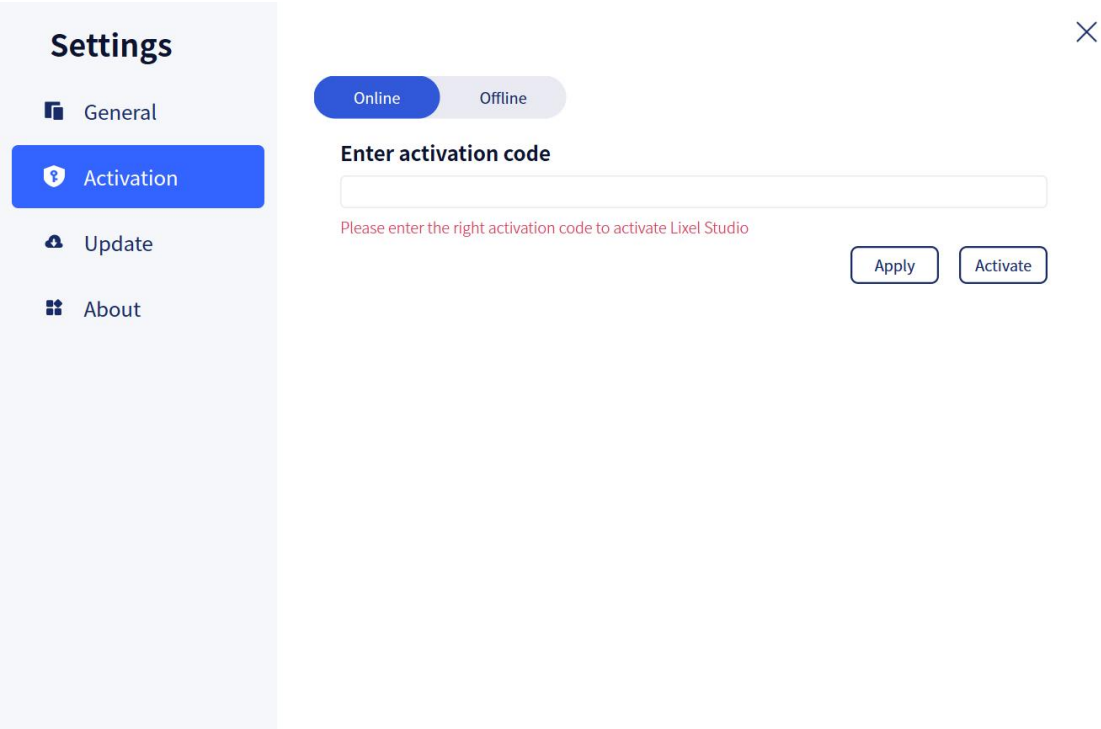
Settings include General, Activation, Updates, and About.

- **General**: This section allows you to switch the software language, currently supporting Chinese and English. After changing the language, a restart of the software is needed. It also shows the path to the log files of the current software. Clicking on it will directly navigate to that path. (If restarting the software doesn't change the language, then please try reinstall and choose the correct language.)

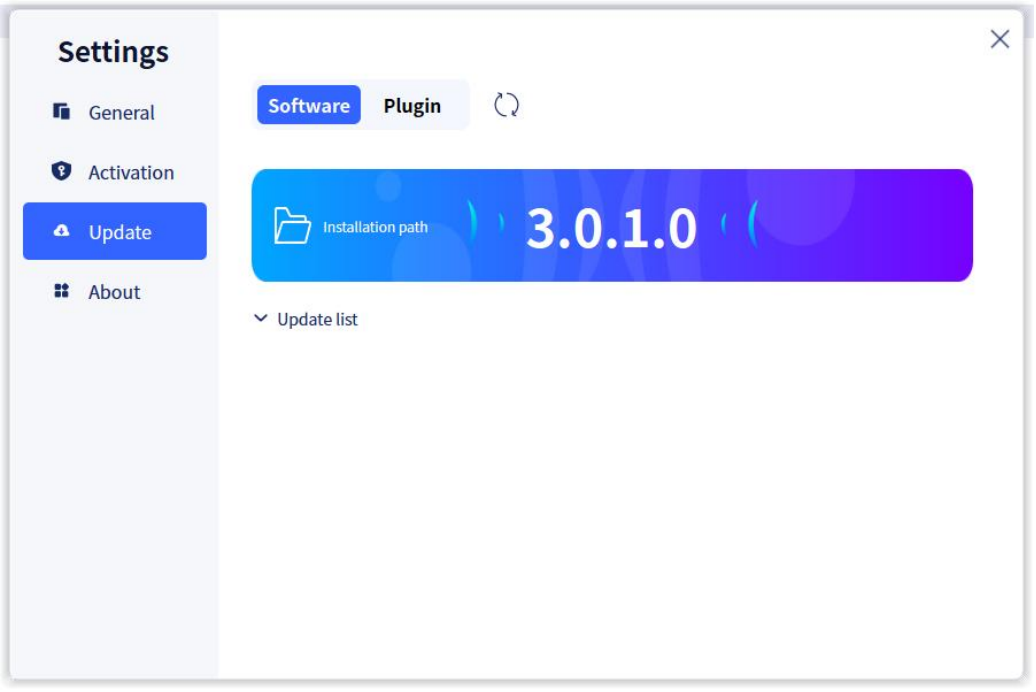


◦ **Activation**: This section displays the corresponding authorization information. The current authorization period, including basic authorization and paid plug-in authorization is displayed. If you need to update the authorization, click the Update authorization button below to update the authorization. Both online and offline updates are supported.

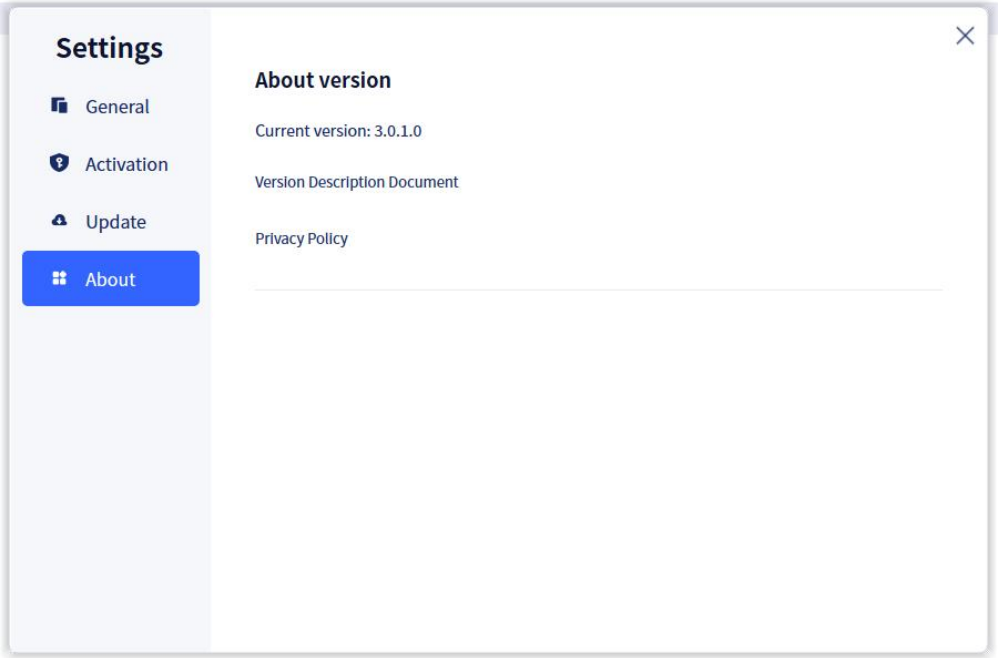




- **Update**: If there are updates, they will be shown on this page. You can click the refresh button on the right side of the plugin to check for updates. (In the image below, no updates are displayed because there are no updates available for the software.) If there are updates, click the "Download" button on the right side of the corresponding software/plugin in the update list to download the installation package for that version. After the download is complete, click the "Install" button on the right side to proceed with the installation.



- **About**: This section shows the current version information. Clicking on "Version Description Document" will directly navigate to the official website, displaying the release notes for the current version. Clicking on "Privacy Policy" will navigate to the software's privacy policy statement.



(7) Quick Operation

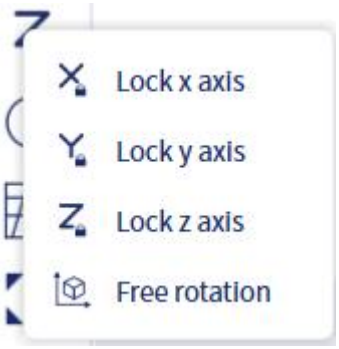
The left-side quick operations include Six Views, Axis Locking, Measurement, Camera Settings, EDL Display, and Workbench Display Switching.

1. Six Views

The Six Views include Front View, Back View, Left View, Right View, Top View, and Bottom View, which are used to provide different perspectives for displaying the point cloud data.

2. Axis Locking

Axis Locking includes X-axis Lock, Y-axis Lock, Z-axis Lock, and Free View, which are used to provide different directional constraints for three-dimensional viewing of the point cloud.



3. Camera Settings

Camera Mode is used to switch the viewing perspective of the point cloud display. Currently, the software provides two modes: Perspective View and Orthographic View.

3.1 Perspective View

- "Perspective View" mainly mimics the way the human eye observes the 3D world, making the point cloud data appear more realistic, with objects appearing larger when closer and smaller when farther away. Clicking "Perspective View" will automatically switch the perspective to orthographic mode.

3.2 Orthogonal View

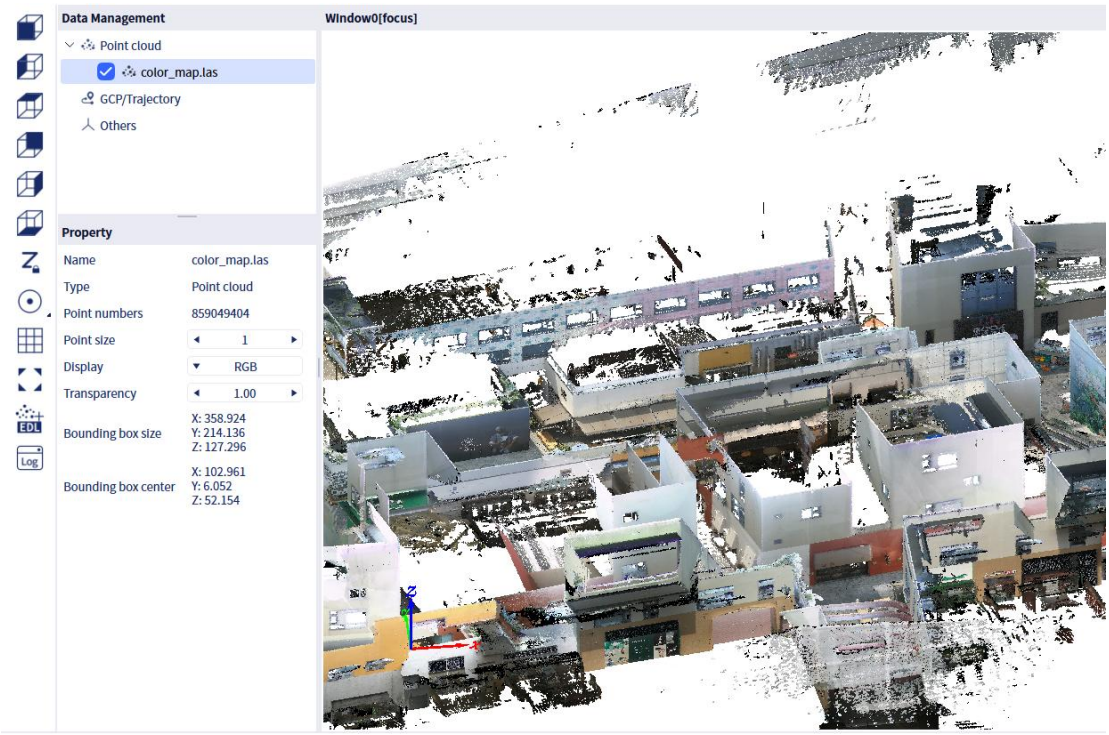
- "Orthogonal View" ensures that the size of the data in the point cloud does not change with the viewing angle. Clicking "Orthographic View" will automatically switch the perspective to orthographic mode.

3.3 Global View

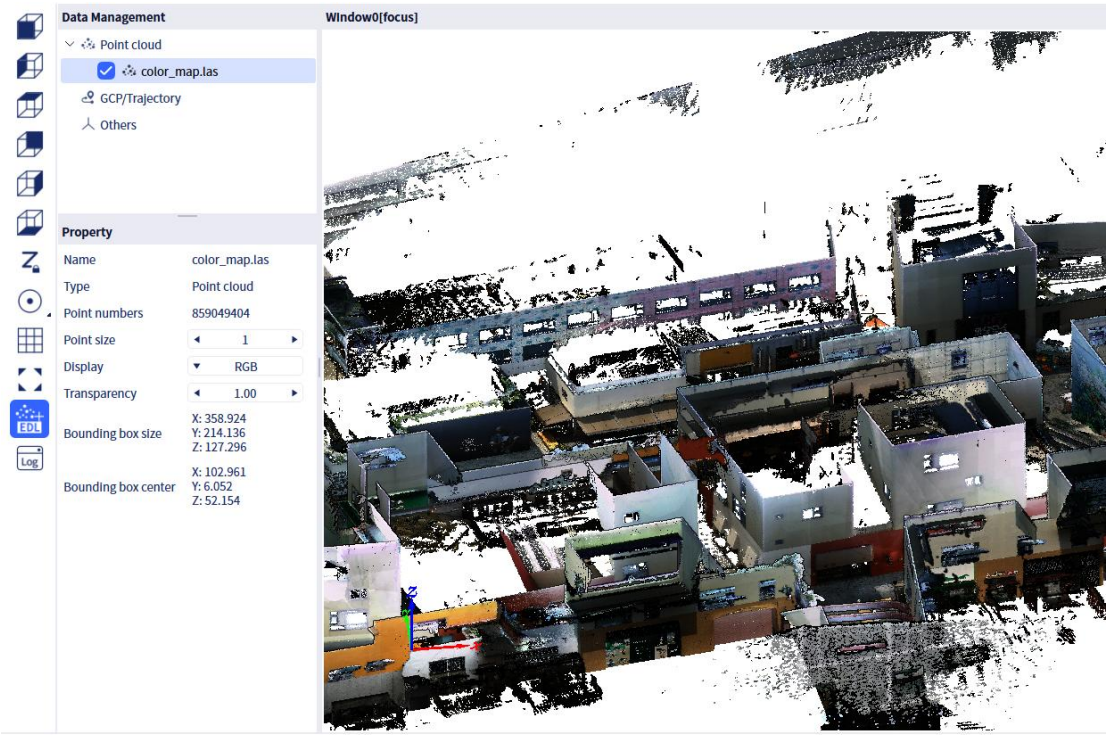
- "Global View" readjusts the perspective to restore the point cloud data to side view, centering it in the window.

4. EDL Mode

EDL (Eye Dome Lighting) Display enhances the display of feature contours in point cloud data. Clicking "EDL Display" will enhance the display effect of the point cloud data in the currently active window using the EDL method. The specific display effect is shown in the figure below.



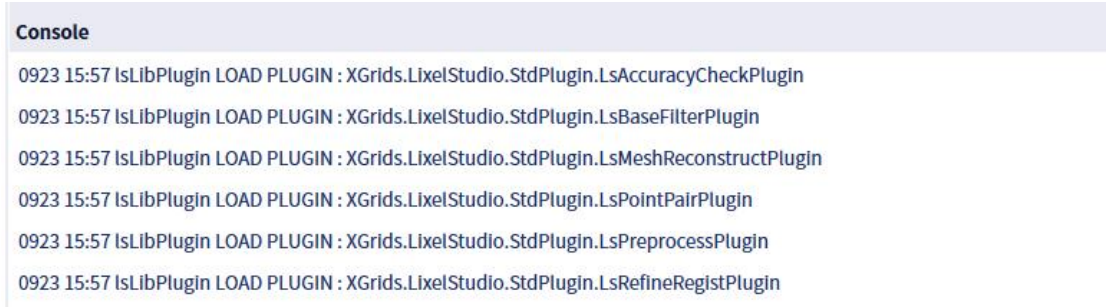
(EDL disabled)



(EDL enabled)

5. Workbench Display Switching

Clicking on the Workbench Display Toggle will display the workbench window at the bottom of the central view area, showing the progress status of the program. If not needed, you can also click on the blank area next to it to hide the workbench.

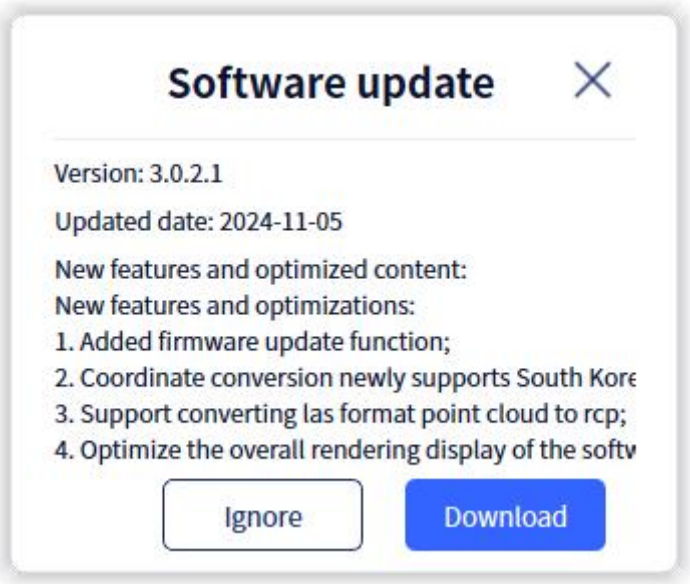


(8) Online software update

1. Software update

Note: When using the online update function to download updates, be sure to open the software in administrator mode.

The software has added online update reminders. If there is a software update, a pop-up window will be displayed after opening the software project. The pop-up window will simultaneously display the update version number, update date, and new features and optimized content items.

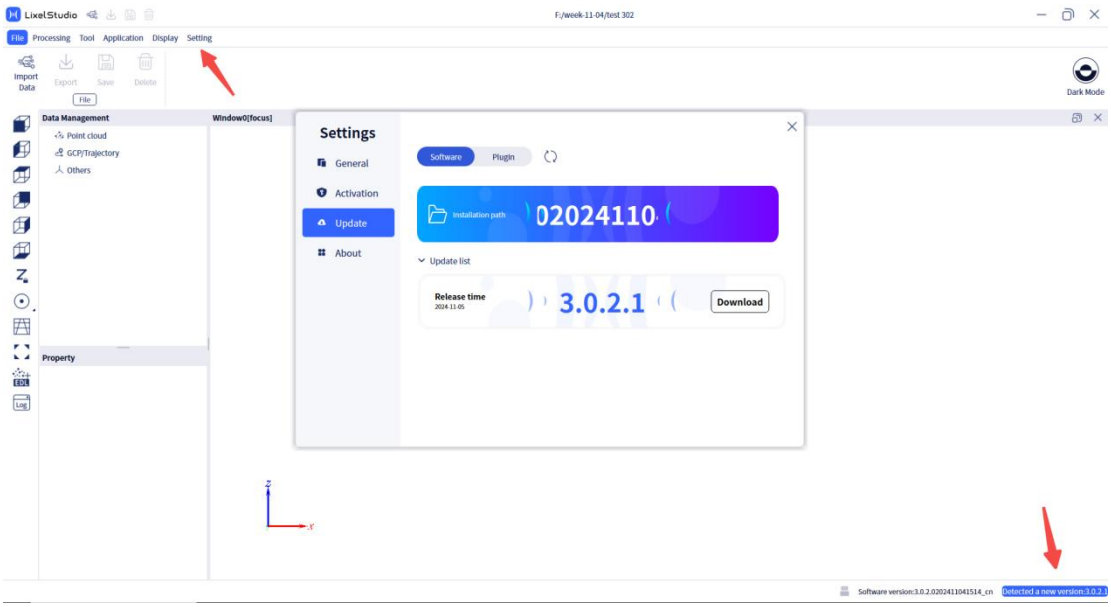


Users can choose whether to update immediately as needed. If you click Download, the software will be automatically starting download. After the software is downloaded, a pop-up window will appear to prompt whether to close the software and update. Click Yes, the program will close the current software and start the update. Click No, the program will not be updated. If you need to install a new version later, you can go to Settings → Update and click Install to update.

Note: Do not perform other operations during the update process to ensure the smooth update. The software update takes a certain amount of time, please wait patiently. The software will automatically restart after the update is completed.

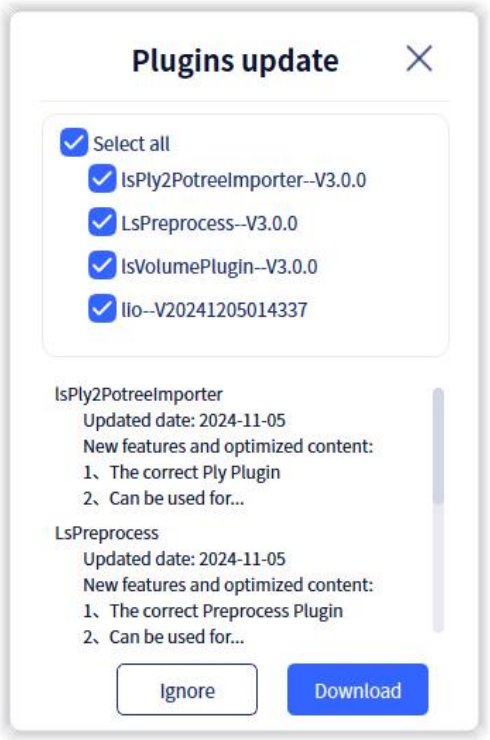
Click "Ignore" and the software will not prompt you to update the version next time you open it. However, users can see the update prompt in the settings and in the lower left corner of the software. Click the close button in the upper right corner and the software will prompt you to update the version next time you open it.

Users can click Settings → Update, or click the update prompt in the lower right corner of the software to view the current main program update content.



1. Plugin update

In addition to software update, LixelStudio also provides updates for individual functional plug-ins. For plug-in updates, users can choose the content they want to update (it is strongly recommended to check all and update in a timely manner).



After making your selection, click Download and the software will

automatically download the updated plug-in. After the download is complete, a pop-up window will appear asking you whether to close the software and update it. Click Yes and the program will close the current software and start the update. Click No and the program will not be updated. If you need to install a new version later, you can go to Settings → Update and click Install to update.

Note: Do not perform other operations during the update process to ensure the smooth update. The software update takes a certain amount of time, please wait patiently. The software will automatically restart after the update is completed.

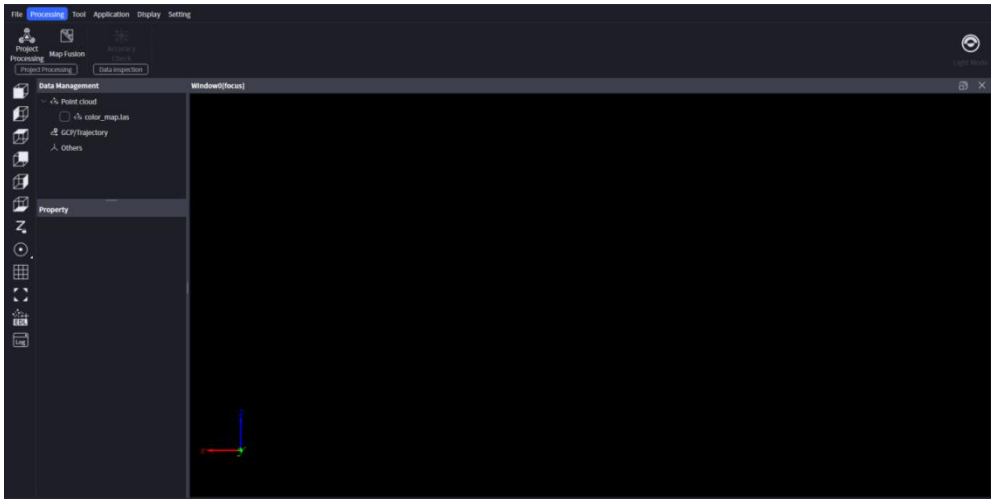
Click "Ignore" and the software will not prompt you to update the version next time you open it. However, users can see the update prompt in the settings and in the lower left corner of the software. Click the close button in the upper right corner and the software will prompt you to update the version next time you open it.

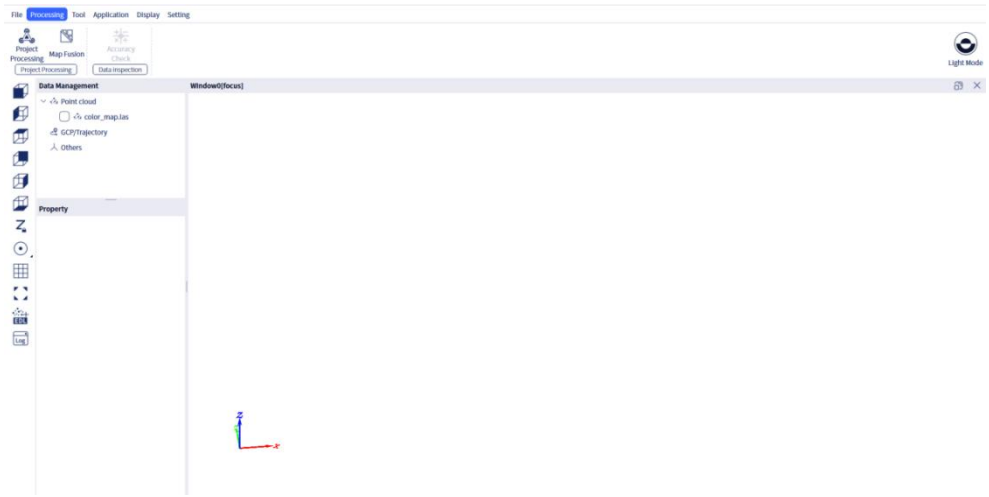
Users can click Settings → Update → Plugins to view the current plugin update content. Hover the mouse over the corresponding plugin to view the detailed update optimization content. Click Update (Install) to update the corresponding plugin. Click Install All above to update all plugins.

(9) Other

1. Dark Mode/Light Mode:

- Clicking "Dark Mode"/"Light Mode" on the far right of the function bar allows you to switch between dark and light display modes of the software.



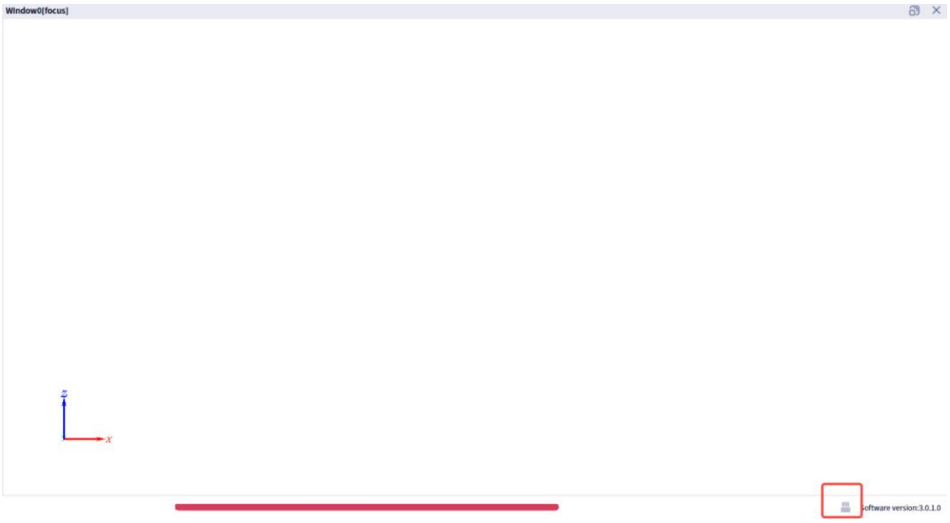


2. Project Directory

The current LixelStudio project directory is shown at the top. Clicking it will take you to that folder.

3. Device Connection

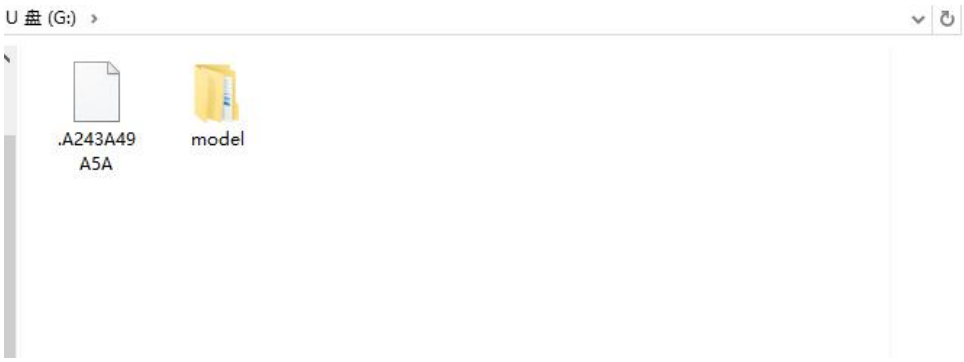
On the bottom right of the interface, this USB button will allow you to open USB mode of your device after it's connected. Without detecting a connected device, this button will not be highlighted.



After turning on the XGRIDS handheld scanning device, connect the device to the computer using a USB cable. Wait for about 30 seconds until the USB drive button lights up. If the computer's sound is enabled, there will also be an audio prompt indicating that the device has been successfully connected.

Click the USB drive button to display the information of the currently connected device, including the current device firmware information and storage capacity. Click the "USB Drive" button at the bottom right to switch to USB drive mode. In the current mode, the folder button on the left is not available.

Click the "USB Drive" button at the bottom right to enable the device's USB drive mode, which will automatically open the device's data folder.



Note: Each time you switch USB modes, the device will disconnect and reconnect. Please wait for a few seconds.

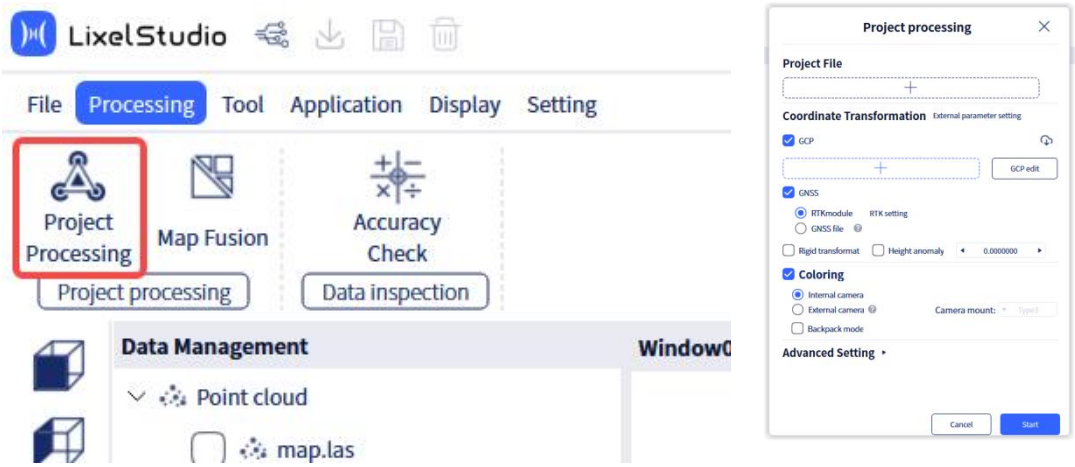
VI. Main Functions

(1) Processing

1. Project Processing

Project processing mainly involves post-processing the raw data obtained from XGIRDS Innovation's handheld scanners L1, L2, L2 Pro and K1 to obtain the required point cloud data. The project processing module includes functions such as SLAM mapping optimization (e.g., loop closure, dynamic object removal), coordinate transformation, point cloud coloring,

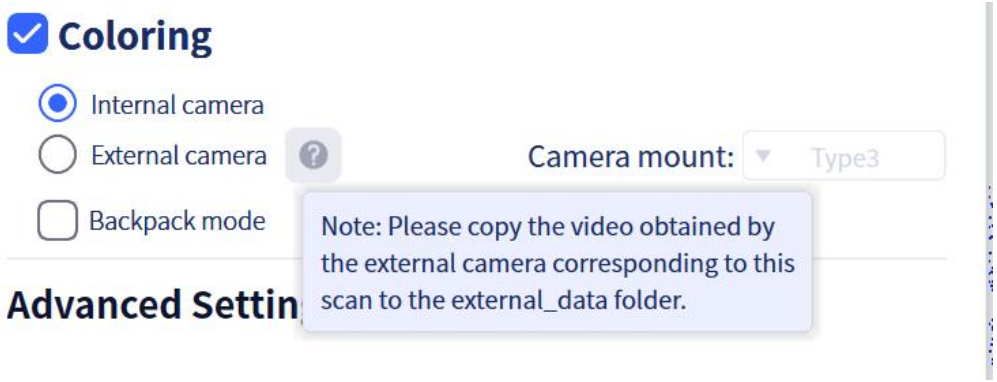
and more, which are primarily used for secondary refinement post-processing of scanned data.



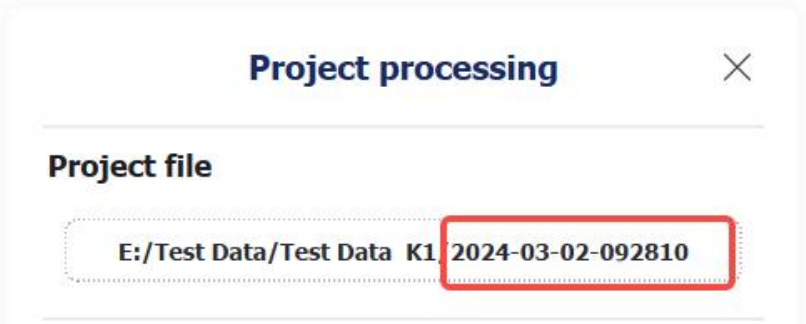
Note: During one-click processing, please do not perform other operations in the software.

Click on "Project Processing" in the menu bar to enter this function. The interface is shown in the figure below.

The "?" symbol next to a function will display the corresponding function's precautions. Moving the mouse over this symbol will automatically display them.

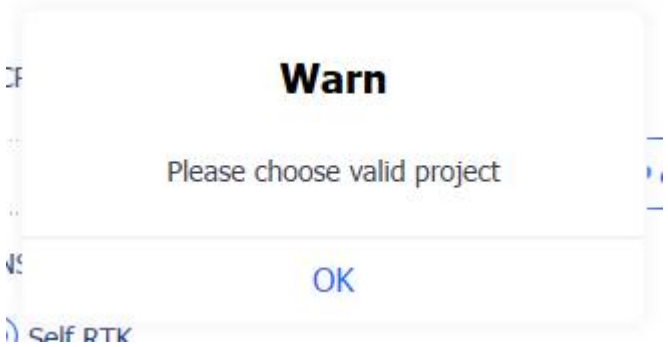


Click "Project File" and select the project data folder to be processed. The project file path should be selected to the corresponding project directory (i.e. the folder copied from the scanning device).

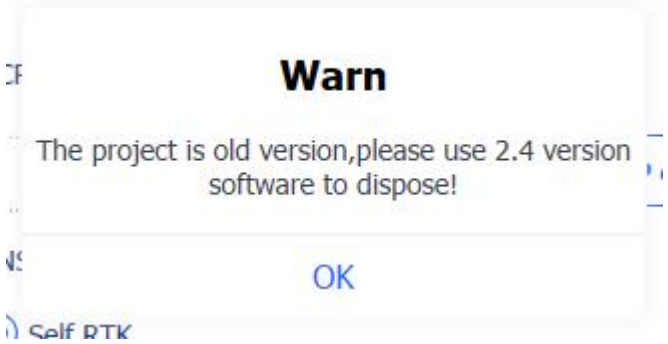


Note: This version of LixelStudio Project Processing feature only supports processing data for Lixel series handheld scanners, and supports for all L2 Pro data and firmware versions 1.4.0 and above for L1 and L2, and supports firmware versions 1.2.0 and above for K1. If the data is previous firmware versions for L1 and L2, please use LixelStudio 2.4.5 and previous software versions to process it.

If the project file is selected correctly, subsequent operations can be selected in order. If the project data of the non-Lixel series handheld scanner is selected, an error will be reported.



If the selected project data is from a device with an older firmware version (before 1.4.0), there will also be a warning message.



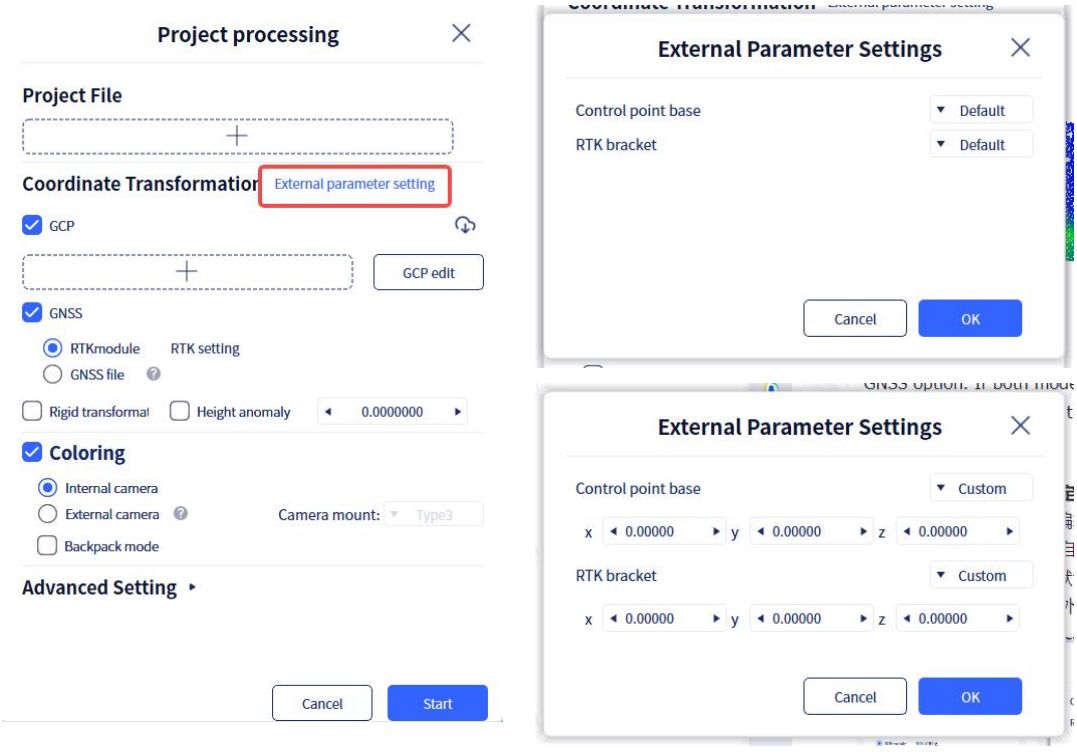
After selecting the project, you can choose the processing options based on specific needs.

1.1 Coordinate Transformation

The coordinate transformation function primarily provides the capability to transformation point cloud data to the corresponding absolute coordinate system based on external ground control points or GNSS data. If control points were marked using instruments during data collection, you can select the control point option. If using the RTK module, you can select the GNSS option. If both modes are used simultaneously, both options can be selected at the same time.

1.1.1 External Parameter Setting

External parameter settings allow users with customized bases and RTK to edit the external parameters of the control point base and RTK bracket. For the external parameters of the control point base, the default settings are generally used. If modifications are needed, click "Custom" to manually input the corresponding external parameters. Similarly, for the external parameters of the RTK bracket, the default settings are generally used. If modifications are needed, click "Custom" to manually input the corresponding external parameters. When both types of external parameters are set to default, modifications are not supported.

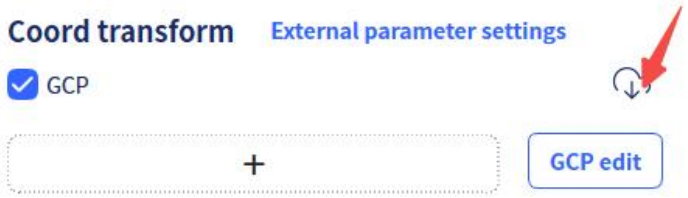


1.1.2 **Ground Control Points**

Coordinate transformation based on control points requires that control points have been marked during the field scanning process, and a corresponding control point coordinate file with the absolute coordinates is needed.

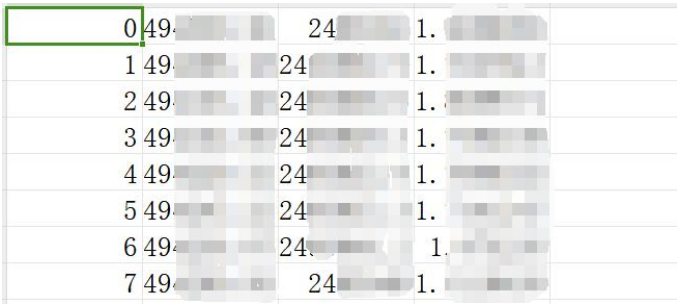
This function not only transformation the point cloud data from a relative coordinate system to an absolute coordinate system but also uses the constraint information of the control points to improve the accuracy of SLAM mapping, resulting in higher precision point cloud data.

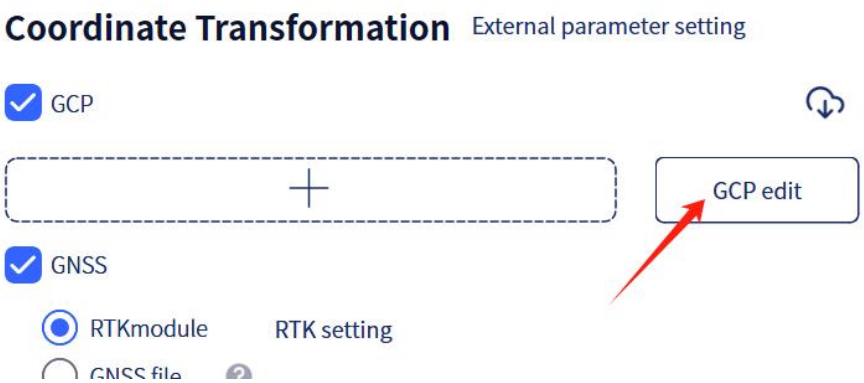
1. **Using External Control Points for Coordinate Transformation:** First, you need to select the control point file (in .txt or .csv format). The specific format should be: **Point Name, Easting, Northing, Elevation**. Click the download button on the right to download the control point template. Edit the control points according to the actual field situation.



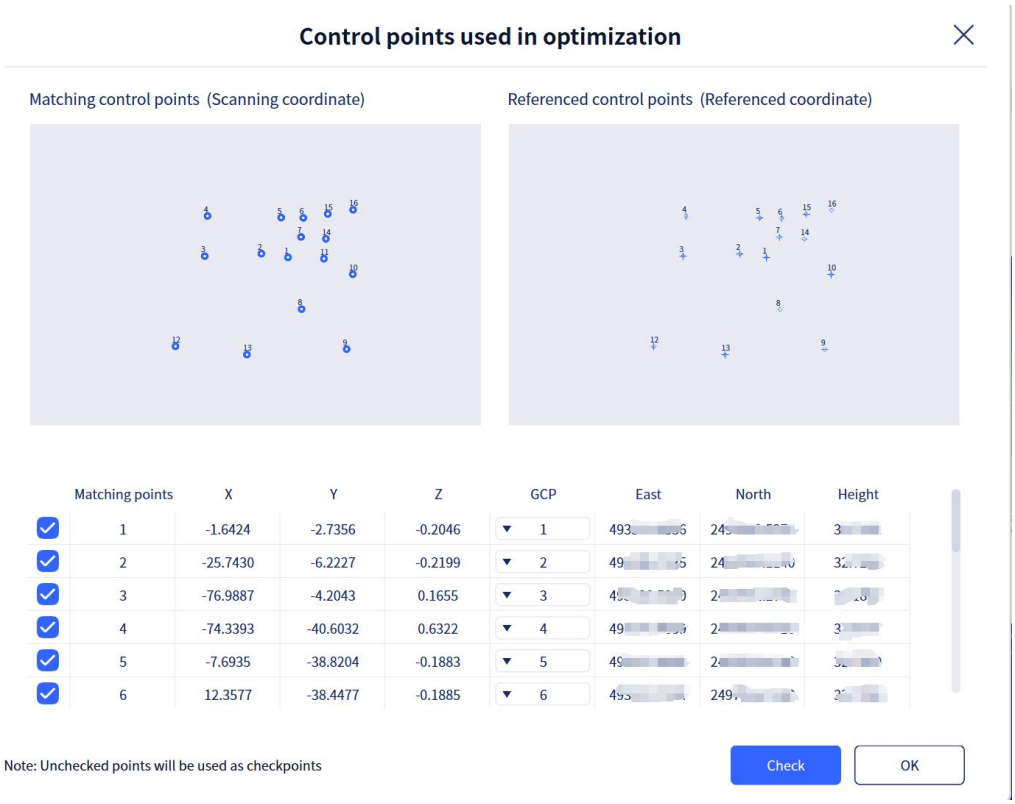
Note:

- The extension of the .xls table file cannot be directly modified to .csv. It needs to be saved in csv format, otherwise it will cause the data to be unable to read normally.
- Note that the control point names must be expressed in English and numbers.
- **Note that the point name should be consistent with the control point number recorded on the LixelGO app as much as possible. If they are inconsistent, enter the control point editing and make a selection.**

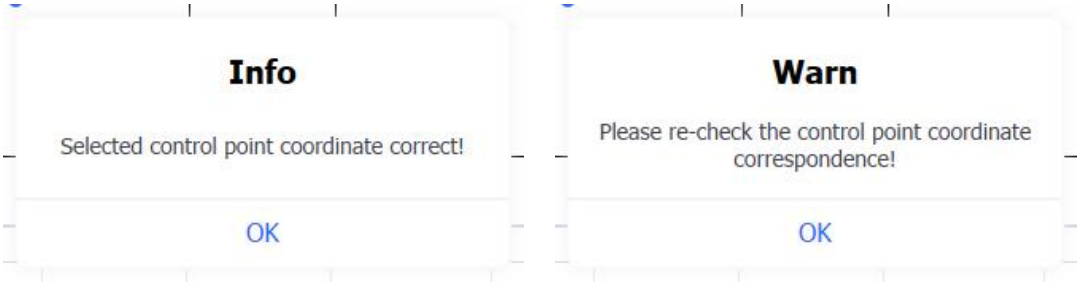




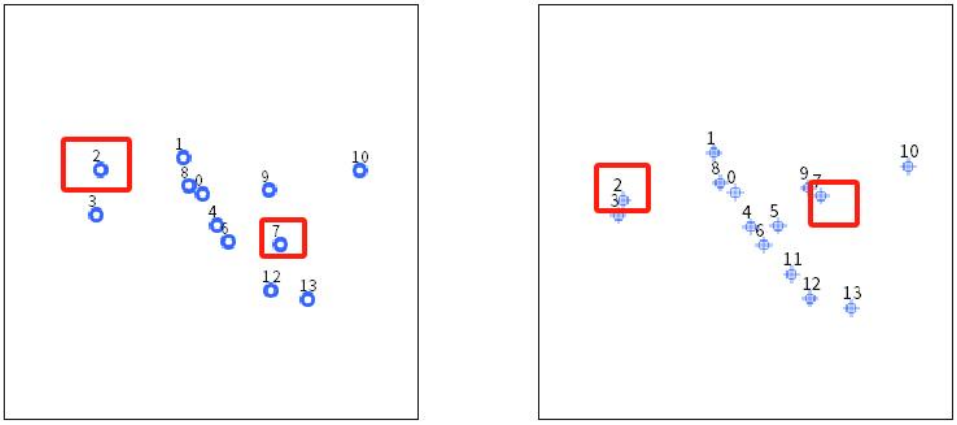
2. Click the GPC edit button on the right to open the control point edit window. The left side of the interface displays the coordinates where your Lixel handheld device marked the points (the default coordinate system is the scanning coordinate system), and the right side shows the true value coordinates of the control points (the default is the absolute coordinate system). At the bottom of the interface, the coordinate values of the control points are displayed. Users can select the corresponding control points to determine the control points be used in coordinate transformation. The checked control points will be used as conversion points for SLAM mapping, and the unchecked and matched control points will be used as check points. The output control point conversion report will simultaneously display the accuracy results of these two types of points.



3. Click "Check" and the software will automatically verify the correspondence between the control points. If the control points are correct, it will display "Selected control point coordinates are correct." The user can then click "Confirm" to exit the control point edit window. If there is an error with the control points or if there is an issue with the correspondence, it will display "Please recheck the control point coordinate correspondence."

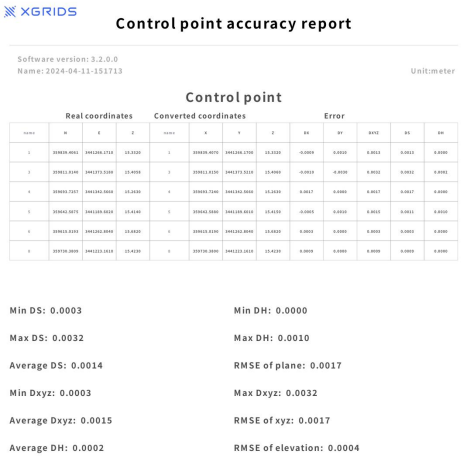


4. Based on the point cloud position diagram displayed on the interface, you can make a preliminary judgment about which control points have issues. As shown in the figure below, the control point file is clearly selected incorrectly.



5. **Note:** The number of selected points must be greater than 3. Otherwise, the control point transformation cannot be performed.

6. After confirmation, click "Confirm" to return to the engineering processing interface. Upon completing the engineering processing, a control point accuracy report will be output in the "Report" folder within the project directory.


XGRIDS

Control point accuracy report

Software version: 3.2.0.0
Name: 2024-04-11-151713

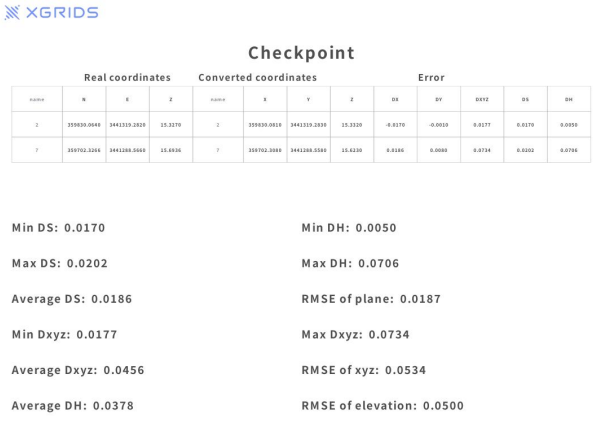
Unit:meter

Control point

	Real coordinates			Converted coordinates			Error					
name	N	E	Z	name	X	Y	Z	DX	DY	DXYZ	DS	DH
1	359839.4041	3441269.1718	15.3320	1	359839.4079	3441269.1700	15.3320	-0.0069	0.0020	0.0072	0.0021	0.0000
3	359811.8240	3441273.5100	15.4959	3	359811.8150	3441273.5110	15.4960	-0.0910	-0.0030	0.0032	0.0032	0.0001
4	359693.7257	3441342.5668	15.1630	4	359693.7240	3441342.5668	15.1630	0.0017	0.0000	0.0017	0.0017	0.0000
5	359642.5875	3441339.6018	15.4140	5	359642.5860	3441339.6018	15.4150	-0.0065	0.0020	0.0015	0.0011	0.0010
6	359615.8193	3441282.8940	15.6920	6	359615.8190	3441282.8940	15.6920	0.0003	0.0000	0.0003	0.0003	0.0000
8	359739.2699	3441223.1618	15.4230	8	359739.2690	3441223.1618	15.4230	0.0909	0.0000	0.0909	0.0909	0.0000

Min DS: 0.0003
Max DS: 0.0032
Average DS: 0.0014
Min Dxyz: 0.0003
Average Dxyz: 0.0015
Average DH: 0.0002

Min DH: 0.0000
Max DH: 0.0010
RMSE of plane: 0.0017
Max Dxyz: 0.0032
RMSE of xyz: 0.0017
RMSE of elevation: 0.0004


XGRIDS

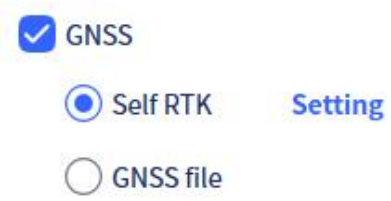
Checkpoint

	Real coordinates			Converted coordinates			Error					
name	N	E	Z	name	X	Y	Z	DX	DY	DXYZ	DS	DH
2	359830.0648	3441319.2820	15.3270	2	359830.0818	3441319.2830	15.3320	-0.0170	-0.0010	0.0177	0.0170	0.0050
7	359702.3266	3441288.5660	15.6926	7	359702.3069	3441288.5580	15.6230	0.0196	0.0080	0.0734	0.0202	0.0706

Min DS: 0.0170
Max DS: 0.0202
Average DS: 0.0186
Min Dxyz: 0.0177
Average Dxyz: 0.0456
Average DH: 0.0378

Min DH: 0.0050
Max DH: 0.0706
RMSE of plane: 0.0187
Max Dxyz: 0.0734
RMSE of xyz: 0.0534
RMSE of elevation: 0.0500

1.1.3 GNSS



1. XGRIDS RTK

If the RTK module of XGRIDS is used for scanning, you can check the RTK option. After checking, you can click on Settings to enter the RTK setting module and edit the RTK data.

The RTK setting module mainly includes adjusting the parameters of the acquired RTK data to adjust the GNSS data involved in SLAM mapping and coordinate transformation.

After checking, you need to click Settings to enter the RTK settings module. After editing and confirming the RTK data and making sure that the RTK data is available and the coordinate transformation settings are correct, the engineering processing can use the RTK data and process the results with the expected accuracy.

- **RTK Settings - RTK Data Filter**

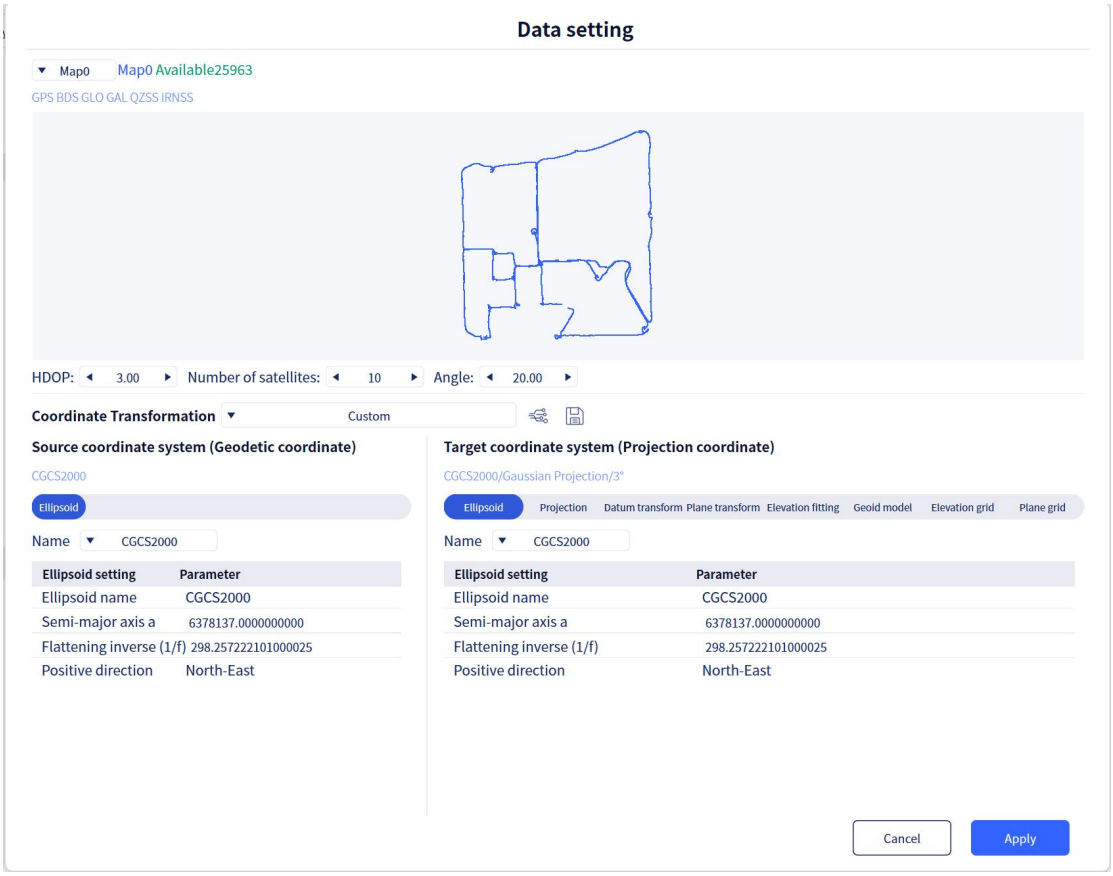
The RTK setting module mainly includes adjusting the parameters of the acquired RTK data to adjust the data involved in the SLAM mapping and the coordinate transformation.

The parameters of RTK data mainly include HDOP, satellite number, and

tilt angle. For HDOP (Horizontal Dilution Of Precision), the smaller the HDOP value, the better the distribution intensity of satellite spatial position, which is more conducive to the calculation fixed solution. In addition, the number of satellites represents the number of satellites at the time of scanning, and the more satellites there are, the more conducive it is to the calculation of fixed solution. The tilt angle represents the tilt angle of the RTK module during scanning. The smaller the tilt angle, the more conducive it is to the accuracy of fixed solution. The tilt angle should not exceed 20 ° by default. **Therefore, the smaller the HDOP value, the higher the number of satellites, the smaller the tilt angle, and the higher the Confidence Level of the obtained RTK data.**

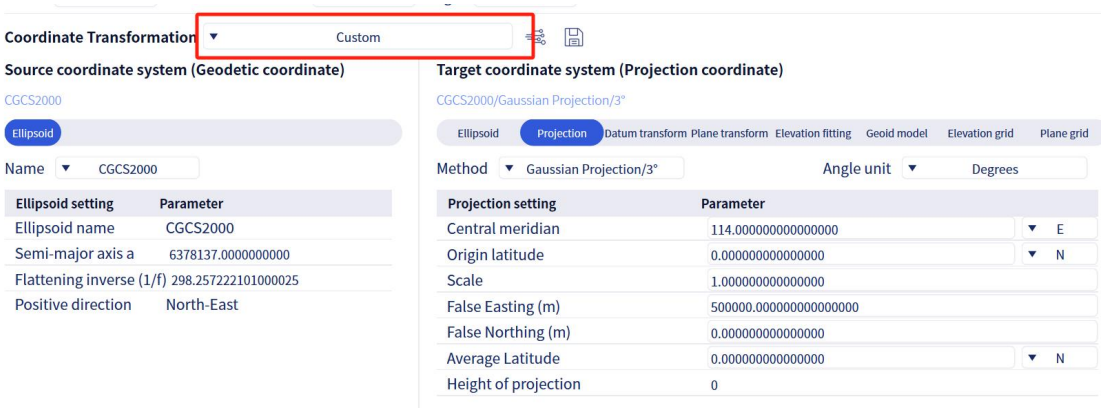
During the setup, users can make modifications based on their actual needs, but usually, the default parameter values are sufficient. While adjusting, please pay attention to the distribution of RTK data. Try not to affect the distribution, ensuring it remains evenly spread across the entire trajectory. If the RTK data is unevenly distributed, only covers a segment of the trajectory, or has excessive intervals, it will lead to issues with the final coordinate transformation accuracy.

While making adjustments, pay attention to whether the data in the top left corner of the window is in a usable state. If it shows a red unusable state, it indicates that the effective GNSS data under the current parameters is less than what the software requires for calculation. In this case, you need to increase the HDOP, decrease the number of satellites, or increase the tilt angle, or adjust all three comprehensively. Adjust until the data state turns green and is usable, only then can you use RTK for coordinate transformation. If it remains in an unusable state, coordinate transformation cannot be performed.



- **RTK Settings - Coordinate Transformation**

The coordinate transformation function supports users to transform source coordinate systems to the desired target coordinate systems. At the same time, the software has built-in coordinate systems for some countries and regions, such as Hong Kong and New Zealand. These built-in coordinate systems support use when the data source ellipsoid is WGS84 when collecting with an RTK module. That is, when the source ellipsoid is WGS84 during collection, the built-in coordinate system can be directly transformed to the corresponding country/region coordinate system. If the collected data source ellipsoid is not WGS84 or the built-in coordinate system does not contain the required target coordinate system, you need to set the coordinate transformation to custom, and then adjust the source coordinate system and target coordinate system according to actual needs.



The following table provides a detailed description of the built-in coordinate system:

Coordinate system	**Explanation**
HK1980(EPSG2326)_HKPD	Hong Kong 1980 Grid System Hong Kong Principal Datum (HKPD)
MountEden2000(EPSG2105)_AUK46	NZGD2000 / Mount Eden 2000 Auckland 1946 (AUK46)
NZTM(EPSG2193)_NZVD2016	EPSG2193 / New Zealand Transverse Mercator (NZTM) New Zealand Vertical Datum 2016 (NZVD2016)
JGD2011(EPSG6673)_GSI2011	Japanese Geodetic Datum 2011(JGD2011) / Japan Plane Rectangular CS V GSI 2011
JGD2011(EPSG6677) _GSI2011	Japanese Geodetic Datum 2011(JGD2011) / Japan Plane Rectangular CS IX

	GSI 2011
ETRS89(EPSG4647)_DHHN2016	European Terrestrial Reference System 1989 (ETRS89) / UTM zone 32N (zE-N) Deutsches Haupthoehennetz 2016 DHHN2016
KGD2002（EPSG5186)_ KNGeoid18	Korean Geodetic Datum 2002 / Central Belt 2010 KNGeoid18

- **RTK Settings - Source Coordinate System**

If the source coordinate system is set to WGS84 or CGCS2000 when collecting data, the corresponding coordinate system will be automatically identified. If other Operating Reference Station (CORS) Network is used during collection, the user needs to specify the ellipsoid of the source coordinate system.

If the source coordinate system is WGS84, the target ellipsoid defaults to WGS84 and the projection mode defaults to UTM projection.

If the source coordinate system is CGCS2000, the target ellipsoid defaults to CGCS2000, and the projection mode defaults to Gaussian three-dimensional zone projection.

Currently, the built-in ellipsoids include WGS84, CGCS2000, XIAN_1980, BEIJING 1954, GRS80 and INTERNATIONAL. If it is another ellipsoid, the user can select "Other", enter the major axis a, the inverse of the flattening (1/f), and confirm the source ellipsoid parameters.

- **RTK Settings - Target Coordinate System**

The target coordinate system parameter settings include the parameters of ellipsoid, projection, datum transformation, plane transformation, elevation

transformation, geoid, elevation grid and plane grid. The projection coordinate system and elevation system of the output data can be adjusted by a combination of single or multiple transformation parameter settings.

In order to ensure the accuracy of point cloud, when processing, it is necessary to confirm the use of a certain parameter or a combination of multiple transformation parameters based on the projection coordinate system and elevation system of the confirmed source coordinate system and target coordinate system.

The setting and adjustment of the coordinate system generally requires surveying and mapping expertise. For easy understanding, some common examples are described in the " RTK Setting Coordinate Transformation Operation Examples" below.

① Ellipsoid

The ellipsoid of the target coordinate system currently supports CGCS2000, WGS84, ITRF2008, XIAN80, BEIJING54, GRS80 etc. Users can also select "Custom" and enter the major semi-axis a, the inverse of the flattening (1/f) and confirm the source ellipsoid parameters.

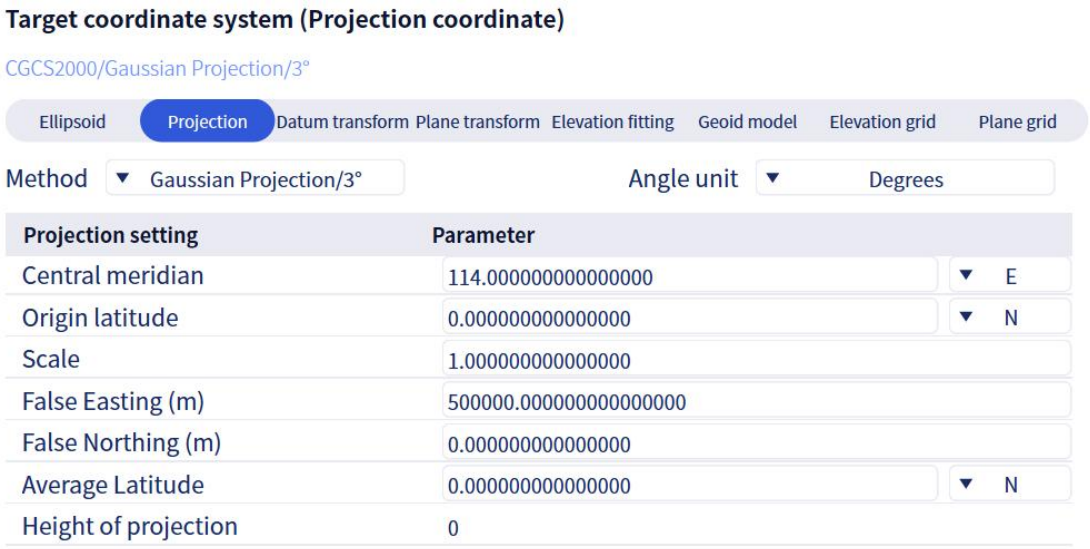
② Projection

Projection settings are used to set the parameters required for projection.

Currently Gaussian projection(3°), Gaussian projection(6°), UTM projection, Mercator projection, Transverse Mercator projection and Oblique Mercator projection is supported.

Each projection method requires the setting of the central meridian, latitude origin, scale, false easting, false northing, average latitude and height of projection. Different coordinate systems have different requirements. To ensure the accuracy of coordinate transformation, please confirm and enter these parameters. Central meridian, latitude origin, mean latitude, please note whether the area is in the southern hemisphere or northern hemisphere,

eastern hemisphere or western hemisphere. If it is in the northern hemisphere, select N with the right button, if it is in the southern hemisphere, please change the right button to S. If it is in the eastern hemisphere, select E with the right button, if it is in the western hemisphere, please change the right button to W. Please enter positive numbers for longitude and latitude data.

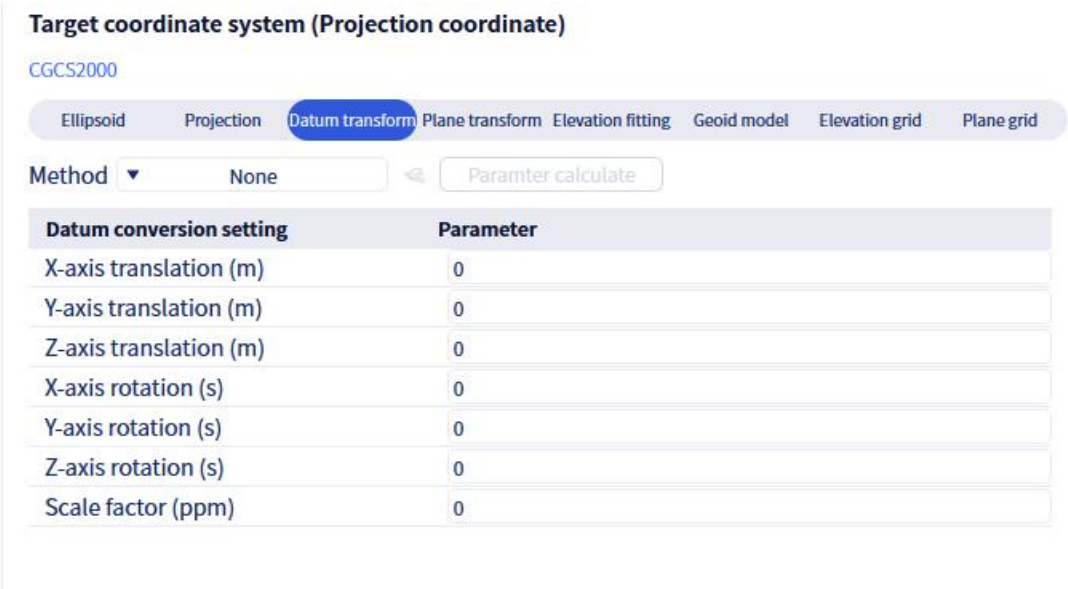


③ Datum transformation

Datum transformation can transform the datums of two different coordinate systems. Currently, the most commonly used datum transformation method is the Bursa seven-parameter transformation method.

When the source ellipsoid and the target ellipsoid are inconsistent, the Bursa seven-parameter transformation method can be used to achieve relatively accurate coordinate transformation; if the source ellipsoid and the target ellipsoid are similar, the source ellipsoid can be directly considered to be the target ellipsoid for processing, which has a relatively low impact on the accuracy of the coordinate transformation. When the accuracy requirement is not high, the datum transformation can also be ignored.

Users can input the Bursa seven parameters themselves or calculate them using the "Parameter Calculate" tool. It is recommended to calculate the parameters using the "Parameter Calculate" tool.



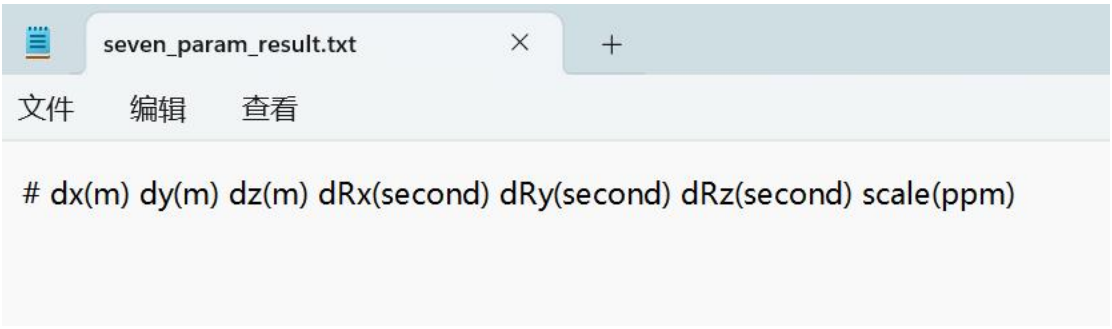
- **Input the seven parameters of Bursa**

Input the Bursa 7 parameters, users should generally confirm whether the source coordinate system and the target coordinate system are consistent with the coordinate system adapted by the Bursa 7 parameters used, otherwise the transformation result will be invalid or not as expected. Enter the corresponding X-axis translation (meters), Y-axis translation (meters), Z-axis translation (meters), X-axis rotation (seconds), Y-axis rotation (seconds), Z-axis rotation (seconds) and scale factor (ppm) parameters. Click Apply to complete the setting.

Please note that the unit of the scale factor is ppm. Some users have seven-parameter scale factors in units of K, which need to be transformationted according to the formula k = (ppm / 1000000) + 1.

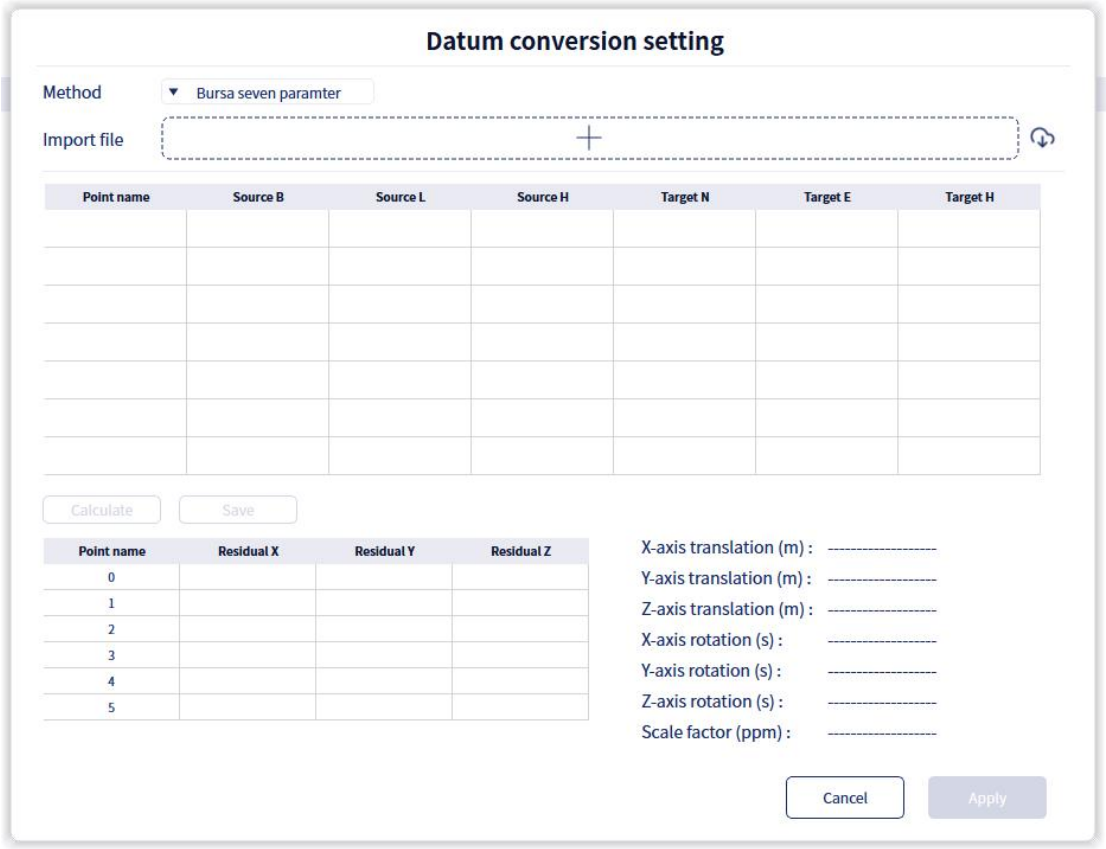
Note: The scale factors of the seven parameters supported by LixelStudio3.0.2.1 and earlier versions are inconsistent with the current version. Please pay attention when using it.

The user can enter the seven parameters into the corresponding positions of the interface, or choose to import the file. The following figure is a parameter file template for seven parameters:



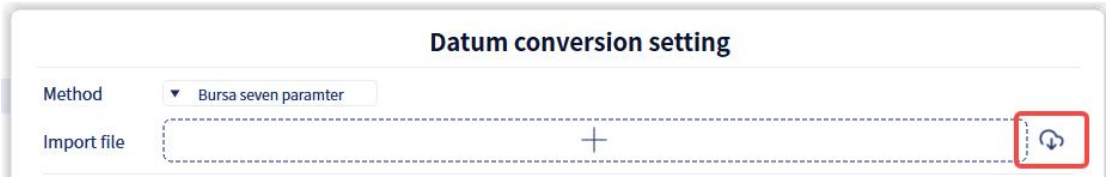
- **Calculate the Bursa seven parameters using the "Parameter Calculate" tool**

To use the "Parameter Calculate" tool to calculate the Bursa seven parameters, you need to first obtain the control point pairs containing the geographic coordinates (BLH) of the source coordinate system and the projection coordinates (NEZ) of the target coordinate system, and then import them into the "Parameter Calculate" according to the format of the control point pairs. Click "Calculate" to obtain the seven parameters, and click "Apply" to complete the setting of the seven parameters. The following figure is the "Parameter Calculation" interface of Datum Transformation-Bursa Seven Parameters:



To obtain control point pairs, it is required to obtain the geographic coordinates (BLH) in the source coordinate system and the projection coordinates (NEZ) in the target coordinate system at the same location. At least three control point pairs are required. The more points used, the higher the transformation accuracy.

The standard format of the control point pairs can be obtained by clicking the file download button on the "Parameter Calculation" interface of the Datum conversion setting.



The format of the control point pair needs to be in txt format, and it needs to be arranged in the order of name, latitude, longitude, height, N, E, and Z, and separated by commas in English characters. Latitude, longitude, and height are the geographic coordinates of the source coordinate system, and N,

E, and Z are the projection coordinates of the target coordinate system. The figure below is a template for the seven-parameter calculation control point pair file.

```
#source                                target
Name B(dd:mm:ss.ssssss) L(dd:mm:ss.ssssss) H(m) N(m) E(m) H(m)
n1
n2
n3
```

The calculated seven-parameter file will be arranged with spaces as follows: X-axis translation (meters), Y-axis translation (meters), Z-axis translation (meters), X-axis rotation (seconds), Y-axis rotation (seconds), Z-axis rotation (seconds) and scale factor (ppm). Note that the scale factor unit is ppm. Some users have seven-parameter scale factors in K, which need to be transformed according to the formula k = (ppm / 1000000) + 1.

The following is a seven-parameter parameter file template:

```
# dx(m) dy(m) dz(m) dRx(second) dRy(second) dRz(second) scale(ppm)
```

The Bursa seven-parameter standard model used by LixelStudio is of the following form:

$$\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1+m) \begin{bmatrix} 1 & -\theta_z & \theta_y \\ \theta_z & 1 & -\theta_x \\ -\theta_y & \theta_x & 1 \end{bmatrix} \begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix}$$

Note:

(1) DX translation (m)

(2) Y translation (m)

(3) Z translation (m)

(4) x axis rotation (in seconds)

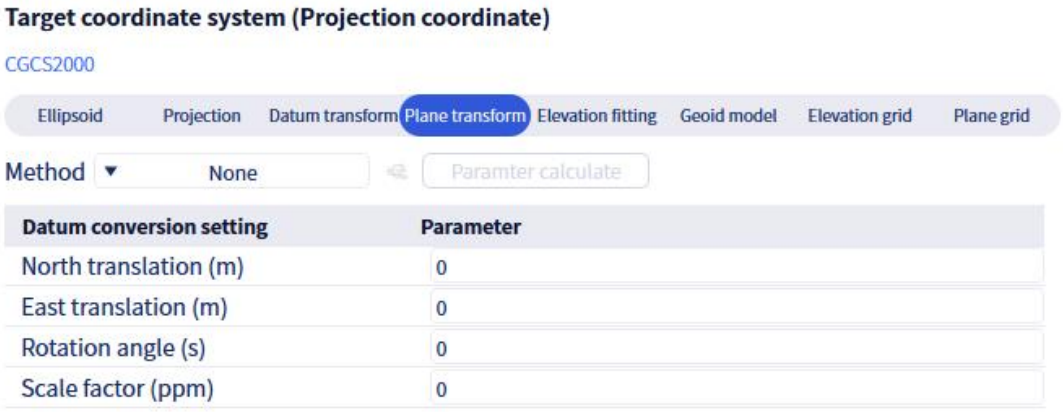
(5) Y axis rotation (in seconds)

(6) Z axis rotation (in seconds)

(7) scale factor (PPM)

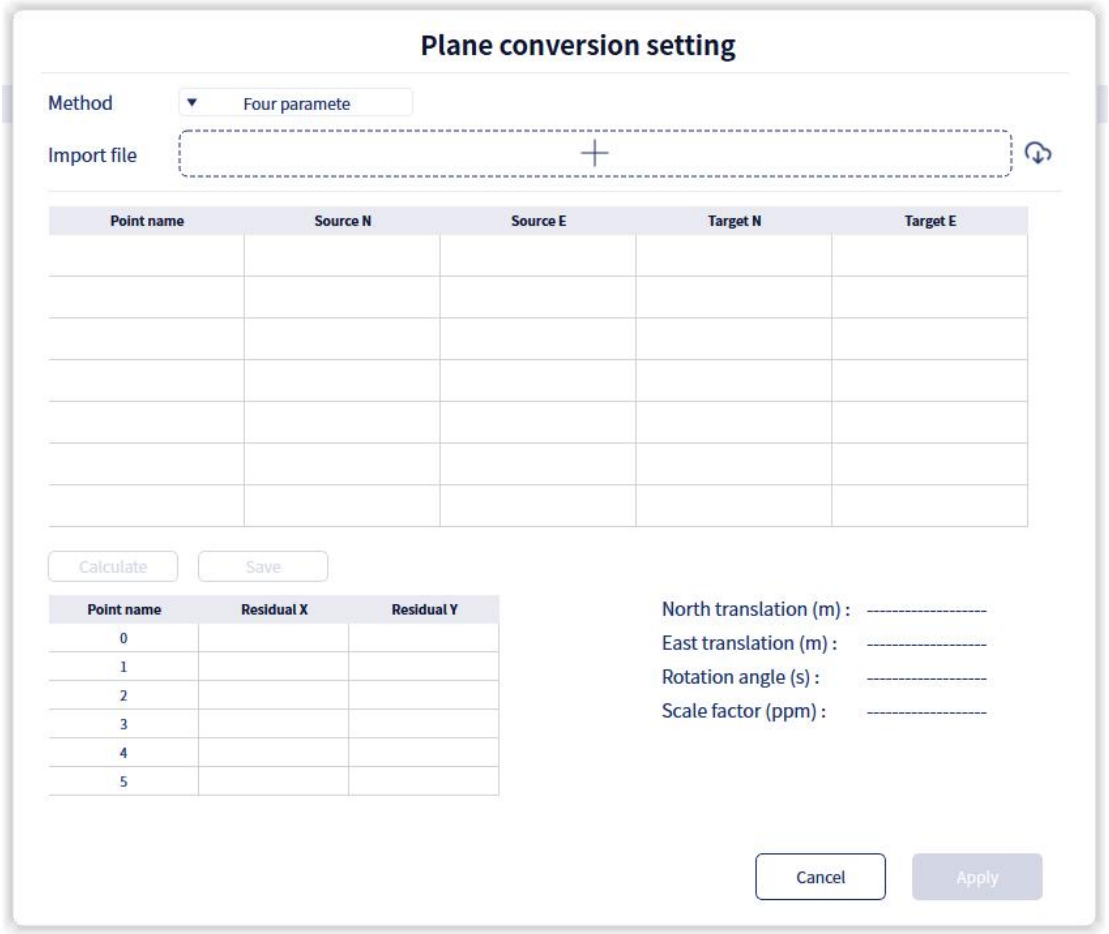
④ Plane transformation

Plane transformation is used to transform the source plane coordinate system to the target plane coordinate system. It contains a translation, rotation and scaling of the data. Currently, the commonly used four-parameter method is supported.



At least two control point pairs are required for calculation. Each control point pair needs to contain the projection coordinates of the source coordinates (North East) and the projection coordinates of the target projection system (North East) to calculate the north offset, east offset, rotation angle and scale factor. The more points used, the higher the plane transformation accuracy.

The control point pair file format can be downloaded by clicking the standard file download button next to the imported file in the interface of the Plane conversion setting.



The format of the control point pair needs to be in txt format, and it needs to be arranged in the order of name, source N, source E, target N, and target Z, separated by commas (English characters). Source N and source E are the projection coordinates of the source coordinate system, and target N and target E are the projection coordinates of the target coordinate system.

```
#source    target
Name N(m) E(m) N(m) E(m)
```

Four-parameter control point pair file template

```
# dx(m) dy(m) dR(second) scale(m)
```

Four-parameter parameter file template

The four-parameter standard model used by LixelStudio is of the following form:

$$\begin{bmatrix} X_1 \\ Y_1 \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \end{bmatrix} + (k) \begin{bmatrix} cos(\theta) & sin(\theta) \\ -sin(\theta) & cos(\theta) \end{bmatrix} \begin{bmatrix} X_0 \\ Y_0 \end{bmatrix}$$

⑤ Elevation fitting

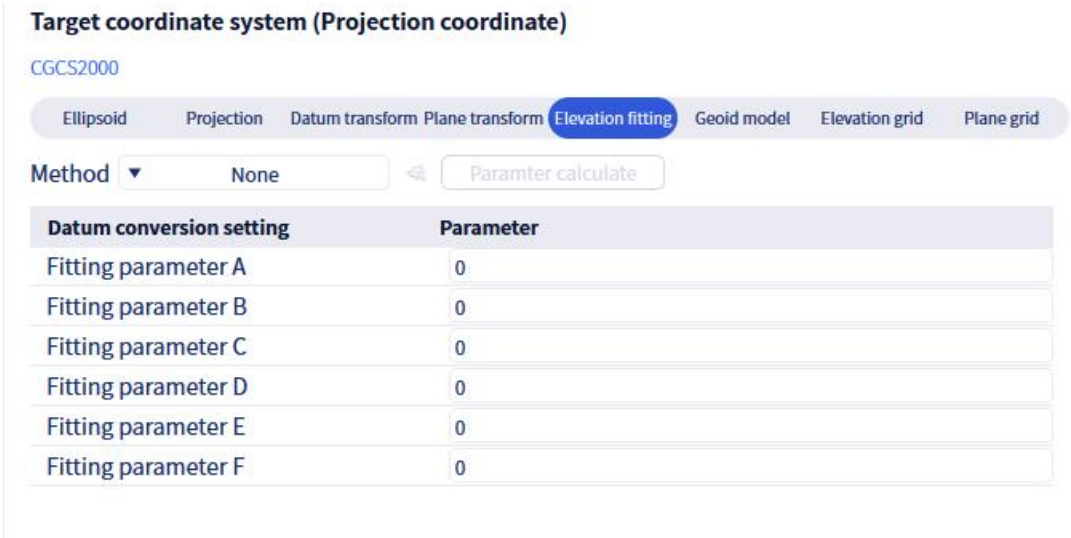
The purpose of elevation fitting is to transform the source elevation system to the target elevation system. Currently, two methods are supported: fixed difference correction using elevation anomaly and surface fitting.

- **Using fixed difference correction of elevation anomaly**

  For specific operation methods, please refer to "Height Anomaly".

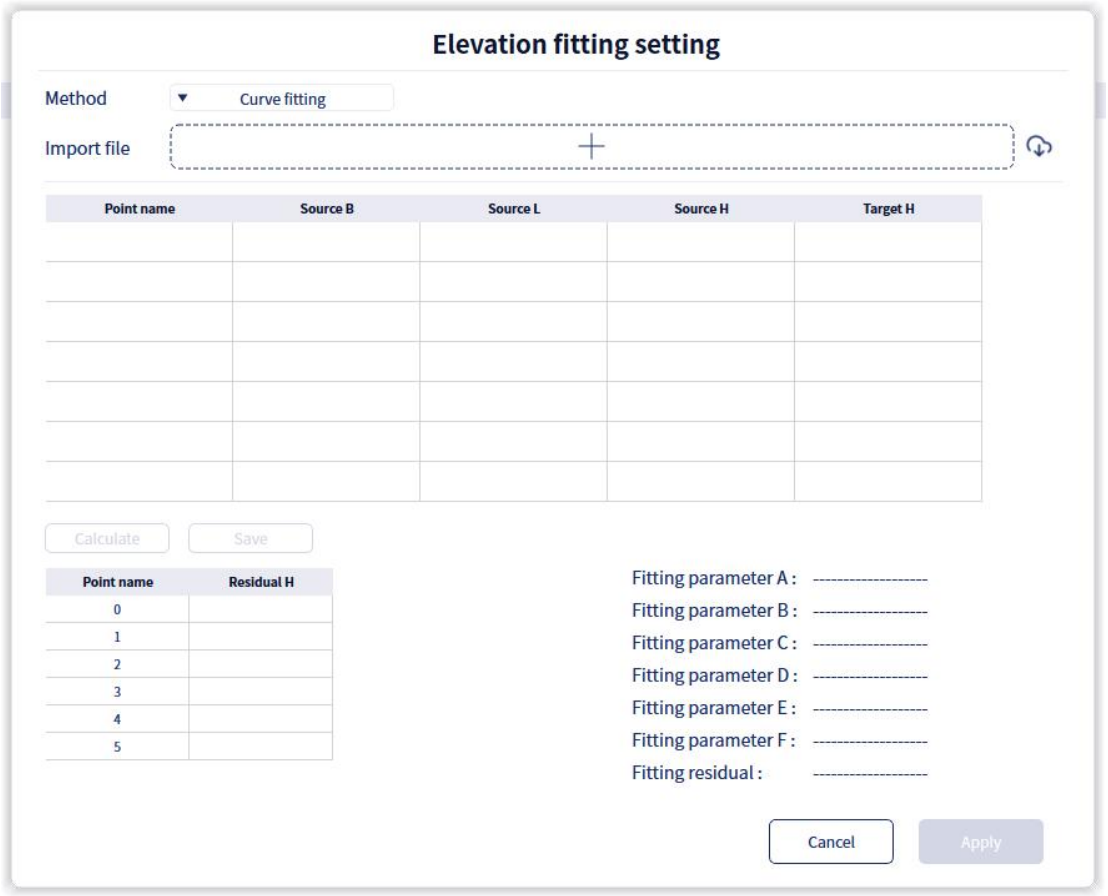
- **Surface fitting**

It is suitable for data in a larger area (2km²-10km²), with large undulating hills and mountains, and large changes in elevation anomalies. It is necessary to use multiple control point pairs to fit a surface, simulate the changes in elevation anomalies in this area, and fit and calculate the different differences between the source elevation system and the target elevation system at different locations in this area. The elevation system of the source data can be transformed to the target elevation system.



At least 6 control point pairs are required for calculation. Each control point pair needs to contain the geographic coordinates of the source coordinates (BLH latitude, longitude and height) and the elevation of the target elevation system, and needs to be stored in the surface fitting control point pair format. After importing into the parameter calculation, the surface

fitting parameters A, B, C, D, E, and F can be calculated. The more points used, the more accurate the surface fitting and the higher the elevation fitting accuracy. The following figure shows the surface fitting parameter calculation interface:

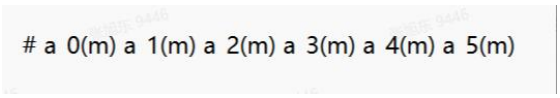


Surface fitting control point pair format: It needs to include the geographic coordinates (BLH) of the source coordinate system and the elevation H of the target coordinate system, separated by spaces. The units of B and L need to be in degrees, minutes, and seconds (dd:mm:ss.ss) format. The elevation units of the source and target coordinate systems are meters. You can click the download button to download the corresponding template.

After the calculation is completed, you can also click Save to store the

calculation results. By clicking the "Save" button and can be used in subsequent data through "Import File". Click "Apply" to complete the setting of elevation fitting parameters.

Surface fitting control point pair file template



Surface fitting parameter file template

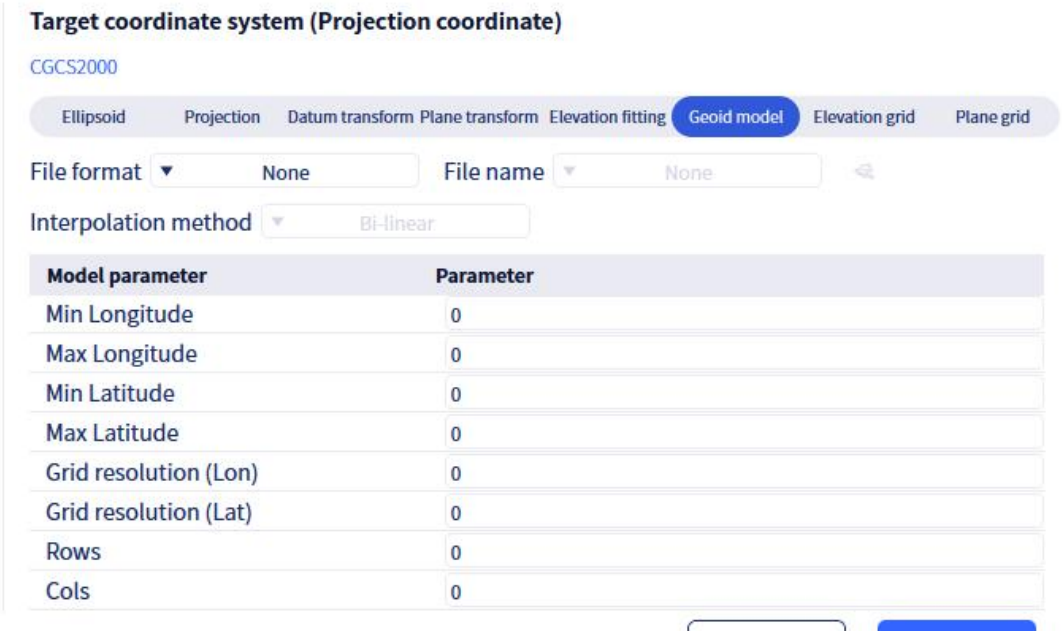
⑥Geoid

The geoid transformation parameters can be used to fit the elevation using the geoid model. The geoid model is a grid model that describes the specific geoid difference at different locations within a certain range. It is generally provided by large international non-profit organizations, or provided by national surveying and mapping bureau, and is generally stored in the form of a grid.

Multiple sets of data within a large area covered by the geoid model can be fitted using the same geoid model transformation elevation system.

Before use, please confirm whether the target elevation system corresponding to the geoid model you are using. Only when the geoid model is correct can the elevation transformation be completed accurately.

When using it, you need to select the "File Format" first. Currently, LixelStudio supports geoid data stored in .tif/.asc/.gri/.gtx/.dat file formats. Then, select the built-in geoid model in the "File Name" or import it yourself to complete the geoid transformation parameter setting.



The built-in geoid models currently available are:

Format	Geoid Model	Description
tif	NZGD2016.tif	New Zealand geoid model. NZVD2016
	GCG2016v2023.tif	German Geoid Model DHHN2016
asc	gsigeo2011_ver2_2.asc	Japanese Geoid Model GSI 2011
gri	hybrid_geoid.gri	Korean Geoid Model KNGeoid18
gtx	NZGeoid2016.gtx	New Zealand Geoid Model NZVD2016
dat	KNGeoid18.dat	Korean Geoid Model

		KNGeoid18

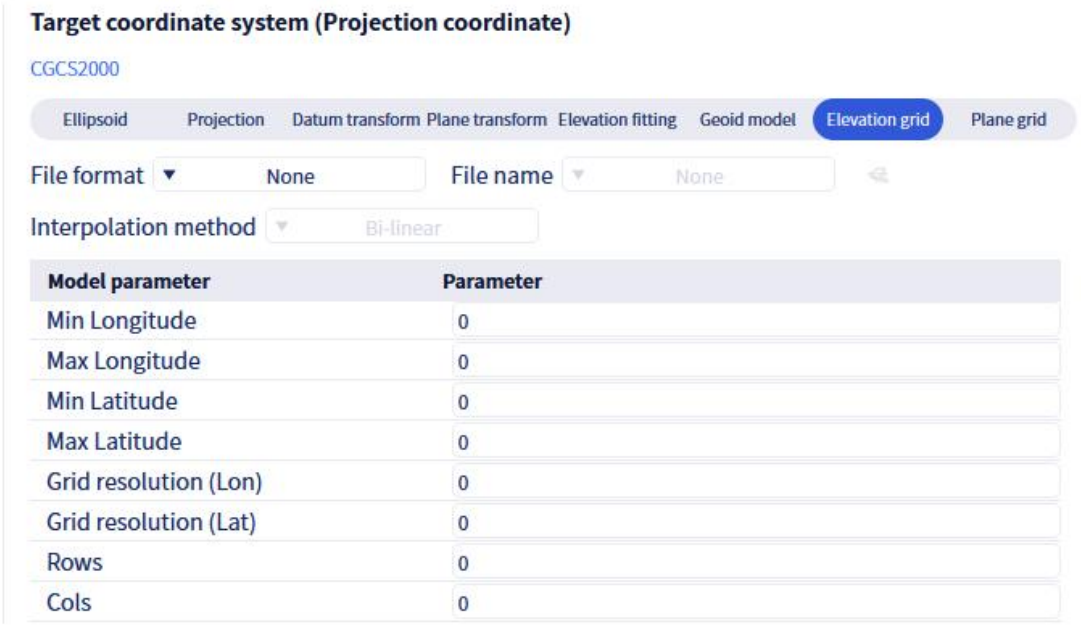
⑦Elevation grid

The elevation grid transformation parameters can be used to fit the elevation using the elevation grid model. The elevation grid model is a grid model that describes the specific elevation difference between two different elevation systems at different locations within a certain range.

Multiple sets of data within a large area covered by the elevation grid model can use the same elevation grid model to transform the elevation system for elevation fitting.

Before use, please confirm whether the target elevation system corresponding to the elevation grid model you are using. Only when the elevation grid is correct can the elevation fitting be completed accurately.

When using it, you need to select the "File Format" first. Currently, LixelStudio supports grid data stored in .tif/.asc/.gri/.gtx/.dat file formats. Then, select the built-in elevation grid model in the "File Name" or import it yourself to complete the elevation grid transformation parameter setting.



Currently, LixelStudio has a built-in elevation grid model of

AUCKHT1946.tif which is Auckland 1946 height (AUK46).

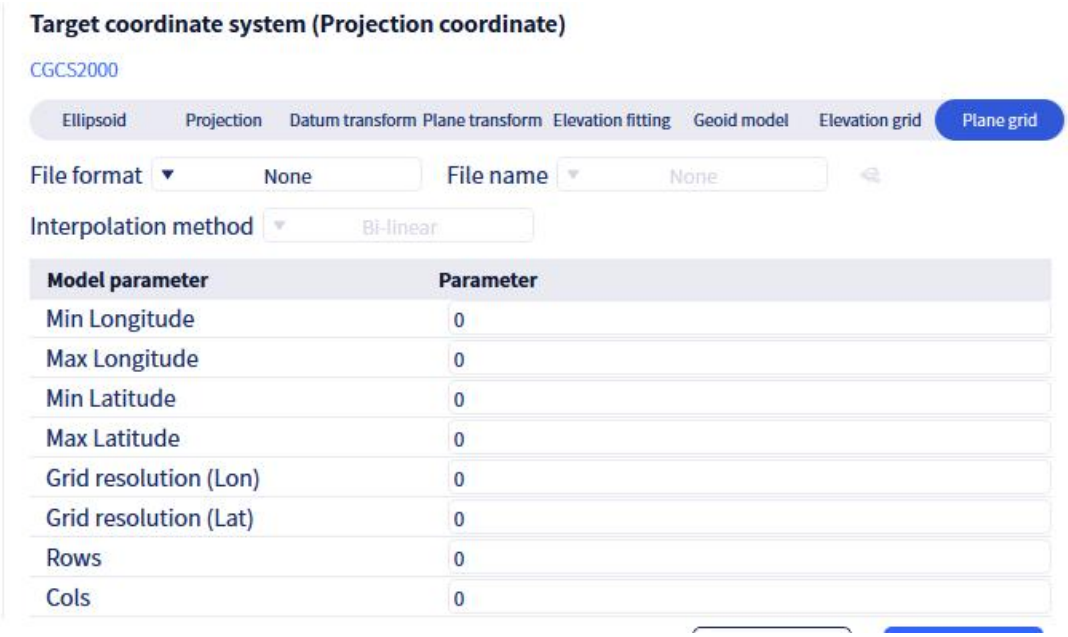
⑧ Plane grid

The plane grid transformation parameters can be transformed using the plane displacement grid model. The plane displacement grid model is a grid model that describes the difference between the plane coordinates of different locations in two different projection coordinate systems within a certain range.

For multiple sets of data within a large area covered by a plane grid model, the same plane grid model can be used to transform the plane coordinates of different projection coordinate systems for plane transformation.

Before use, please confirm whether the target coordinate system of the plane grid model you are using are consistent with the coordinate system you expect to transform. Only when the plane grid is correct can the plane transformation be completed accurately.

When using it, you need to select the "File Format" first. Currently, LixelStudio supports grid data stored in .txt and .xData (XGRIDS' s own data format) file format. Then, select the built-in elevation grid model in the "File Name" or import it yourself to complete the elevation grid transformation parameter setting.

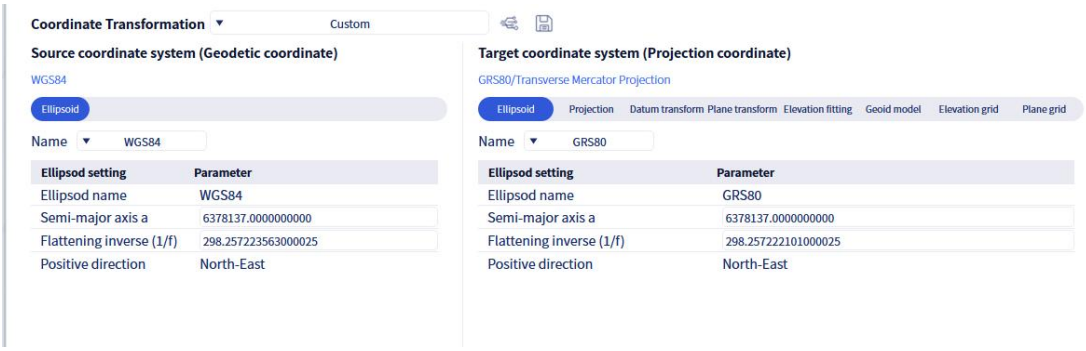


- **How to export the point cloud to the New Zealand MountEden2000(EPSG2105)_AUK46 coordinate system?**

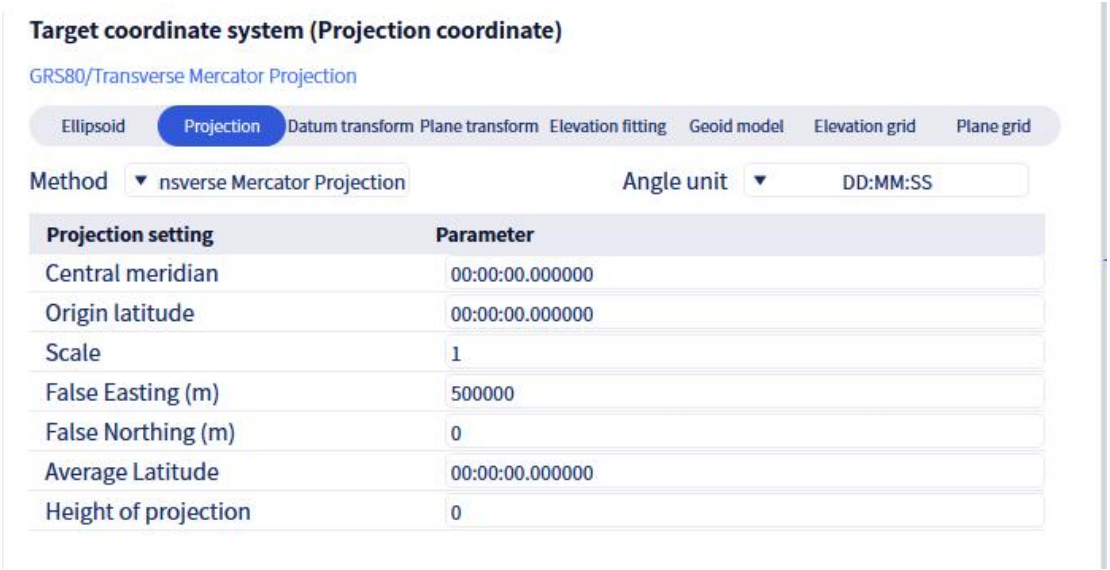
Auckland’ s commonly used coordinate system is MountEden2000(EPSG2105). Its ellipsoid is the GRS80 ellipsoid and projection is transverse Mercator projection. The elevation system is the orthometric system AUK46. The coordinate system of the collected data is WGS84, and the elevation system is geodetic height.

In order to output the point cloud to the MountEden2000(EPSG2105)_AUK46, when completing data collection and setting the coordinate transformation data, it is necessary to set the source ellipsoid, target ellipsoid, projection parameters, geoid and elevation grid transformation parameters. The specific operations are as follows:

- Set **the source ellipsoid** to WGS84 and **the target ellipsoid** to GRS80.

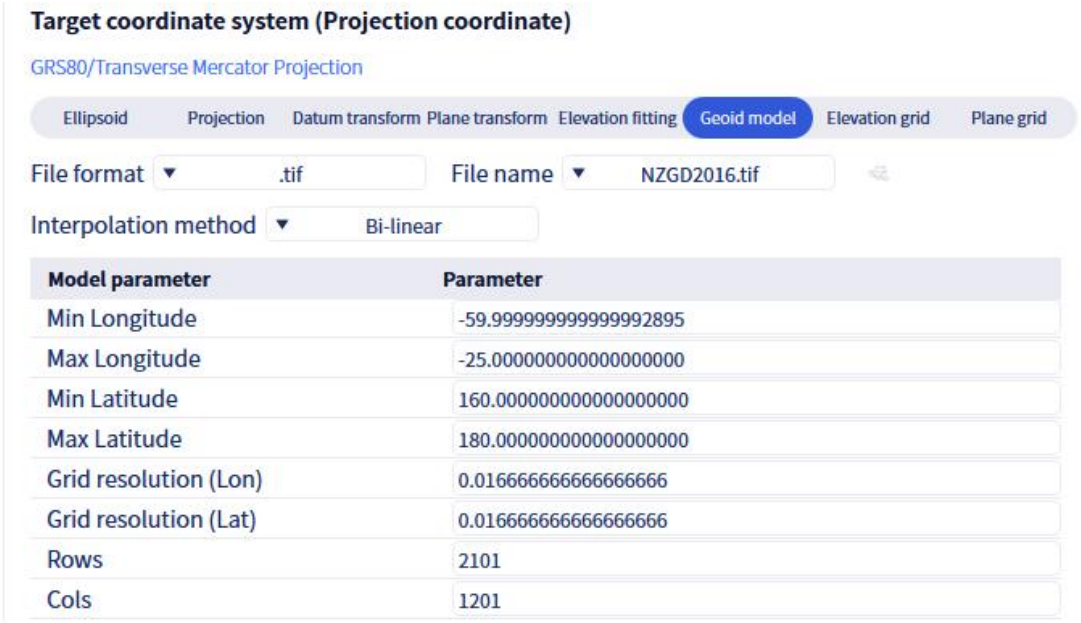


- **The projection parameters** are set to Transverse Mercator. Please modify the projection parameters according to actual needs.

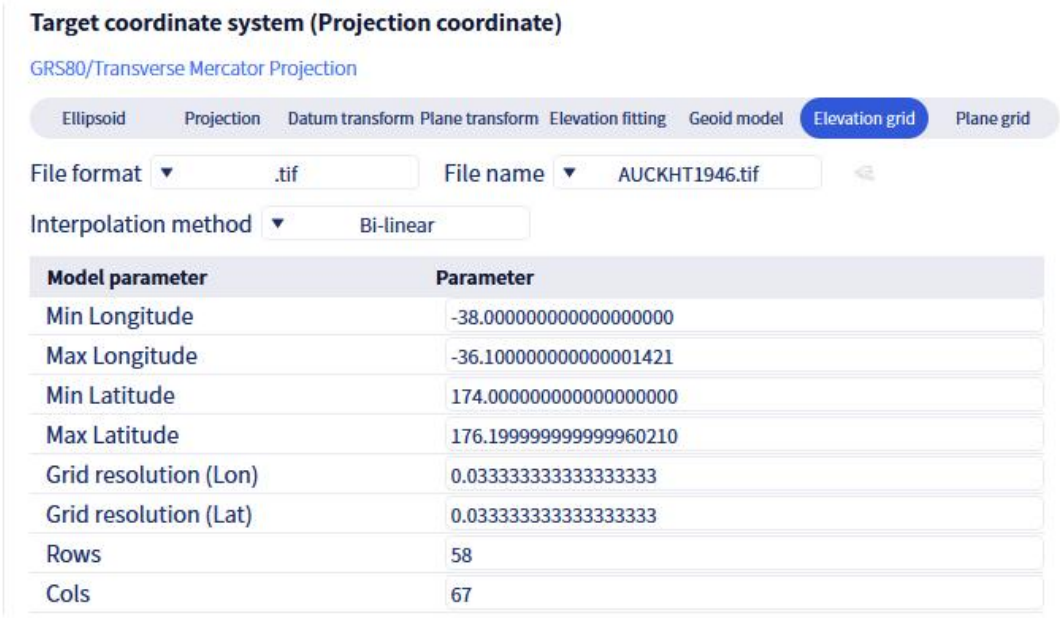


- No setting of datum transformation parameters is required.

- **the geoid parameters**, set the "File Format" to tif format or all, import the corresponding tif geoid model in the "File Name", and set the "Interpolation Method" to bilinear interpolation.



- **the elevation grid parameters**, set the "File Format" to .tif format or all, import the corresponding .tif format elevation grid model in "File Name", and set the "Interpolation Method" to bilinear interpolation. Then click Apply to complete the RTK data editing and confirmation.



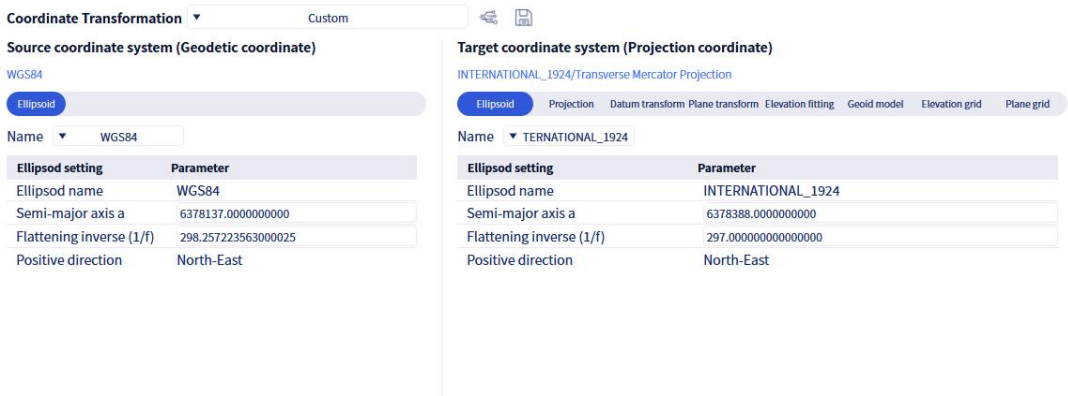
Currently, this transformation method has been built into the built-in coordinate system of coordinate transformation. Set "Coordinate Transformation" to " **MountEden2000(EPSG2105)_AUK46**" to complete the RTK data editing and confirmation.

- **How to export the point cloud to the HK1980(EPSG2326) coordinate system?**

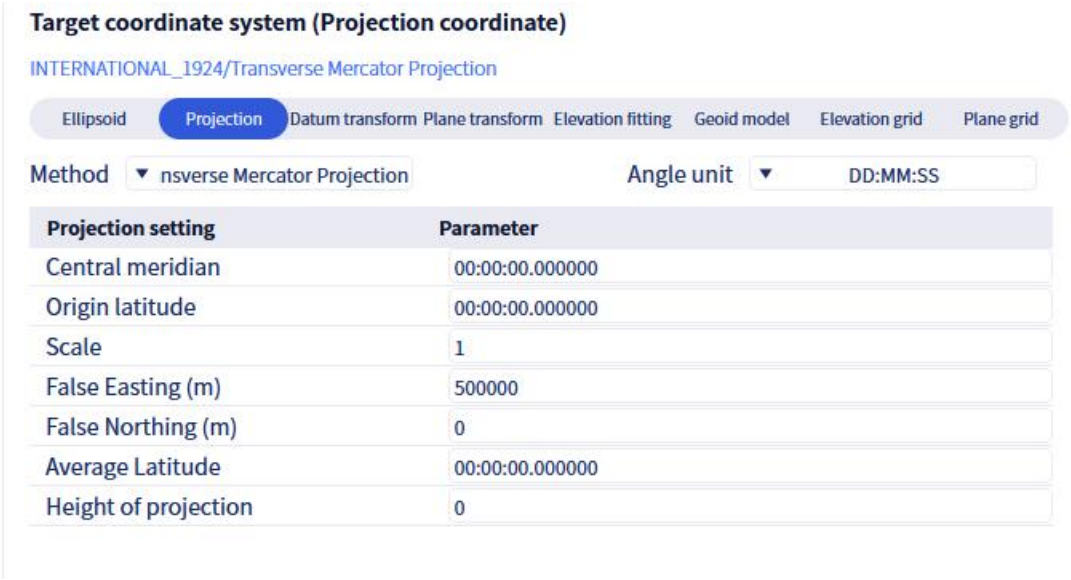
The commonly used coordinate system in Hong Kong is the HK1980. Its ellipsoid is the INTERNATIONAL_1924 ellipsoid and projection is the Transverse Mercator projection. The elevation system is the HKPD. The coordinate system of the collected data is WGS84, and the elevation system is geodetic height.

In order to output the point cloud to the target coordinate system, when completing data collection and setting the coordinate transformation data, it is necessary to set the source ellipsoid, target ellipsoid, projection parameters, and elevation grid transformation parameters. The specific operations are as follows:

- Set **the Source Ellipsoid** to WGS84 and **the Target Ellipsoid** to INTERNATIONAL_1924.

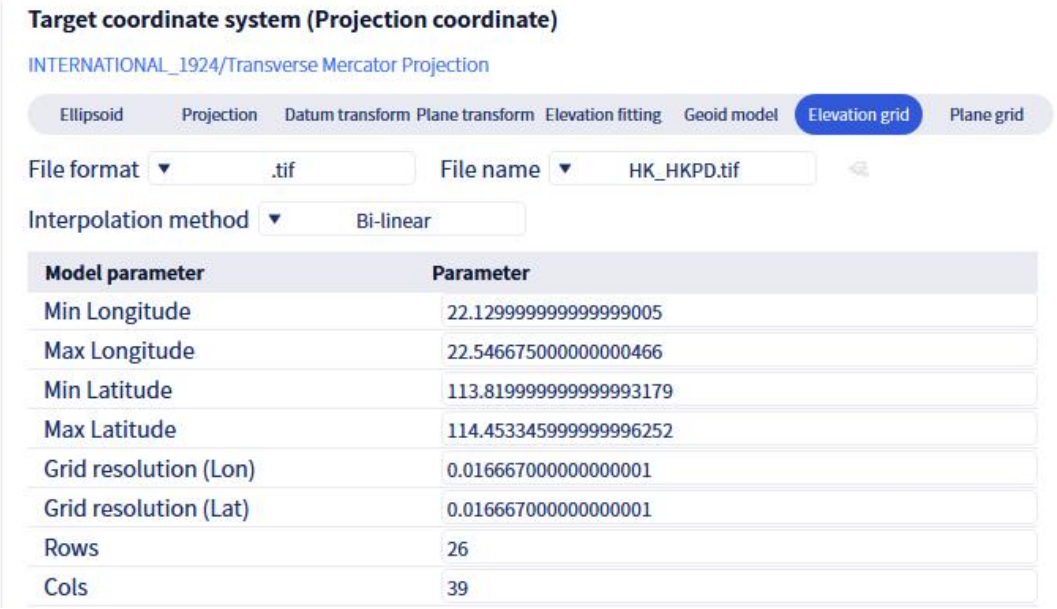


- **The projection parameters** are set to Transverse Mercator. Please modify the projection parameters according to actual needs.



- **the datum transformation parameters**: those parameters are the seven parameters provided by the Hong Kong government. You can input them according to the data on the government' s official website.

- **the elevation grid parameters**, set the "File Format" to .tif format or all, import the corresponding .tif format elevation grid model in "File Name", and set the "Interpolation Method" to bilinear interpolation. Then click Apply to complete the RTK data editing and confirmation.



Currently, this transformation method has been built into the built-in coordinate system of coordinate transformation. Set "Coordinate

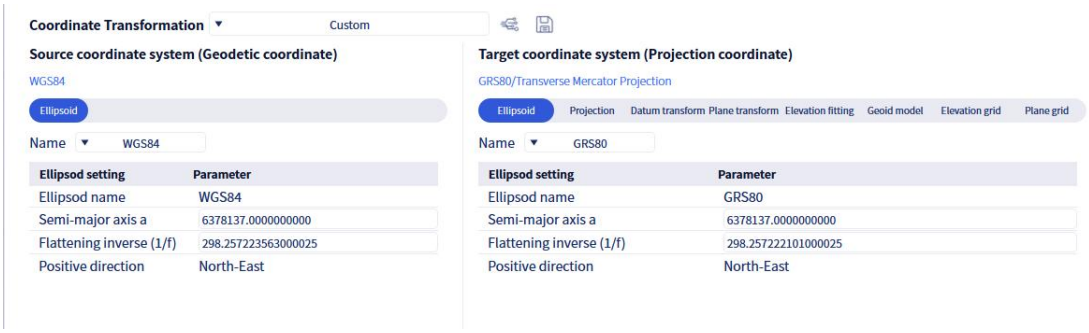
Transformation" to " HK1980(EPSG2326)_HKPD" to complete the RTK data editing and confirmation.

- **How to export the point cloud to the Japanese referenced coordinate system JGD2011?**

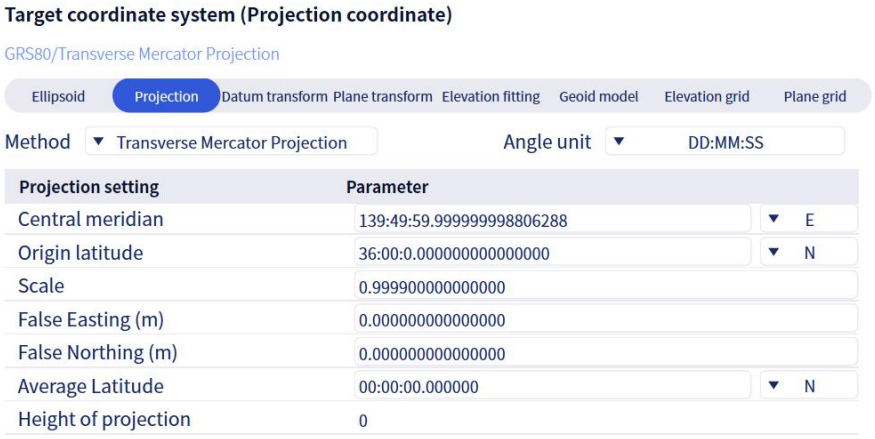
The commonly used coordinate system in Japan is JGD2011, which requires the use of GRS80 ellipsoid and Transverse Mercator projection, and the elevation system is the orthometric system. The RTK data coordinate system provided by the local RTK service provider is WGS84, and the elevation system is geodetic height.

In order to output the point cloud to the referenced coordinate system JGD2011 and the normal elevation system, when completing the data acquisition and setting the coordinate transformation data, it is necessary to set the source ellipsoid, target ellipsoid, projection parameters and geoid transformation parameters. The specific operations are as follows:

- Set **the source ellipsoid** to WGS84 and **the target ellipsoid** to GRS80.

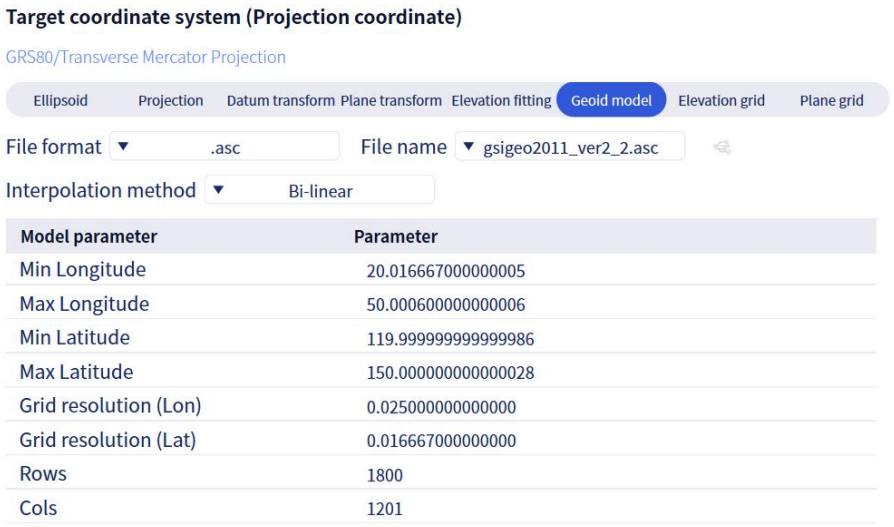


- **The projection parameters** are set to Transverse Mercator. Please modify the projection parameters according to actual needs.



- **the datum transformation parameters,** no need to set.

- **the geoid parameters**, set the "File Format" to .asc format or all, import the corresponding .asc geoid model in "File Name", and set the "Interpolation Method" to bilinear interpolation. Then click Apply to complete the RTK data editing and confirmation.



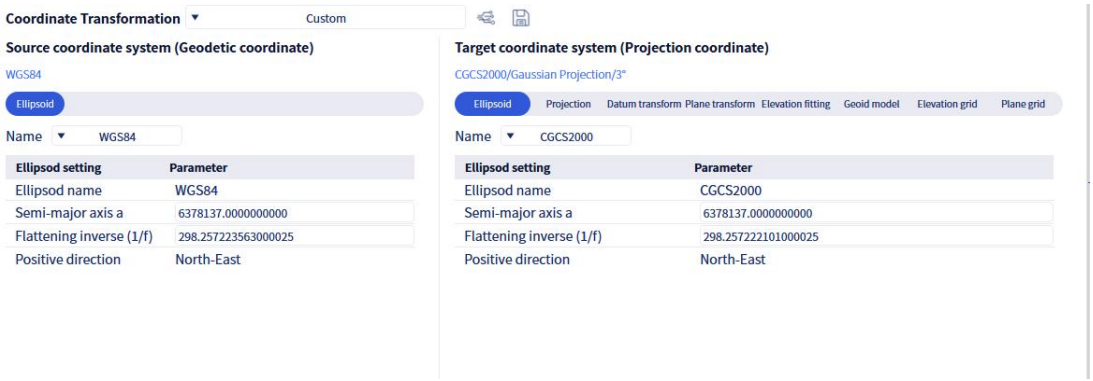
Currently, this transformation method has been built into the built-in coordinate system of coordinate transformation. Set "Coordinate Transformation" to " JGD2011(EPSG6677) _GSI2011" to complete the RTK data editing and confirmation.

- **How to export point cloud data with the source coordinate system of WGS84 to CGCS2000 coordinate system?**

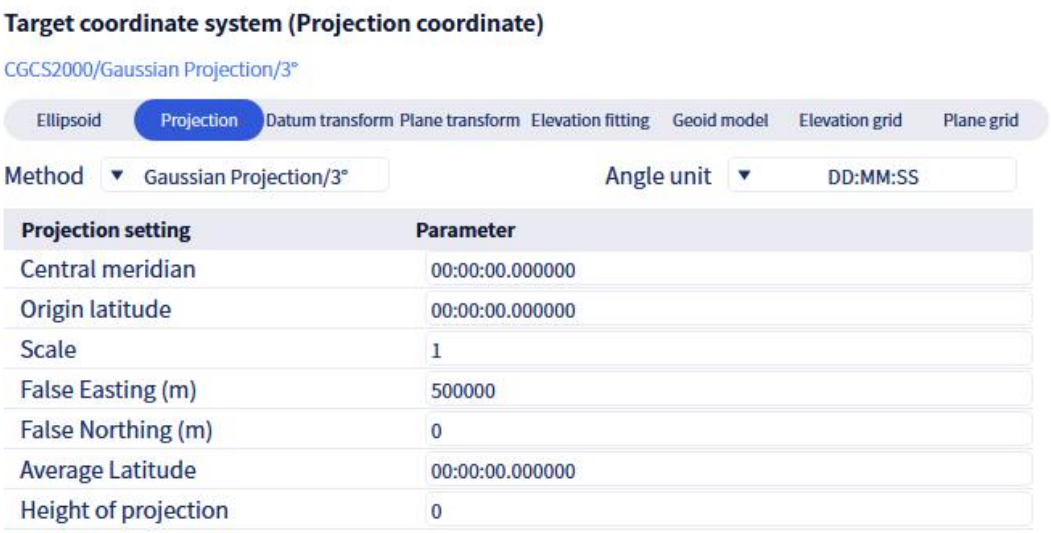
The commonly used coordinate system in China is the CGCS2000 coordinate system, which requires the use of the CGCS2000 ellipsoid and Gaussian projection/3°, and the elevation system is geodetic height. If the coordinate system of the RTK data obtained is WGS84, and the elevation system is geodetic height. In order to complete the high-precision transformation, the Bursa seven-parameter benchmark transformation method is required.

In order to output the point cloud to the GCS2000 coordinate system, when completing data acquisition and setting the coordinate transformation data, it is necessary to set the source ellipsoid, target ellipsoid, projection parameters and reference transformation parameters. The specific operations are as follows:

- Set **the source ellipsoid** to WGS84 and **the target ellipsoid** to CGCS2000.

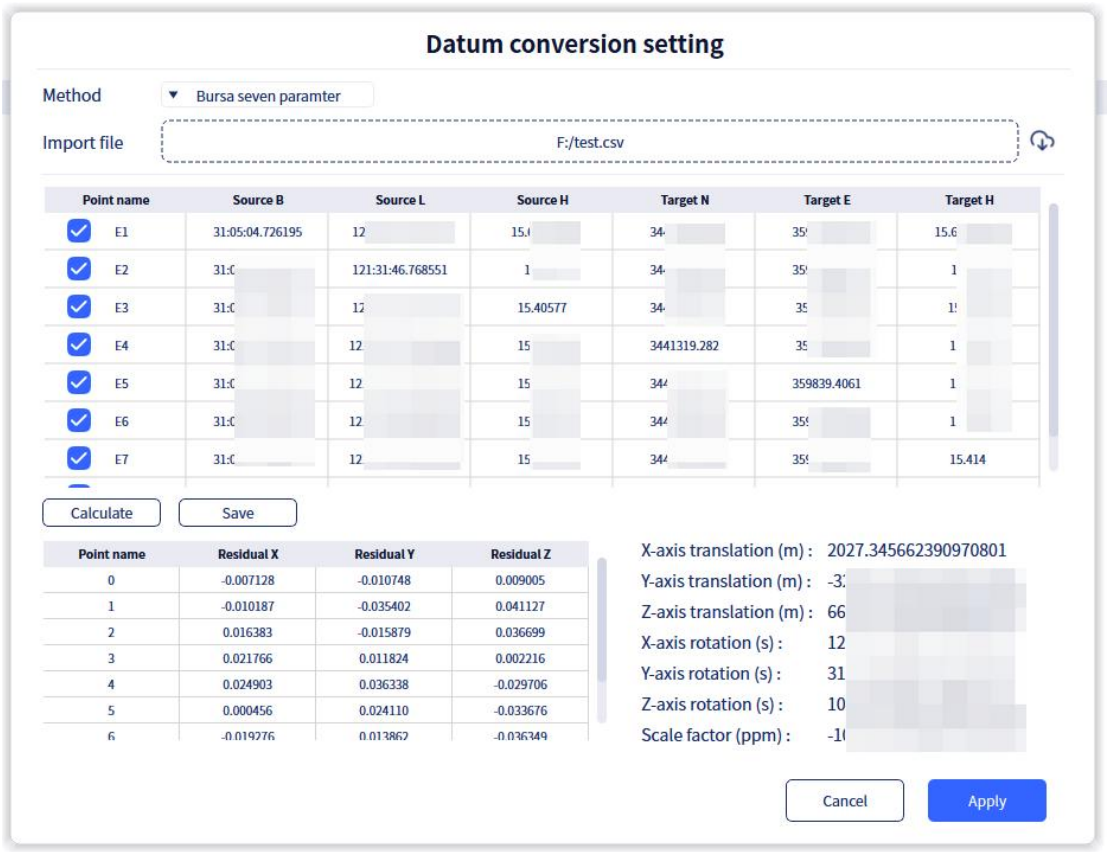


- **The projection parameters** are set to Gaussian projection/3°. Please modify the projection parameters according to actual needs.

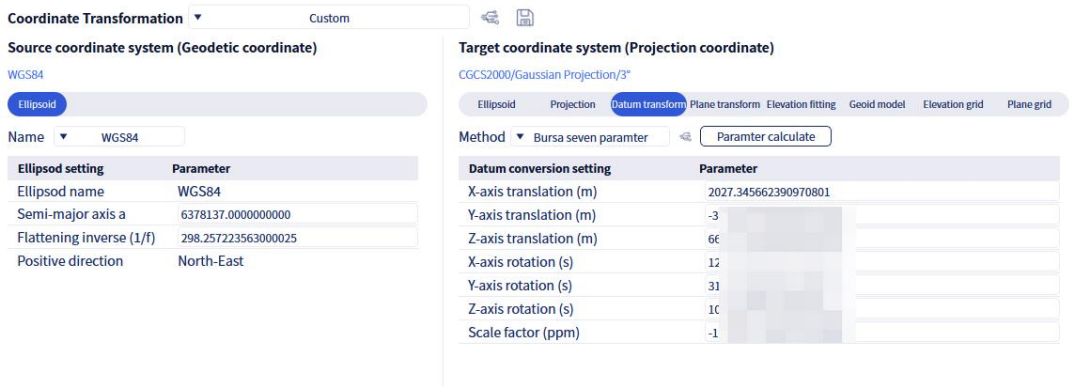


- **the datum transformation parameters**, click "Parameter Calculate", import the standard control point pair file prepared in advance, click Calculate, confirm that the residuals are all less than 0.01, and click Apply to complete the datum transformation parameter setting.

Select standard control point pairs to calculate the datum transformation parameters.



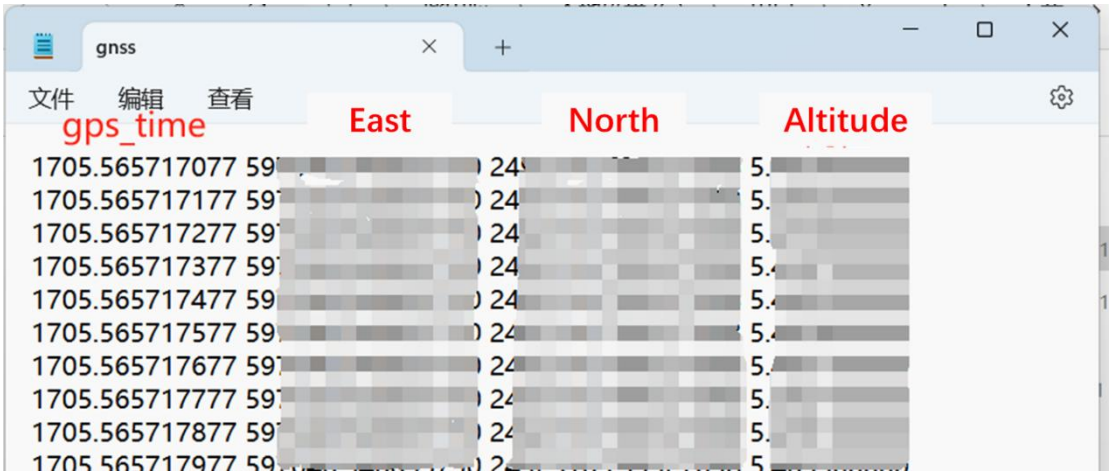
Then click Apply to complete the RTK data editing confirmation. You can also click Save to save the parameters for later use.



2. GNSS files

If users need to transform the point cloud data to a specific coordinate system, they can first copy the gnss.csv recorded by the scanner in the project_data folder and use other software for coordinate transformation. After transformation, save the newly transformed gnss.csv file to the external_data folder of the corresponding project directory. When the GNSS

File option is checked, the software will automatically read the files in the external_data folder and use the gnss.csv file for coordinate transformation. The transformed gnss.csv format is gps_time east coordinate, north coordinate elevation, as shown in the figure below.

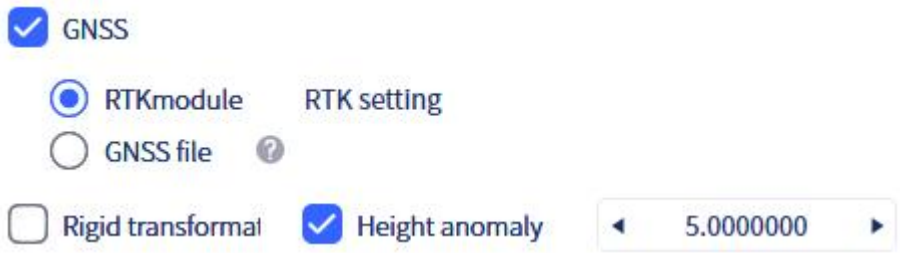


c. **Rigid Transformation**

If you check "Rigid Transformation," the external control points or GNSS information will only be used for the rigid transformation of the point cloud and will not be used for SLAM mapping optimization. For those who require high accuracy in point cloud data, it is recommended not to check this option.

d. **Height Anomaly**

If the user needs to transform the default ellipsoidal elevation system of the GNSS file to another elevation system, they can check this option and fill in the corresponding values.



1.2 Coloring

The coloring function mainly uses image data from the built-in camera or external panoramic camera to color the point cloud, obtaining point cloud data with true color information. If you choose external panoramic camera coloring, you need to simultaneously start recording with the external panoramic camera during scanning.

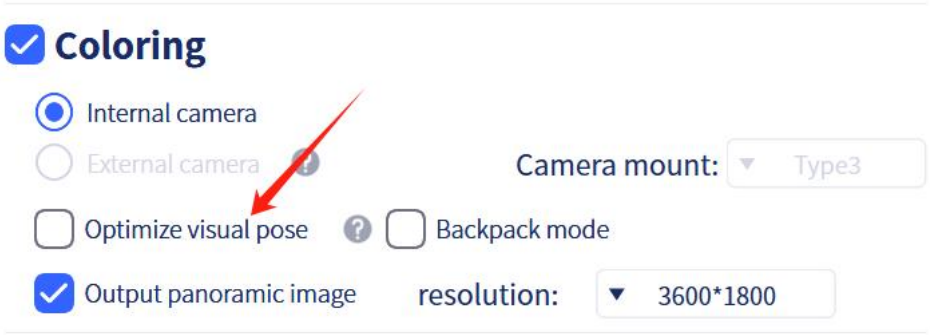
If you need to color the collected point cloud data, you can check this option and select the appropriate coloring method.

- **For L1 Devices**: Only the external camera mode coloring is supported. Please select the type of mount used and whether it is collected in backpack mode based on the actual usage situation. Before performing engineering processing, please copy the two same-named insv video files from the Insta360 camera corresponding to this scan to the external_data folder of the corresponding scan project folder.

- **For L2 Devices**: Both built-in three-camera mode coloring and external panoramic camera mode coloring are supported. If using built-in camera coloring, directly select the built-in camera mode. If using external camera coloring, please select the type of mount used and whether it is collected in backpack mode based on the actual usage situation. Before performing engineering processing, please copy the two same-named insv video files from the Insta360 camera corresponding to this scan to the external_data folder of the corresponding scan project folder.

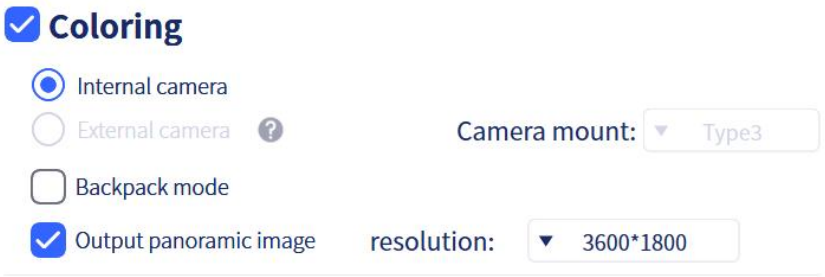
- **For K1 Devices**: Only the built-in dual-camera mode coloring is supported. Please directly select built-in camera coloring.

- **For L2 Pro Devices**: Only the built-in dual-camera mode coloring is supported. Please directly select built-in camera coloring. **For areas with rich textures, if you need to further optimize the coloring effect, you can enable the "Optimize visual pose" option.**



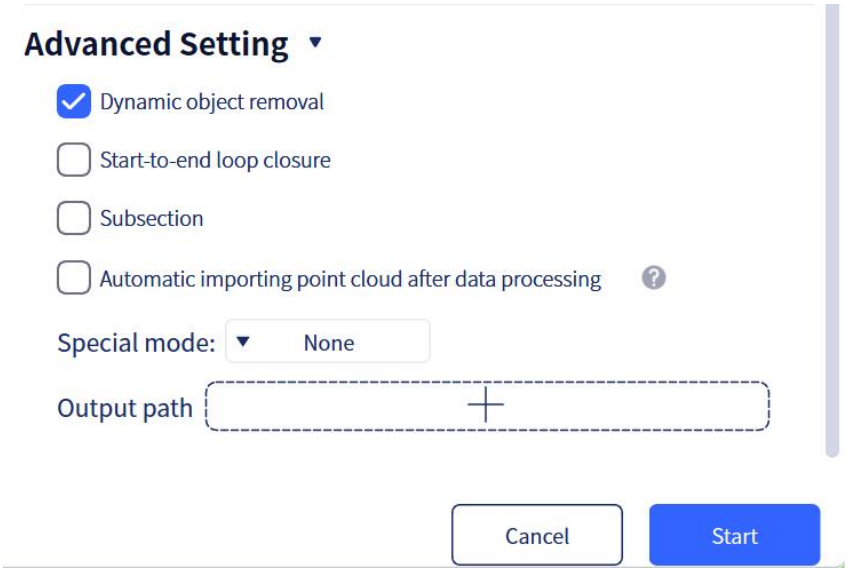
- **For K1 and L2pro devices**: if you need to generate panoramic images or use the panorama overlay function, please make sure to check the "Output Panoramic Images" option and select the resolution parameter. After processing, the corresponding panoramic images will be generated in the result folder.

Note: Please select correctly according to the actual collection situation. Incorrect selection will lead to coloring errors or even failure. Therefore, please choose carefully based on the actual situation.



1.3 Advanced Settings

The advanced settings provide users with four SLAM mapping-related parameters: Dynamic Object Removal, Start-to-end Loop Closure, Subsection, Automatic Load Point Cloud After Data Processing, and Special Mode.



1.3.1 Dynamic object removal

The Dynamic Object Removal function is designed to remove point cloud noise data of dynamic objects collected during scanning, in order to obtain better point cloud data. For better removal results, please strictly adhere to relevant collection guidelines during data acquisition.

1.3.2 Start-to-end loop closure

The Loop Closure function mainly enhances the constraints of SLAM mapping and improves the overall accuracy of point cloud data. If the walking trajectory forms a loop (i.e., the scan ends at the starting point) during data collection, you can check this option.

1.3.3 Point Cloud Subsection

The point cloud subsection function can segment the point cloud results after project processing according to the size specified by the user. It is not enabled by default. After checking, the default segment size is 1gb. The user can also select the segment size according to actual needs.

1.3.4 Point Cloud Enhancement (L2 Pro data only)

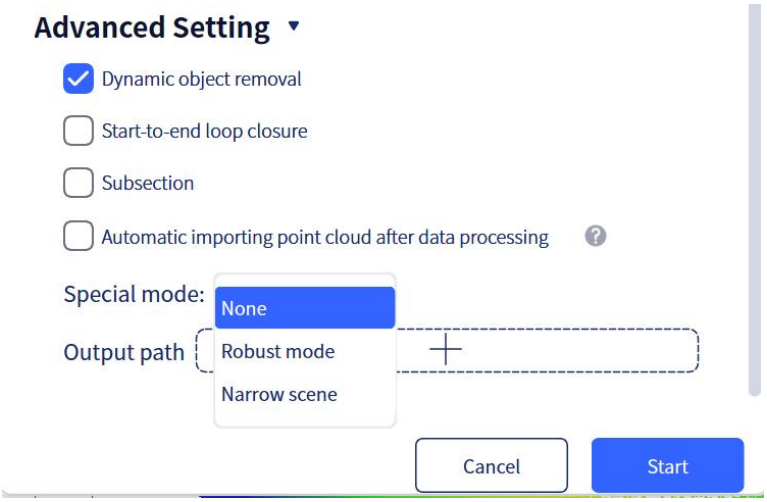
The point cloud enhancement function is mainly intended for the L2 Pro device. Using the point cloud enhancement function results in denser and more uniform point cloud data, but the efficiency of project processing will be reduced. Currently, the software offers two modes of point cloud enhancement:

1. **5mm**: If this option is selected, the point spacing in the enhanced point cloud data will be 5mm.

2. **1mm**: If this option is selected, the point spacing in the enhanced point cloud data will be 1mm.

Note: Selecting either of these options will decrease the efficiency of project processing. After point cloud enhancement, the result data will be enormous and thus will be saved at multiple tiles.

1.3.5 Special mode



(1) Robust mode

The robust mode is mainly used for mapping in scenarios with partial degradation or intense motion. If the conventional mapping mode fails and the processing report indicates "LIO too few, please try robust mode," you can select this option to reprocess the project. Note: This mode increases the success rate of mapping, but the accuracy of these scenarios may be compromised.

(2) Narrow scene

The narrow scene mode is mainly used in narrow and straight scenes such as underground tunnels, mining tunnels and long straight corridors. Enabling it in other common scenes processing project may cause SLAM mapping to fail.

Note:

1. The narrow scene mode can improve the robustness of SLAM mapping in underground tunnels, mining tunnels and long straight corridors, and improve the success rate of SLAM mapping within 500m. For narrow

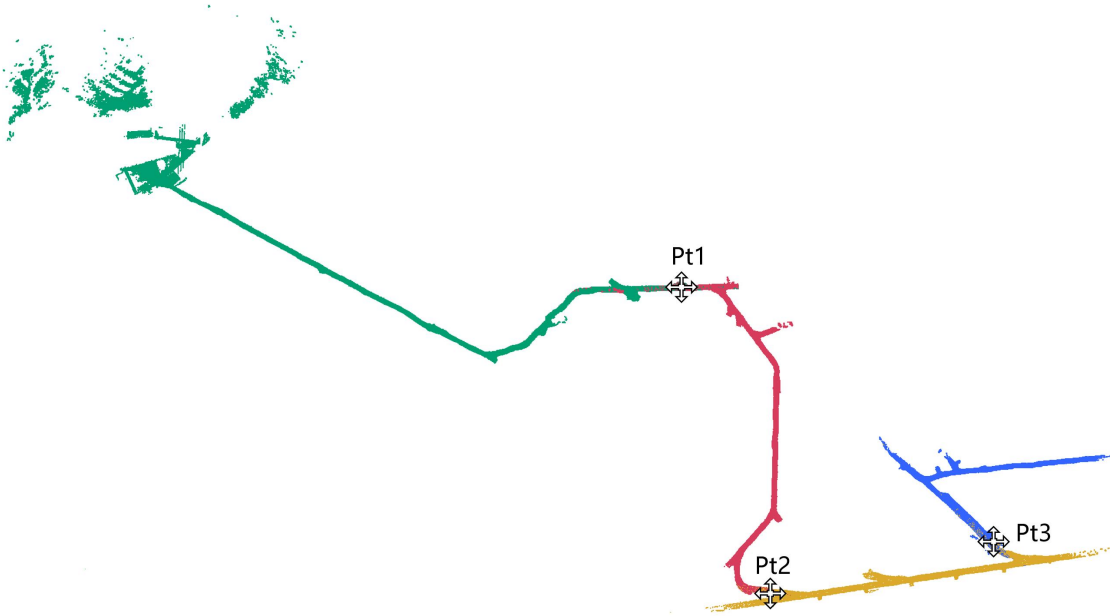
scenes with long scanning time, due to factors such as dynamic objects/motion/degradation, the challenge is still great and there is a possibility of failure.

2. During scanning, for narrow scenes that require a long time to acquire, it is recommended to perform multiple scans. It is recommended to scan every 500 meters and add control points at the beginning and end of each scan (control point coordinates are optional), and use multi-map fusion to fuse the point cloud. It is recommended to scan in segments, collecting one segment every 500m). For specific operations, please refer to map fusion based on control points (relative control points/absolute control points). The control points of the first set of data are set at the end of the scan, the control points of the intermediate data are set at the beginning and end of the scan, and the control points of the last set of data are set at the beginning of the scan. The names of the control points at the connection positions must be consistent, and the scanning placement and direction must be consistent.

Case:

The scanning area is a mine tunnel about 1 km long. The scene is dark, the texture features are weak, and the internal geometric structure is repeated, which poses great challenges to both vision and LiDAR.

In order to ensure the success rate of SLAM mapping, this scene was performed several scans according to the rules. The specific scans and control points are shown in the following figure:



After actual verification, it is found that the required point cloud data can be obtained more accurately by using multiple scans and map fusion processing (selecting narrow scenes).

1.3.6 **Import point cloud after processing**

If selected, the processed data will be automatically imported into the software. If processing multiple project datasets with large point cloud data, it will occupy considerable disk space. Please ensure you have sufficient disk space available. Note: For data with "Point Cloud Enhancement" selected, due to the increased data size after enhancement, this option is not selectable by default.

1.3.7 **Output path**

Users can specify the path to save the processing result file. If not specified, it will be output to the LixelStudio project save folder by default.

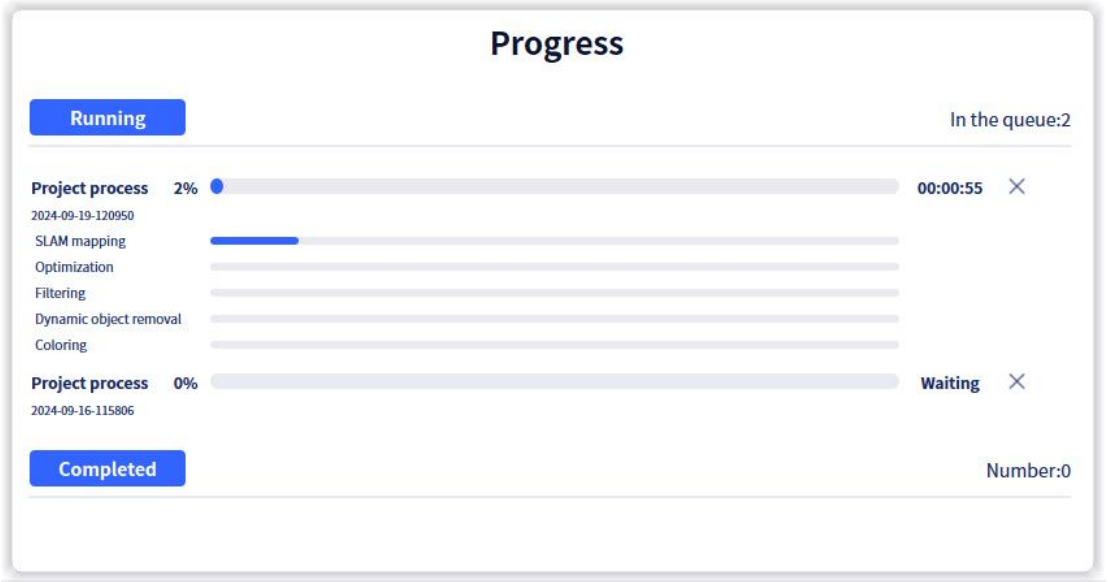
1.3.8 **Progress task queue**

All tasks can be found in the progress queue at the bottom of the software window. You can add a new project processing task to the queue without having to wait until your current task is finished. All tasks in the queue will be performed one by one (while your computer is still awake).

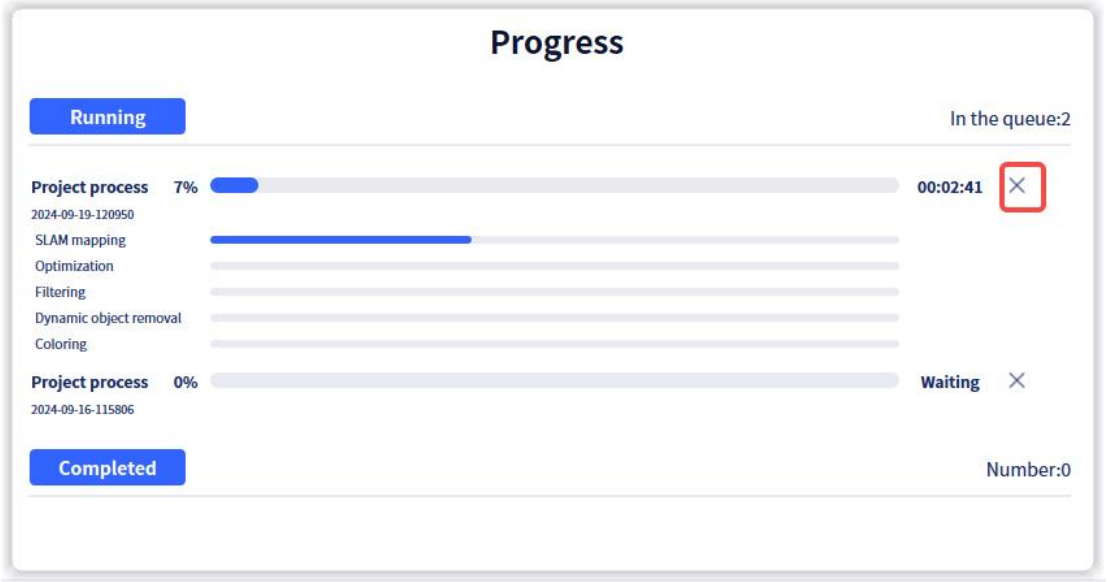
Users can select different options for different processing tasks

according to their actual needs. After selecting the options, click "Start," and the software will immediately begin the processing task. The corresponding project processing tasks will be automatically added to the task queue and processed in order.

Clicking on the process bar at the bottom of the software will display the current processing, waiting, and completed projects. For data that is being processed, all processing steps and progress will be shown.

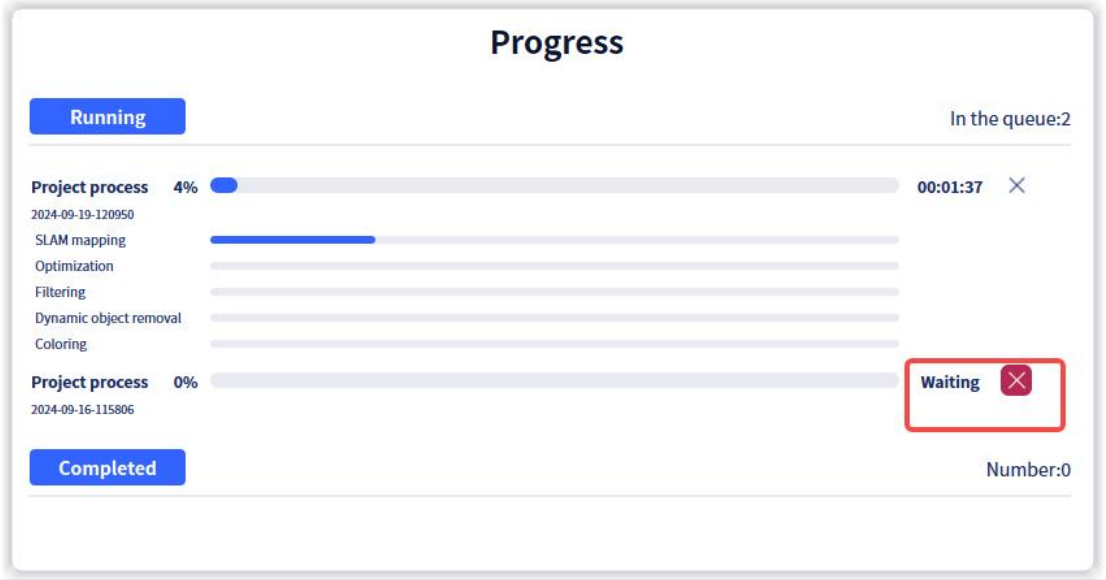


If you need to cancel, click the "X" button on the right side to cancel the ongoing task. Note: After cancellation, the task will appear in the completed list and display as "Failed." Clicking the folder icon on the right side will open the processing results folder. Opening the processing results will show that the reason for failure is "Cancelled by user."



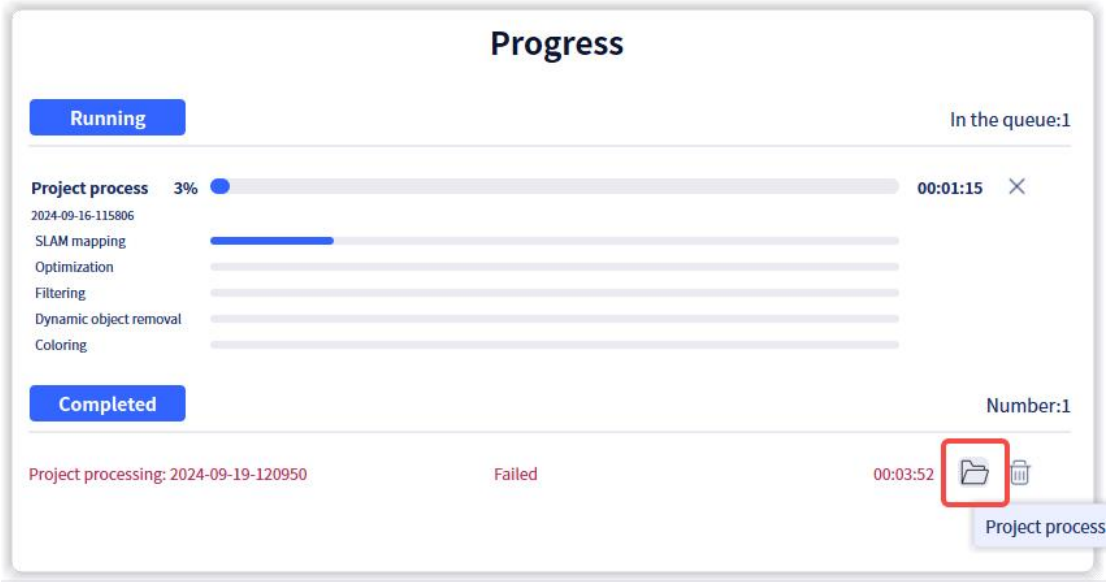
Project name	2024-09-19-120950
Create time	24-09-23:18:22:54
Start time	24-09-23:18:22:54
End time	24-09-23:18:26:46
Processing content	SLAM mapping Optimization Filtering Dynamic object removal Coloring
Result	Fail
Failed step	SLAM mapping
Failed reason	Cancelled by user

For tasks that are waiting, only the project name is displayed. If the user needs to cancel, they can click the "X" button on the right side to delete the project.



For completed projects, if there are failed projects in the completed queue, the bottom progress bar will be displayed in red, and the failed projects will be highlighted in red. If all projects in the completed queue are successful, the bottom progress bar will be displayed in blue.

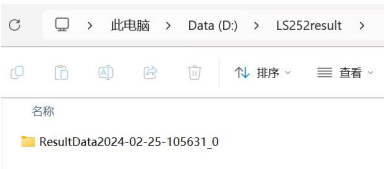
Clicking the folder icon on the right side will open the processing results folder. Clicking the delete icon on the right side will remove the project from the completed list.

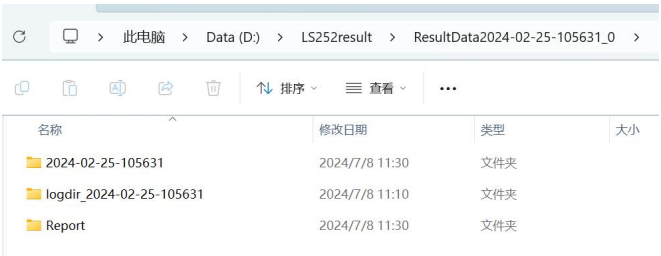


1.3.8 Saving path of project processing

If the output path is not specified in the advanced settings, the project processing result file will be saved in the current LS project folder by default; if the output path is specified, the result folder will be saved in the corresponding path. The result folder will be saved under the name of " **ResultDataproject file _0** " (after the file name, " _0 " represents the result of the first processing of the project. If the same project file is processed again and saved in the same path, the result file name of the second processing will be followed by " **_1** ", and so on).

In the result folder, the corresponding post-processing point cloud file, point cloud three-view screenshots, trajectory file, image file (if coloring is checked), etc. will be saved in the folder named after the project files. The logdirXXXX folder saves the log files of project processing. The report folder saves the processing report and the control point transformation accuracy report (if the control point coordinate transformation is checked).





2. Map Fusion

The Map Fusion function primarily stitches and merges multiple point cloud datasets into a single map. The Multi-Map Fusion function includes joint global optimization of multiple datasets, coordinate transformation and coloring. It supports fusion based on RTK, control points, connection points, and resume scanning mode.

Note:

a. The current version supports a maximum fusion of 10 sets of projects, and each scanning time needs to be within 20 minutes.

b. After the map fusion is successful, each map is saved separately. If you need a complete map after fusion, you can import and merge multiple sub-maps.

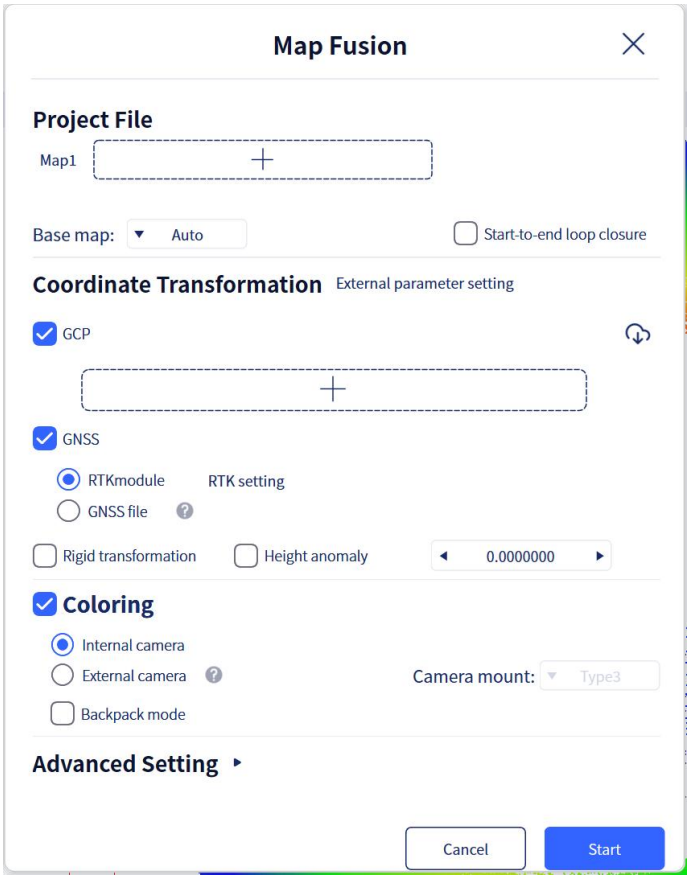
c. If colorization is required, all files to be colorized need to use the same coloring mode. For example, all projects use the internal camera for coloring, and all data use the external panoramic camera for coloring.

d. The map fusion function only supports merging projects scanned by the same device type (for example, no cross-merge between L2 and K1).

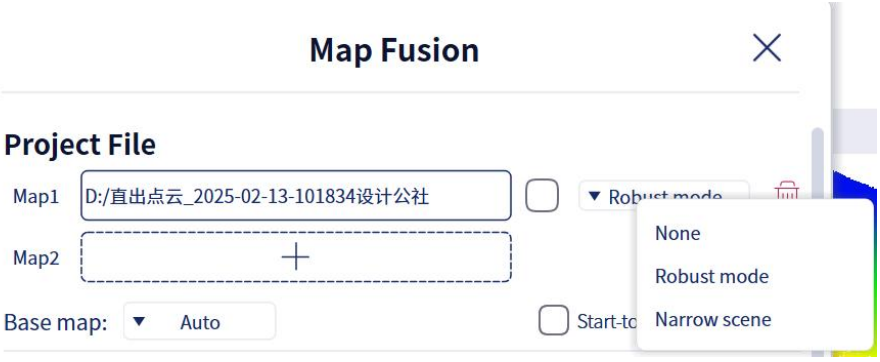
Map fusion supports using the four methods (RTK, GCP, connection point, and resume scanning mode) in a mixed manner, as long as at least one method is used between two projects.

For multi-map fusion, regardless of the fusion mode, in order to achieve better fusion result, there should be as many overlapping as possible between adjacent maps. It is recommended that the length of the overlapping path be larger than 15 meters, and it is recommended to be between 15 and 30m. The adjacent overlapping areas should be located in scenes with rich features as many as possible, and degraded scenes such as open spaces, long corridors, and smooth tunnels should be avoided.

If coordinate transformation using GCP is required, the minimum requirements are as follows: there must be a connection relationship (relative control points or continuous scanning) between all maps, and there must be at least 3 or more absolute control points in all maps (control points must not be in a straight line).



First, click "Add Project" to select multiple map project data to be merged.



According to the actual situation of the project, check whether each map was scanned in a start-to-end closed loop manner. Or does it need to be processed in a special mode? If so, please check.

Based on the actual project situation, select the reference map. If "Auto" is selected, the first map in the list will be used as the reference map by default.

The subsequent coordinate transformation operation requirements are consistent with the "1.1 Coordinate transformation" operation requirements.

If you need to colorize the acquired point cloud data, you can check this

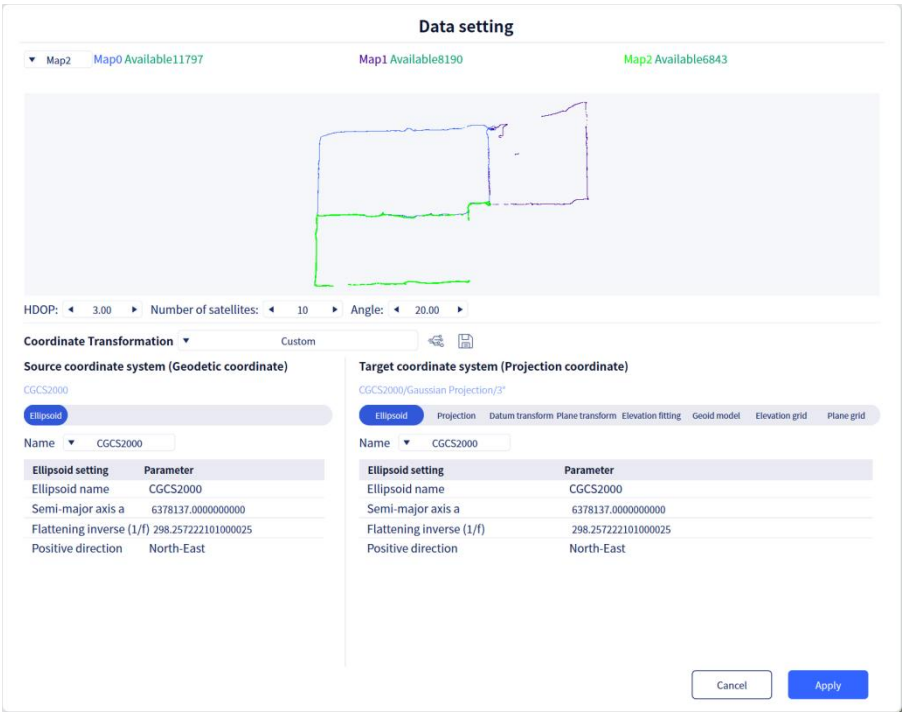
option and select the corresponding coloring method. The specific options are consistent with project processing. For detailed operations, please refer to the project processing content. Note: Please make the correct selection according to the actual collection situation. If you make the wrong selection, it will cause coloring errors or even failures. Therefore, please choose carefully according to the actual situation.

Users can also check different options for different processing according to their actual needs. If you click Start, the software will pop up a window to ask the user to check whether the file path of multiple segments of data is correct. If it is correct, the software will start the task processing immediately. If it is not correct, the user can cancel it and re-select the file before starting again.

2.1 Map Fusion Based on RTK

For map fusion based on RTK, after selecting GNSS, you need to set the RTK data of each map. The setting interface will display the trajectory status of each map. You can select each map in the upper left corner and set the corresponding parameters to ensure that each map data is available.

Coordinate transformation is consistent with project processing. Please refer to the steps in project processing for details.



2.2 Map Fusion Based on Ground Control Points

For map fusion based on control points, please import the control point file. The control point file format should be: Point Number, Easting, Northing, Elevation, and the file extension should be .CSV or .TXT. The control point file format is consistent with the project processing format. Please ensure that the point names are consistent between the device record and external GCP file. You can also modify the known control point numbers on the computer using a text editor to avoid coordinate transformation errors or failures.

2.3 Map Fusion Based on Connection Points

During scanning, if the scene is indoors or in an area without GNSS signals and there are no known control points available for reference within the survey area, you can plan relative control points in the scanning scene without needing to obtain the absolute coordinates of these control points. You only need to mark these control points using the scanner during the scanning process. Ensure that there is at least one common (shared) control point between the multiple maps being scanned. During fusion, the software establishes relationships between multiple maps and further optimizes them through the common overlapping areas of the maps.

Note:

1. The direction of marking control points with the device must be consistent across multiple instances. For example, if the device is facing north when recording control point A for the first time, it should also be placed facing north when recording the same control point the second time. It is recommended to use the official calibration board and target paper for marking control points.
2. To achieve better multi-map fusion results, try to ensure that there is a significant length of overlapping path between the two maps being fused. The recommended length for the overlapping path is 15-30 meters.

2.4 Map Fusion Based on Resume Scanning

During the mapping process, if there is an interruption due to device issues (such as low battery shutdown or manual interruption), you can use the continuous scanning function to continue scanning the remaining area. After completing the scanning, several maps will be generated.

Map fusion based on resume scanning involves reading the map

association information from the continuous scanning process, stitching multiple maps together, and performing multi-map fusion through joint global optimization.

If you need to colorize the acquired point cloud data, you can select the appropriate coloring method. The specific options are consistent with project processing. For detailed operations, please refer to the project processing-coloring content.

Note: Please select correctly according to the actual collection situation. Incorrect selection will lead to coloring errors or even failure. Therefore, please choose carefully based on the actual situation.

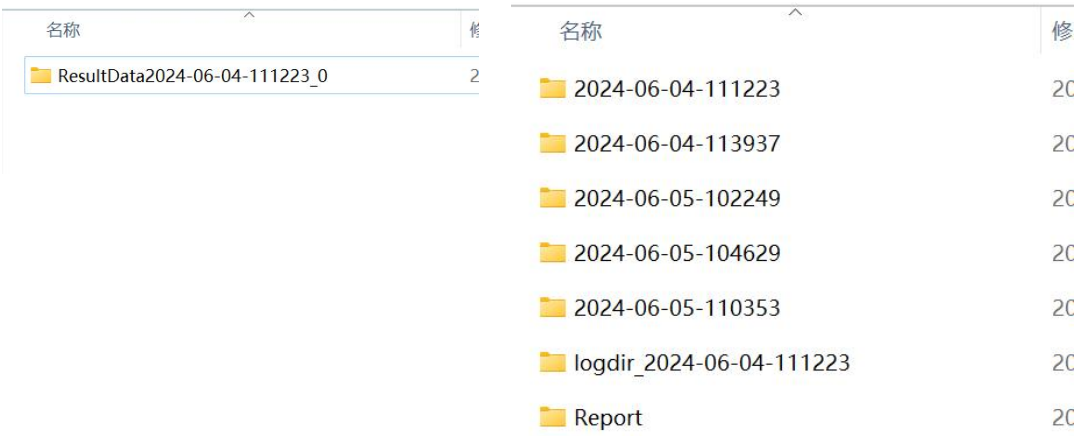
Users can select different options based on their actual needs to perform different types of processing. If you click "Start," the software will prompt a window for the user to verify whether the file paths of multiple segments of data are correct. If they are correct, the software will immediately start processing the task. If they are incorrect, the user can cancel and reselect the files before starting again.

2.5 Saving path of map fusion

If the output path is not specified in the advanced settings, the map fusion

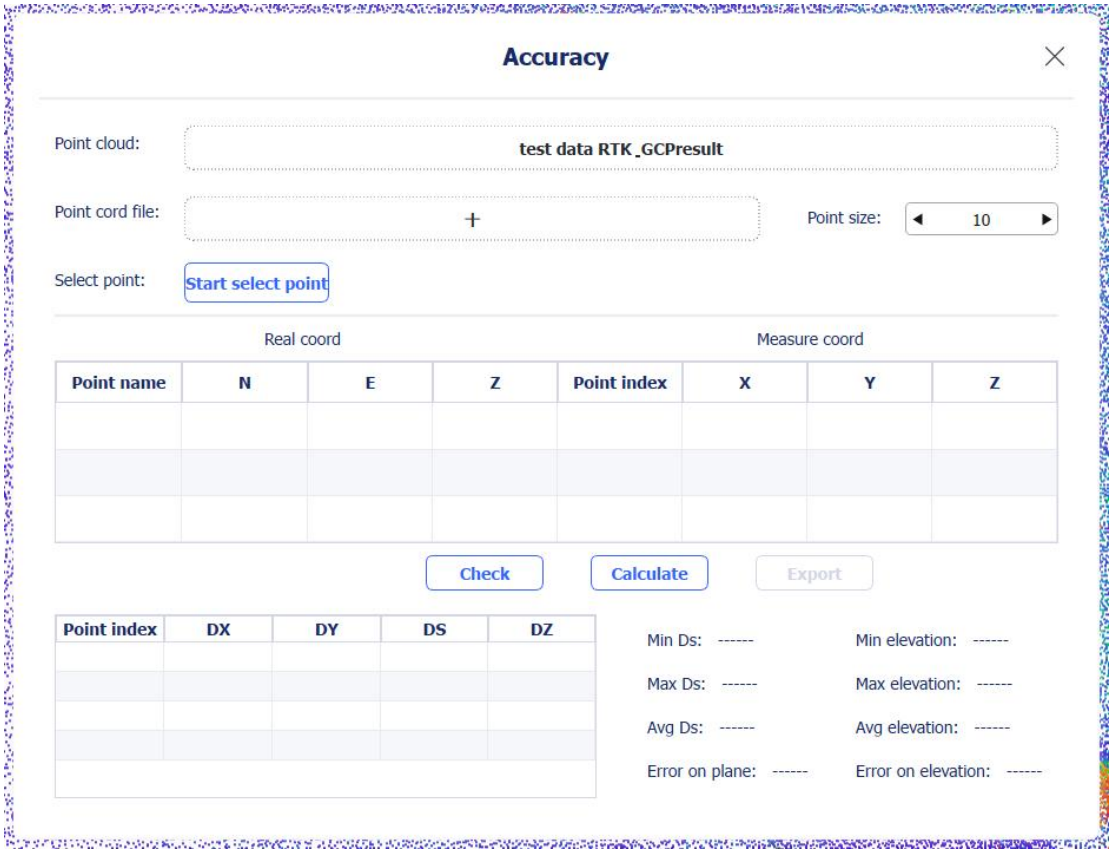
result file will be saved in the current LixelStudio project folder by default; if the output path is specified, the result folder will be saved in the corresponding path. The result folder will be saved under the name " **ResultData benchmark map project file _0** " (after the file name, " **_0** " represents the result of the first processing of the project. If the same project files are processed again for map fusion and saved in the same path, the result file name of the second processing will be followed by " **_1** ", and so on).

In the result folder, multiple fused map files will be saved separately in the result folder named after their project files, including corresponding trajectory files, photo files (if coloring is checked), etc. The logdirXXXX folder saves the log files of map fusion. The Report folder saves the report of map fusion and the accuracy report of control point transformation (if the control point coordinate transformation is checked).



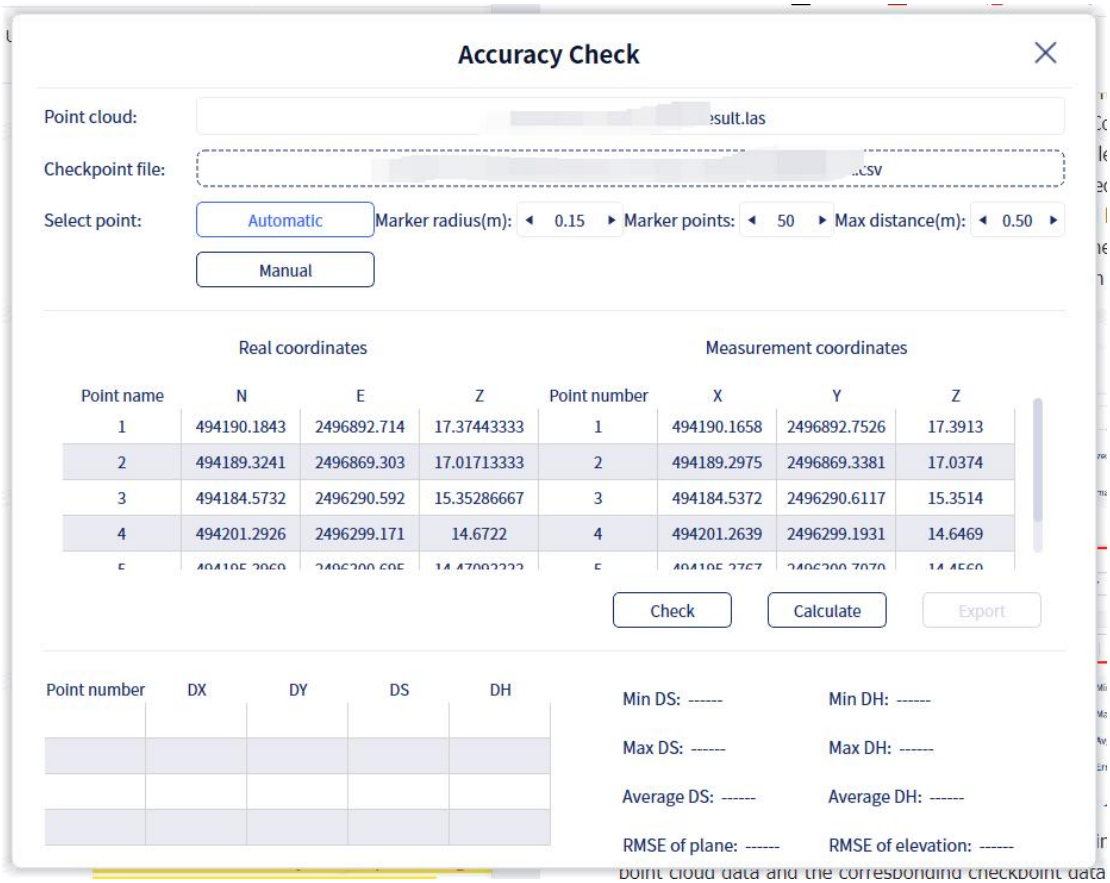
3. **Accuracy Check**

The accuracy checking function is mainly used to verify the accuracy of the scanned data. It primarily compares the checkpoint coordinates after control points/RTK transformation to their true coordinates. First, select the point cloud data under your Data Management window that needs to be checked, then click "Accuracy Check." After selecting the data to be checked, the software will automatically display the point cloud data in intensity color form. The software interface is shown below:



3.1 Automatic Point Selection

Click on "Point Coordinate File" and select the true coordinate file of the checkpoints. The checkpoint file format is the same as the control point format, either .txt or .csv. The specific format is: Point Name, Easting, Northing, Elevation, or Point Name, Y Coordinate, X Coordinate, Elevation. After importing the coordinate file, the interface will display the coordinate data of the imported points. Simultaneously, these checkpoints and their names will be displayed in the data window. If you need to adjust the size of these points, you can do so in the "Point Size Adjustment" section on the right. The default point size in the software is 10.



If you have scanned reflective targets (at the checkpoints) during data collection, you can click the auto-selection function, and the software will automatically extract the coordinates of the target center points. The auto-selection function provides three parameters:

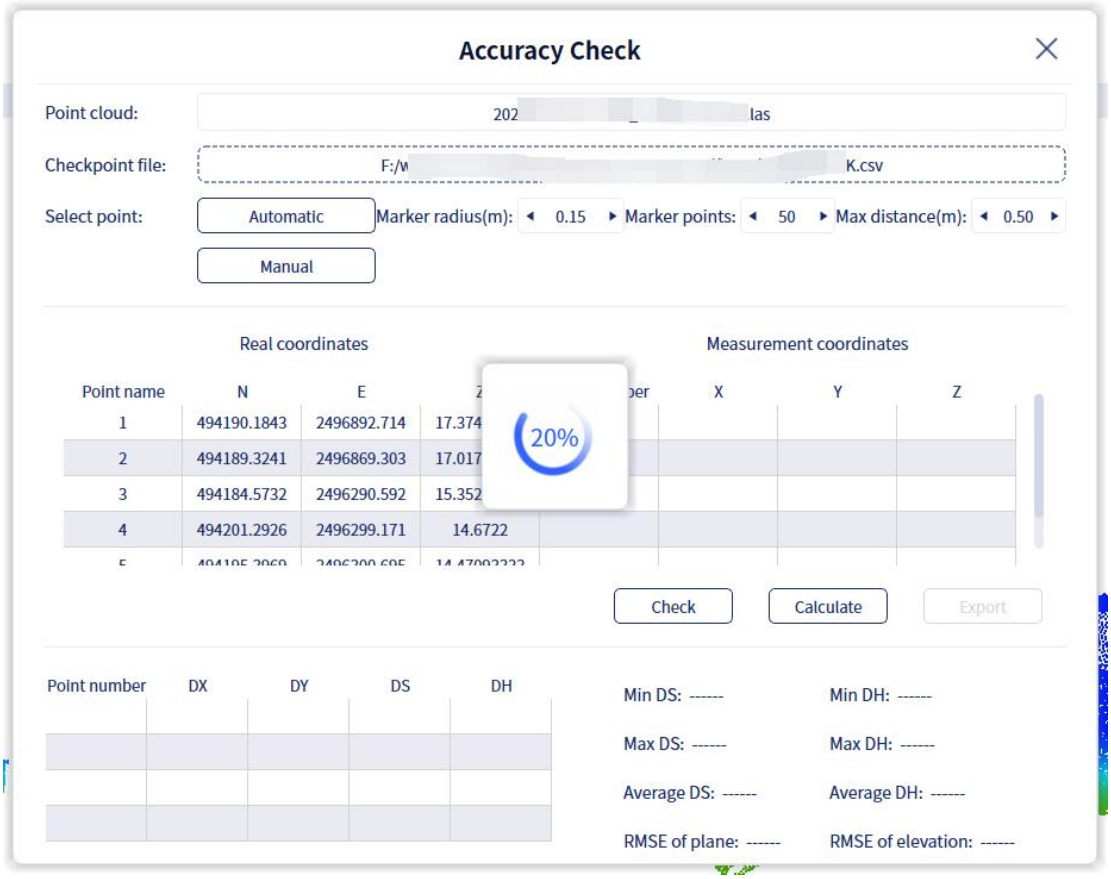
- Target Radius: The radius of the standard circular reflective target specific to the area, default is 0.15m, range: 0.1-1m.

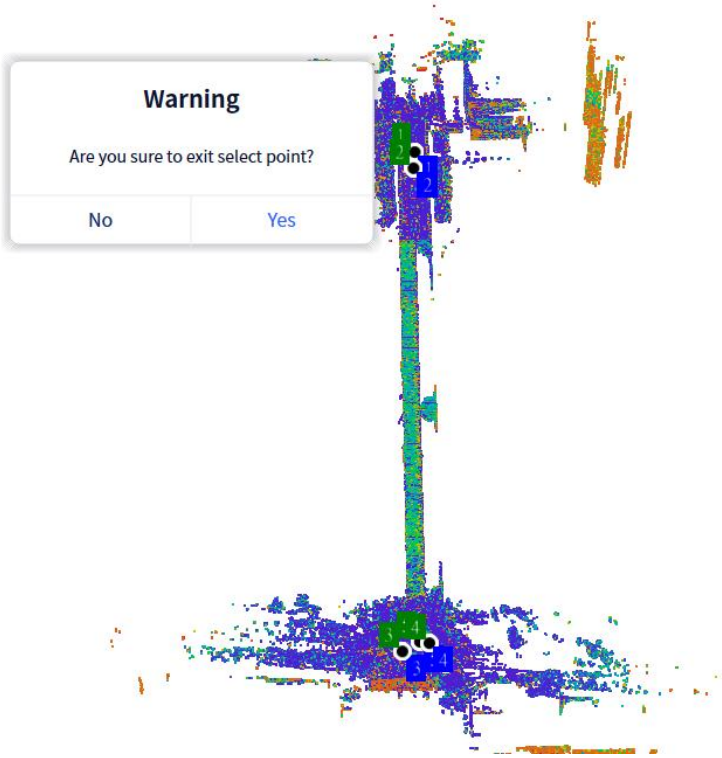
- Target Points: The minimum number of points the software searches for when automatically extracting the target, default is 50, range: 50-200. To ensure extraction accuracy, try to pause slightly at the target during scanning to capture more target points.

- Maximum Matching Distance: The search range for the distance between the target center and the actual true value, default is 0.5m, range: 0.01-1m.

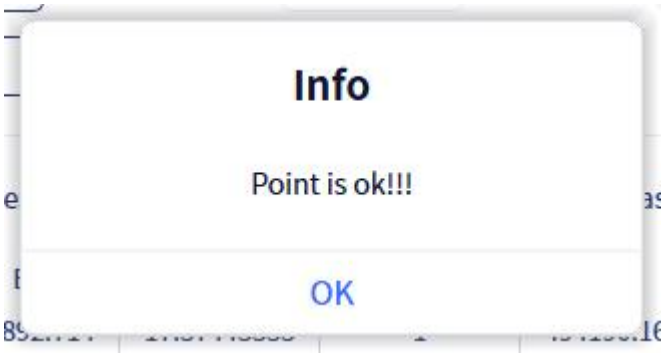
Clicking on auto-selection will prompt the software to automatically search for targets in the point cloud and match them with the imported true value points, displaying them in the point cloud. You can inspect the automatically selected points. If the inspection is accurate, press the "Esc" key to exit the point selection mode and click "Yes" to return to the accuracy check interface. [If you want to continue adding points, you can continue to

select points in the software. For specific operations, see the "Manual Point Selection" function.] The automatically extracted target center points will be displayed in the interface.





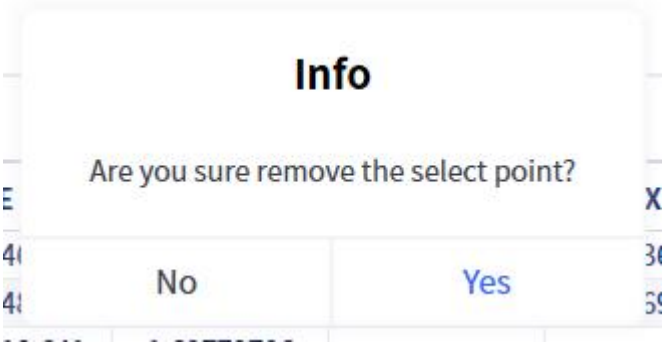
Clicking on "Check" will prompt the software to automatically perform verification calculations between the selected data and the checkpoints. If the deviations of the selected points are within the limit range, calculations can proceed.



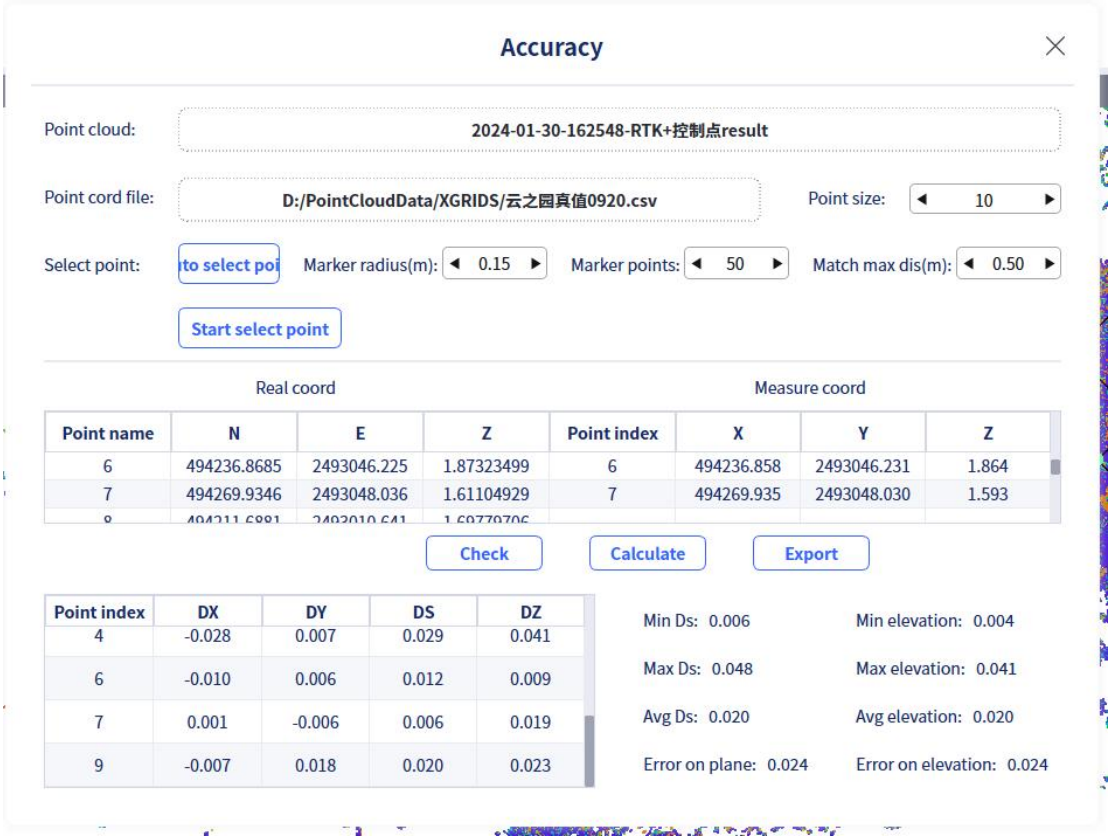
Note: The number of points selected for accuracy checking must be greater than or equal to 3. Otherwise, the calculation cannot proceed.

For points with significant deviations, a prompt will be given, and the coordinates will be highlighted in red. The user can then confirm whether the point selection is correct based on the prompt. If there is an issue with the point selection, you can double-click the corresponding point data row,

confirm the deletion of the point as prompted, and re-select the point.



Clicking on "Calculate" will prompt the software to automatically check the deviations between all point pairs. If within the tolerance range, it will calculate the coordinate deviations between each point pair, the planar error, as well as the maximum, minimum, and average values of the planar error and elevation error, and the mean square error for both planar and elevation. After the calculations are completed, you can export the corresponding calculation results.



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Accuracy checking report

Unit:meter

Point index	DX	DY	DS	DZ
10	-0.031	0.036	0.048	0.004
12	-0.007	0.005	0.009	0.006
13	-0.008	0.009	0.012	0.017
3	-0.026	-0.000	0.026	0.039
4	-0.028	0.007	0.029	0.041
6	-0.010	0.006	0.012	0.009
7	0.001	-0.006	0.006	0.019
9	-0.007	0.018	0.020	0.023

Min Ds: 0.006 Min elevation: 0.004

Max Ds: 0.048 Max elevation: 0.041

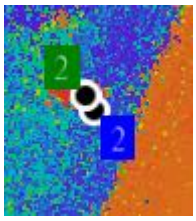
Avg Ds: 0.020 Avg elevation: 0.020

Error on plane: 0.024 Error on elevation: 0.024

3.2 Manual point selection

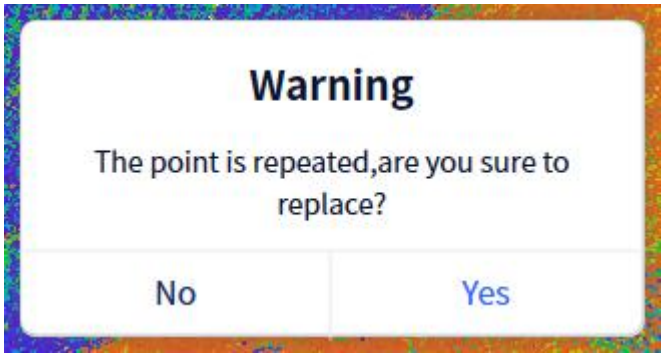
If the feature points do not have reflective targets affixed, the user can manually select points. Click on "Manual Point Selection" to begin selecting checkpoints in the point cloud data. I Click the checkpoint position in Point

Cloud with the left mouse button, and select the default green label.

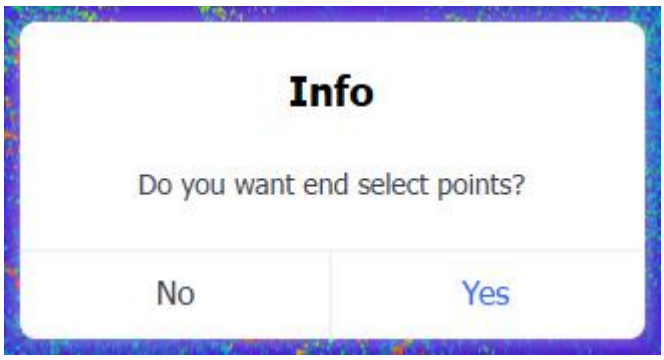


Left-click in the point cloud to select the checkpoint location, and the selected point will be labeled with a green tag by default. [Note: The software will automatically search for the true value points near the selected point and automatically display the tag for that point.]

If you need to replace a selected point, reselect a point near the existing one. A pop-up window will prompt you to confirm the replacement. Click "Yes" to update the selected point.



Sequentially perform the above point selection operations in the point cloud. After completing the point selection [supporting a minimum selection of 3 points], press the Esc key and confirm to exit the point selection mode and enter the accuracy check interface. The software will automatically record the coordinates of the points selected in the point cloud.



Clicking on "Calculate" will prompt the software to calculate the coordinate deviations between each point pair, the planar error, as well as the maximum,

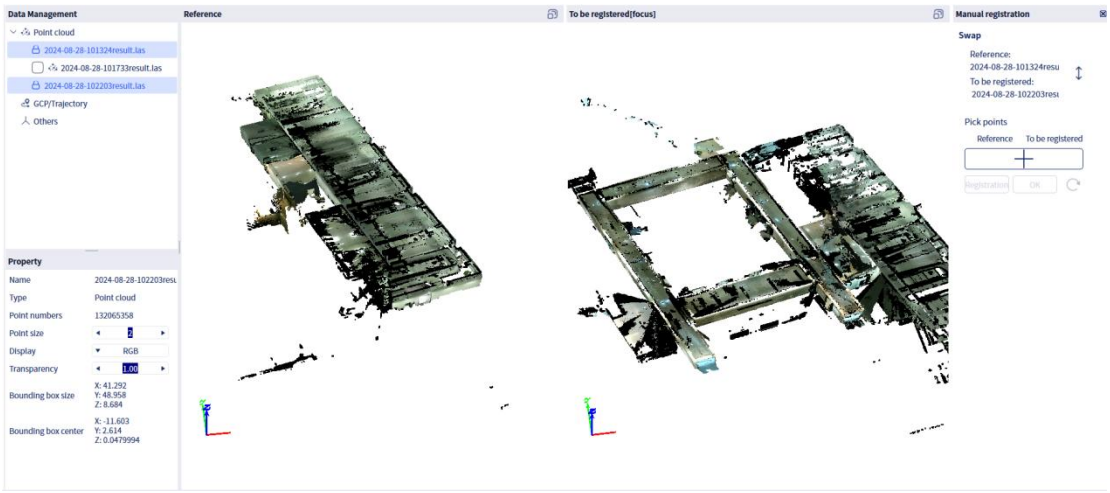
minimum, and average values of the plane error and elevation error, and the mean square error for both plane and elevation. After the calculations are completed, you can export the corresponding calculation results. Once the calculation is complete, click "Export" to export the accuracy check report. The report will be exported by default to the "Report" folder within the software project folder.

(2) Tools

1. Manual Registration

The manual registration function allows users to align different point clouds by selecting corresponding points on two point clouds. First, create two new windows and display the two point clouds to be registered in different windows. By selecting at least three pairs of corresponding points in the two windows, the algorithm aligns the point clouds based on the relationship between the coordinates of the corresponding points.

Select the two point clouds in the data list and click "Manual Registration" to perform the registration.

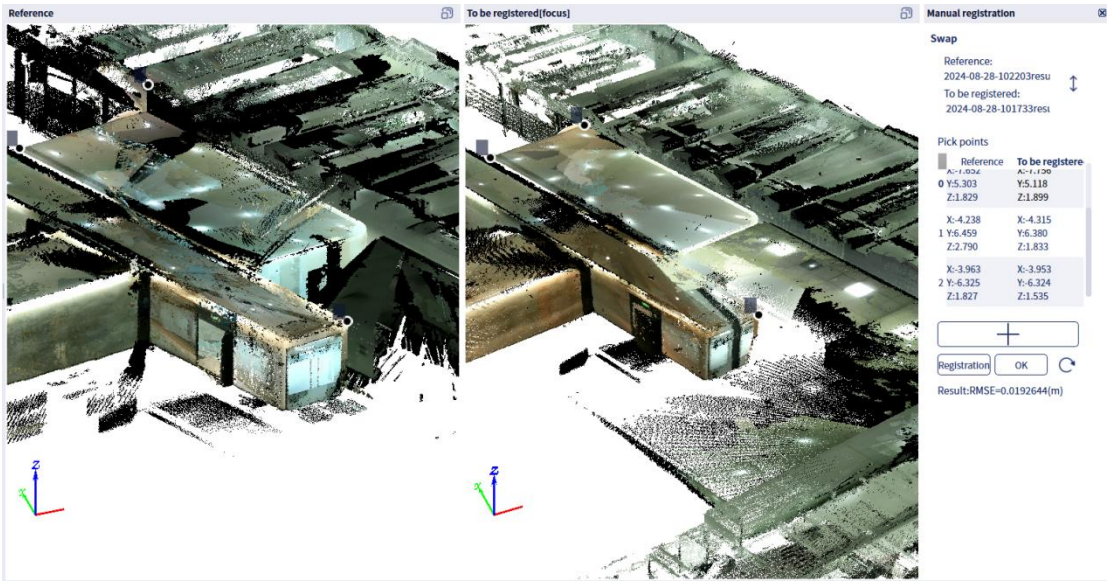


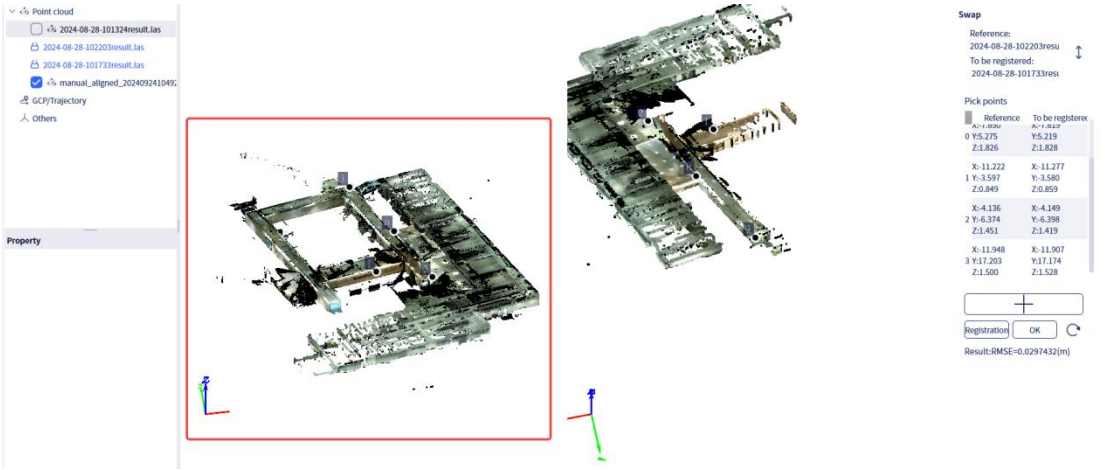
Click "Manual Registration" to open the manual registration window and select the point clouds that need to be registered. You can also click the arrows to swap the roles of the reference and the point cloud to be registered.

After selecting, click the plus sign to add corresponding points and start the point selection process. Select points in both the reference point cloud window and the point cloud to be registered window to choose corresponding points in each point cloud. Select at least 3 corresponding points.

Choose feature points from relatively regular objects for point selection. Ensure the selected points are not on the same plane or line to avoid affecting the registration results. Once selection is complete, choose "Register," and the software will automatically perform the registration. Upon completion, a pop-up window will display the root mean square error (RMSE) of the registration. If you are not satisfied with the result, you can choose to reset, re-select corresponding points, and re-register.

After confirming the result, you can click the "Confirm" button to complete the registration. The software will generate a new registered point cloud in the data list on the left and import both point clouds into a single window. After registration, the software will automatically import a point cloud with the prefix "manual_aligned," which is the registered point cloud. The registered point cloud is stored independently and will not affect other point clouds.

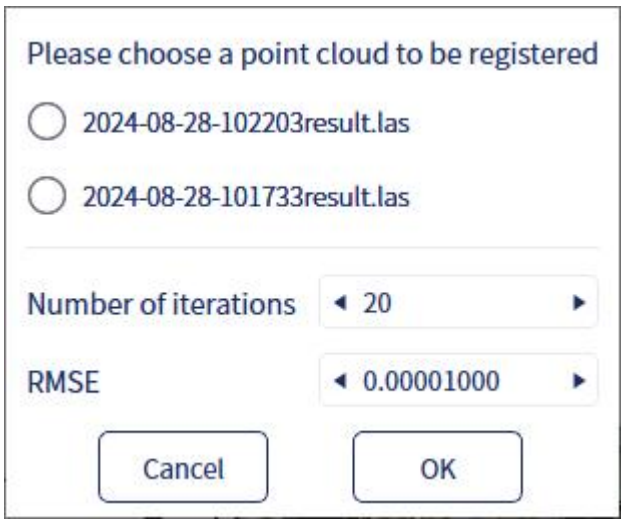




2. **ICP Registration**

ICP registration uses the ICP (Iterative Closest Point) method to further improve registration accuracy. When two point clouds have already undergone preliminary registration and are approximately aligned, you can choose ICP registration to enhance the precision of the alignment.

First, select the two point cloud datasets that need to be registered in the data list on the left. Click "ICP Registration" to open the ICP registration interface. Based on the actual project needs, determine the reference point cloud and the point cloud to be registered.

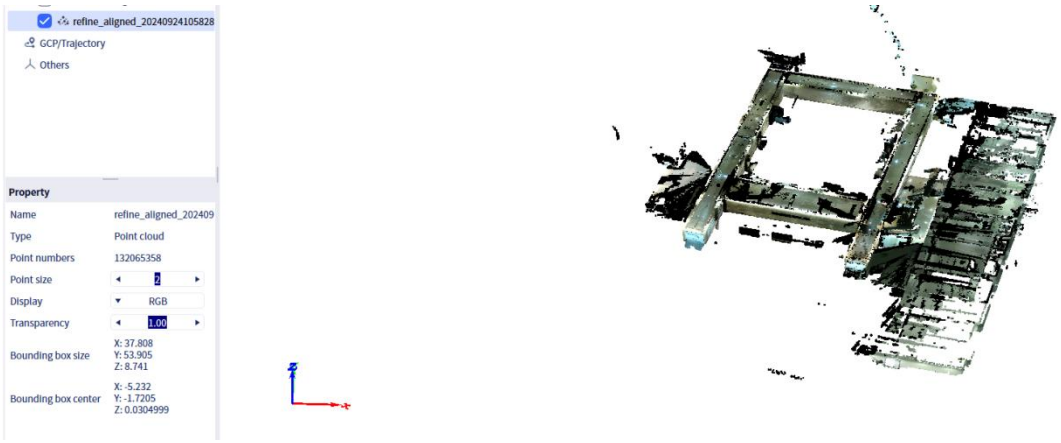


Parameter settings need to include the number of iterations, root mean square error (RMSE), and voxel radius.

- Number of Iterations: This refers to the maximum number of iterations the software will perform during the registration calculation of the two point clouds. The default is 20, with a parameter range of 1-100.

- Root Mean Square Error (RMSE): This refers to the error difference between the two point clouds after registration. The default is 1e-9, with a parameter range of 1e-4 to 1e-10.

After setting the parameters, click "Confirm" to let the software automatically perform the registration. Once the registration is complete, the software will generate a new registered point cloud in the data list on the left and import both point clouds into a single window.

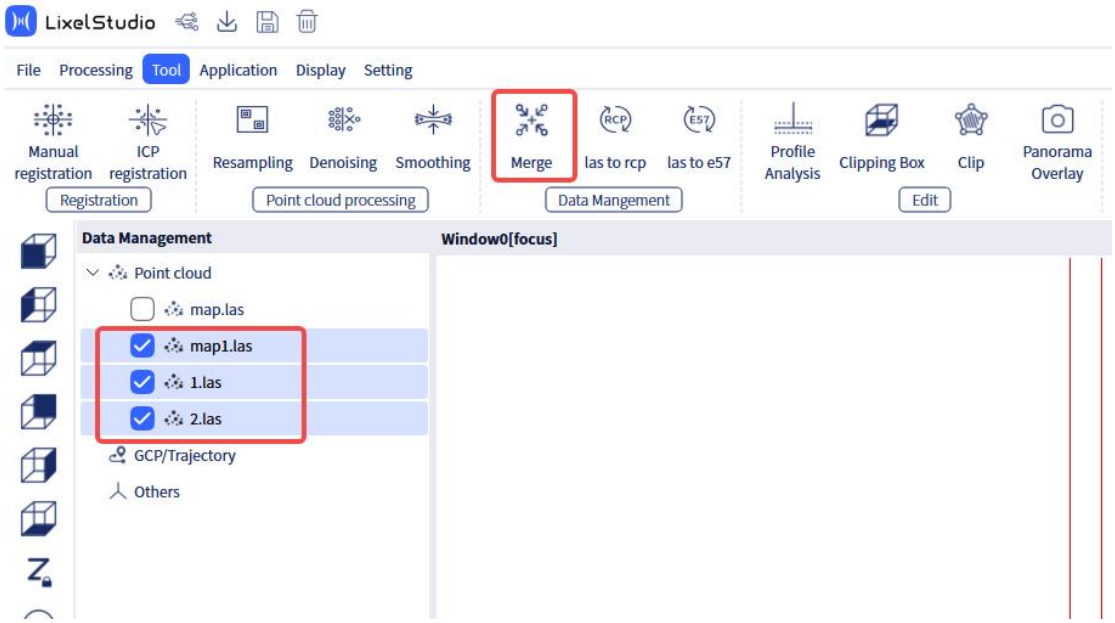


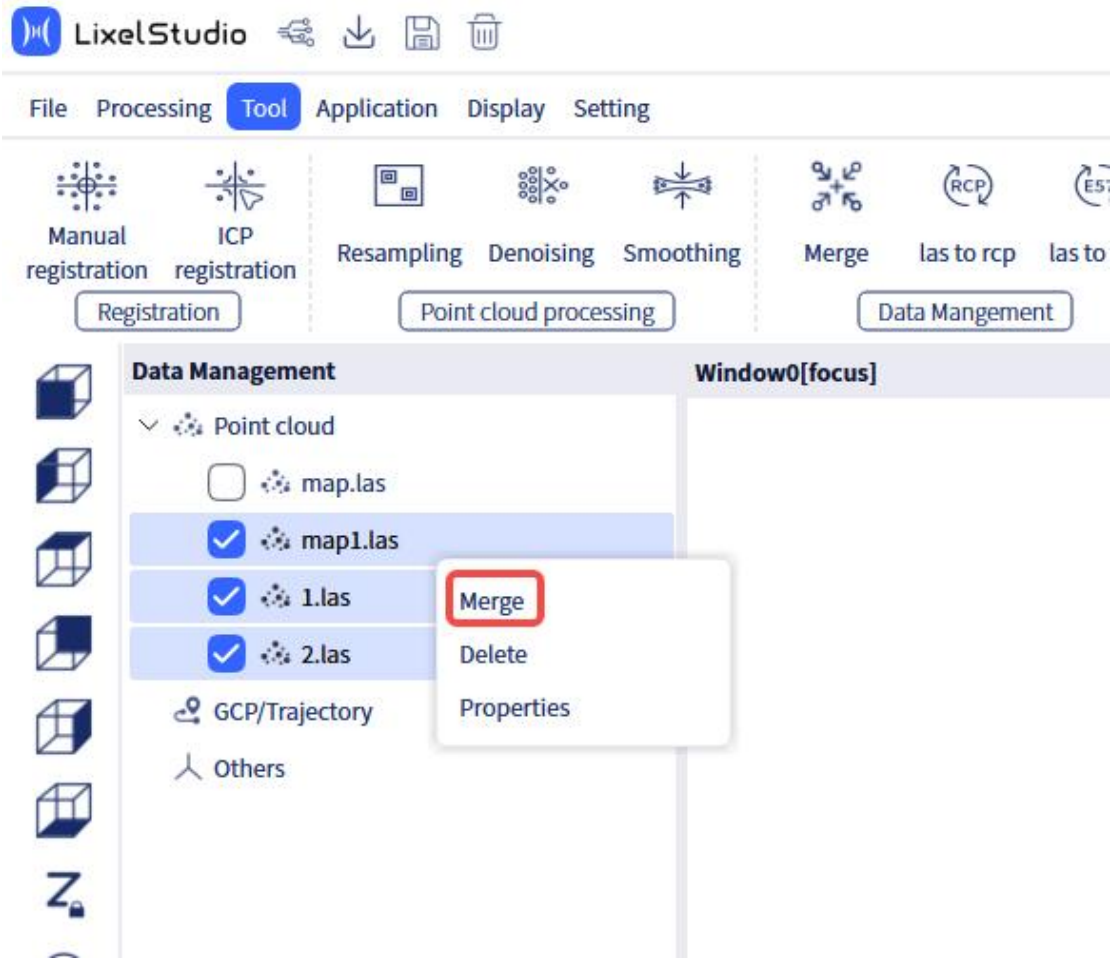
3. Data Management

3.1 Merge

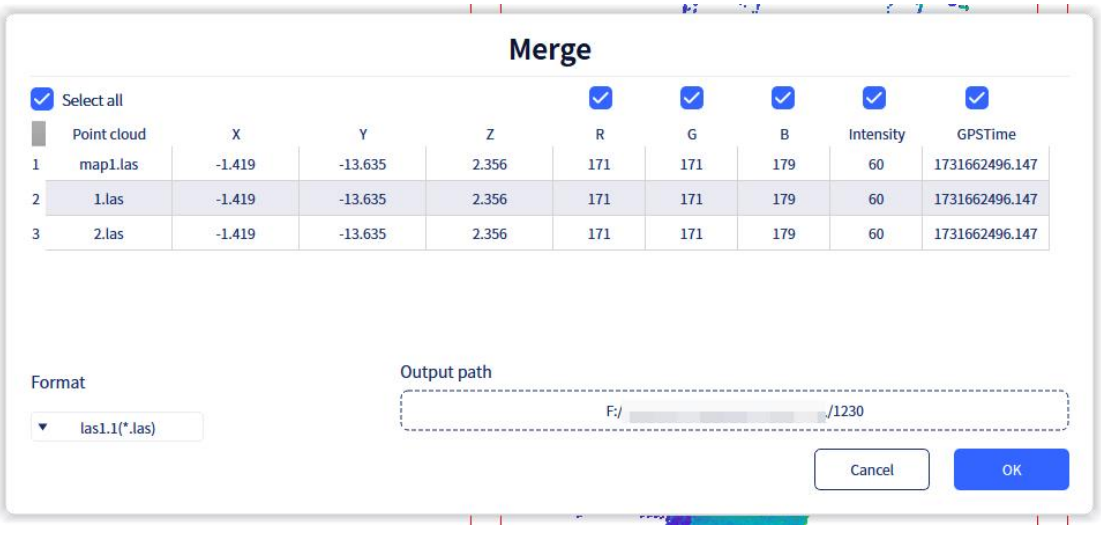
The merge function supports selecting multiple point clouds and merging them into one point cloud. Currently, only LAS data from versions 1.1 to 1.4 are supported.

When performing a merging operation, the user needs to first click on multiple point cloud data that need to be merged in the data layer on the left, and then click "Merge" in the data conversion, or right-click and select "Merge".





After selecting Merge, a pop-up window will appear to confirm the attributes to be merged. By default, all fields are merged. Users can also decide which fields to cancel according to their needs. After canceling, the merged point cloud will not have the corresponding field attributes. Currently, RGB, intensity, and GPS time fields are supported.

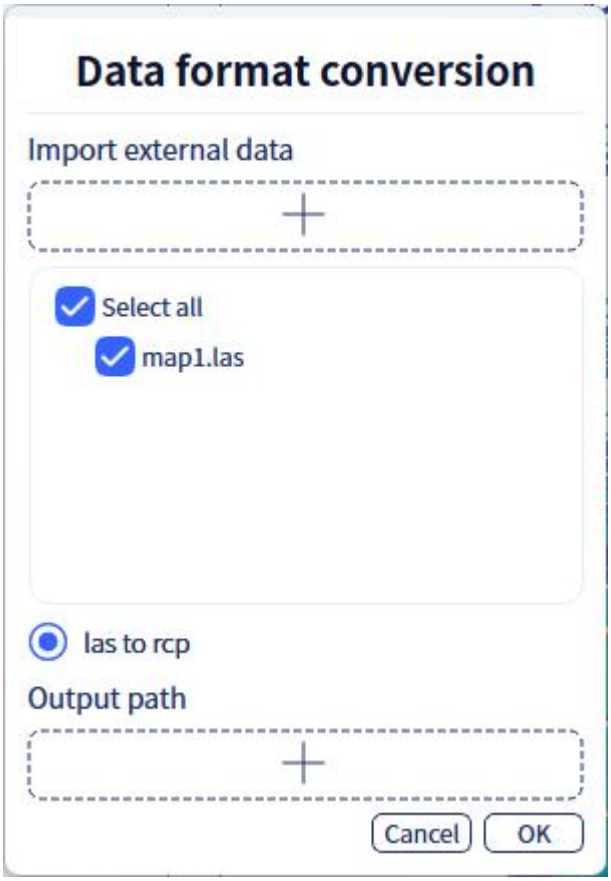


3.2 las to rcp

Select the imported point cloud data that needs to be converted and click Data Conversion. A pop-up window will be displayed to show the data format conversion window. The window will show the currently selected point cloud data. You can also click "Import External Data" to select other las data that has not been imported. The selected point cloud will be displayed in the window synchronously.

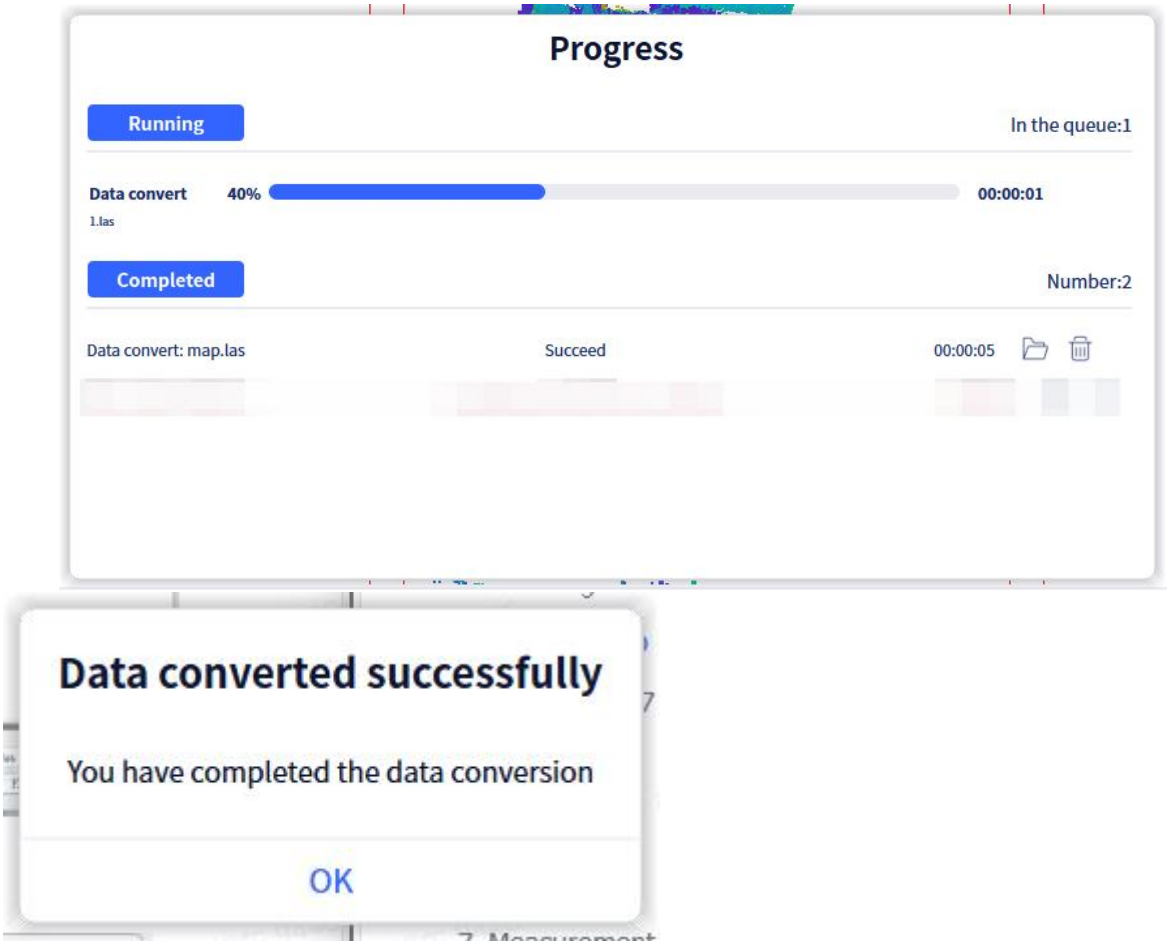
Note: Only .las format point cloud data can be converted, and a maximum of 10 point clouds can be selected for conversion at a time. After the data selection is completed, the user can still select point clouds in the check box to confirm the final data to be converted.

When converting to RCP format, please be careful not to use other functions of the software, and try to avoid using other high-performance software on your computer.



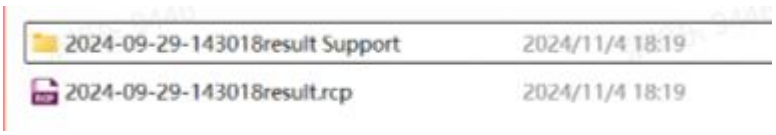
After the selection is complete, select the output path. Click OK and the software will start converting.

The software conversion progress can be viewed in the progress bar.



After the conversion is successful, a pop-up window will pop up. You can also click the folder button on the right side of the progress bar to open the converted data file path.

Note: The converted .rcp format data contains two parts, one is the .rcp data index, and the other contains the folder where the corresponding data is located. If you need to copy it to another path, you need to copy both files at the same time. The converted .rcp supports Auto CAD and Recap versions 2020 and later.

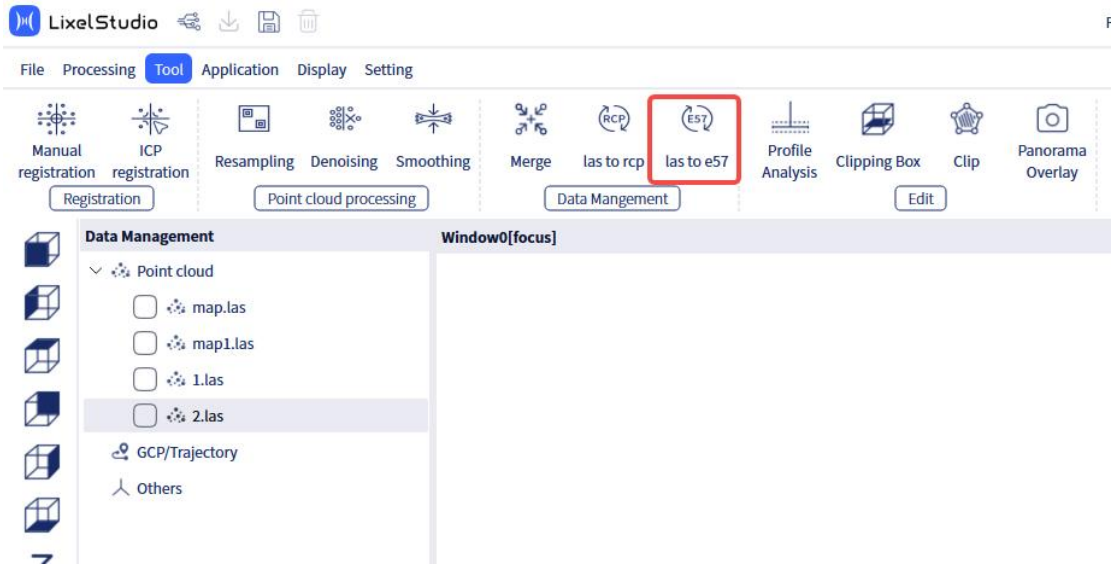


3.3 las to e57

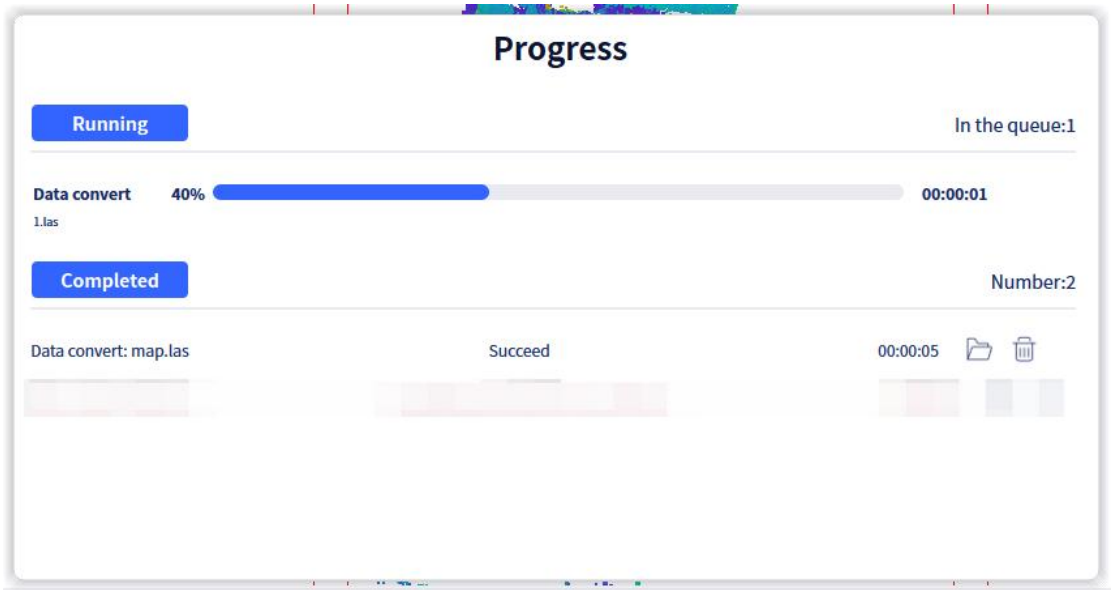
The las to e57 function supports converting las format point cloud data to structured e57. Note that before converting to structured e57, you need to

import the colored point cloud and the corresponding pose, otherwise the data conversion will not be performed normally. Currently, only one las data conversion is supported at a time.

When converting, the user needs to first click on the point cloud data in the data layer on the left, and then click on "las to e57" in the data conversion.



In the pop-up conversion window, select the pose corresponding to the colored point cloud. Click OK and wait for the data processing to complete the data conversion.

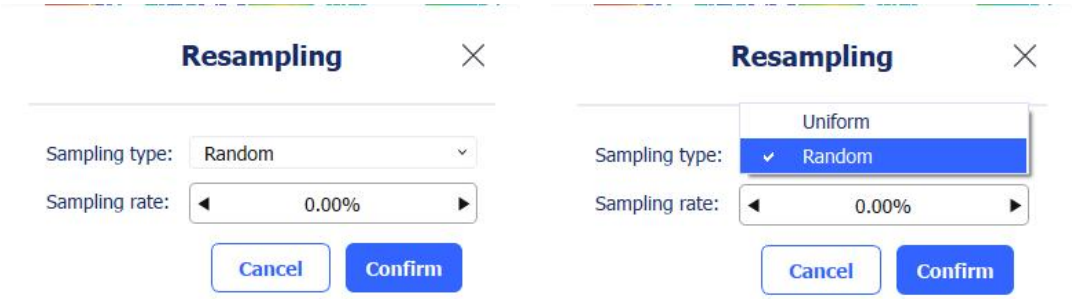


4. Resampling

Point cloud resampling function is to resample point cloud data to reduce

the number of points of the data. The software provides two algorithms for resampling. The first method is to sample randomly according to the sampling rate: you can set the percentage of points to be retained, with a value of 0-100%. The number of points after sampling = the original number of points * the sampling rate. The smaller the value set, the fewer points will be retained.

The second method is to sample according to the minimum point spacing (default): you can set the minimum point spacing between two points. After setting, the algorithm will calculate that the spatial 3D distance between any two points within a certain voxel range will not be less than this value. The larger the data set for the minimum point spacing, the fewer points will be retained.



After executing this function, the process area will display the process of executing this function. After processing, the software will automatically import the resampled point cloud data. If you need to export the data, you can right-click the data and select export, or select the file and click the menu bar "File" - "Export data".

5. Denoising

Point cloud denoising function is to filter out the noise points existing in the point cloud data. The algorithm provided by the software needs to set two parameters: the number of neighborhood point and the multiple of standard deviation. The algorithm searches for neighborhood points for each point in the point cloud according to the specified number of neighborhood points, calculates the average distance from the point to the adjacent point, and the average distance of all points, and calculates the standard deviation and median value of these average distances, and calculates the maximum

distance based on this. If the average distance from the point to the adjacent point is greater than the maximum distance, it is considered a noise point.

When scanning point cloud data is sparse, it is recommended to increase the neighborhood point value appropriately. Standard deviation multiple: The smaller the value is set, the more points will be considered as noise points.

While executing, denoising process will be shown in the progress bar. After processing, the software will automatically import the denoised point cloud data. If you need to export the data, you can right-click on the data and select export, or select the file and click on the menu bar "File" - "Export data".

6. Smoothing

The point cloud smoothing function processes the point cloud data to make the laser points on some surfaces smoother. The algorithm provided by the software requires setting the neighborhood radius. The algorithm searches for neighboring points for each point in the point cloud based on the specified number of neighborhood points.

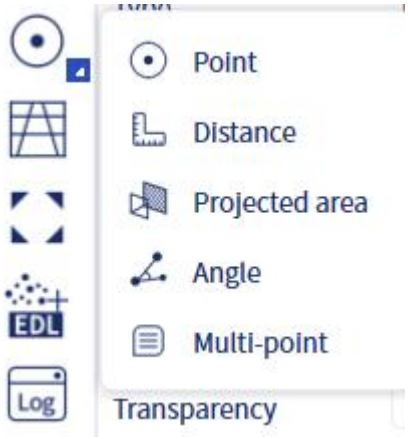
Theoretically, the larger the search radius, the smoother the resulting point cloud will be. However, for structured point cloud data, it is recommended to perform smoothing with the default parameters.

After executing this function, the process area will display the progress of this operation. Once the processing is complete, the software will automatically import the smoothed point cloud data. If you need to export

this data, you can right-click on the data and select "Export," or select the file and click "File" - "Export" from the menu bar.

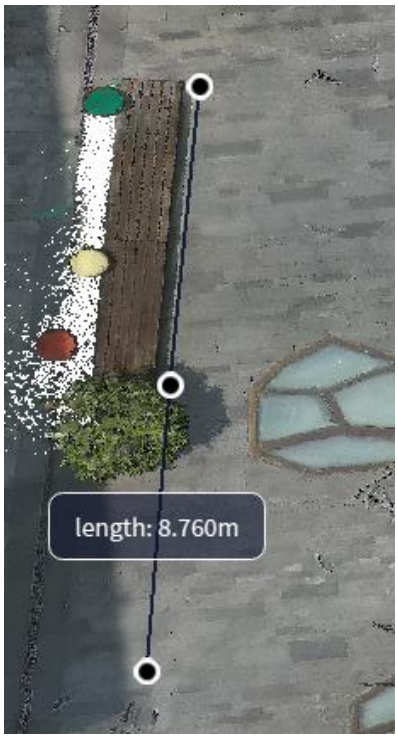
7. Measure

Measure tools include point, distance, projected area, angle, and multi-point functions. Click on the point cloud data to be measured in the data window on the left, click "Measure", and the measure toolbar will pop up, located on the right side of the software, as shown in the figure below.

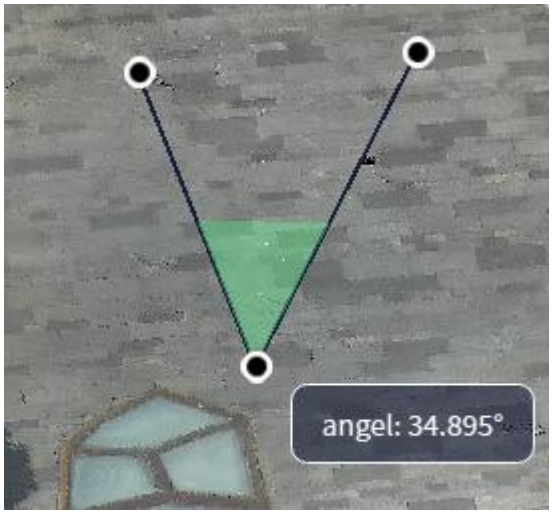


Click "Point Measure", left-click on a point in the point cloud, and the information of the selected point will be displayed, including point coordinates, point cloud color RGB information, intensity signal, etc. Note: Only when the point cloud has the above information during scanning can it be displayed.

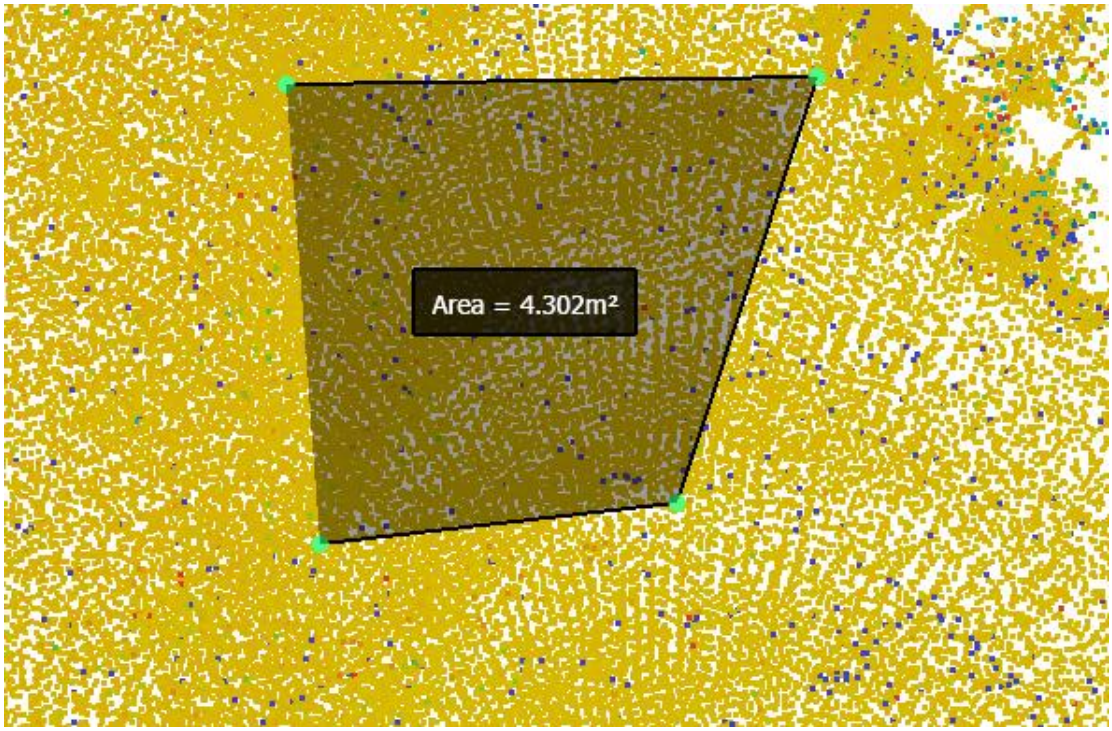
Click "Distance Measure", left-click on two points in the point cloud, and the distance between the selected points will be displayed for measurement. If multiple points are clicked continuously, the distance of continuous line segments between multiple points will be measured. To undo a selection, right-clicking the mouse will undo the previous selection.



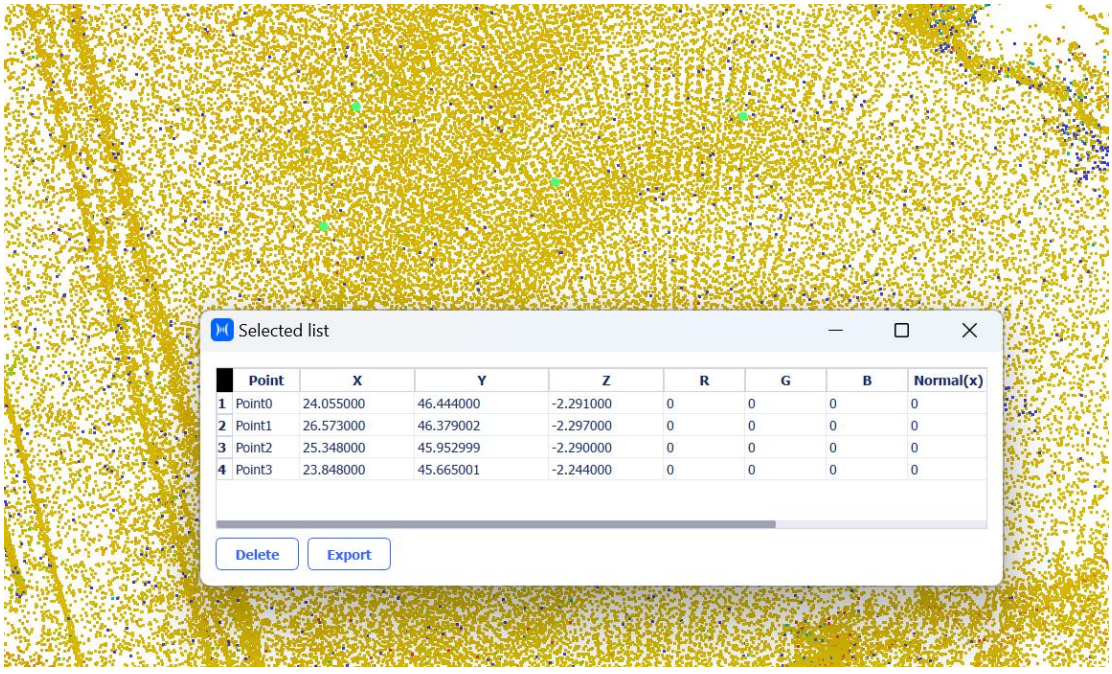
Click "Angle Measure", select three points with the left mouse button, and the degree of angle between the three points will be displayed.



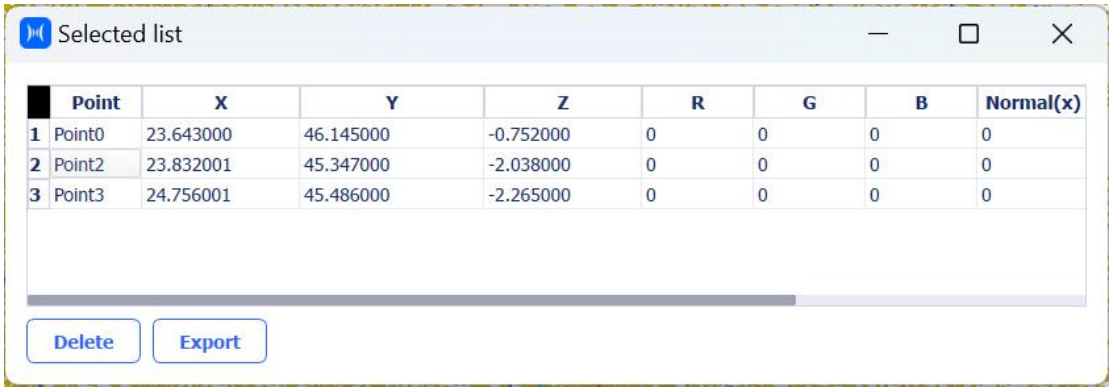
Click "Area Measure", left-click to continuously select the area to be measured, and the area of the selected polygon will be displayed.



Click "Multi-point Annotation", and continuously select multiple points to be measured on the screen with the left mouse button. The coordinates, color, and intensity information of the currently selected points can be displayed in the pop-up window.



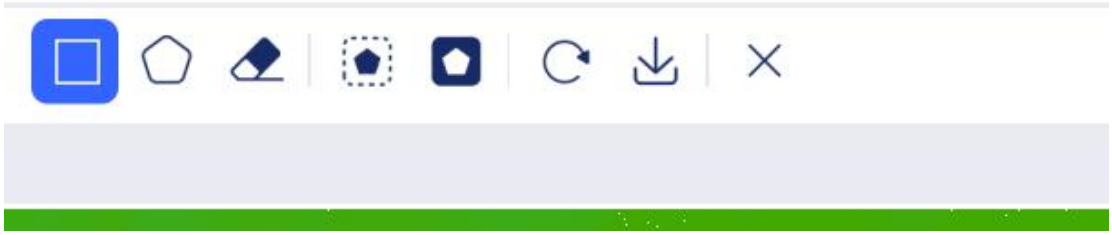
Select a row of point data and click "Delete" to delete the point.



Click "Export" to export the selected point data as a ".txt" file.

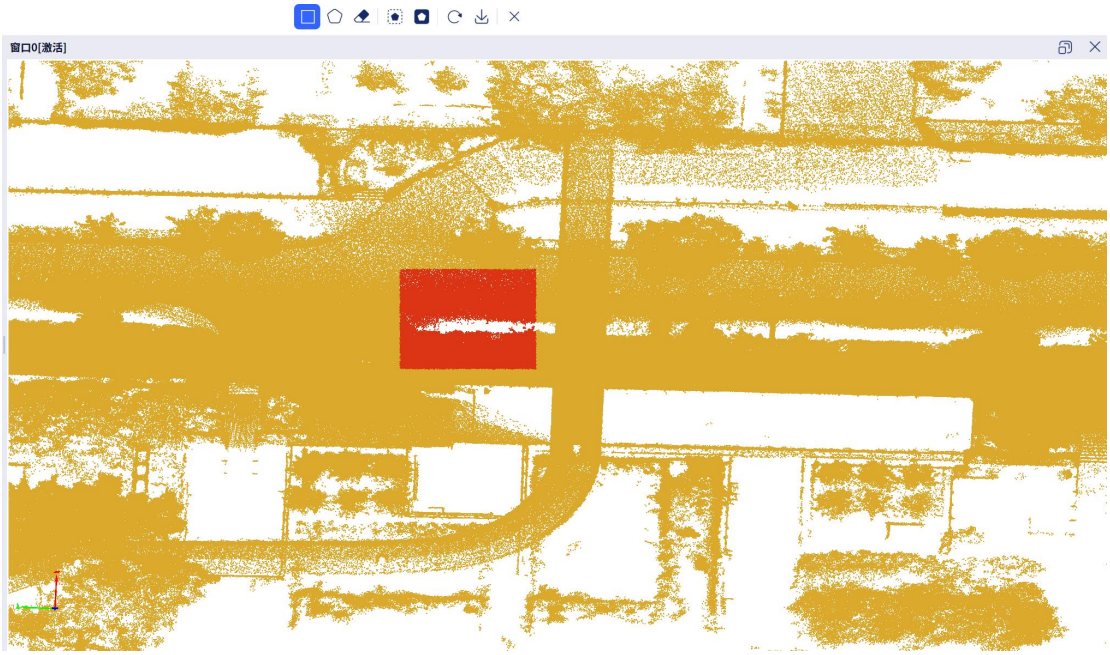
8. Clip

The clip function is mainly used to extract required data from the point cloud. Click on the data that needs to be cut, then click "Clip." The cutting function buttons will appear on the top of the window, with the following main functions from left to right: select by rectangle, select by Polygon, unselect, inner clip, outer clip, reset, save, and close.



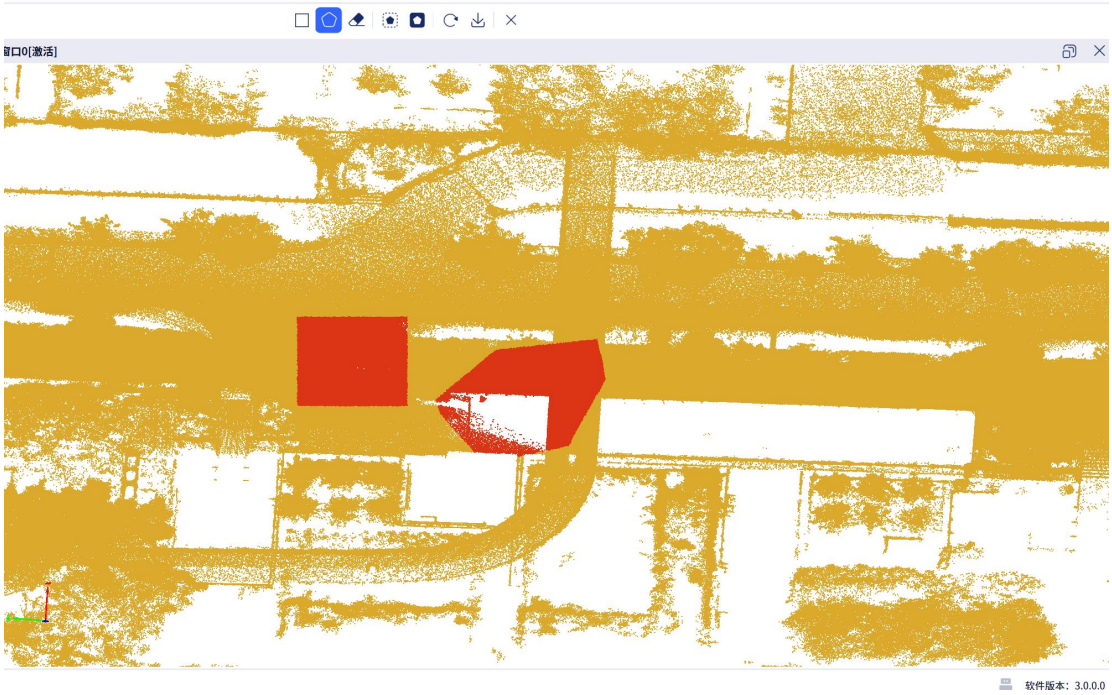
8.1 Select by Rectangle

Click "select by rectangle," then click the left mouse button to select the rectangular area of the point cloud data that needs to be cut. Release the mouse button to complete the selection. The selected point cloud will be highlighted in red.



8.2 Select by Polygon

Click "select by polygon" and then click the left mouse button sequentially to select a polygonal area on the screen. Double-click the left mouse button to complete the polygon selection. Click the right mouse button to cancel the last selected polygon vertex.

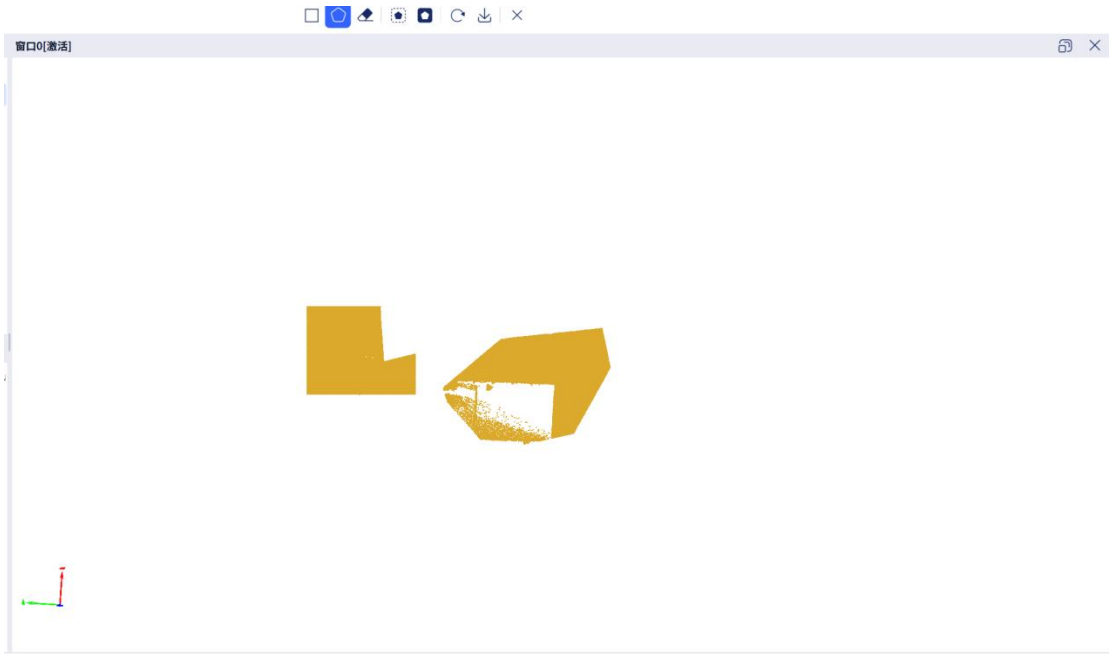


8.3 Unselect

The "unselet" function needs to be used in conjunction with "select by rectangle or select by polygon" It allows you to unselect a previously selected area.

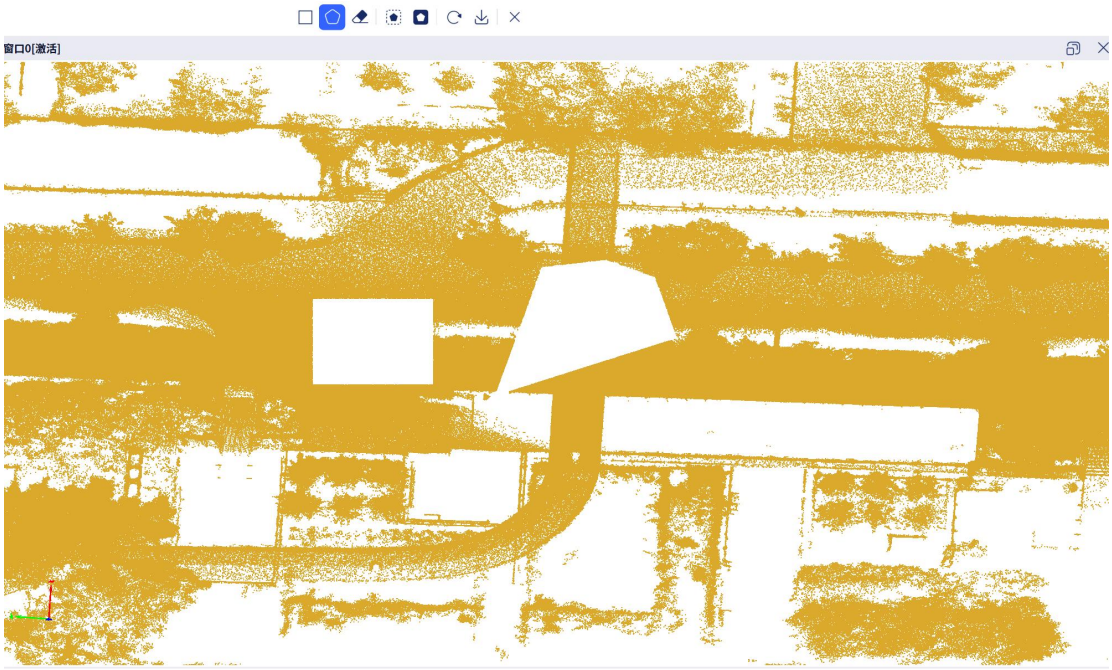
8.4 Inner Clip

Click the "Inner Clip" button to retain the selected point cloud data in the display window and delete the unselected area.



8.5 Outer Clip

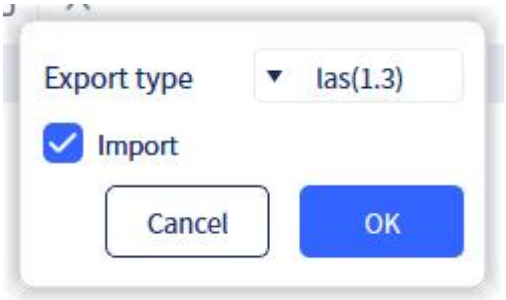
Click the "Outer Clip" button. Unlike the "Inner Clip" function, this will retain the unselected area in the display window and delete the selected point cloud data.



8.6 Save

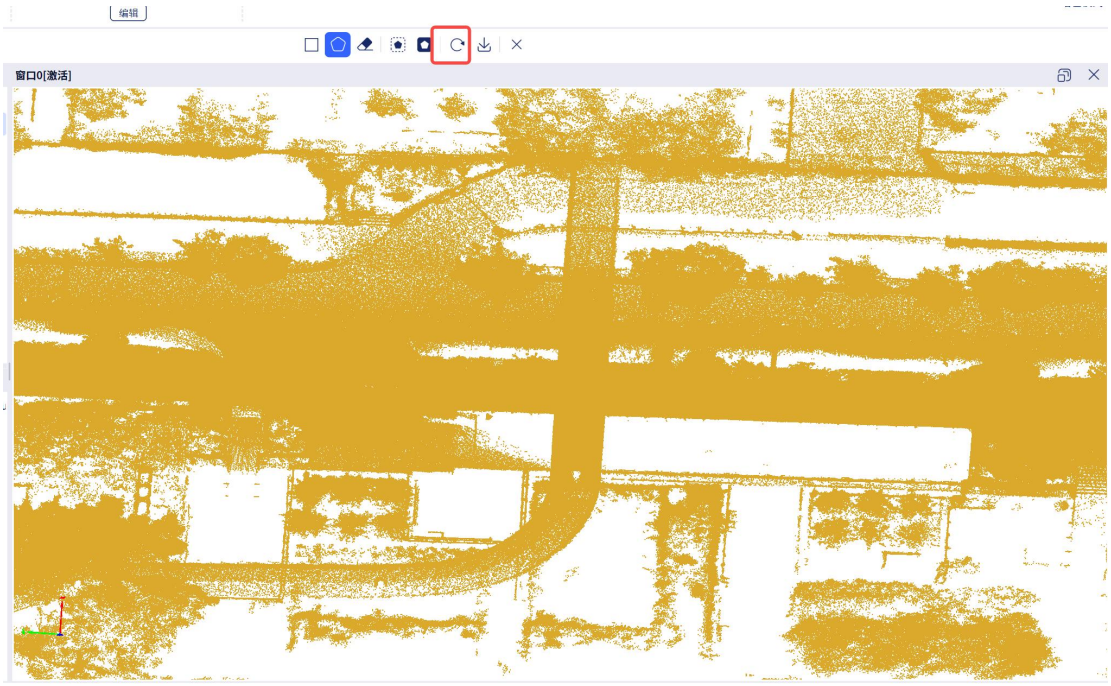
Click "save" to save the cropped results. You can choose the desired data format for saving; currently, las1.1-1.4 versions and ply are supported. You can also choose whether to import the data. If you choose to import, the cropped data will be imported into the software.

Note: Since the current window contains the cropped point cloud, the imported cropped point cloud will not automatically display in the current window. To view the point cloud, exit the cropping function and drag the point cloud into the window.



6.7 Reset and Close

Click "reset" to cancel all selections. "Close" will exit the Clip tool.

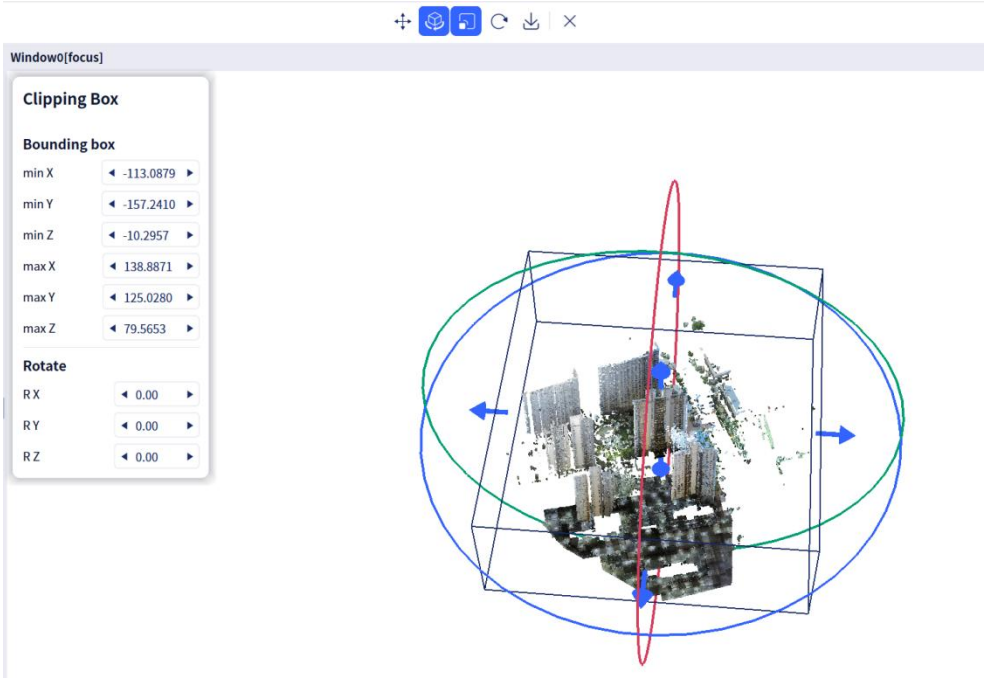


9. Clipping Box

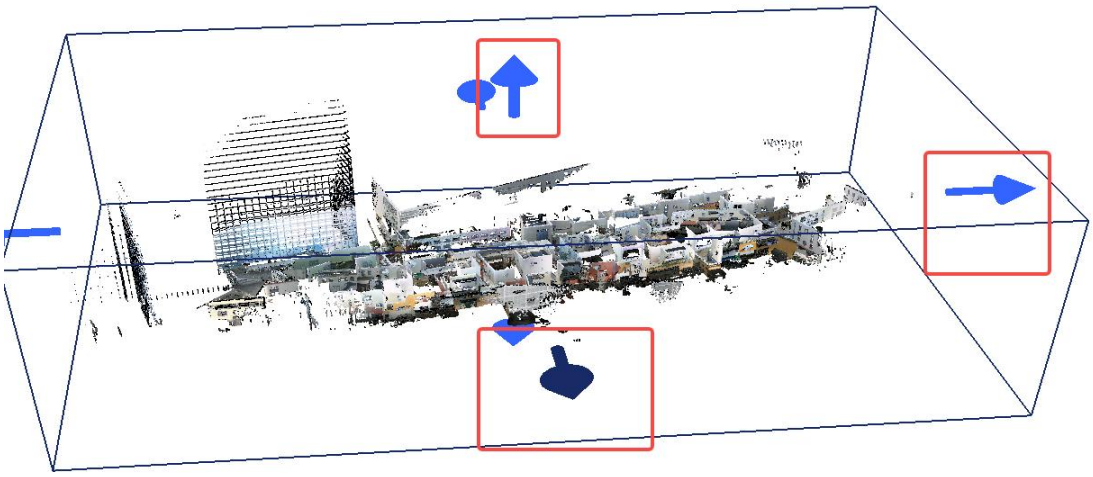
The "Clipping Box" function uses a cutting box to perform cutting

operations on the point cloud data. Click the tool and the 3D cutting function buttons will appear on the top of the window. From left to right, the buttons are: Translate, Rotate, Scale, Reset, Save, and Close.

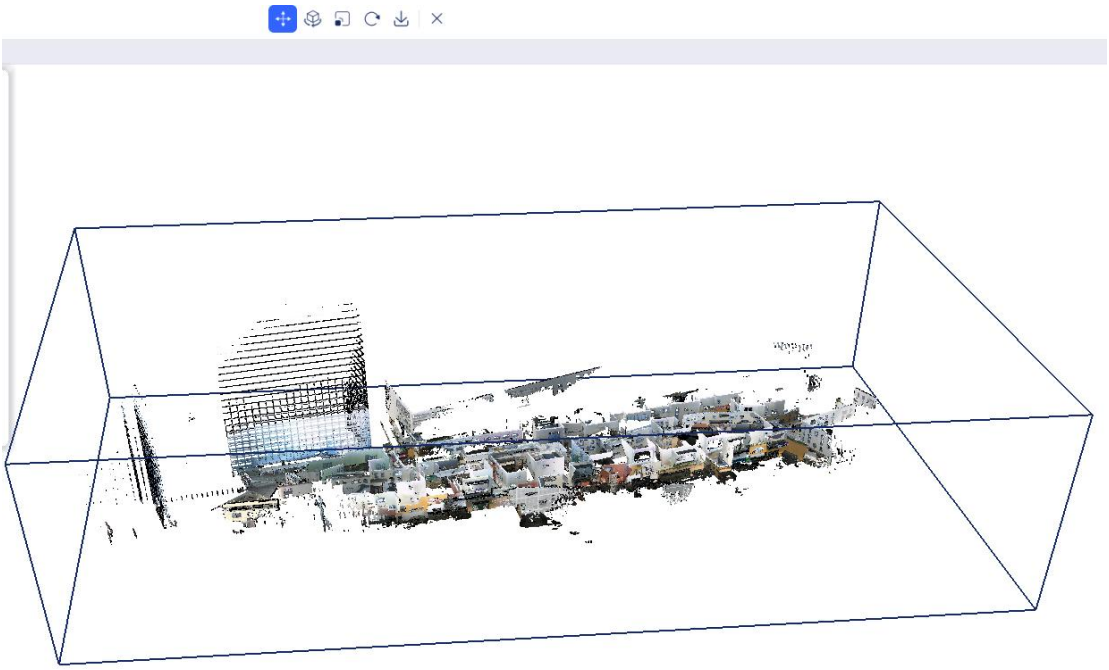
Click the tool and the software will display the bounding box of the current point cloud data, with the scaling buttons for six directions and rotation enabled by default.



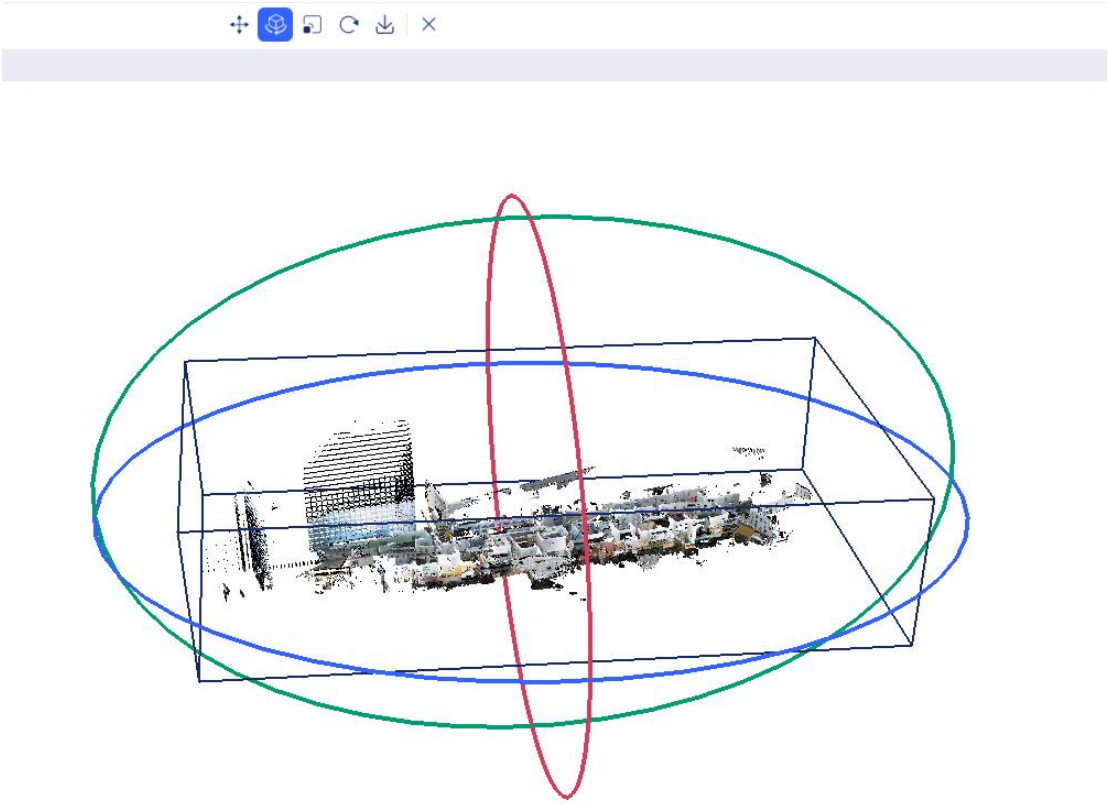
By clicking the six arrows with the left mouse button, you can change the positions of the six planes of the bounding box.



Click "Translate" to move the entire bounding box.



Click "Rotate," then click and select one of the three axes (X, Y, Z axis) and drag the red blue and green lines to rotate the entire bounding box.



Click "Reset" to restore the point cloud to its initial state.

Click "Save" to export the 3D-clipped point cloud data. You can choose the desired data format for saving; currently, las1.1-1.4 versions and ply are supported. You can also choose whether to import the data. If you choose to import, the 3D-cropped data will be imported into the software.

Note: Since the current window contains the 3D-clipped point cloud, the imported 3D-clipped point cloud will not automatically display in the current window. To view the point cloud, exit the 3D clipping function and drag the point cloud into the window.

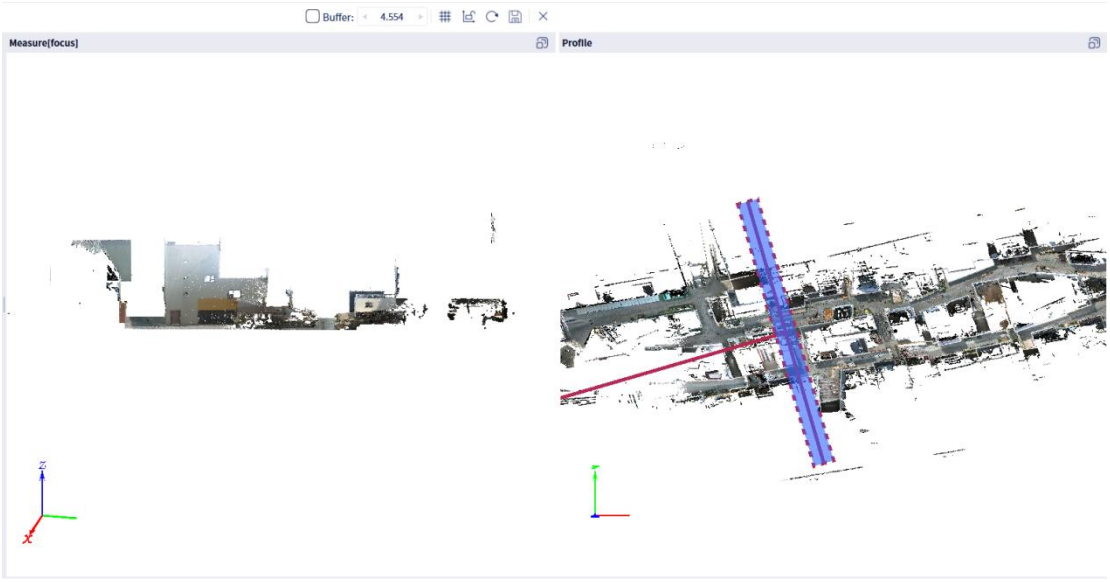
Click "Close" to exit the clipping box tool.

10. **Profile Analysis**

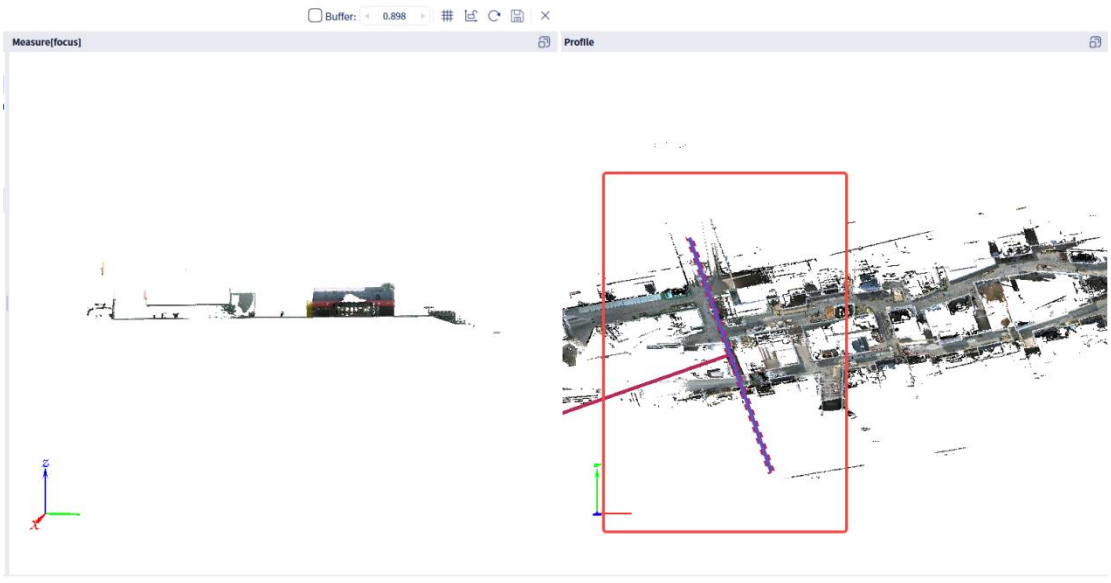
Profile analysis allows users to select any rectangular area in the point cloud data and display the data in that area in a separate window. It also supports distance measurement of the selected data.

Select the point cloud data you want to view, then click "profile analysis" The software will open a cross-section viewing buffer, add a new cross-section viewing measurement function, and open a new cross-section

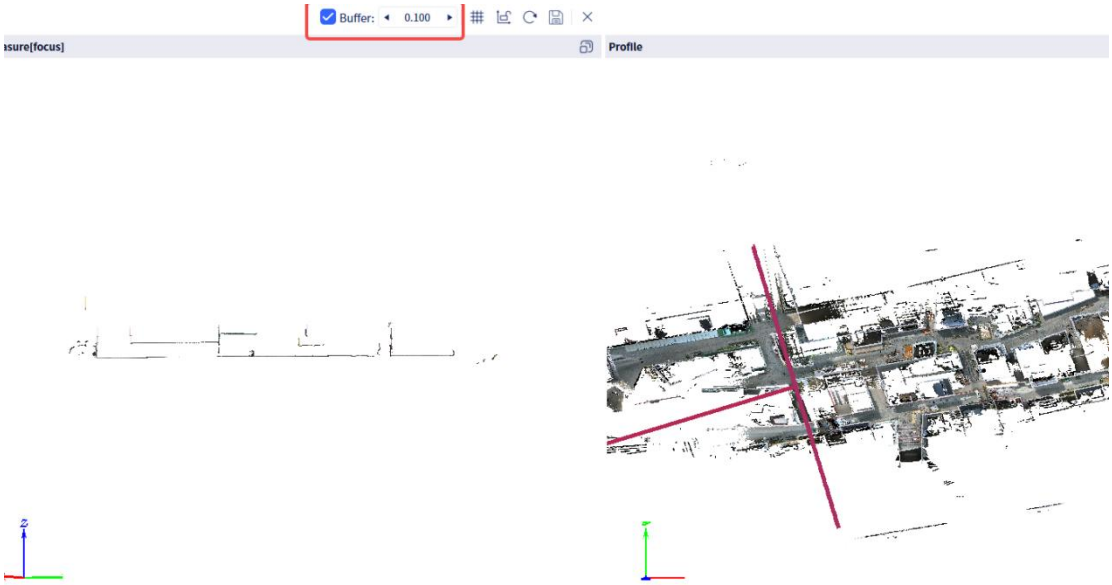
data viewing window.



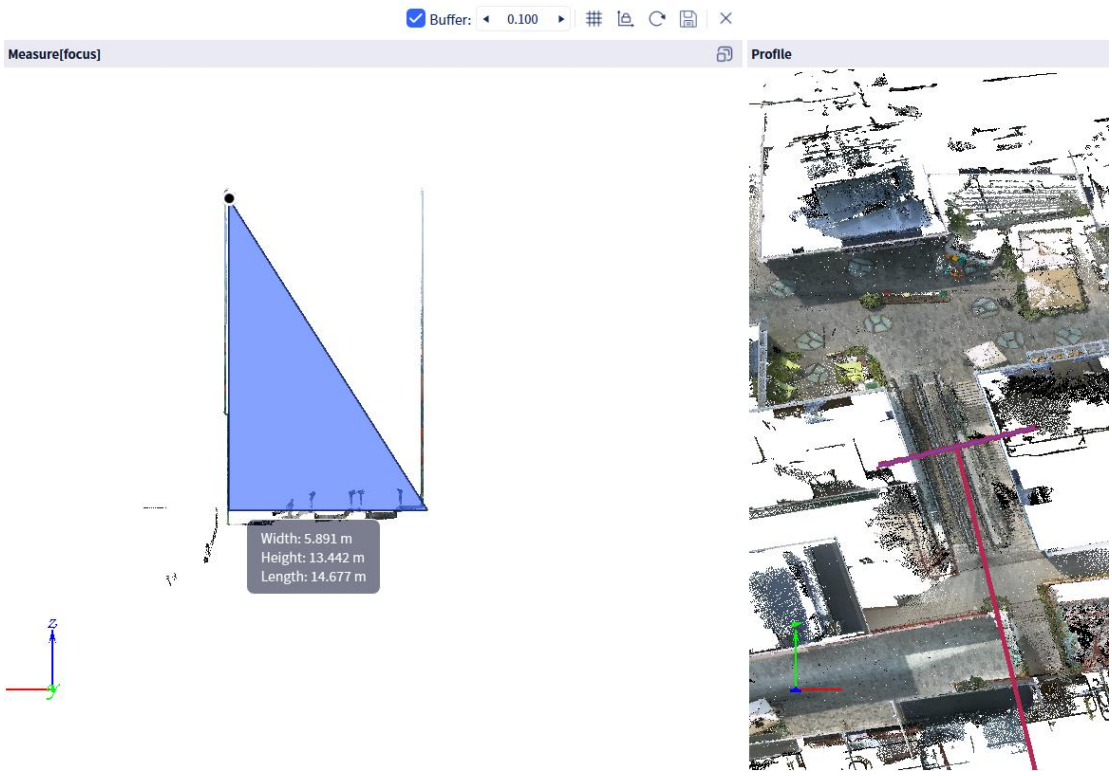
In the main point cloud display window on the right, click and move the mouse to select the point cloud data you want to view in cross-section. Once you have made your selection, double-click to display the selected point cloud data in the cross-section window on the left. While moving the mouse to select points, users can also set a fixed width in the buffer area to select the point cloud data they need to view.



When applying a 0.1 m buffer.



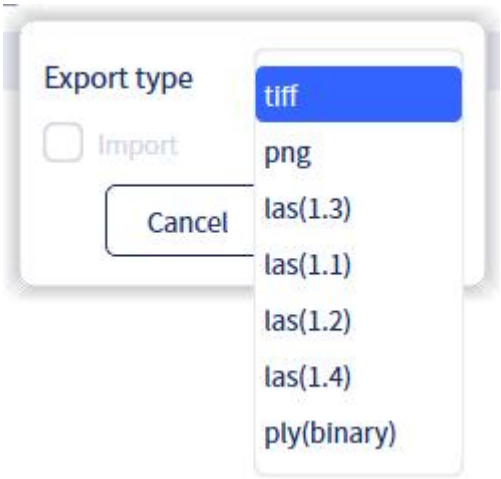
For the data obtained from the cross-section, the software provides corresponding viewing and measurement functions, including view, rotation, and measurement. Users can click the six-view buttons in the left-side quick operations to switch the perspective of the point cloud. Clicking the view button will directly switch the point cloud back to the default side view. Clicking rotate allows users to rotate the point cloud in the cross-section window. Clicking "Measure" lets users click and move the mouse to measure the corresponding distance, and double-clicking the mouse stops the measurement.



Click "Export" to export the cross-section results. You can choose the export format and path. Exporting as a ".las" or ".ply" file will save the cross-section results as point cloud data. Exporting as a ".tiff" format will save the cross-section results as a TIFF image and TFW file of the cross-section window. Exporting as a ".PNG" format will save the cross-section results as a PNG image of the cross-section window.

After selecting the LAS or PLY format, the data can be imported into the software. If you choose to import, the cross-section data will be imported into the software.

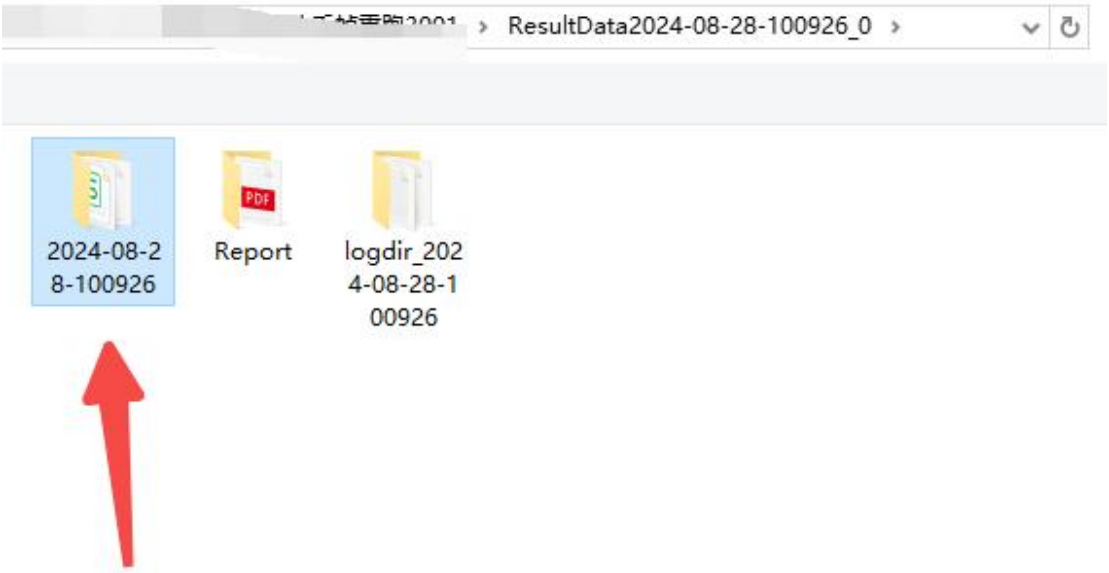
Note: Since the current window contains other point clouds, the imported cross-section point cloud will not automatically display in the current window. To view the point cloud, exit the profile analysis function and drag the point cloud into the window.



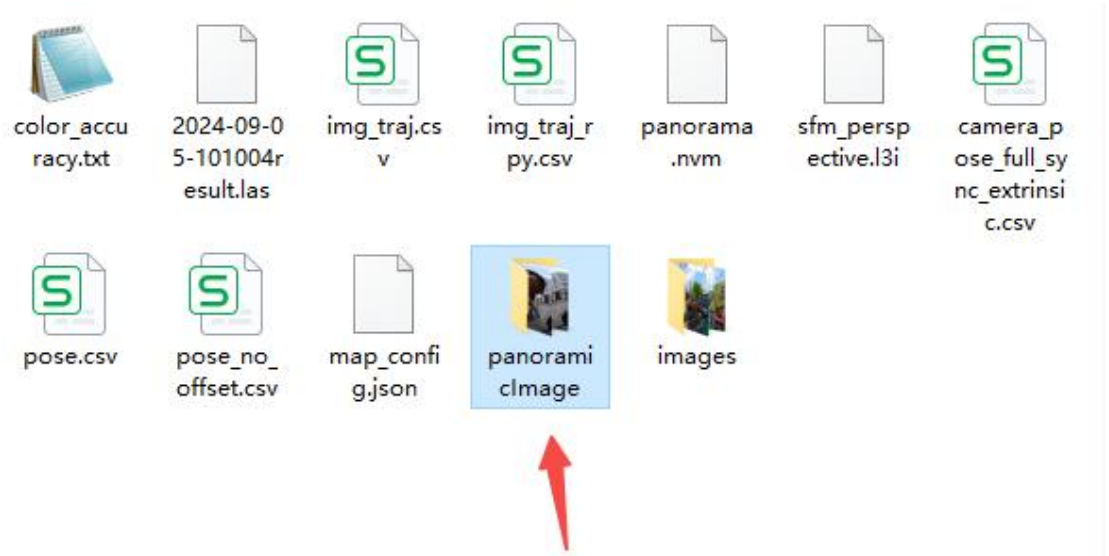
11. Panorama Overlay

The panorama overlay function allows users to measure point cloud data files. The software provides two windows: the left window displays the view overlaying the point cloud with the panoramic image, where you can rotate, zoom, and measure. The right window displays an overall top-down view of the point cloud and the point cloud's trajectory.

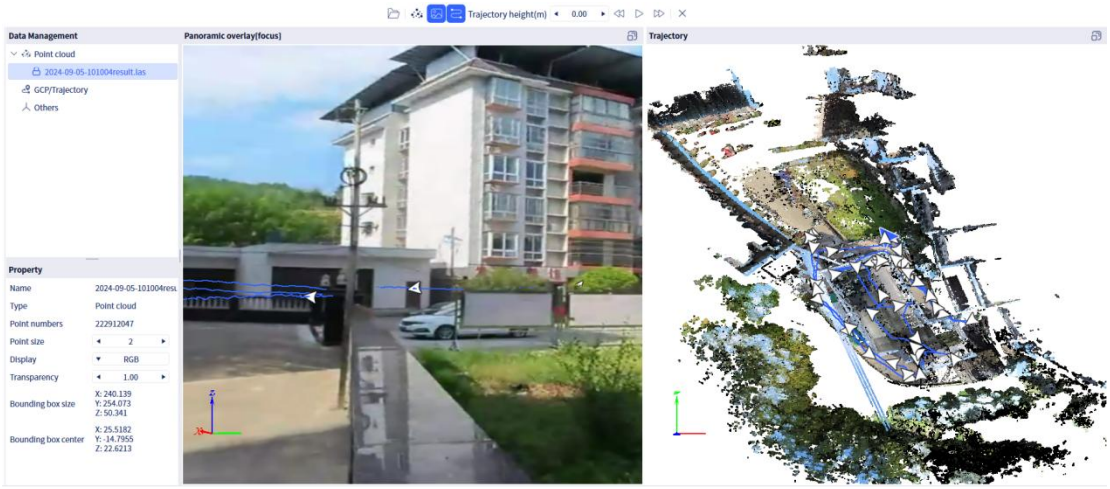
Click on the data from the data list on the left and select the point cloud data for which you need to perform panoramic measurement. Click "Tools" - "Panorama Overlay," and select the data folder (with the same name as the raw data), located in the processed ResultData folder.



Note, in this folder there must be a PanoramicImage folder. Otherwise this function cannot be used.



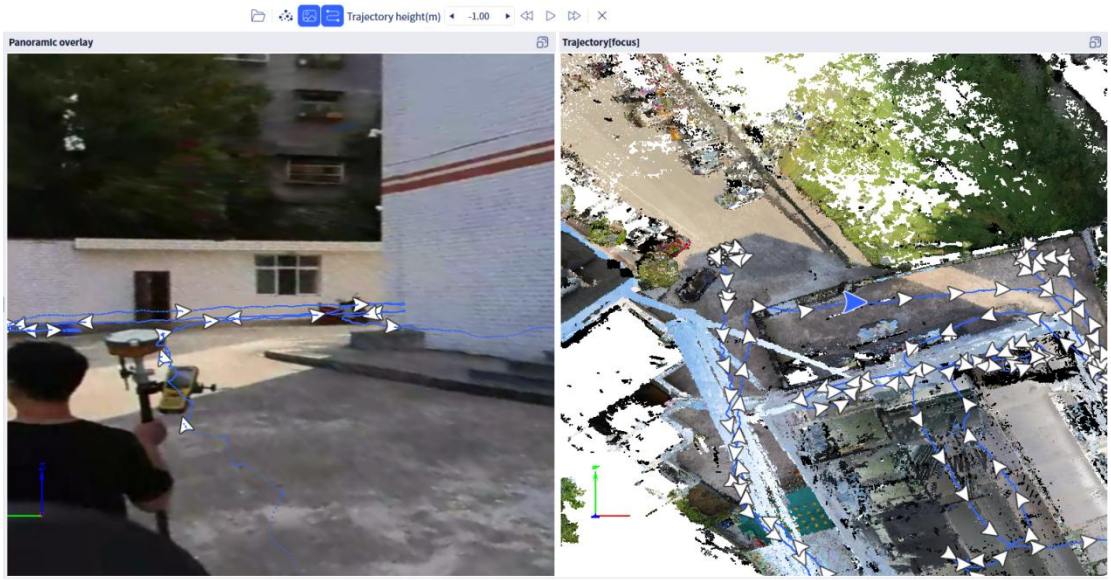
After making your selection, you can proceed to panoramic measurement."



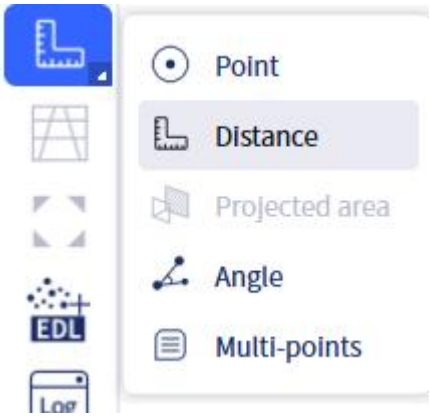
The panorama overlay function bar includes: point cloud, panoramic photo, trajectory, trajectory height, previous frame, play, next frame.

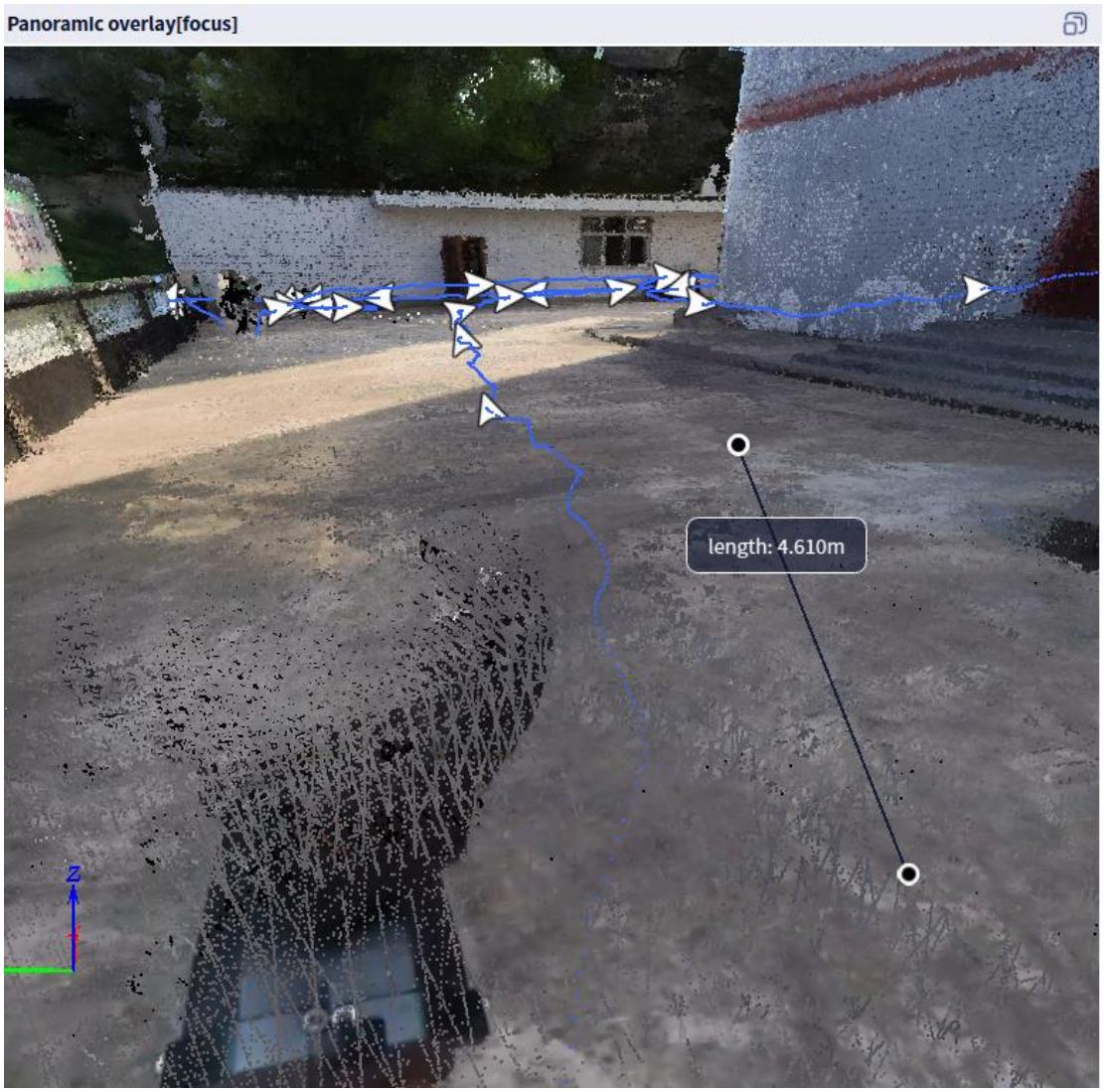
- Point Cloud: Selected by default. If you click to deselect it, only the panoramic photo will be displayed in the left window.
- Panoramic Window: Selected by default. If you click to deselect it, the display of the panoramic photo in the left window will be turned off.
- Trajectory: Selected by default. If you click to deselect it, the global trajectory overlay display window of the point cloud on the right will be turned off.
- Trajectory Height: The default is 0 meters. If you manually adjust the trajectory height, it will be raised or lowered in the display window on the left.
- Previous Frame, Play, Next Frame: Used to play point cloud and photo data frame by frame according to the trajectory. The play button will automatically play frame by frame according to the trajectory.

In addition to using the panoramic overlay function bar for data viewing, you can also directly operate within the window. You can use the mouse to pan, zoom, and rotate the data. The main part of the left window has arrows for each frame. Clicking on the previous arrow will display the data for that frame. The arrow for the selected frame in the left window is displayed in blue. Clicking on the arrows in the right window will directly jump to the arrow position to view the corresponding point cloud and panoramic photo data.



Click on the "Measurement" tool on the left side to perform corresponding measurements on the data, including point, distance, angle, area, and multi-point measurements.





(3) Application

1. Volume

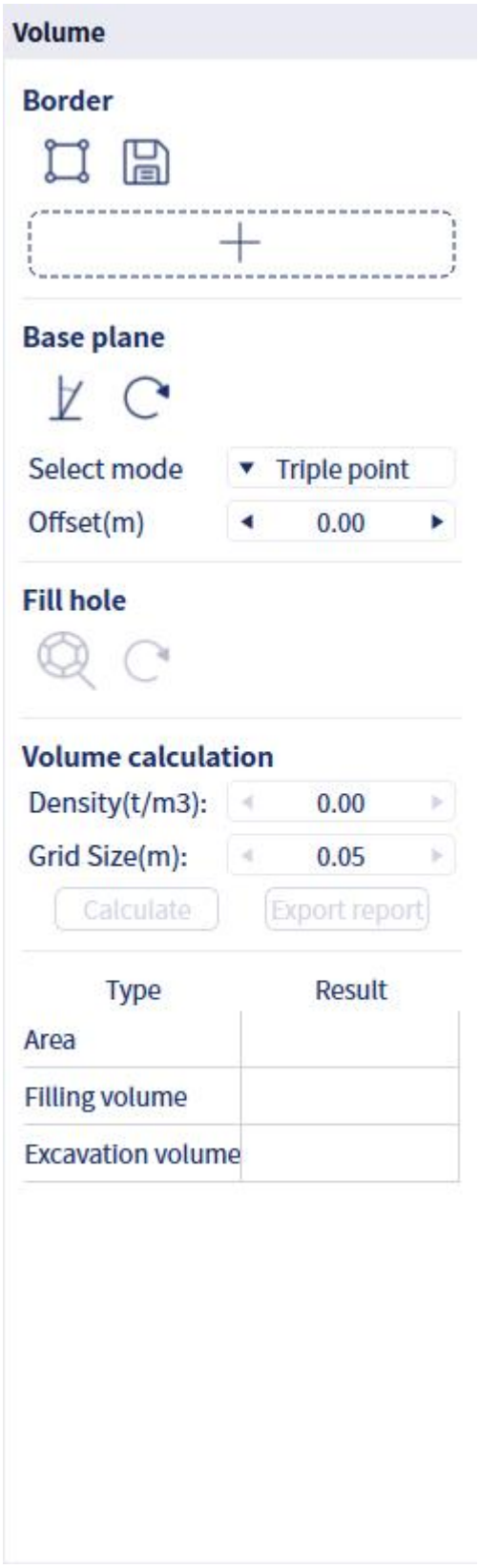
The volume function is mainly used for measuring comparing pile volume from point cloud data. It currently supports the calculation of ordinary piles such as sand piles and coal piles.

Click on "applications" and select a data from the data list. Selecting one point cloud data will default to the calculation of a single period of point cloud data. Selecting two point cloud data will compare the point cloud data from the two periods.

1.1 Volume Calculation

The volume measurement function is mainly used to calculate the point cloud data of the first phase of the heap, stockpile and compare the data of the two phases. Currently, it mainly supports the calculation of data of ordinary heaps, such as sand piles and coal stockpiles.

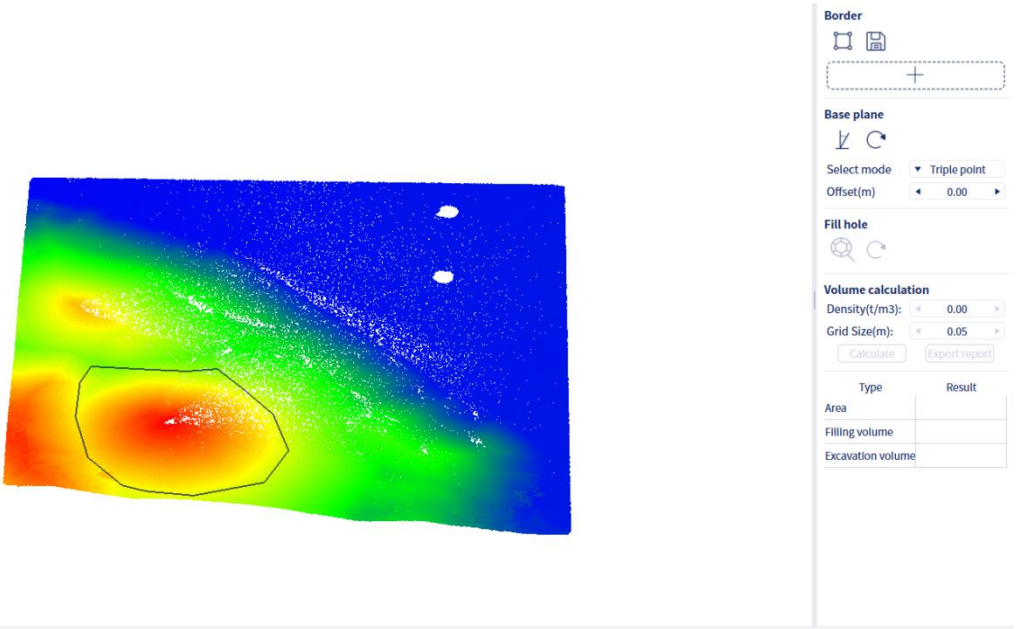
The window for volume calculation pops up on the right side of the interface, including border, base plane, fill hole, volume calculation, and report export.



1.1.1 **Border selection**

Click "border", left-click to select the boundary range of the heap in the

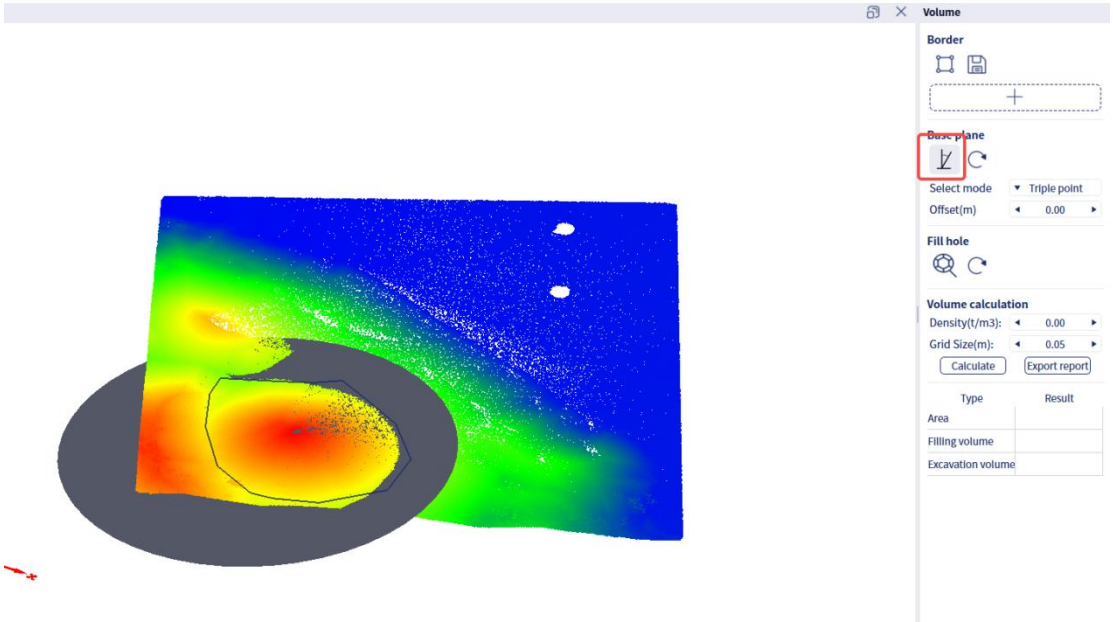
point cloud, and double-click to automatically cut out the heap range. Click the reset button to re-select the boundary.



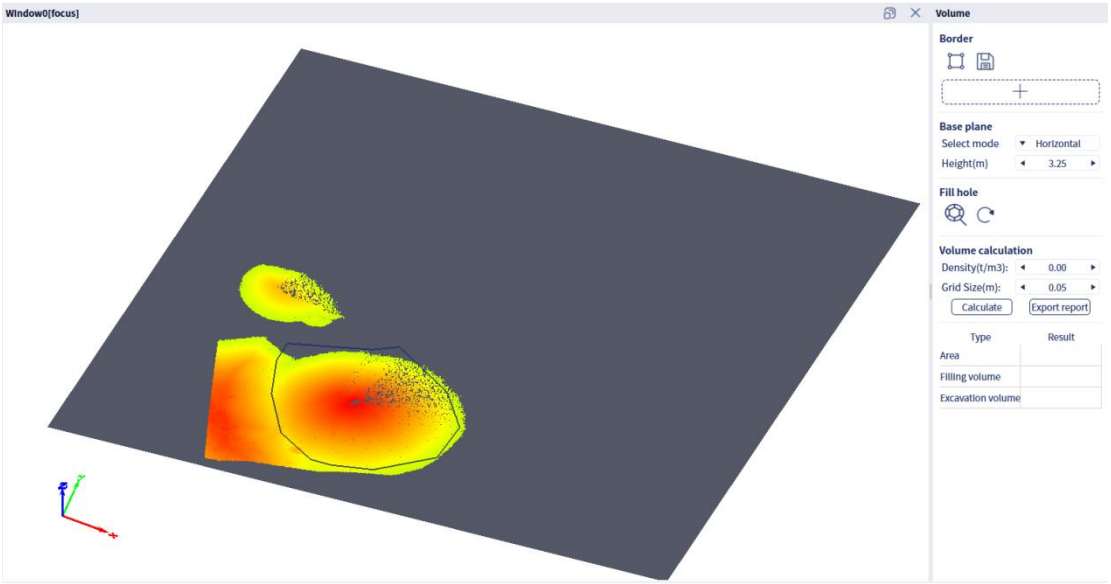
1.1.2 **Base plane selection**

Base plane selection, the software provides three selection modes: three-point selection and horizontal plane.

Select "Three-point selection", click on three points around the heap, and draw the reference surface.



Select "Horizontal Plane". After entering the height of the reference plane in the pop-up window, the reference plane can be automatically generated in the model.



1.1.3 **Fill Hole**

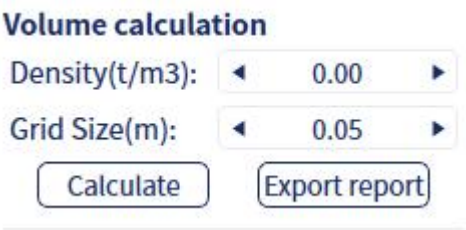
Click the "Fill Holes" button to fill in the point cloud holes in the pile. Left-click to select points, right-click to delete the last point. Double-click to end point selection. If you need to reset, click the reset button to the right of "Fill Holes" to reset the filling results.

Click "Calculate", and the pile volume calculation window on the right will indicate the filling volume and excavation volume of the heap.

Click Export Report to export the calculation results. The report is in the "Report" folder of the project folder.

1.1.4 **Calculate**

Set the mesh construction-related parameters in the right window. Mesh density represents the size of the mesh grid for the point cloud. It is generally recommended to use the default parameters for mesh construction.



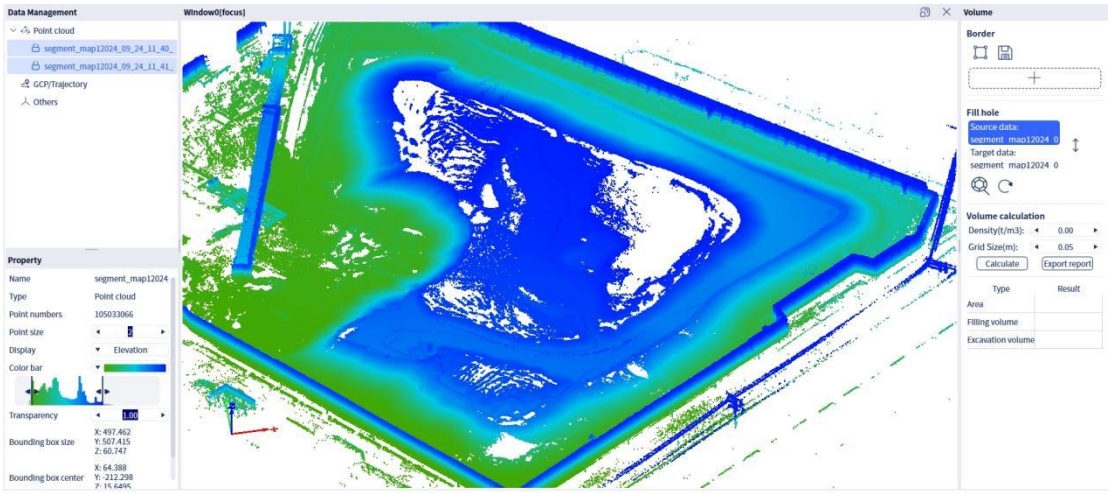
Click the "Calculate" button to start the pile volume calculation. Once the calculation is complete, the corresponding results will be displayed below.

Click "Export Report" to export the results report. You can choose the desired save path and file name.

1.2 Volume Comparison

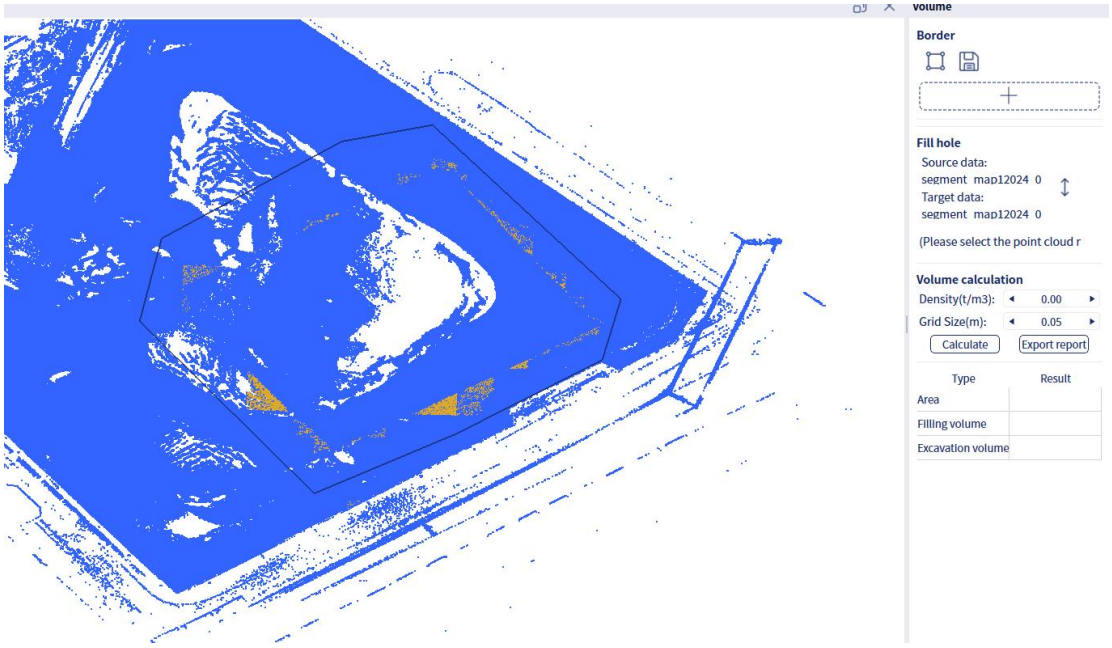
The volume comparison function is similar to the pile calculation function and provides the volume change between two sets of data over different periods. (The two point cloud datasets need to maintain a consistent reference surface, so it is recommended to register the two datasets first.)

Select the two point clouds and click "Volume Comparison" to enter the pile comparison mode. If you need to exit the pile function, click "Volume Calculation" again to exit.



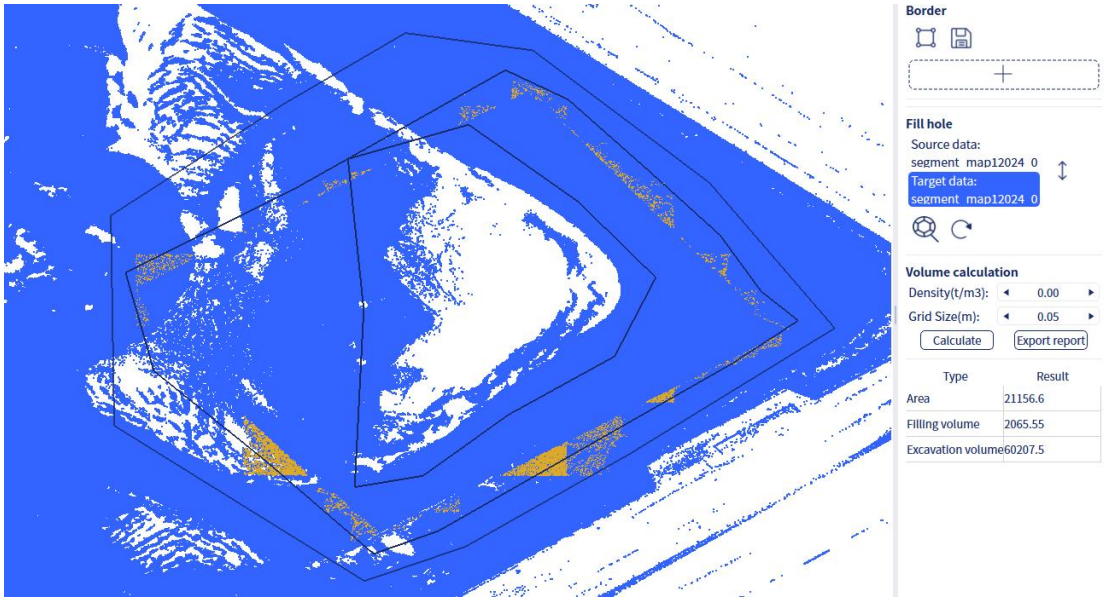
After importing the data, the interface on the left will display the pile calculation window. Similar to the pile calculation function, the pile comparison requires users to perform boundary selection, reference surface setting, meshing, hole filling, and other operations separately for the two sets of point cloud data.

i. Boundary Selection Click "Border" and use the left mouse button to select the boundary range of the pile in the point cloud. Left-click to select, right-click to delete. Double-click to finish, and the pile range will be automatically outlined. Click the save button to save the boundary.



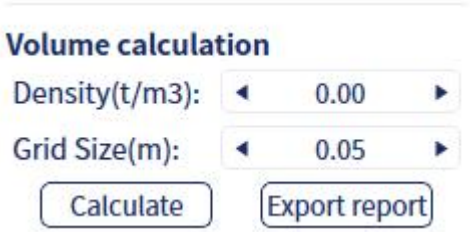
ii. Fill Hole:

You could perform fill hole to any of the two las files if needed. You can click the swap button on the left to confirm.



iii. Volume Calculation:

Set the mesh construction-related parameters in the right window. Mesh density represents the size of the mesh grid for the point cloud. It is generally recommended to use the default parameters for mesh construction.



Click the "Calculate" button to start the volume comparison calculation for the two periods. Once the calculation is complete, the corresponding results will be displayed below.

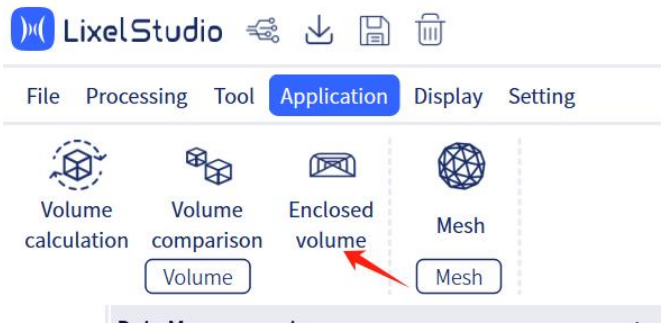
Type	Result
Area	21156.6
Filling volume	2065.55
Excavation volume	60207.5

Click "Export Report" to export the results report. You can choose the desired save path and file name.

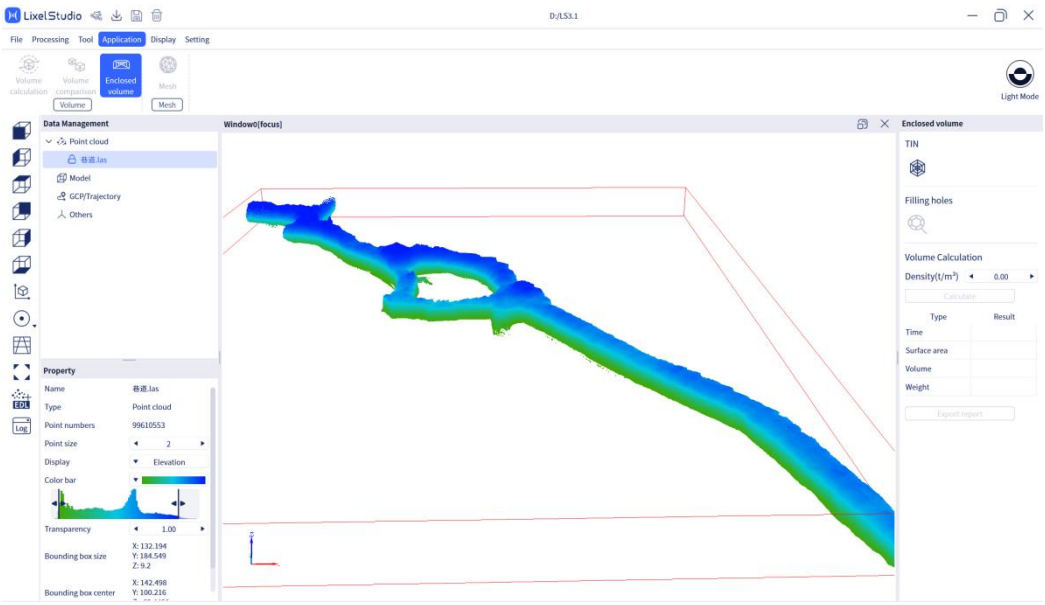
2. Enclosed Area Volume Calculation

The enclosed area volume calculation function is mainly used to calculate the volume of enclosed areas such as mining tunnels and cabins. The volume of the entire area is obtained by calculating the mesh of the point cloud.

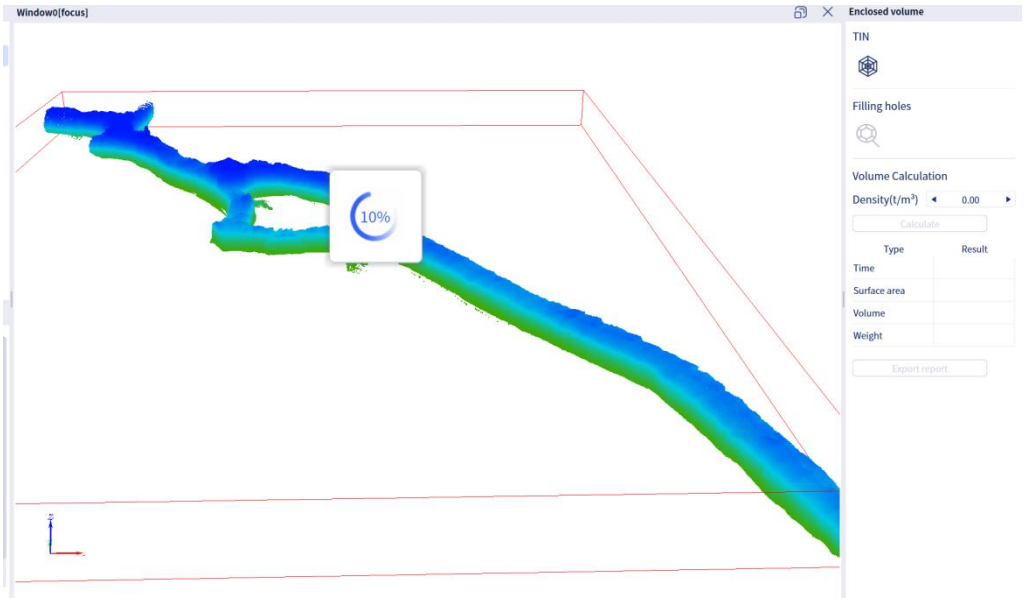
For the calculation of the enclosed area volume, in order to ensure the accuracy of the calculation, it is recommended to first perform denoising and down-sampling operations on the point cloud data to be calculated to ensure that the overall point cloud is clean and only contains the area where the volume needs to be calculated. After selecting the processed point cloud, click "Application" → "Enclosed volume" in the menu bar. Note that only one point cloud can be selected.

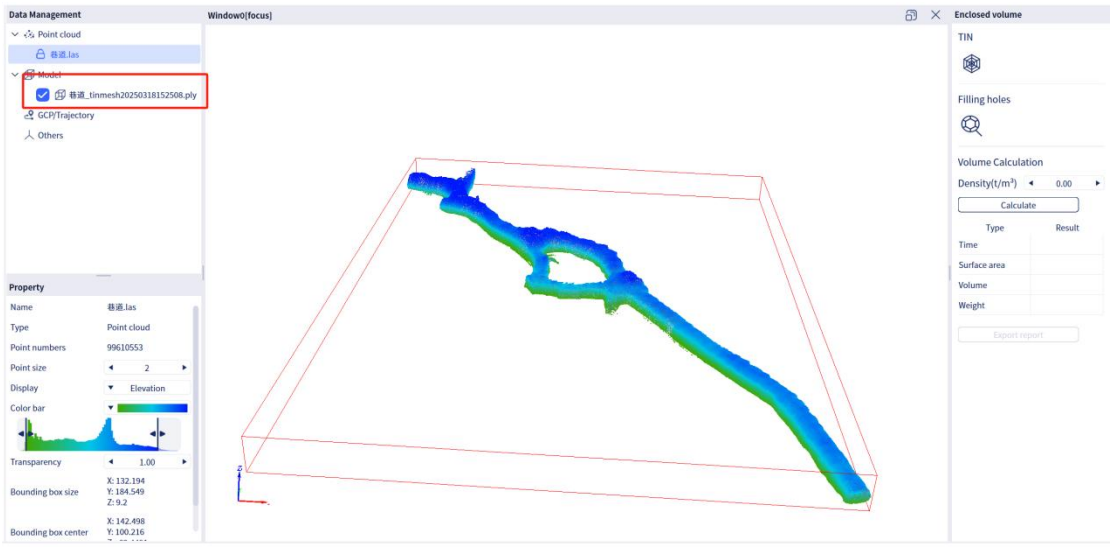


Enter the enclosed area volume calculation interface, and adjust parameters such as TIN construction on the right side of the interface.

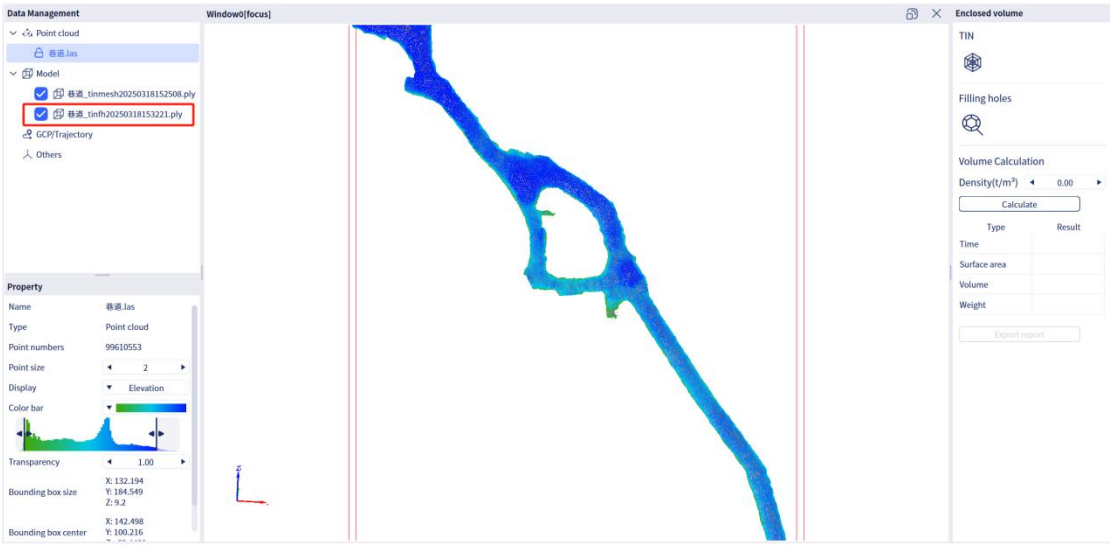


Click on TIN to construct TIN of the selected point cloud. It takes some time to complete, especially for point cloud data with large data size. Please wait patiently until the TIN is completed. After the TIN is constructed, it will be synchronously imported into the software.

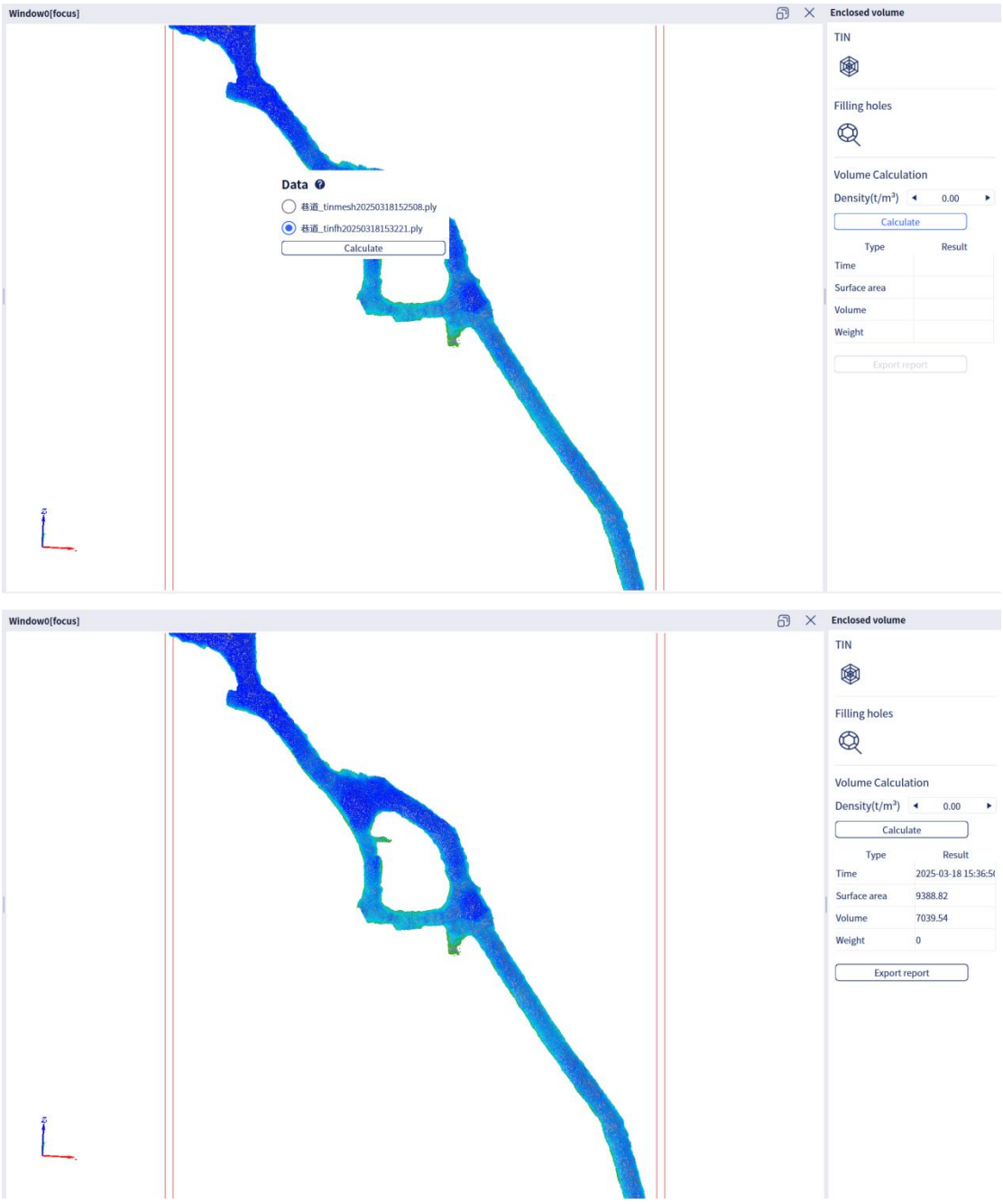




After the TIN is constructed, click Filling holes, and the software will automatically fill holes in the model to obtain a complete and enclosed model. After the holes are filled，the model will also be automatically imported into the software. Note: In order to ensure the accuracy of the calculation results, fill holes as much as possible after the TIN is constructed.



After the TIN construction and hole filling are completed, you can modify the density. If you do not need to calculate the weight, you can leave it unchanged. Click Calculate. Select the XXX_tinflXXXX.ply file (TIN construction plus hole filling results), and click Calculate to get the volume and surface area data of the point cloud data.



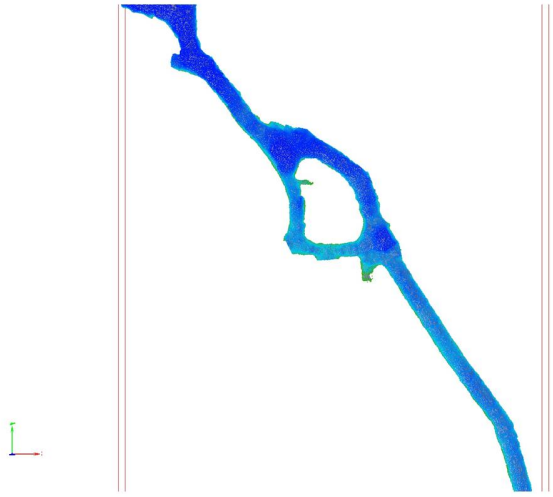
Click Export report to export the result report. You can choose the corresponding save path and file name.

XGRIDS

Enclosed Area Volume Calculation Report

Software version:3.2.0.0

Name	巷道	Time	2025-03-18 15:38:04
Surface area	9388.822m²	Volume	7039.536m³
Weight	0.000t		



XGRIDS

Enclosed Area Volume Calculation Report

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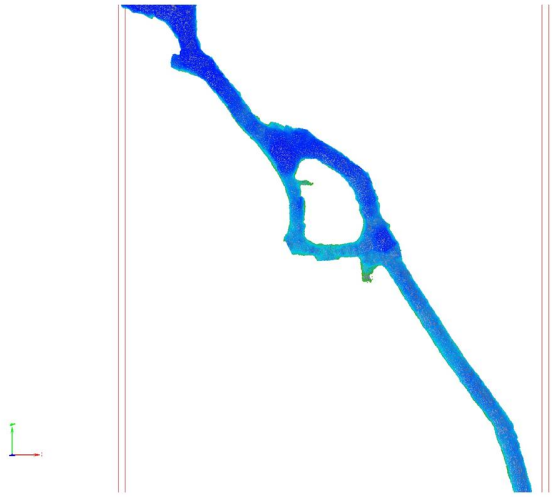
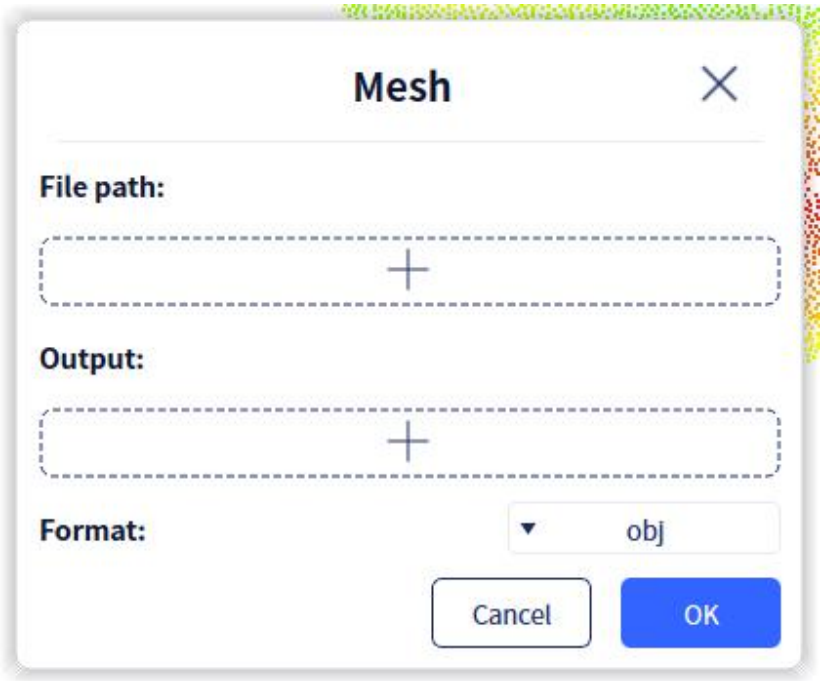


After the calculation is completed, click "Enclosed Volume" in the menu bar again to exit the enclosed area volume calculation function.

3. **Mesh**

The current version of Mesh only supports the result data from L1 and L2 devices after external panoramic colorization and L2 Pro and K1 after internal colorization (check "output panoramic images" option when doing project processing).The Mesh function is based on the laser point cloud data collected by Lixel L1 and L2 and external panoramic camera data, enabling one-click generation of textured 3D models.

Click "Mesh," input the L1 or L2 scan result data folder that has undergone panoramic colorization post-processing, and select the desired export path and format. Currently, ".obj" and ".osgb" formats are supported.



Note:

The current version of the Mesh function only supports processing post-processed and colored LAS result data under 50GB.