LixelStudio

User Manual

V3.0.2.1

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 v3.0.1.0 mainly includes the following modules:

- Project processing module: mainly used to process the data obtained by Lixel series handheld scanner. Including SLAM project mapping, 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 pile volume calculation and Mesh building.

II. Version and Copyright

(1) Version

Software version: LixelStudio V3.0.2.1

Release date: November 8th, 2024

This manual is based on Lixel Studio V3.0.2.1 version. Operations may be different for other versions. Please verify the software version before use.

(2) New Features

1. Export to rcp

Using the Data Conversion tool, you can now convert .las to .rcp.

2. Software Update Notification

If the computer is connected to the internet, the software will automatically check for updates and notify users if any updates are available.

3. Coordinate Transformation

Now supports Japan and Korea regions.

4. Firmware Update for Scanners

Now supports firmware updates for XGRIDS handheld scanners.

5. Mesh

Now supports K1 and L2 Pro data. Note that for L2 Pro, only the post-processed data that are not upsampled (i.e. No point cloud enhancement) are accepted.

6. L2 Pro Map Fusion

Now support Map Fusion for L2 Pro data.

7. 3D Clipping Multiple Point Clouds

Now supports clipping multiple point cloud data layers at once using the Clipping Box tool.

8. Data Import

Now supports applying the coordinate shift information for all data imported at once.

9. L2 Pro Data after Point Cloud Enhancement

Now supports functions such as Accuracy Check, Profile Analysis, and Panoramic Overlay for L2 Pro data after Point Cloud Enhancement.

(4) Optimization and Upgrades

1. Rendering and Display Upgrade

Software rendering display optimization upgrade, enhancing overall display quality.

2. Project Processing Optimization

- Optimized external panorama coloring, filtering, and panorama photo output features during project processing.
- Further enhanced the external camera coloring effect.
- Addressed noise and rounded corner issues in filtering.
- Additionally, the panorama photos output by K1 and L2 Pro have been further improved.

3. Other Optimizations

Fixed some bugs in the previous version of the software. These fixes include missing PLY point cloud data during export, occasional crashes during panorama output, and missing point cloud shading in dark areas.

(5) Trademark

Lixel®, XGRIDS Lixel®, LixelStudio®, and XGRIDS Lixel® are registered trademarks of XGRIDS. All other product names, company names, and brand names mentioned in this document may be trademark properties of their respective holders.

(6) Copyright

Thank you for using LixelStudio software. We are delighted to provide 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

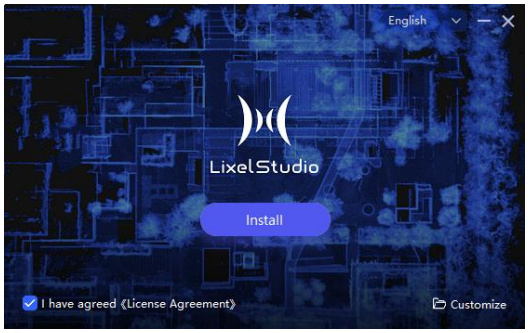
Hard disk: 1T（SSD）

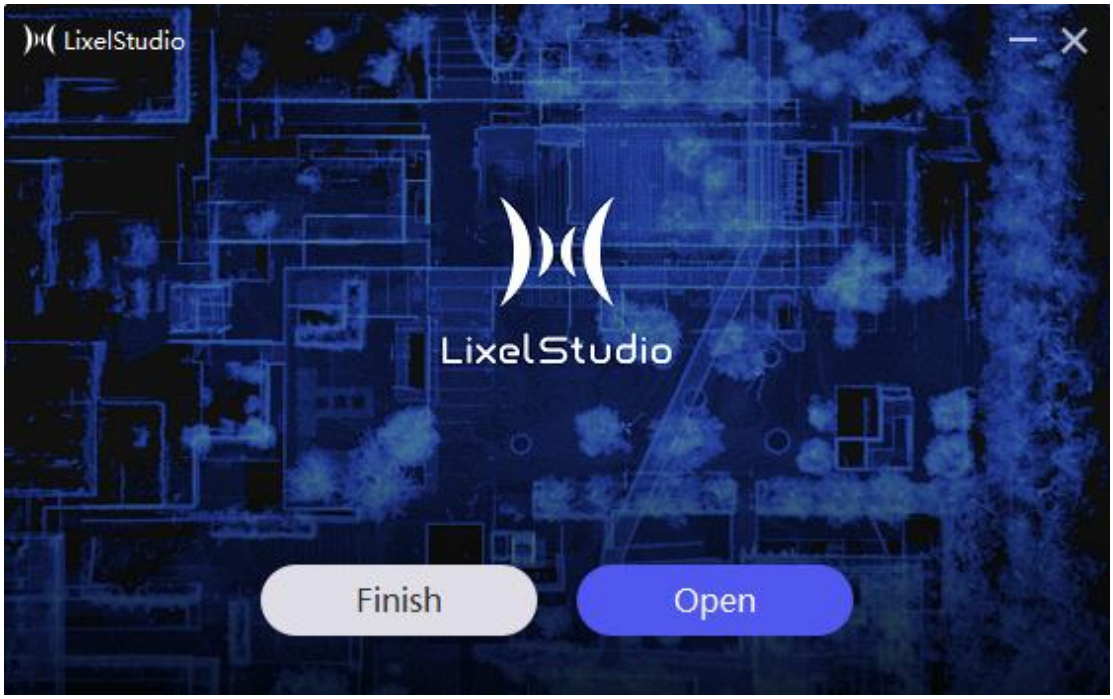
(3) Installation Procedures

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

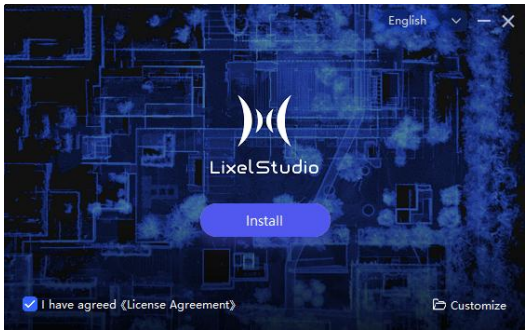
◦ After clicking Install, the program will create the installation path in the default C drive and directly install the program. Once the installation is complete, clicking "Open" will immediately launch the software.

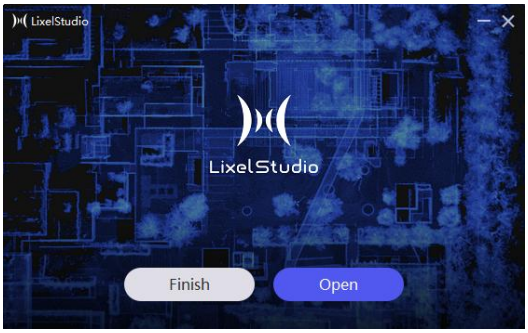




2. Customize Installation

- 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.





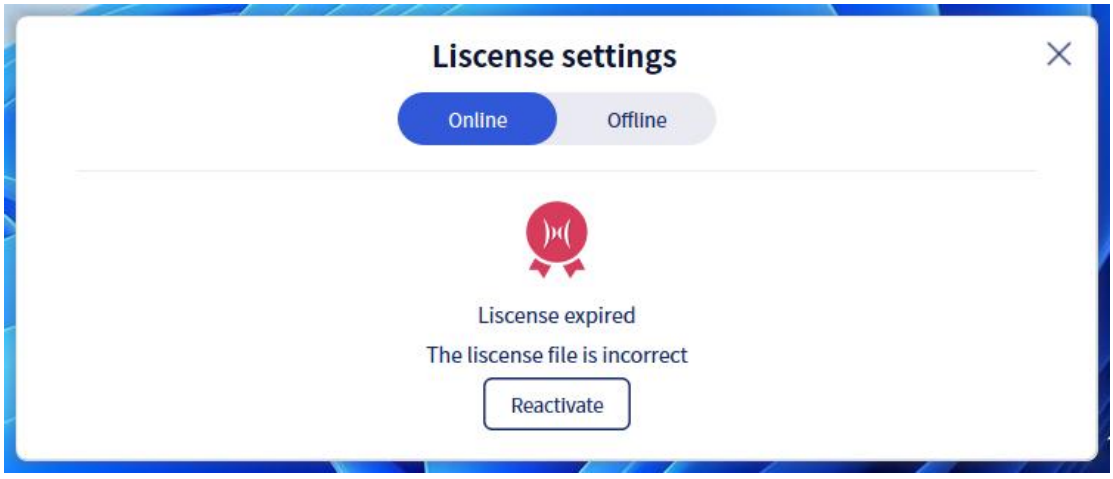
(4) Authorization and Activation

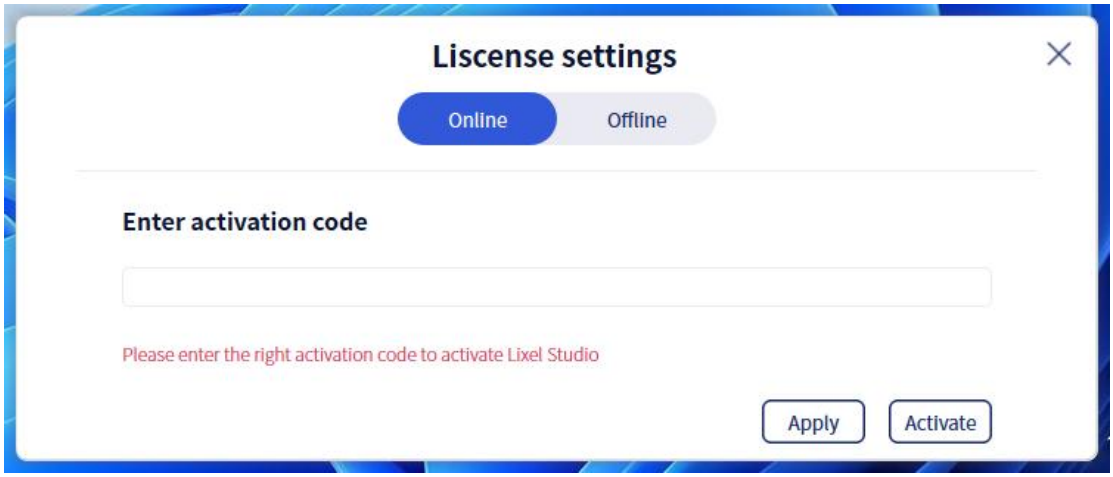
Currently, two methods of authorization and activation are supported: online and offline. The LixelStudio software must be authorized and activated before it can run.

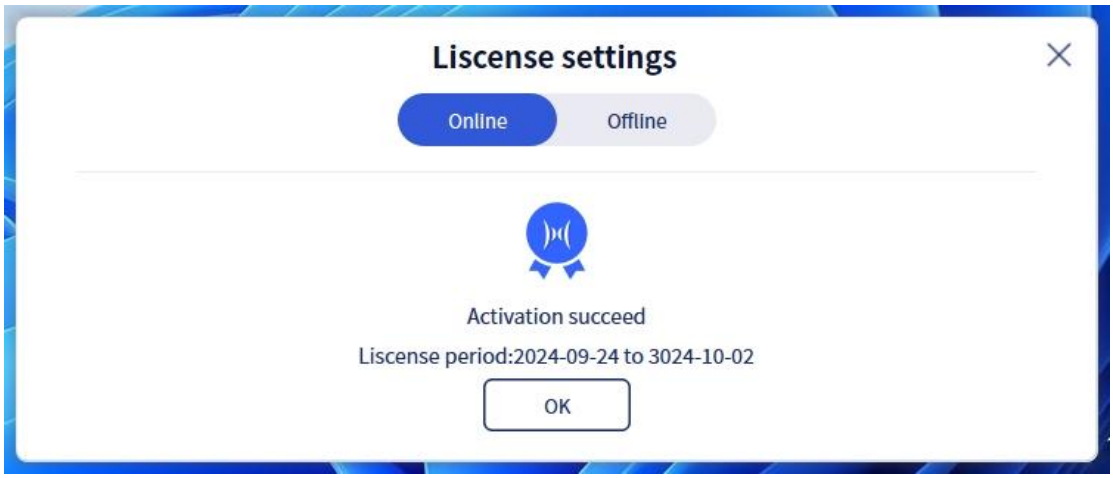
After installing the software for the first time and opening it, the software will display "Authorization Expired/Incorrect Authorization File." If the computer is connected to the internet, you can perform online activation; if the computer cannot connect to the internet, you can perform offline activation.

3. 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.





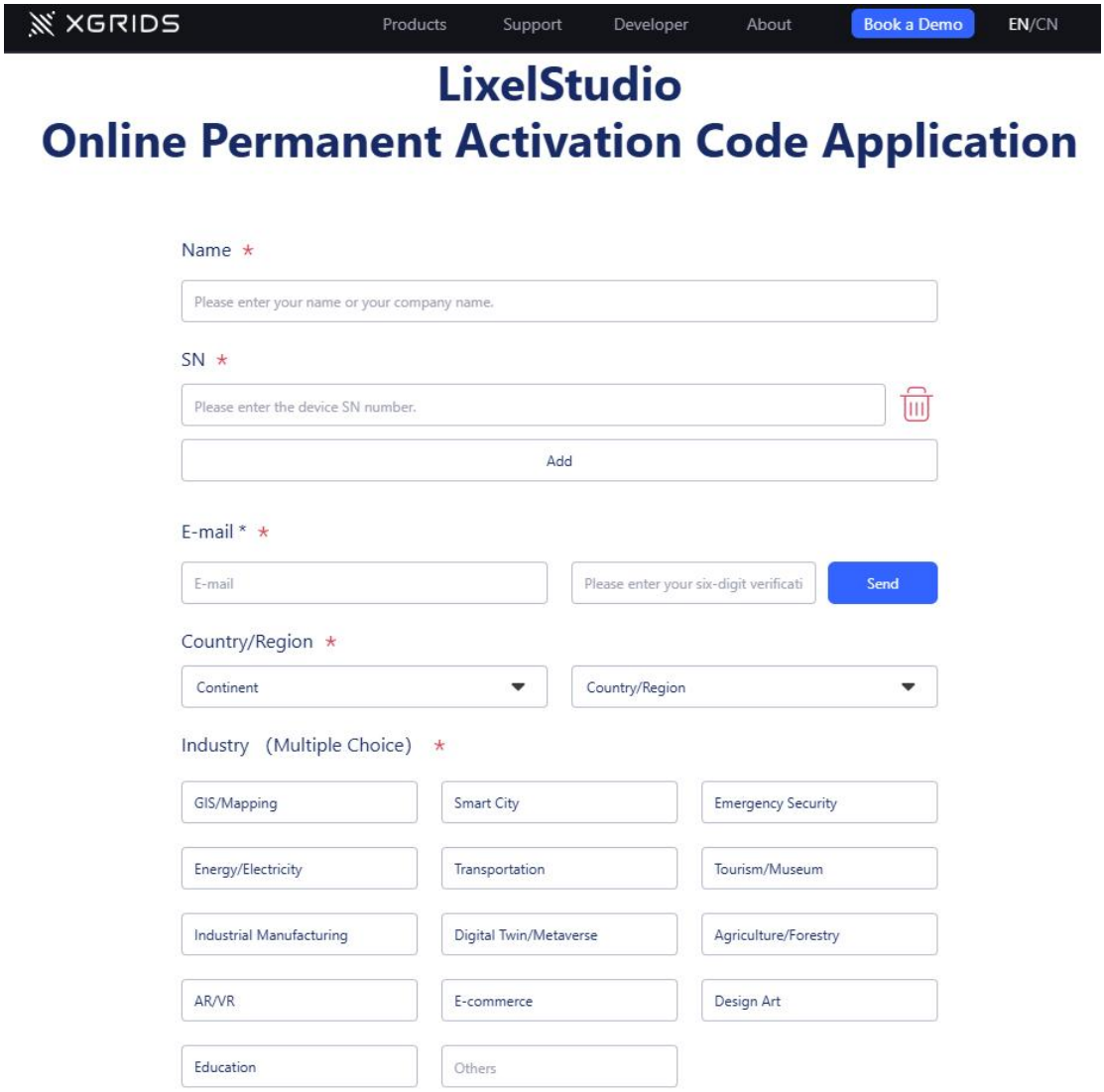


For trial users, you can enter the corresponding trial activation code to activate the software. The trial activation code can be obtained by contacting the respective sales manager or distributor. After entering the code, click "Activate" to successfully activate the LixelStudio software. Once activation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

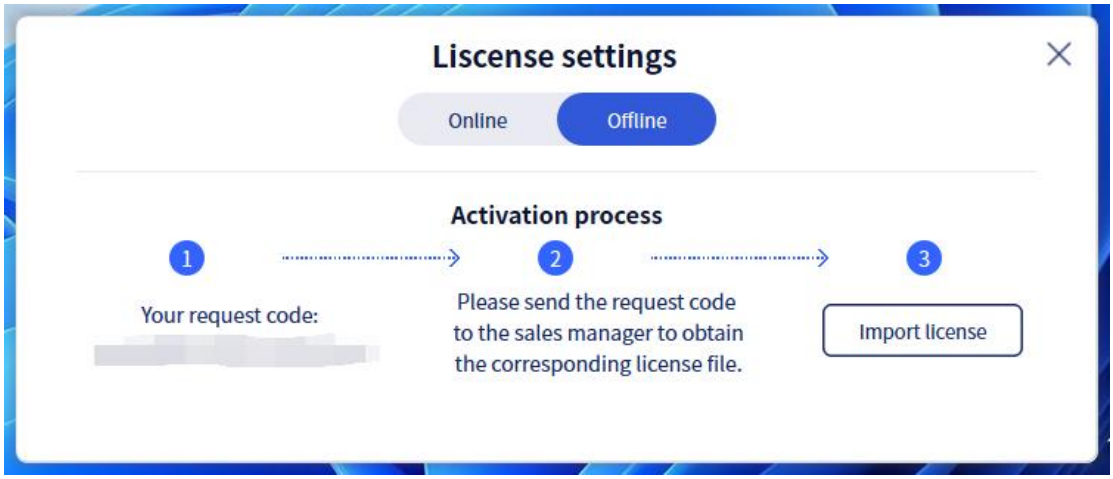
Note: Each device will be equipped with 3 permanent activation codes. You can apply for up to 50 devices at a time. After applying, please save the activation code information to prevent loss. If you unfortunately lose it, you can reapply by logging in to the application website: https://xgrids.com/activationrequest

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.



4. 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

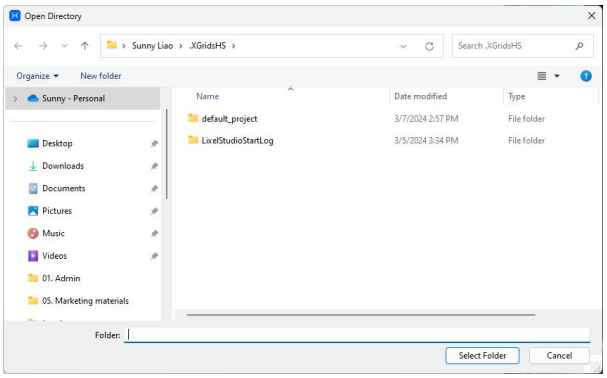
(1) Overall Description of the Interface

1. Welcome Interface

Right-click the software and select "Run as administrator" to open the software. After the software launches successfully, the Lixel Studio welcome page is displayed first. After a moment, you will be directed to the software usage page.

2. **Project Panel**

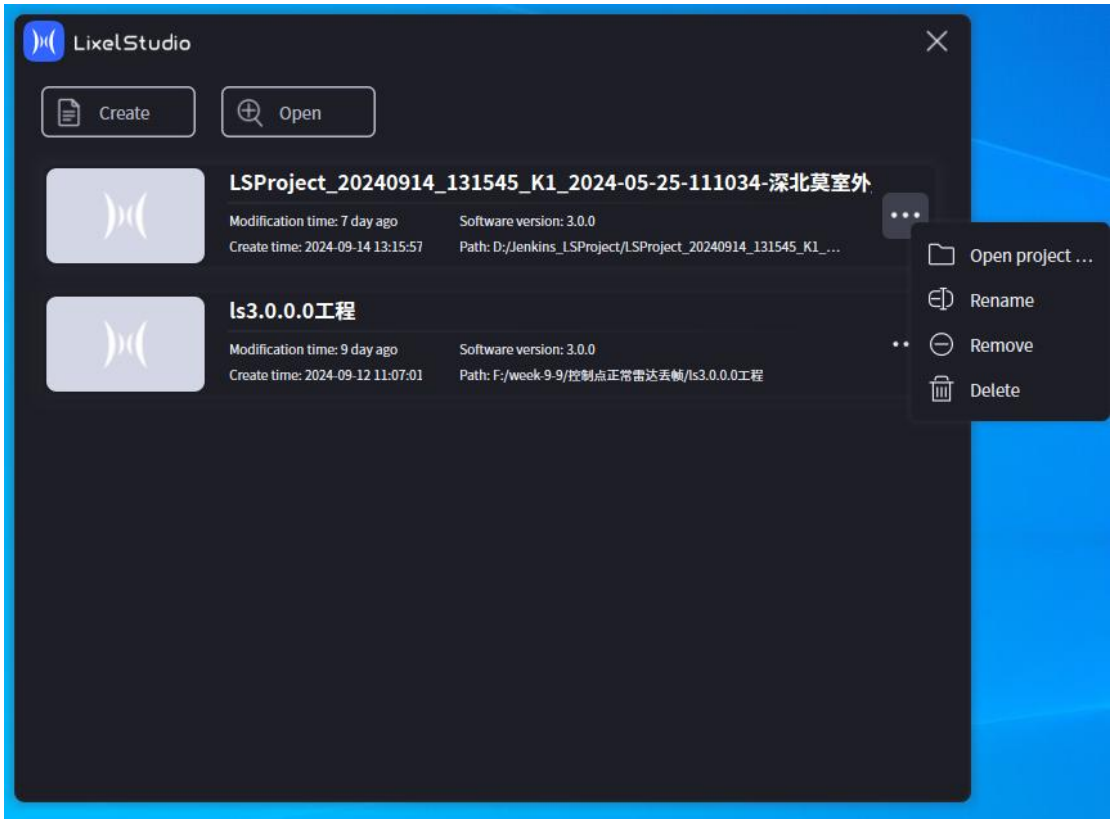
Lixel Studio 3.0.1.0 uses a project-based structure to manage data. Before entering the software's main operation interface, you first need to create a project. Click "New Project" to select the project path, create a new folder, enter the corresponding file name, and select it.



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.

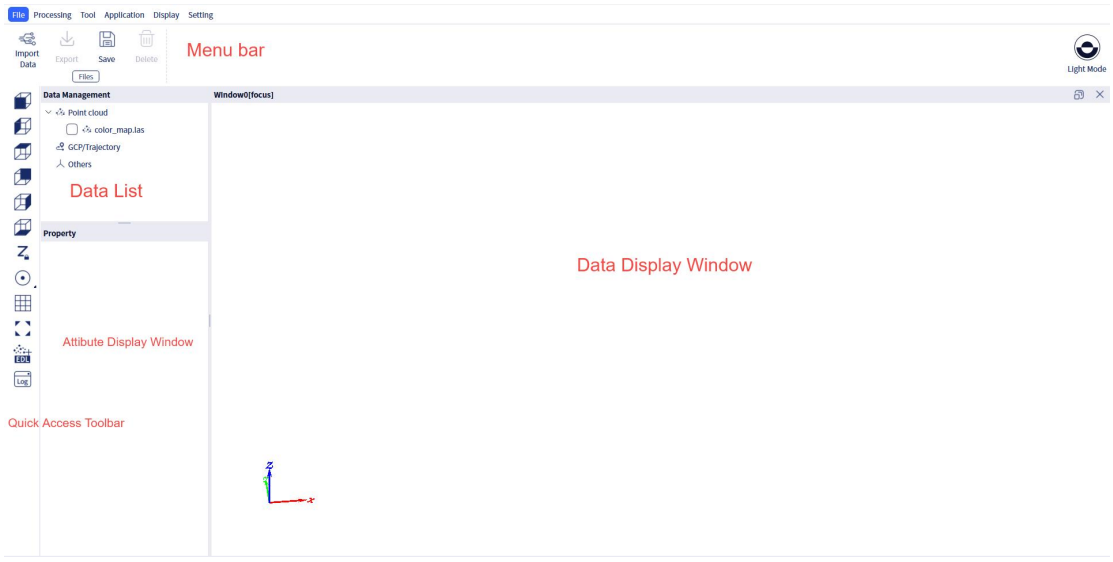
Clicking the "···" to the right of a project allows you to manage the project, including opening the project path, renaming the project, removing the project, and deleting the project.

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 Lixel Studio 3.0.1.0 software, including the menu bar, data list, attribute properties information bar, data display area, and quick operation bar.

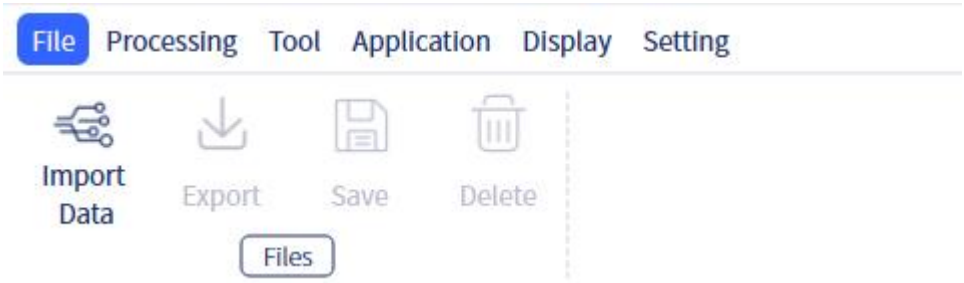


(2) Menu Bar

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

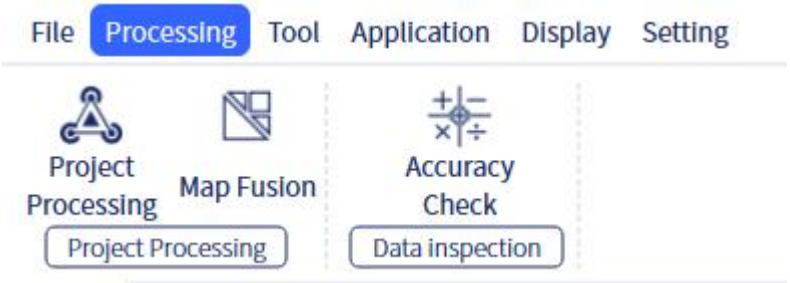
1. File

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



2. Processing

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



3. Tools

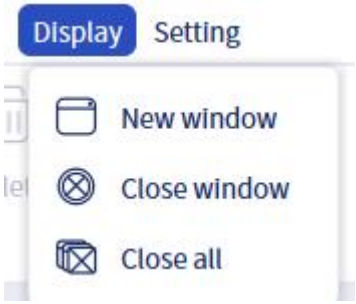
Tools include Manual Registration, ICP Registration, Resampling, Denoising, Smoothing, Profile Analysis, Clipping Box, Clip, and Panorama Overlay.

4. Application

Applications include volume calculation, volume comparison, and Mesh.

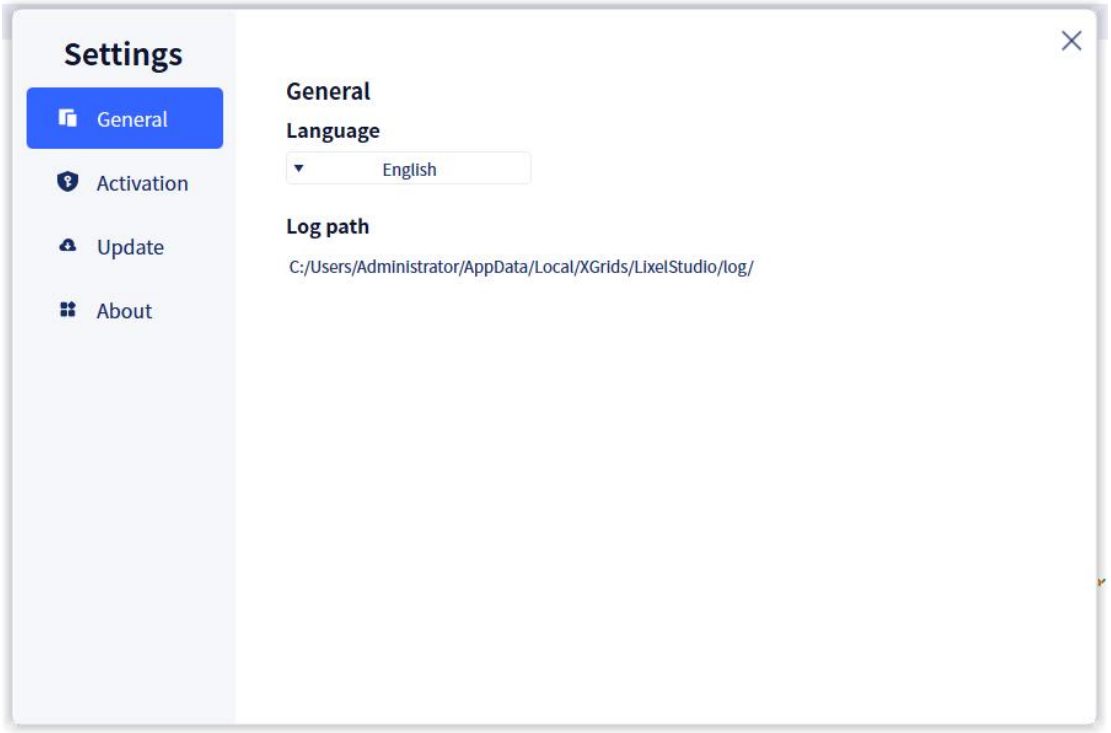
5. Display

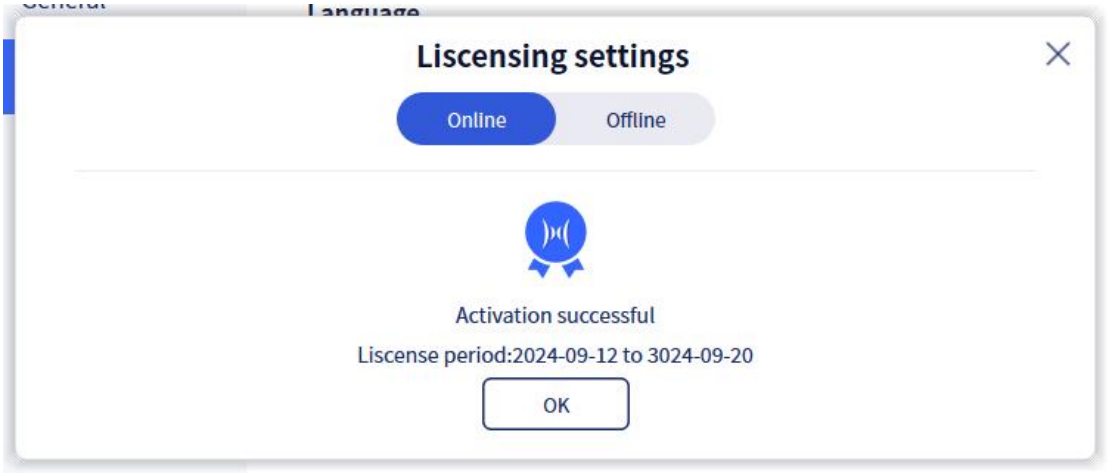
Display includes new window, close window, and close all.

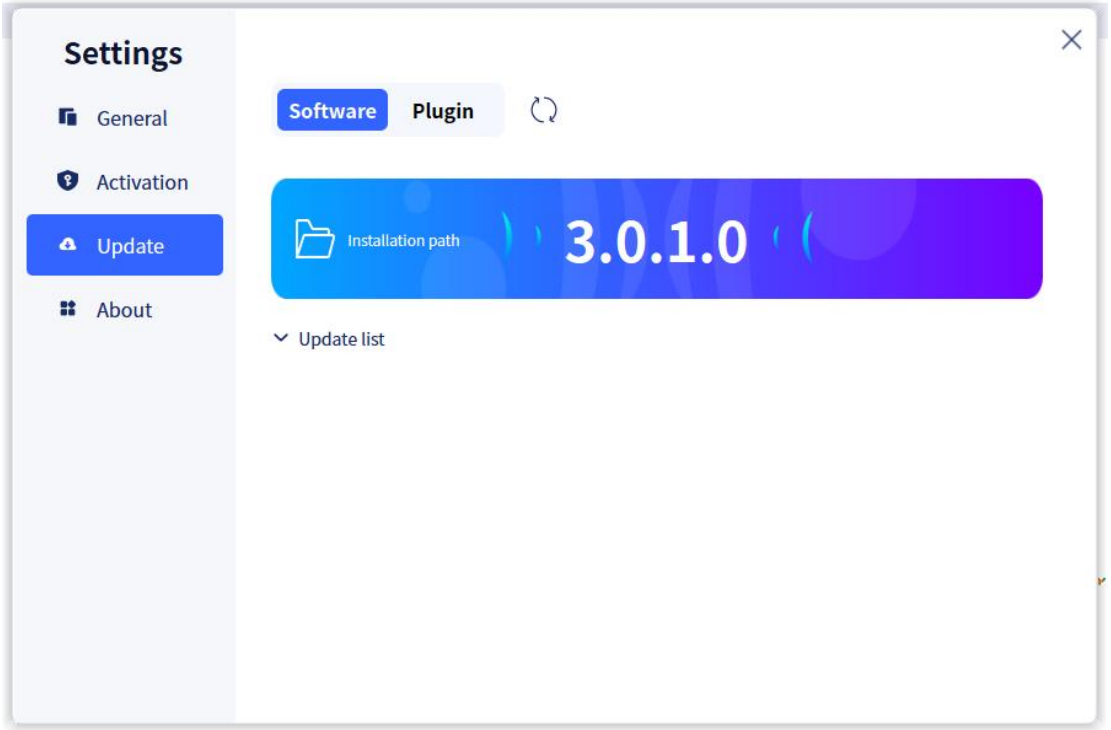


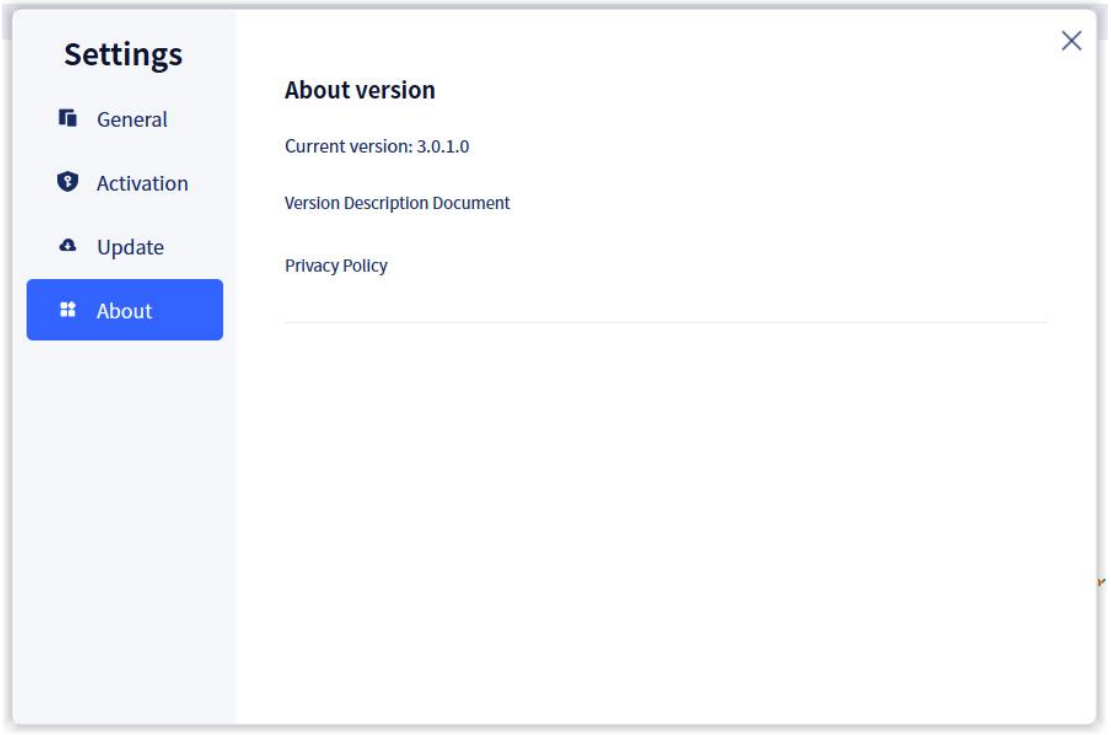
6. Setting

Settings include General, License, Update, and About.




Liscensing settings
Online
Offline
Activation successful
Liscense period:2024-09-12 to 3024-09-20
OK


Settings
General
Activation
Update
About
Software
Plugin
Installation path
3.0.1.0
Update list

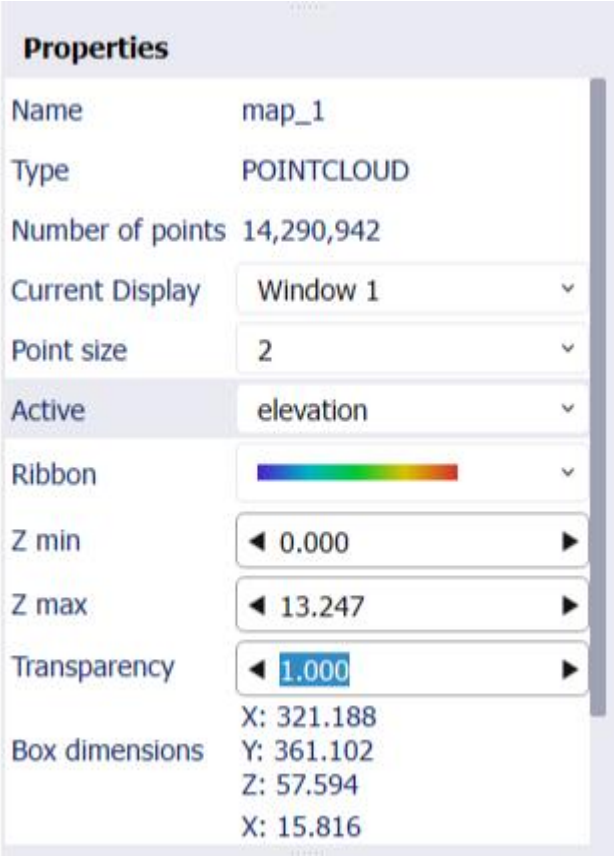


(3) Data List

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.

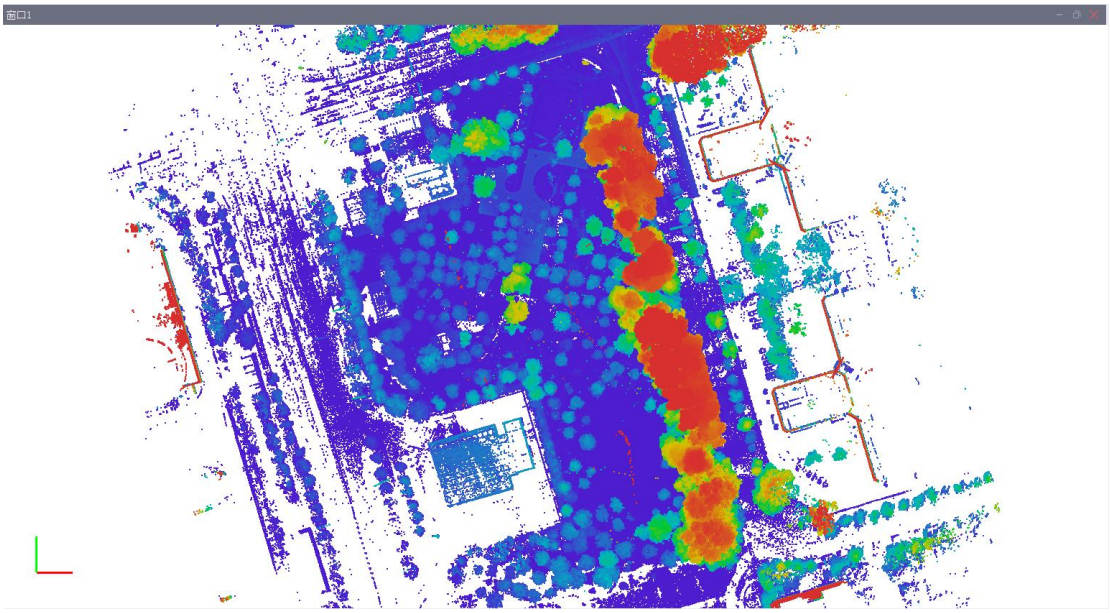
(4) Attribute Information Window

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

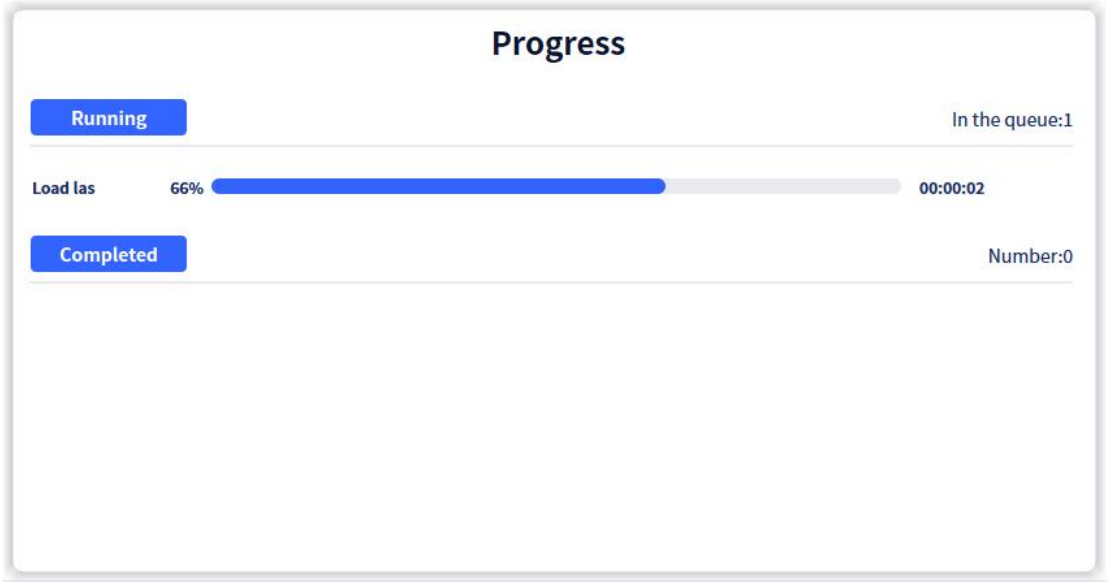
The data display window is located in the central area of the software and is used to display the data that the user has opened. Users can process data such as point clouds and images in the window.



(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.

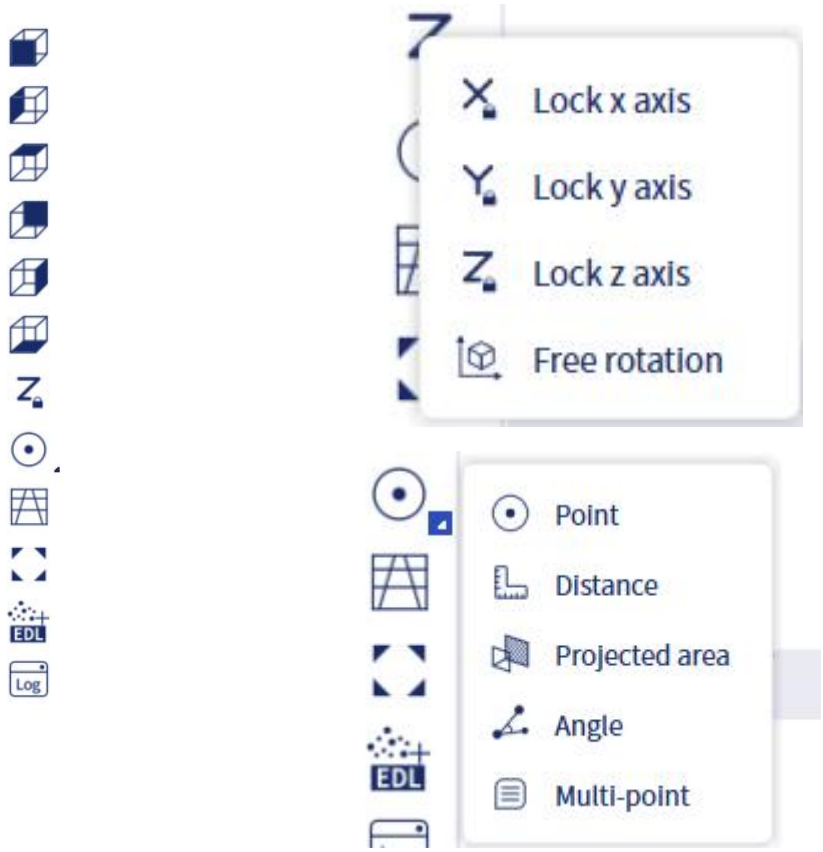
For processing results, they will be displayed in the task queue. Clicking the button on the right can open the result folder. Clicking delete will remove the completed task from the completed queue.



(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**
- **Background Switching**
- **Workbench Display Switching**

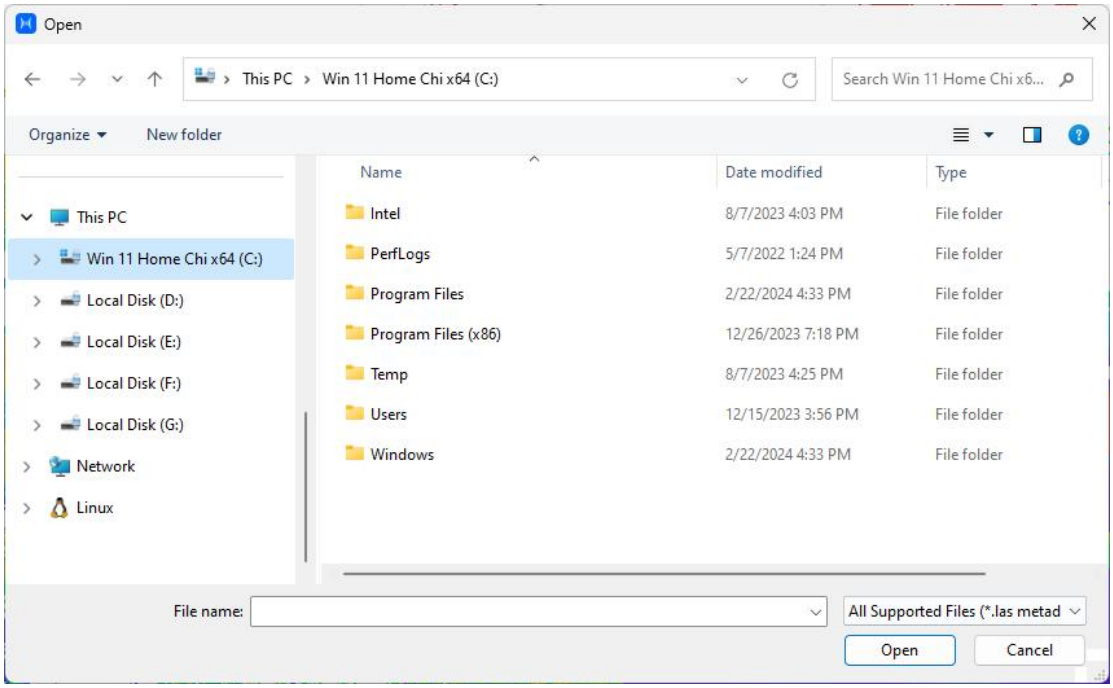


V. Basic Operations

(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, and PLY. It also supports the import of control points and trajectory data in CSV and TXT formats.

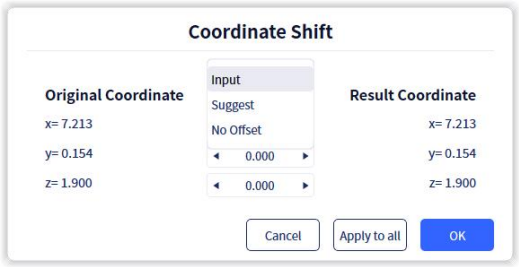


1.1 Import .las data

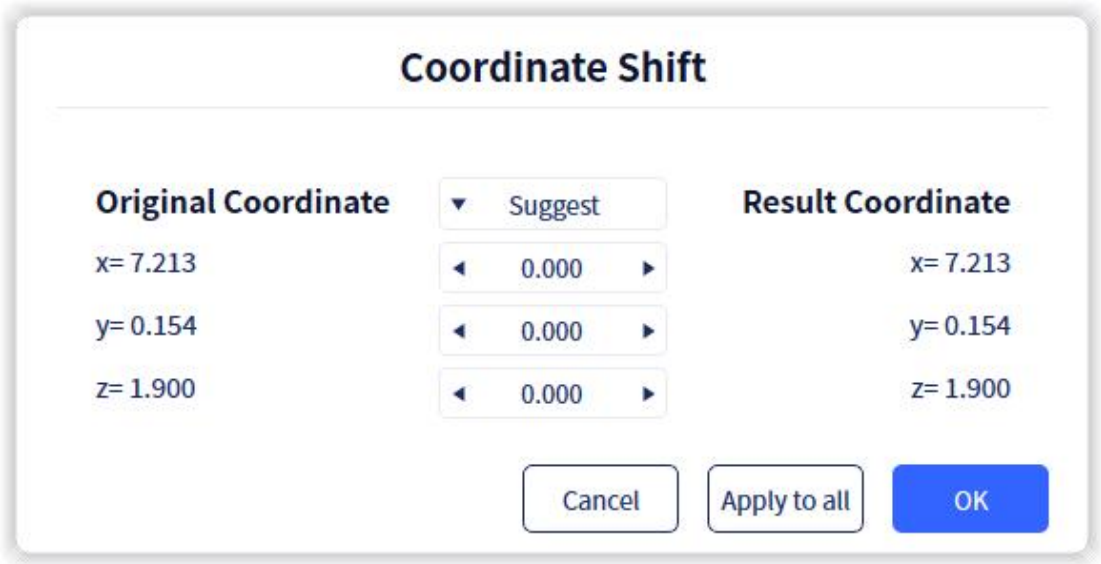
After selecting the .las file to import, the software will prompt you to choose the coordinate offset for rendering display (this offset will only affect the display of the point cloud in the window and will not affect the coordinates of the point cloud data itself).

Currently, the following offset options are provided: Input, Suggested, No Offset, Last Time (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.

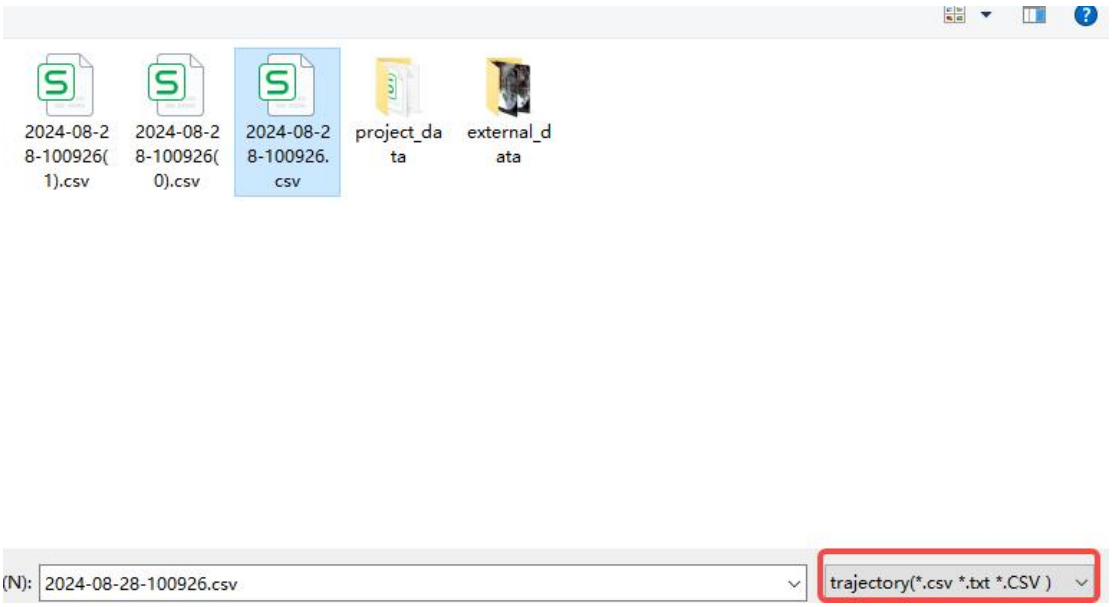


When importing multiple point cloud data sets simultaneously, you can select "Apply to All" to choose the same offset for all point clouds.

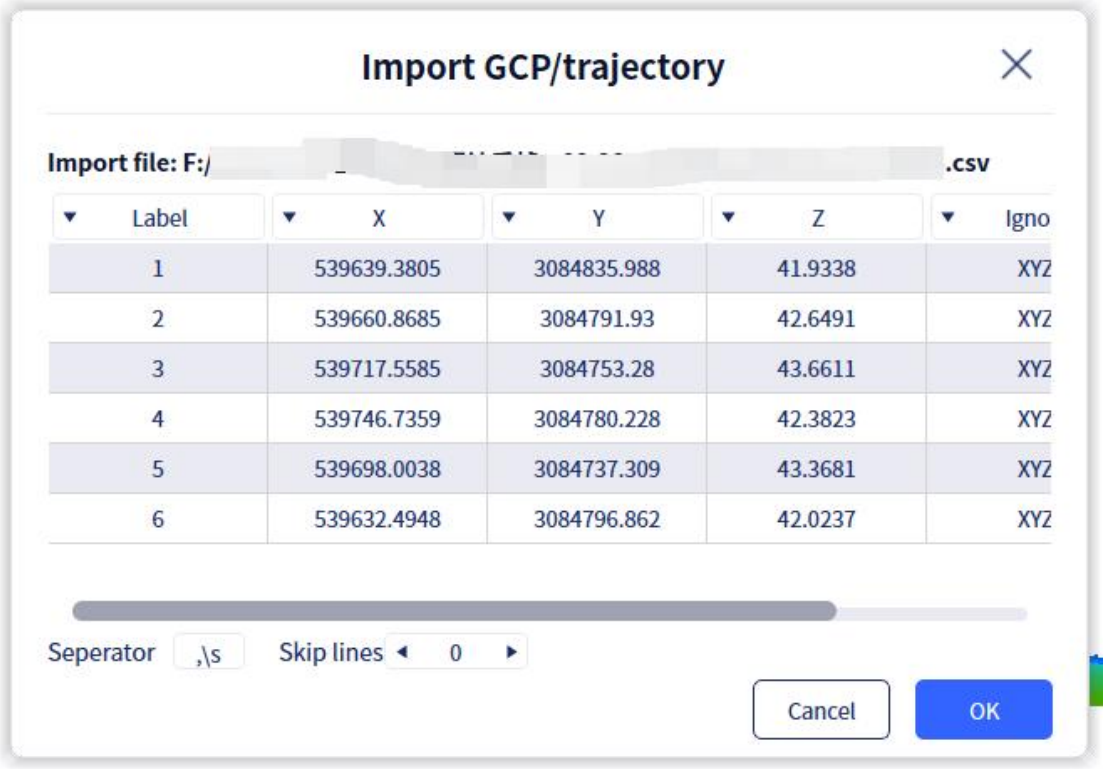


1.2 Import Control Points and Trajectory TXT/CSV Data

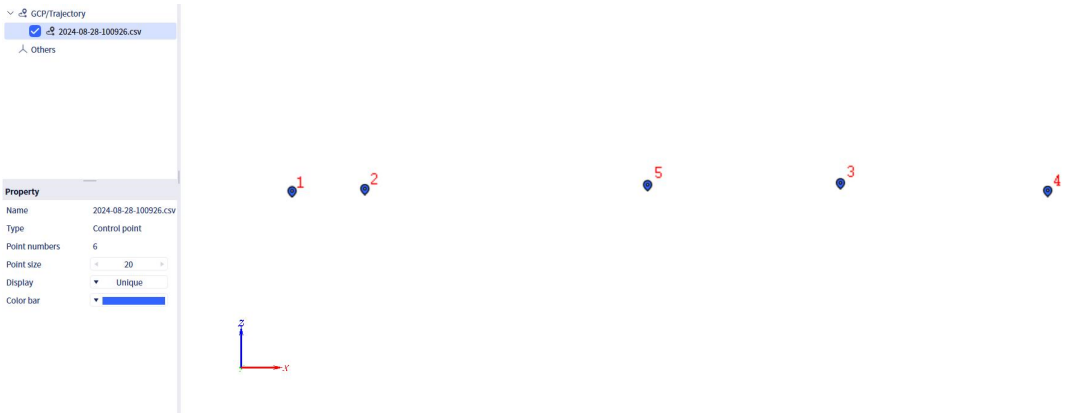
After selecting the .txt/.csv file to import, a dialog box will appear where you can freely choose the delimiter based on the data format and specify whether to skip rows when reading the data.



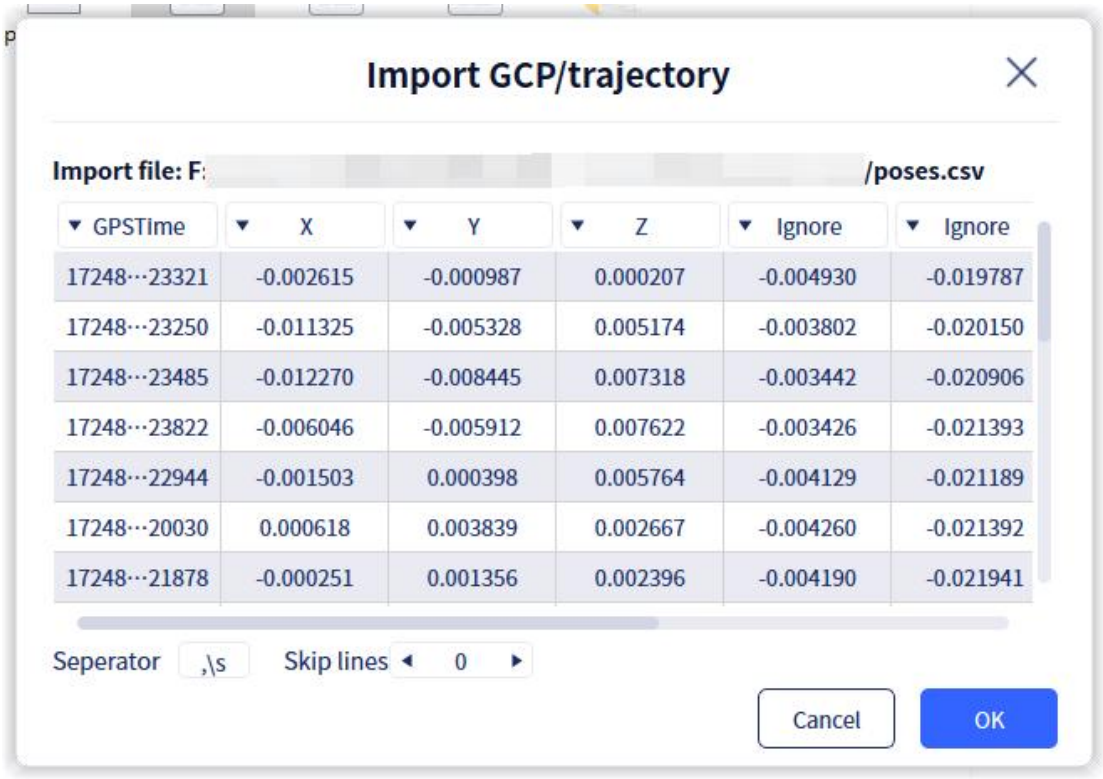
The software will automatically assign information such as X coordinate, Y coordinate, Z coordinate, intensity, and label to each column of data. You can select the appropriate assignment for each column according to your actual needs.

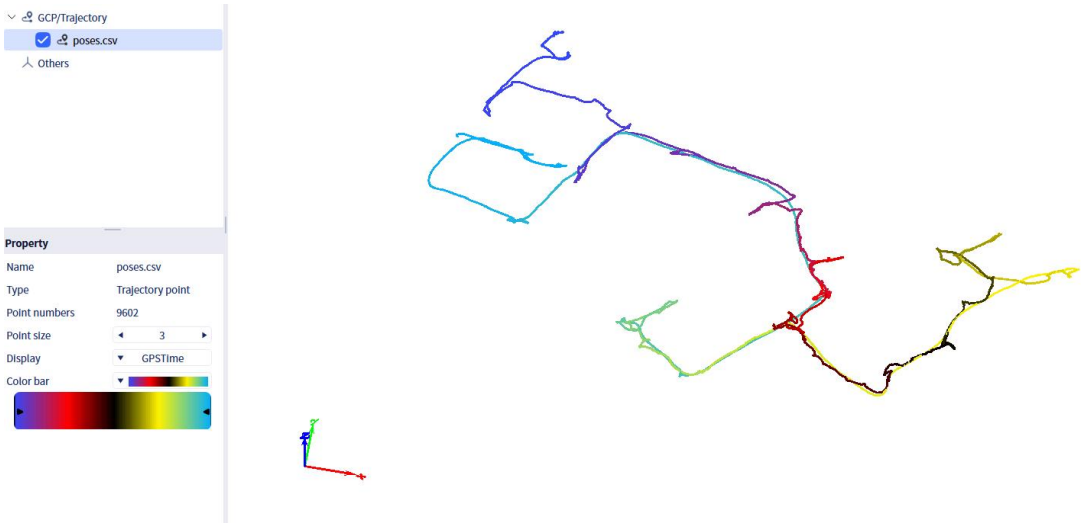


After making your selections, click "Confirm" to import the data. If you are importing control point data and the data includes label information, the imported data points will be displayed with special symbols in the data display box.



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.



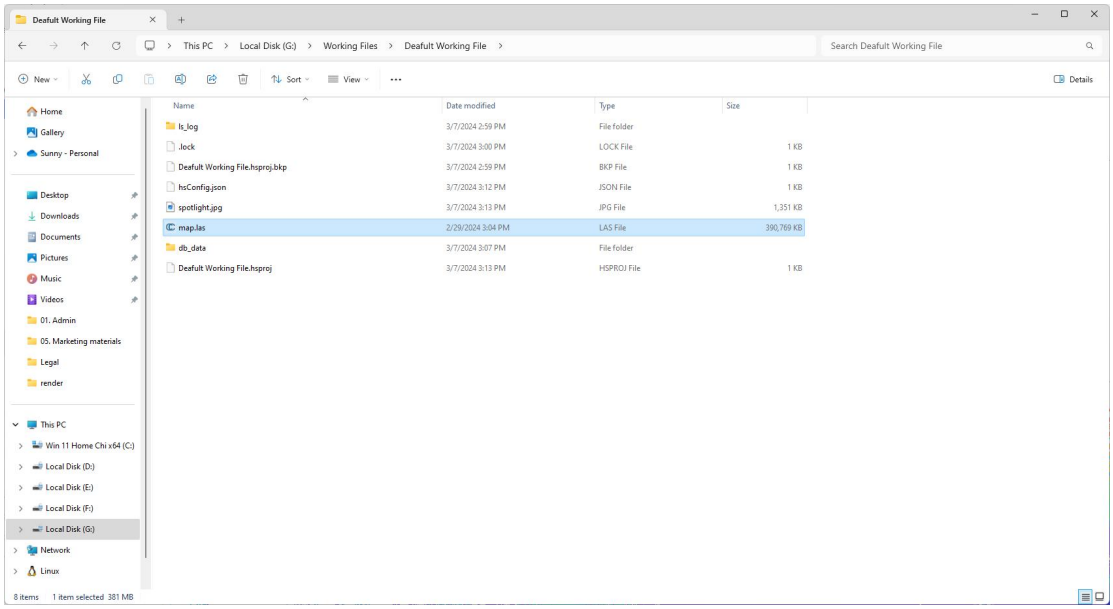


2. Save project

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

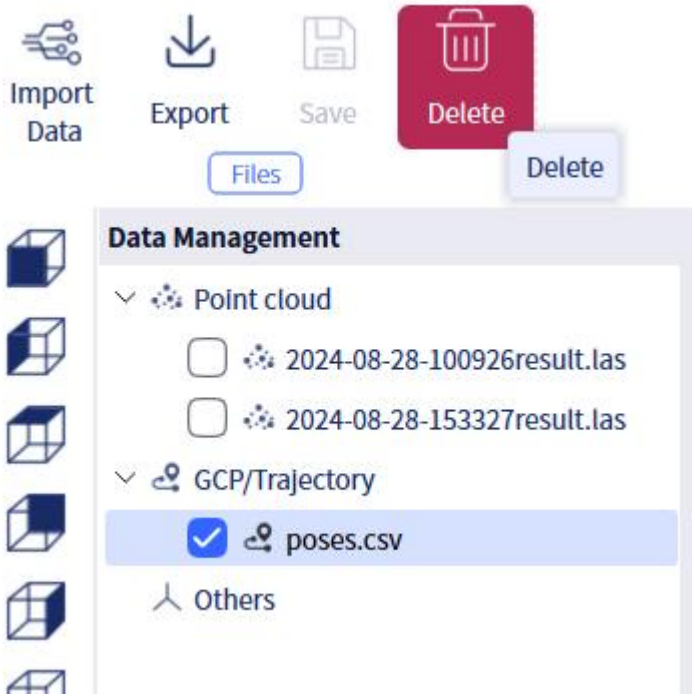
3. Export data

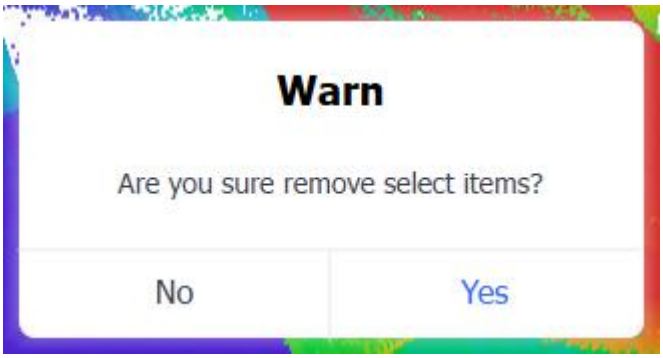
Select the data you need to export and click "Export Data" to export the corresponding point cloud data files to the selected path. Currently, the software supports exporting point cloud data in LAS, LAZ, and PLY formats.



4. Delete data

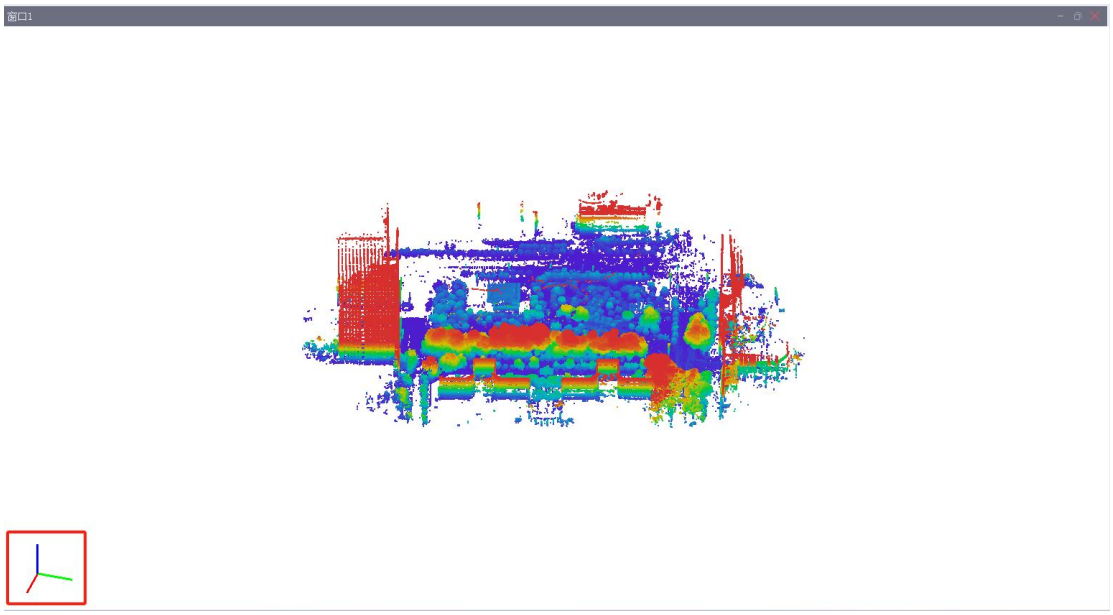
Click on the data file in the corresponding data list, then click "Delete" and confirm to delete the corresponding data.





(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

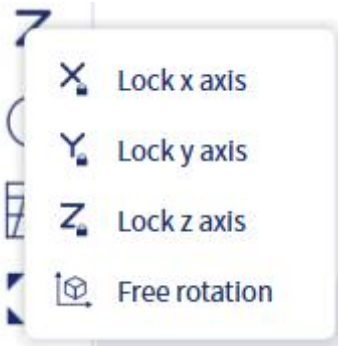
Point cloud data can be zoomed in and out by controlling the mouse wheel. The scroll wheel can be zoomed in forward and out backward.

2. Translation/Pan

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

3. Rotation

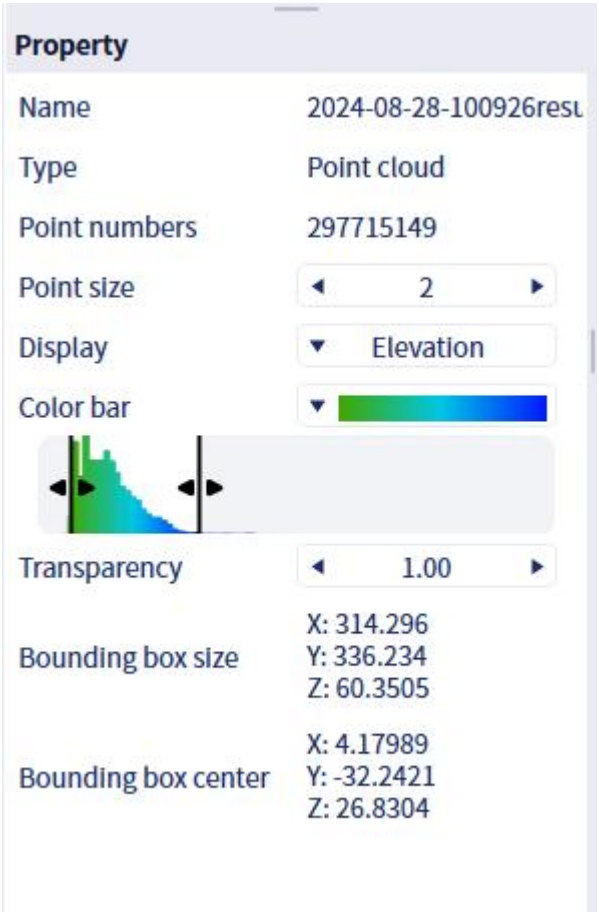
You can rotate point cloud by holding down the left mouse button and dragging the mouse. The rotation center of point cloud is located in the center of the data display window. When rotating, the data can now be translated to the center of the window for easier rotation. If you need to fix the Z-axis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



(3) Attribute Information

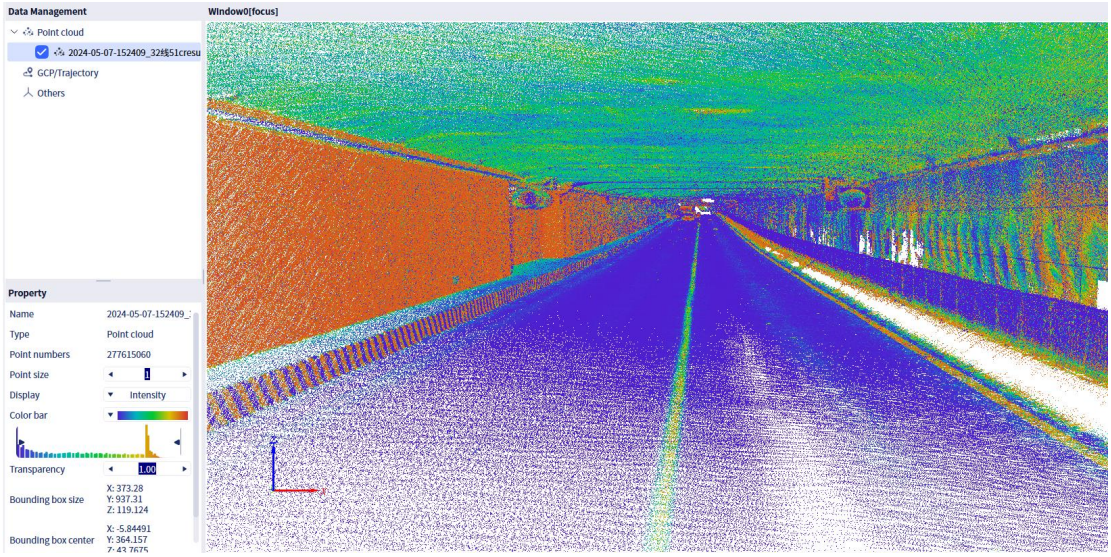
By selecting an individual point cloud data, you can view its basic information, such as point data, in the properties information bar. You can also

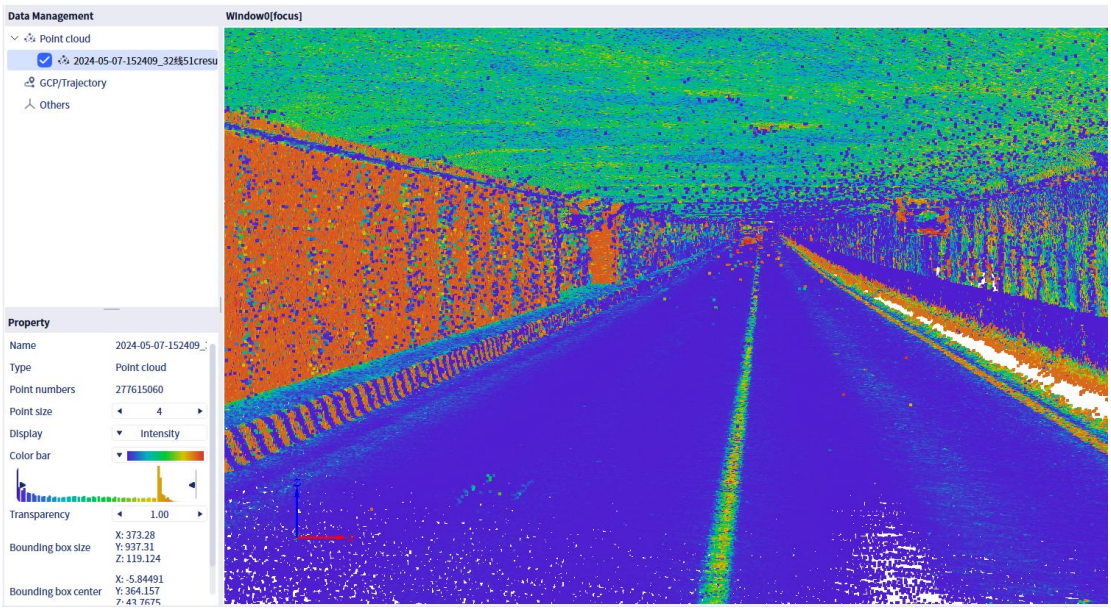
adjust the display mode, transparency, and other settings of the point cloud.



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 color).



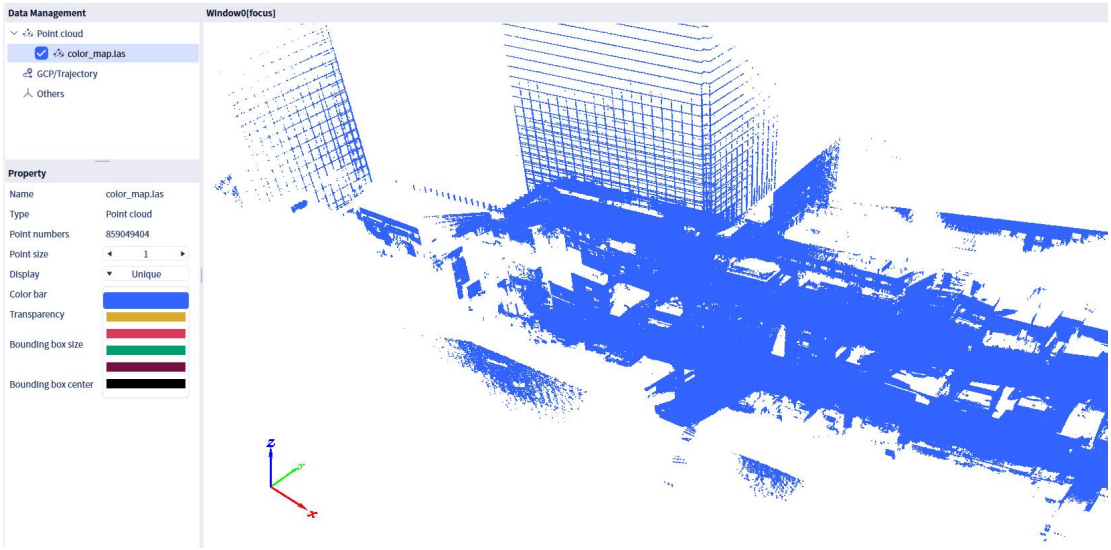


2. **Display mode**

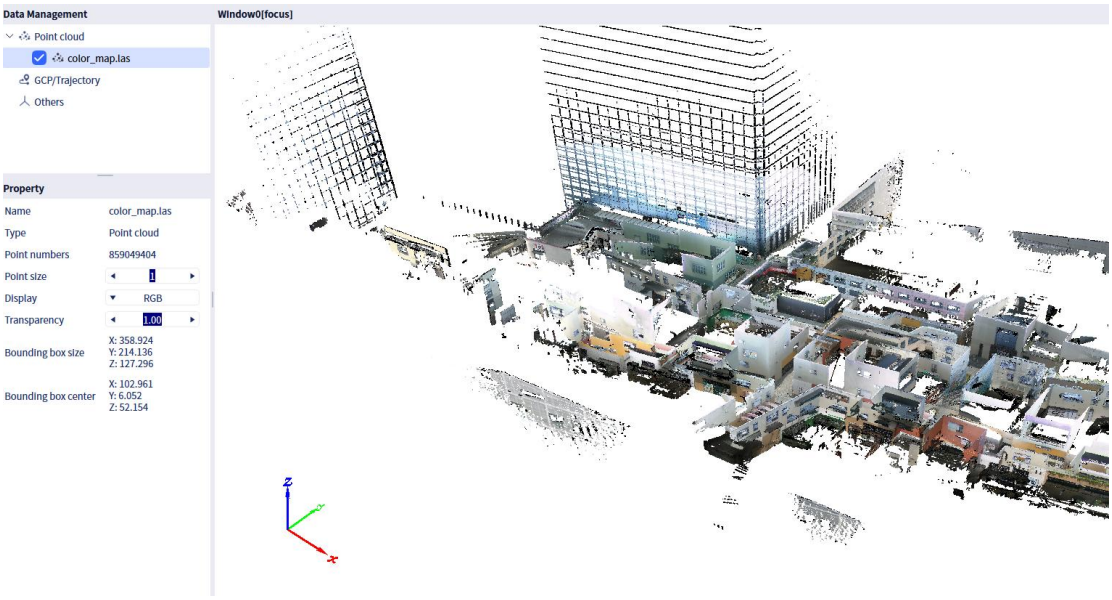
Adjusting the display mode allows you to change the rendering display of the point cloud. Currently, the software provides five different display types: "RGB," "Elevation," "Intensity," "GPS Time," and "Unique." Users can adjust the display mode according to their needs.

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.

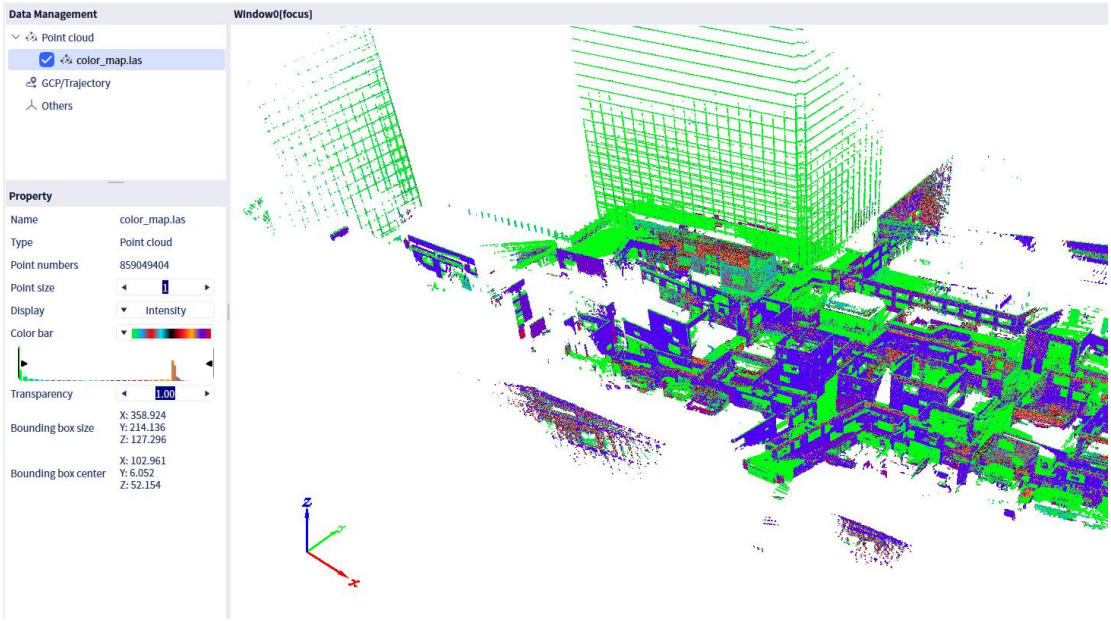


Selecting "RGB" will display the point cloud in its actual colors. The RGB color display effect is as follows:

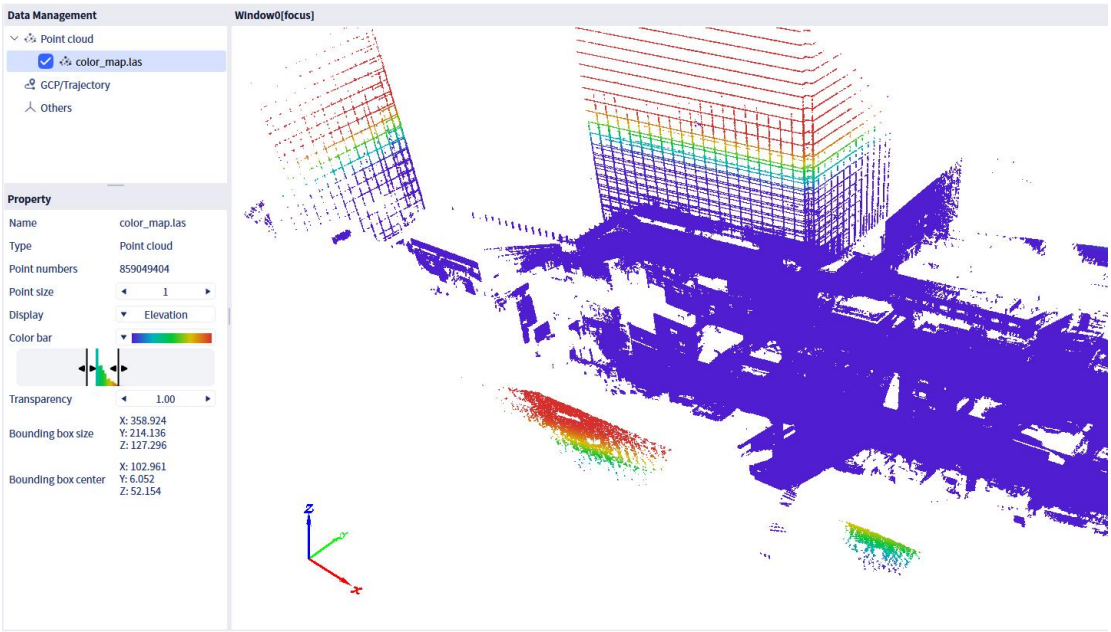


Selecting "Intensity," "Elevation," or "GPS Time" will display the point cloud using different color bands. The software provides various color bands for these display modes, and users can choose the color band according to their needs.

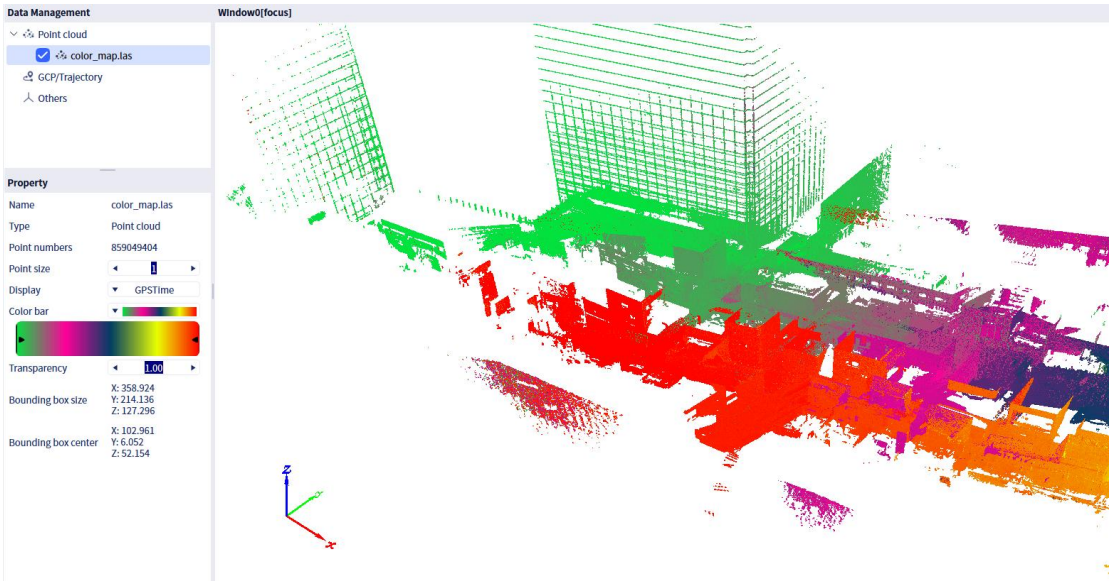
The intensity display effect is as follows:



Elevation display effect:

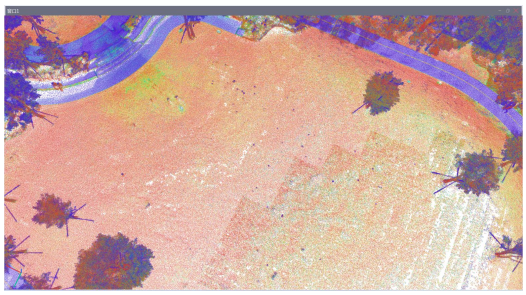


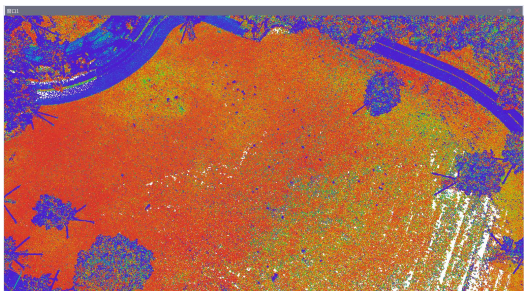
GPS Time display effect:



3. Transparency

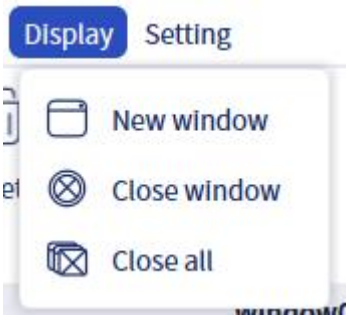
Adjust "transparency" to adjust the transparency of the point cloud data displayed in the current window. 0 is the minimum and 1 is the maximum. The smaller the value, the more transparent the point cloud will appear. The following picture shows the comparison effect (left: transparency 0.1, right transparency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





(4) Display

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



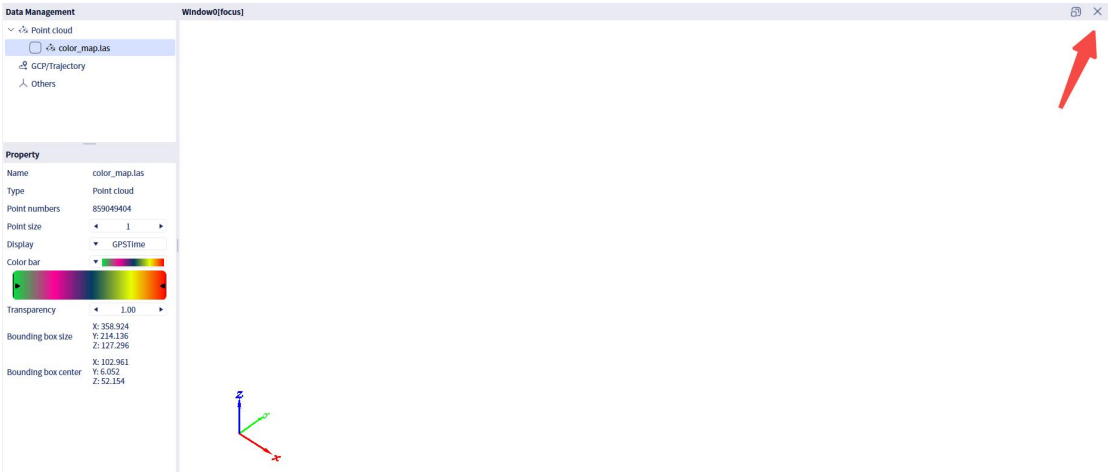
1. New window

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

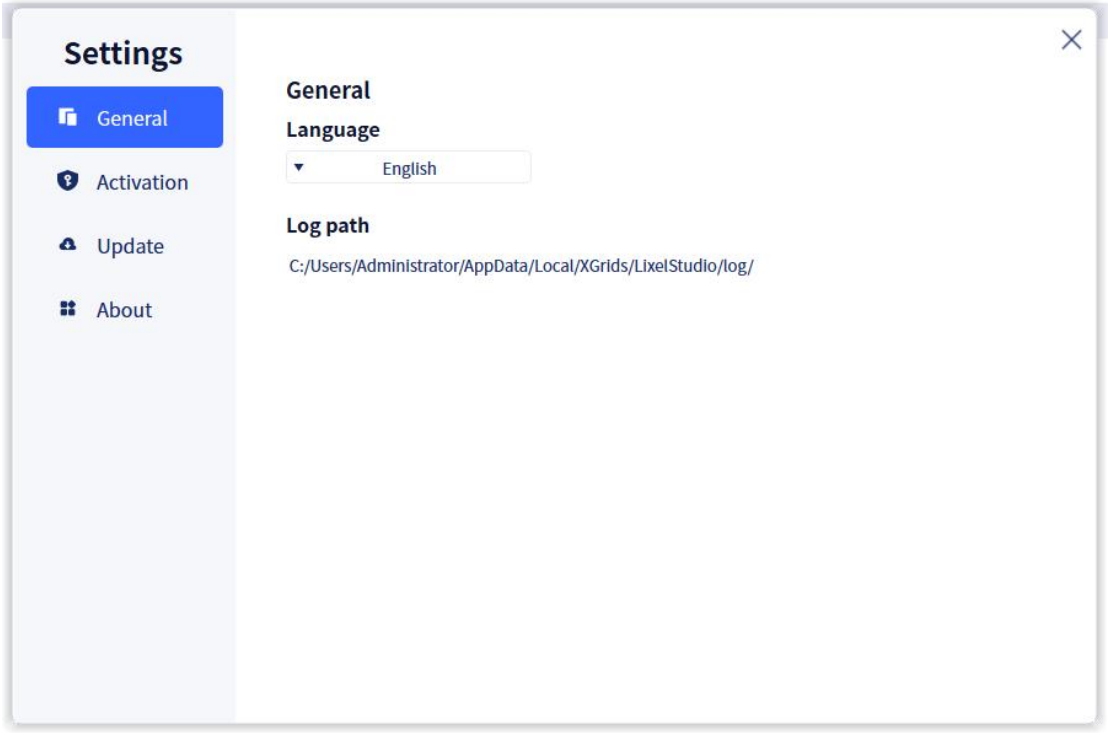
Click "Close All", and the software will close all open windows.

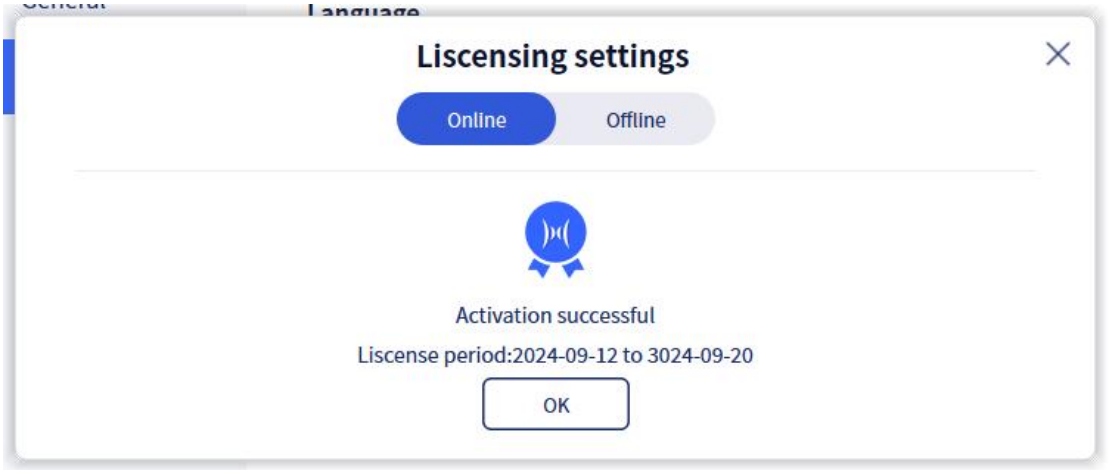
(5) Setting

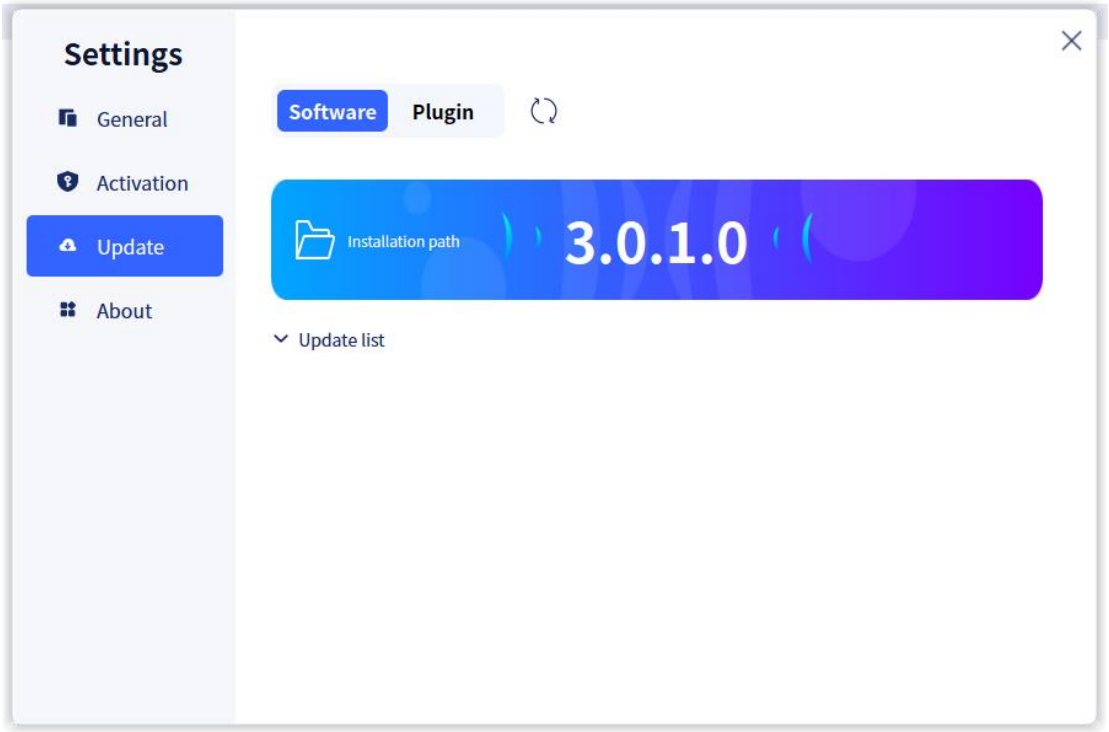
Settings include General, License, Updates, and About.

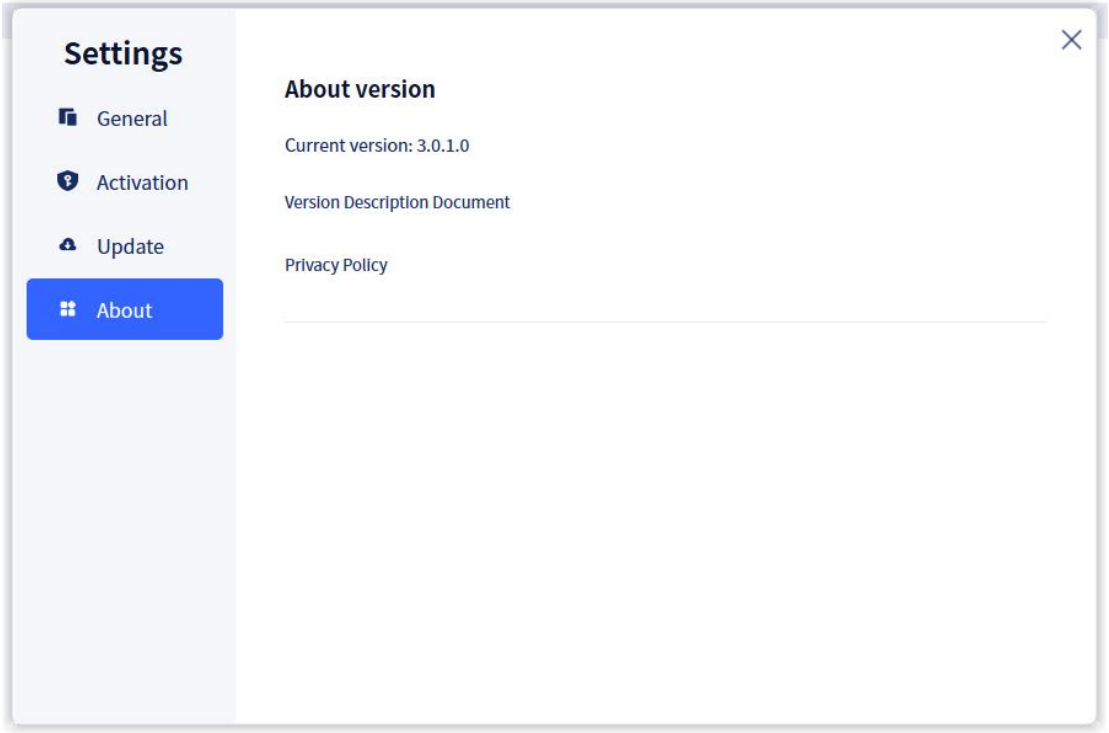
- **General**: This section allows you to switch the software language, currently supporting Chinese and English. After changing the language, a restart of the software is needed. It also shows the path to the log files of the current software. Clicking on it will directly navigate to that path. (If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

- **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.









(6) Quick Operation

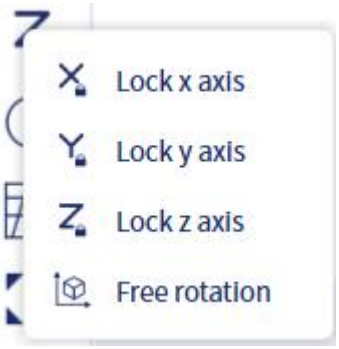
The left-side quick operations include Six Views, Axis Locking, Measurement, Camera Settings, EDL Display, and Workbench Display Switching.

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 perspective mode.

3.2 Orthogonal View

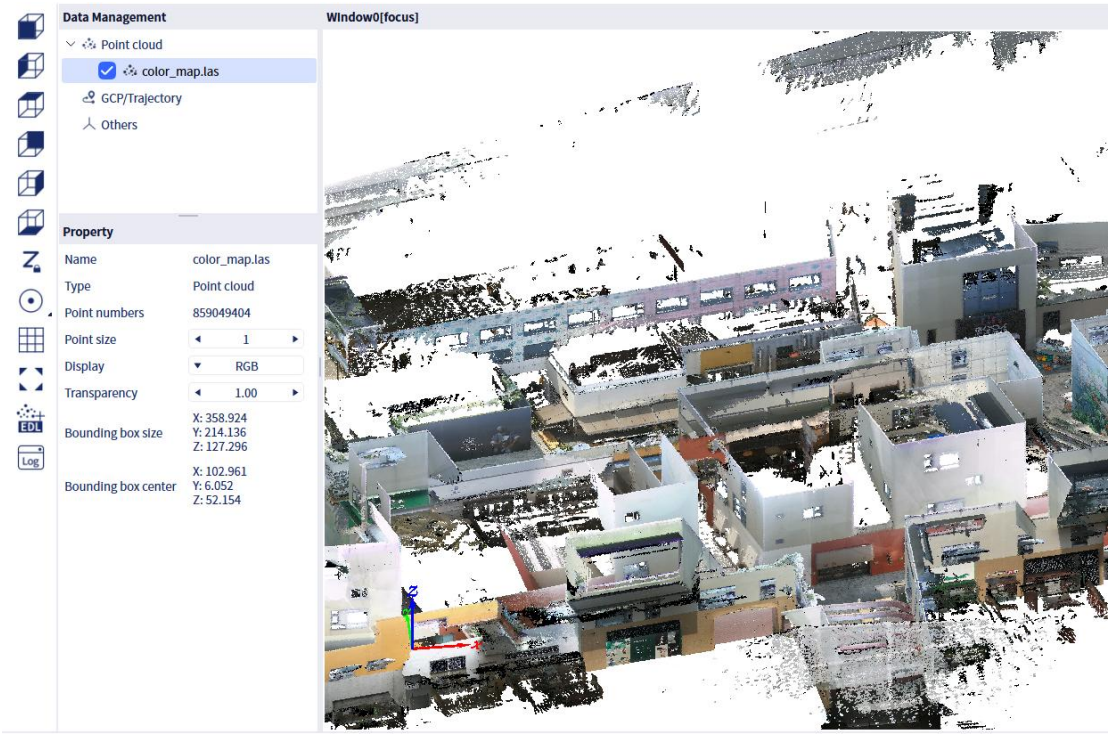
- "Orthogonal View" ensures that the size of the data in the point cloud does not change with the viewing angle. Clicking "Orthographic View" will automatically switch the perspective to orthographic mode.

3.3 Global View

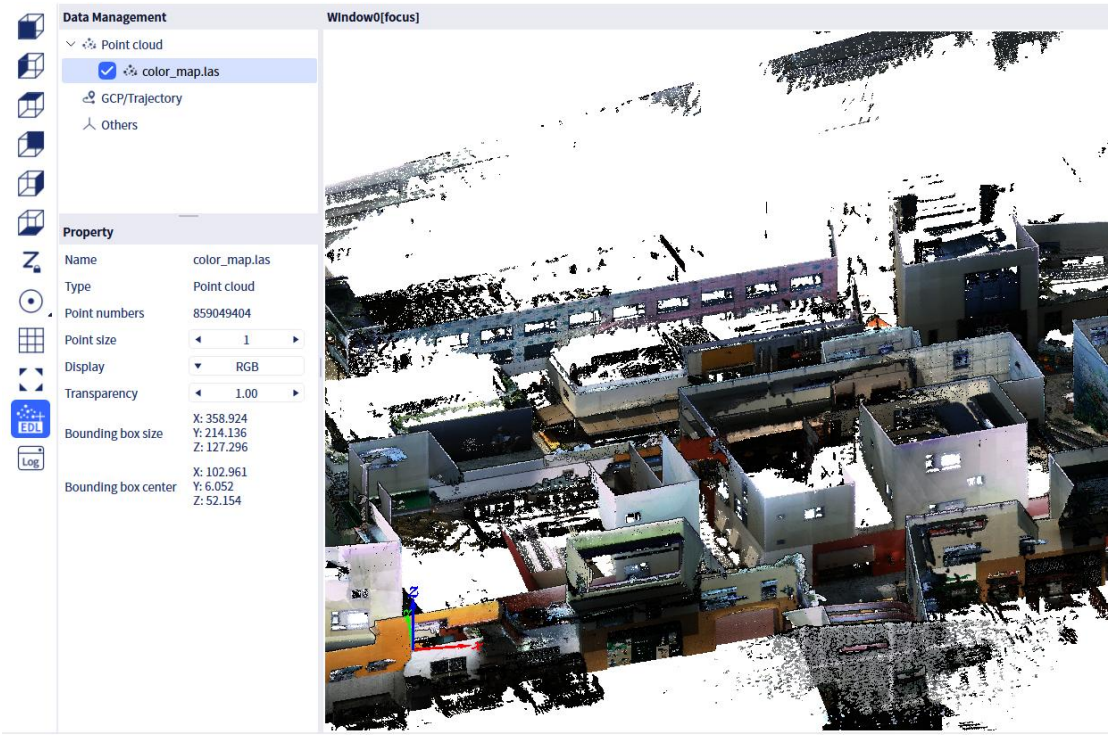
- "Global View" readjusts the perspective to restore the point cloud data to side view, centering it in the window.

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.



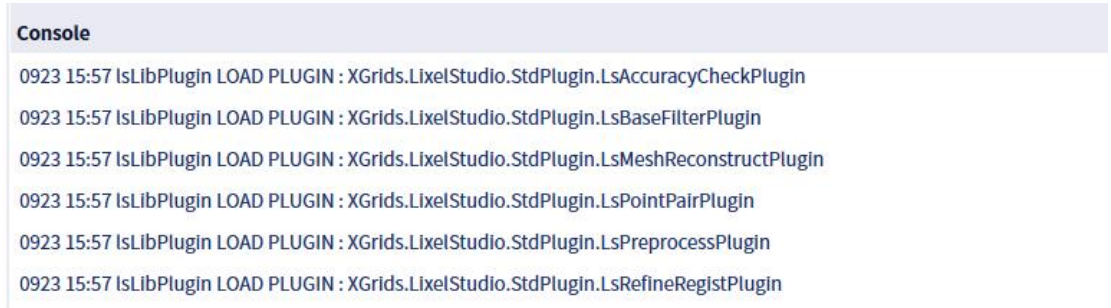
(EDL disabled)



（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.



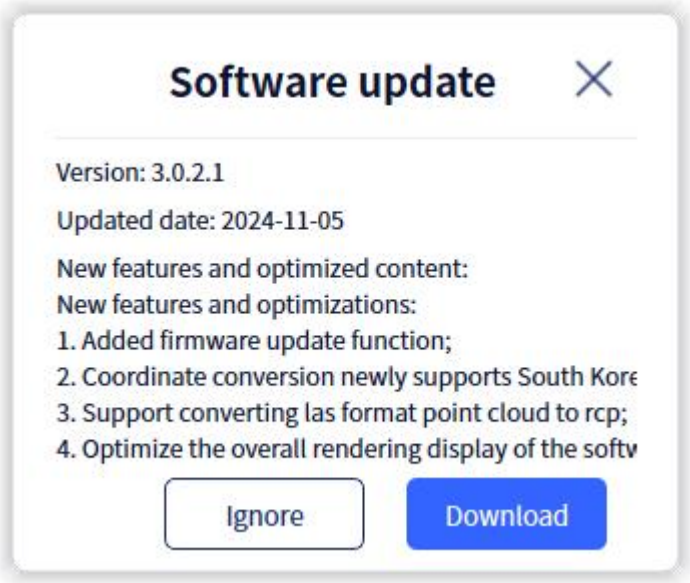
(7) Software Update

6. Updating the Main Software

Note: When using the online update feature to download updates, please make sure to run the software in administrator mode.

The software now includes an online update notification feature. If there is an overall software update, a pop-up window will appear after opening a project. The pop-up will display the new version number, update date, and a list of new features

and optimizations.

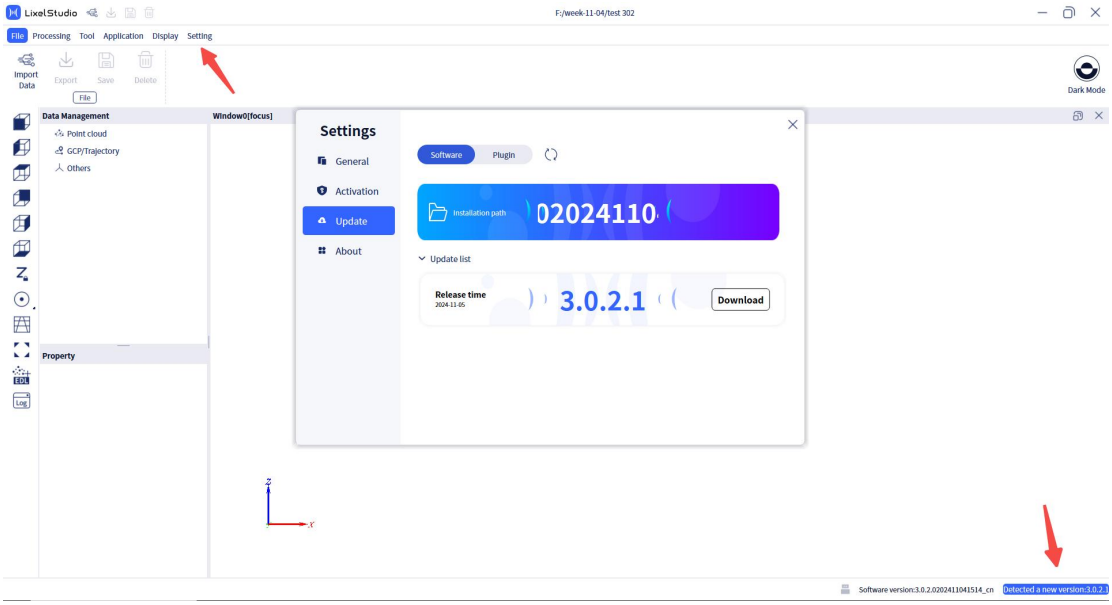


Users can choose whether to update immediately based on their needs. If they click download, the software will automatically download the update in the background. Once the download is complete, a pop-up will prompt whether to close the software and proceed with the update. Clicking "Yes" will close the current software and begin the update. Clicking "No" will not initiate the update. If the user decides to install the new version later, they can go to Settings → Update and click "Install" to proceed with the update.

Note: Please do not perform any other operations during the update process to ensure it proceeds smoothly. The software update will take some time, so please be patient. Once the update is complete, the software will automatically restart.

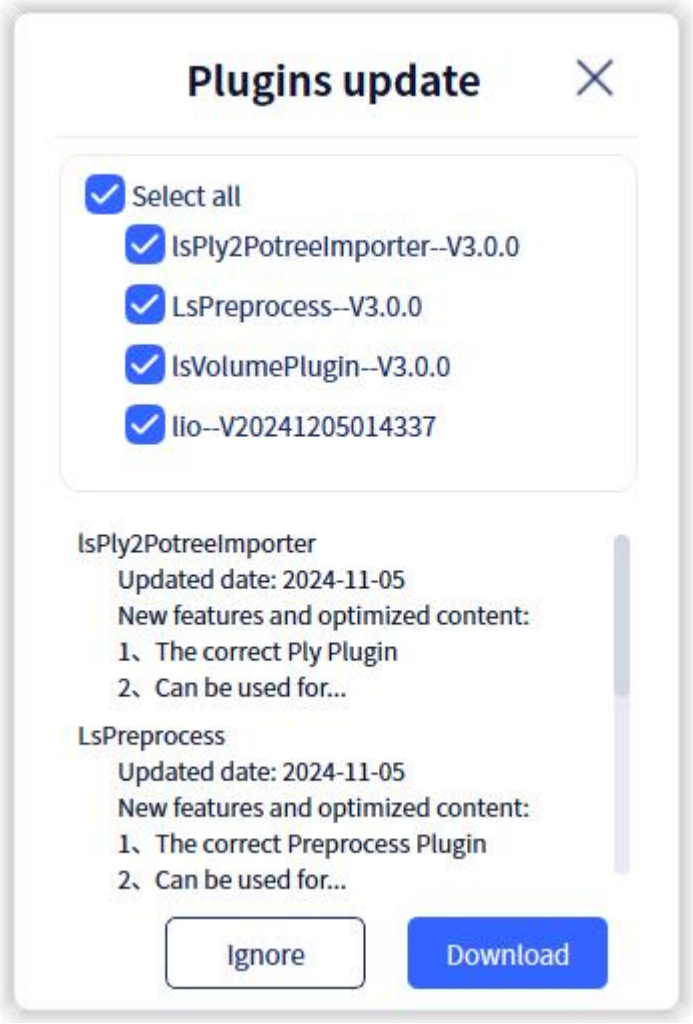
Clicking "Ignore" will prevent the update notification for that version from appearing the next time the software is opened. However, users can still see the update notification in the settings and in the lower left corner of the software. Clicking the close button in the top right corner will cause the update notification to appear again the next time the software is opened.

Users can click on Settings → Update, or click on the update notification in the bottom right corner of the software, to view the current main program update details.



7. Plugins Update

In addition to overall updates, the software also provides updates for individual plugins. For plugin updates, users can choose the specific content they want to update (although it is recommended to update everything).



After making your selections, click download, and the software will automatically download the updated plugins in the background. Once the download is complete, a pop-up will prompt whether to close the software and proceed with the update. Clicking "Yes" will close the current software and begin the update. Clicking "No" will not initiate the update. If you decide to install the new version later, you can go to Settings → Update and click "Install" to proceed with the update.

Note: Please do not perform any other operations during the update process to ensure it proceeds.

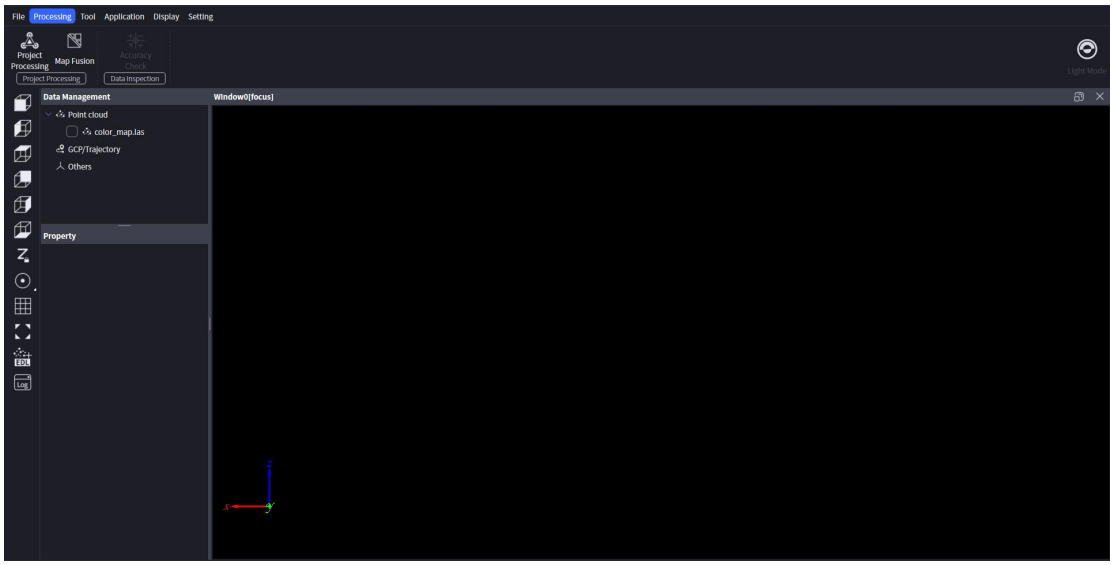
Clicking "Ignore" will prevent the update notification for that version from appearing the next time the software is opened. However, users can still see the update notification in the settings and in the lower left corner of the software. Clicking the close button in the top right corner will cause the update notification to appear again the next time the software is opened.

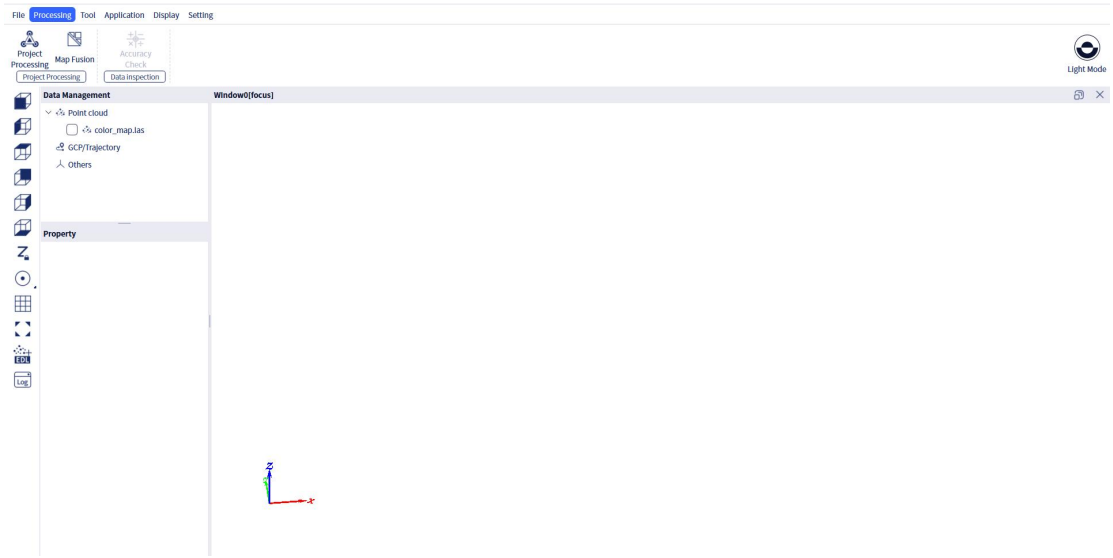
Users can click on Settings → Update → Plugins to view the current plugin update details. By hovering the mouse over the corresponding plugin, users can see detailed update and optimization information. Clicking "Update (Install)" will update the selected plugin. Clicking "Install All" at the top will update all plugins.

(8) 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.



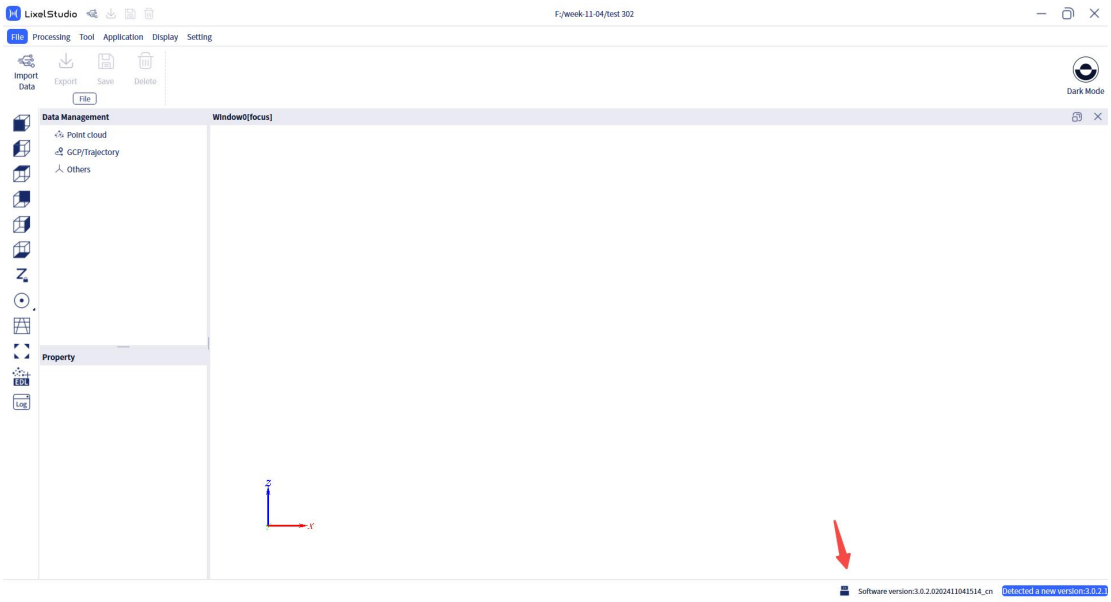


2. Project Direstory

The current Lixel Studio 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.

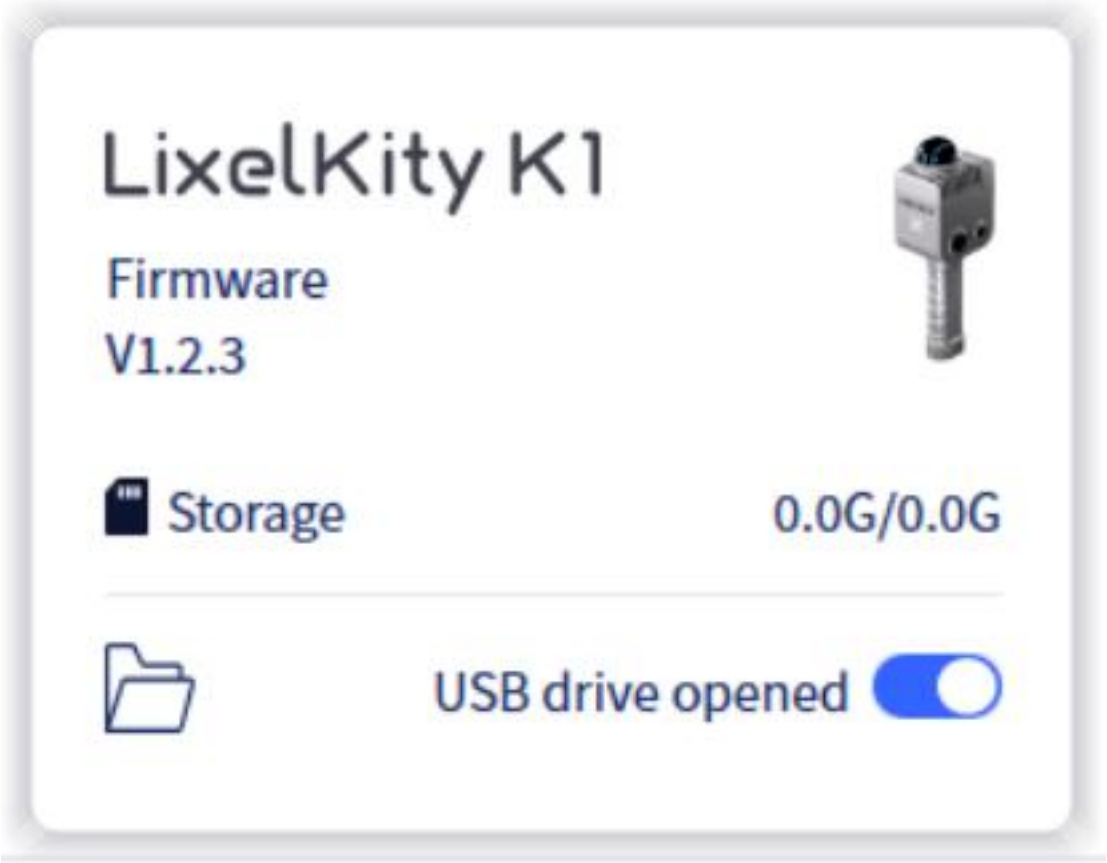


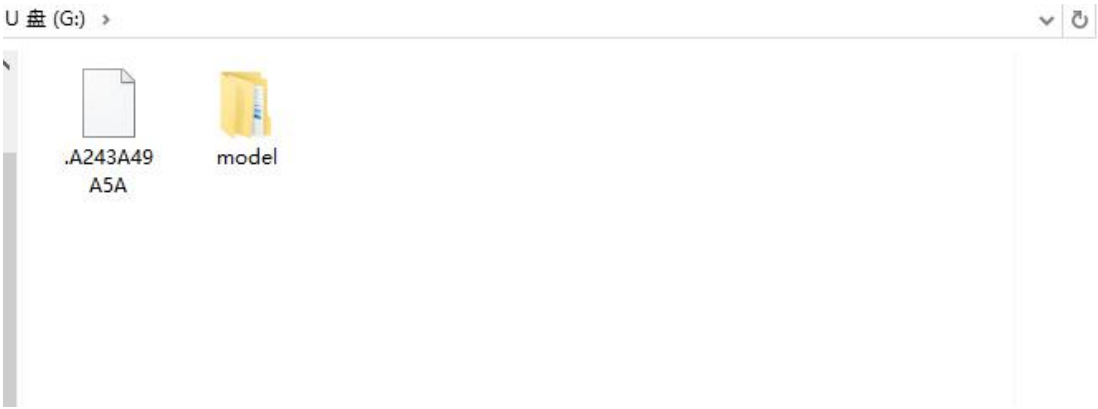
After turning on the XGRIDS handheld scanning device, connect the device to the computer using a USB cable. Wait for about 30 seconds until the USB drive button lights up. If the computer's sound is enabled, there will also be an audio prompt indicating that the device has been successfully connected.

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.

4. Firmware Update

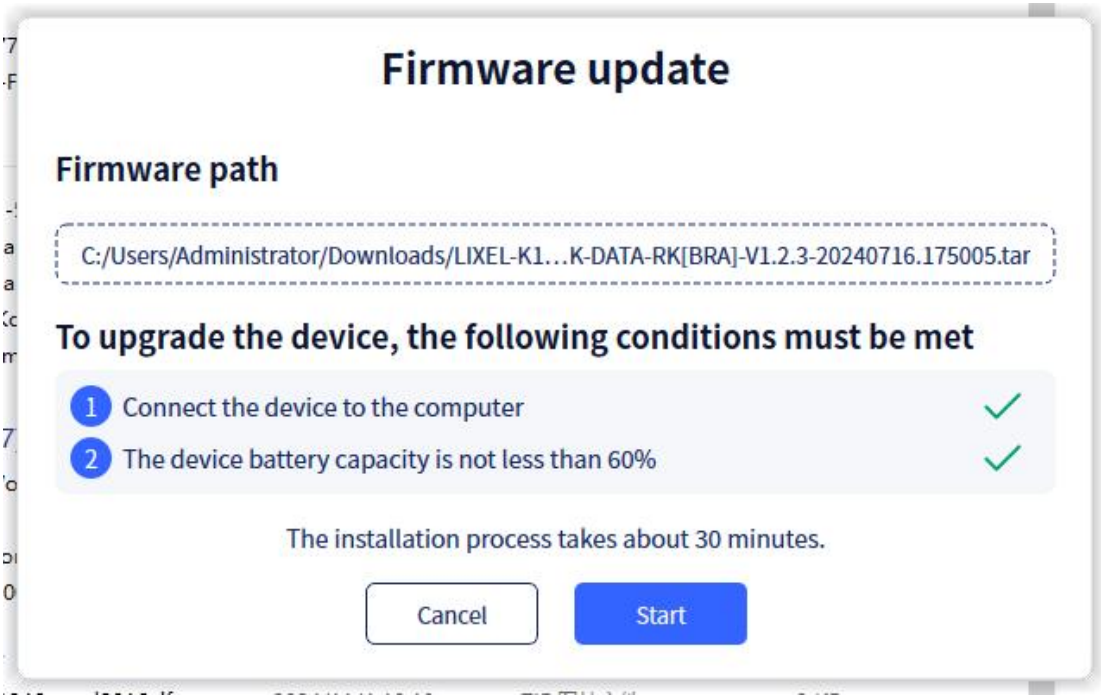
The firmware upgrade feature is used to upgrade the firmware for all handheld scanning devices. After turning on the device and connecting it to the computer using a USB cable, click the device detection button in the bottom right corner and then click the "Update" button to access the firmware update feature.

After clicking the "Update" button, a "Firmware Update" pop-up window will appear. Please note that the firmware update requires the following conditions to be met:

1. The device must be directly connected to the PC running LixelStudio via USB.
2. The device must have a battery level of at least 60%.

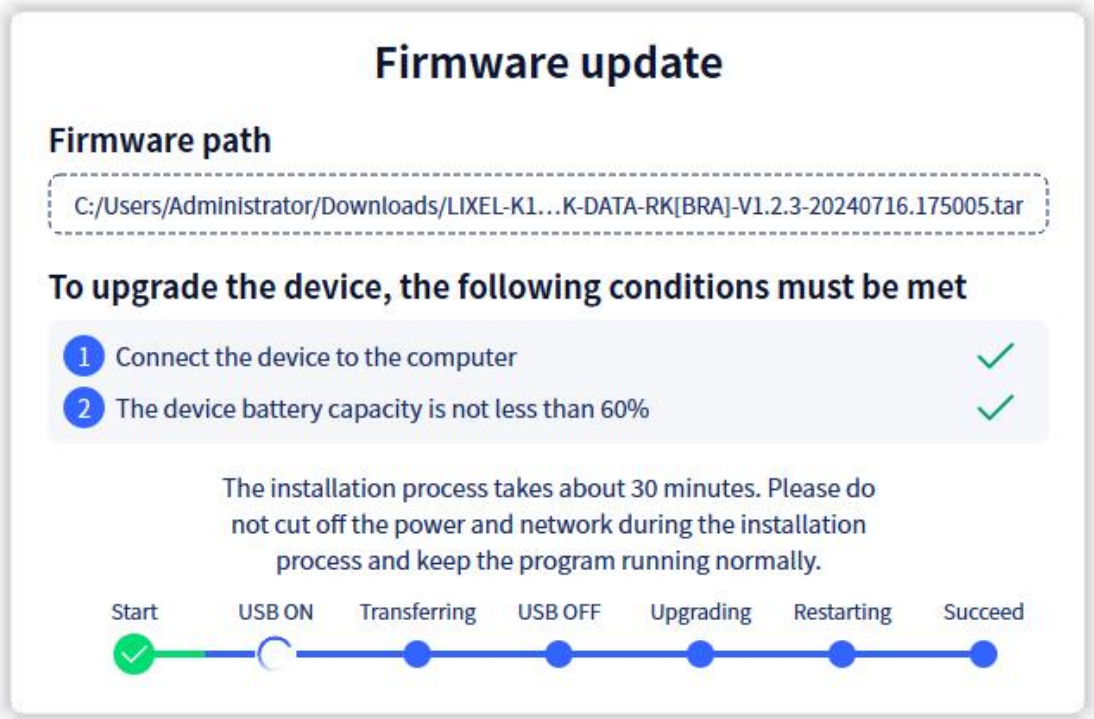
If the device's battery level is below 60%, the firmware update cannot start. Please ensure the device has sufficient battery power before beginning the update.

首先，将需要升级的固件先放置到 PC 计算机本地硬盘上（更新的固件可以从其域创新官网下载）。点击固件地址下方按键，选择对应的固件。



After making your selections, click "Start" to initiate the firmware upgrade process. The installation will take approximately 30 minutes, so please be patient. During the installation, the device will switch between turning on and off USB mass storage mode, which is normal.

Note: During the firmware upgrade process, do not cancel the operation or disconnect the USB cable until the process is either successfully completed or failed.



A pop-up notification will appear indicating that the firmware upgrade was successful.

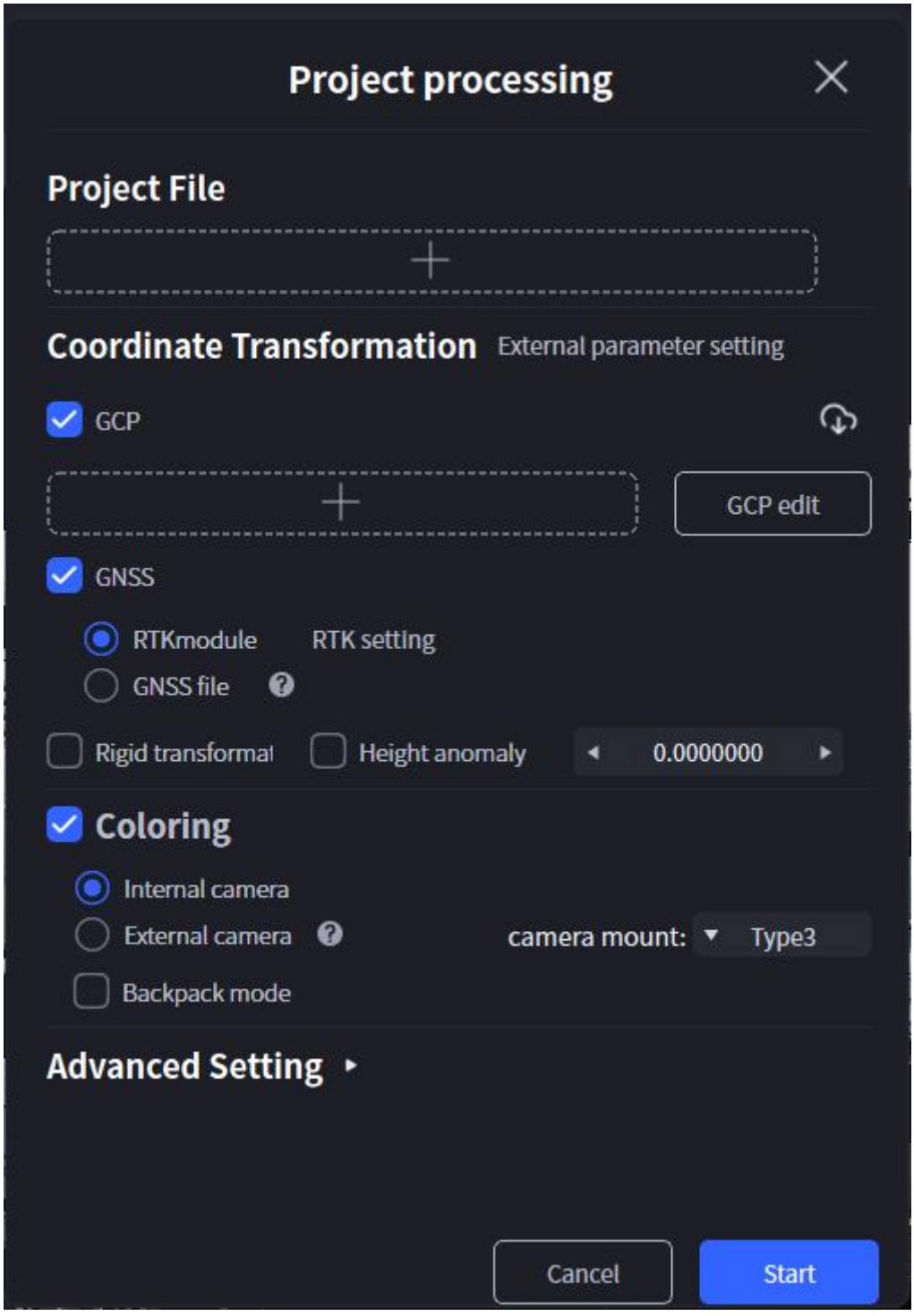
If the upgrade fails, an appropriate error message will be displayed. Please follow the instructions provided in the error message to address the issue. If you have any questions, you can contact technical support for assistance.

VI. Main Functions

(1) Processing

1. Project Processing

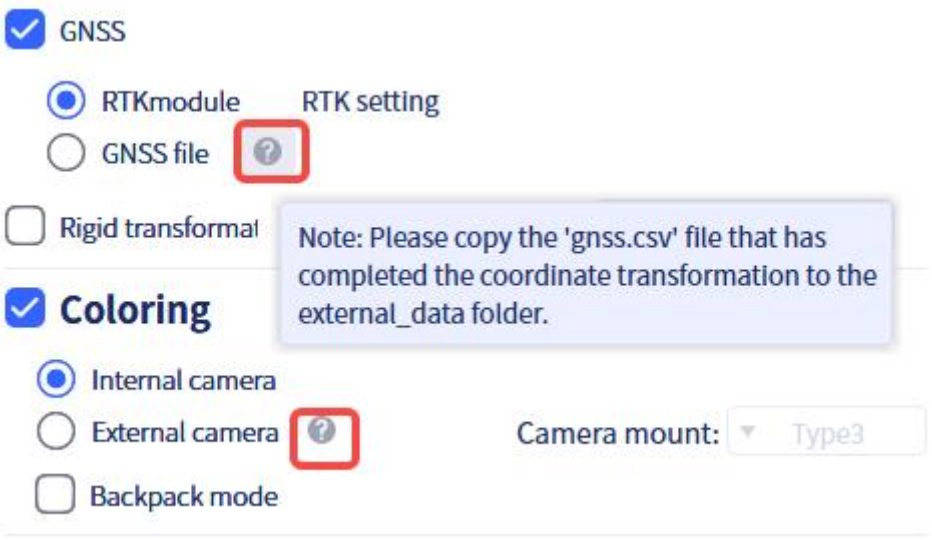
Project processing mainly involves post-processing the raw data obtained from XGIRDS Innovation's handheld scanners L1, L2, L2 Pro, and K1 to obtain the required point cloud data. The project processing module includes functions such as SLAM mapping optimization (e.g., loop closure, dynamic object removal),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



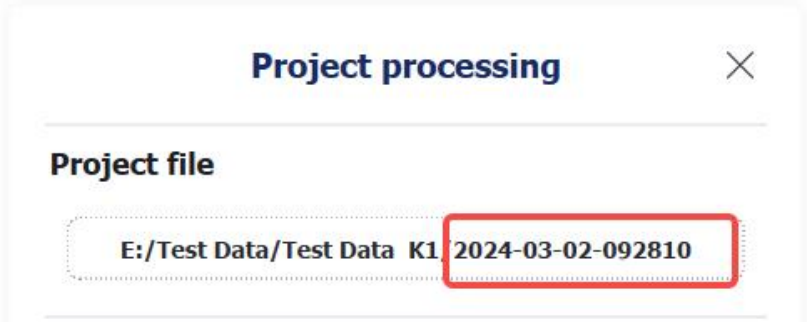
Note: During project processing, please do not perform other operations in the software.

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.

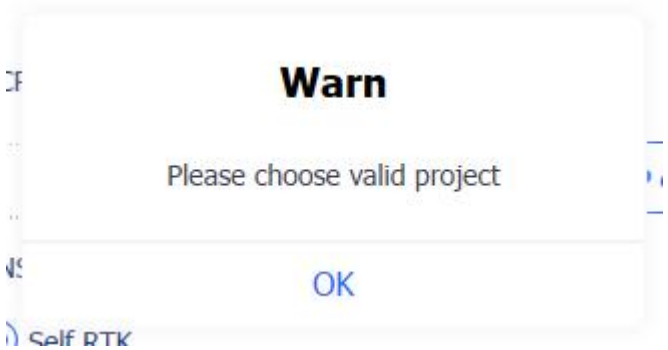


Click "Project File" and select the project data folder to be processed. The project file path should be selected to the corresponding project directory (i.e. the folder copied from the scanning device).

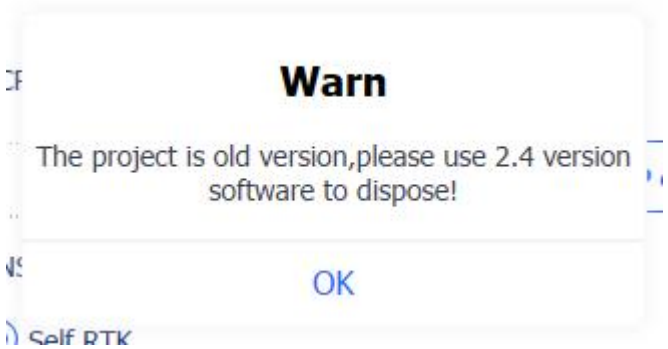


Note: This version of Lixel Studio Project Processing feature only supports processing data for Lixel series handheld scanners, and supports firmware versions 1.4.0 and above for L1 and L2, and supports firmware versions 1.2.0 and above for LK. If the data is previous firmware versions for L1 and L2, please use Lixel Studio 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.



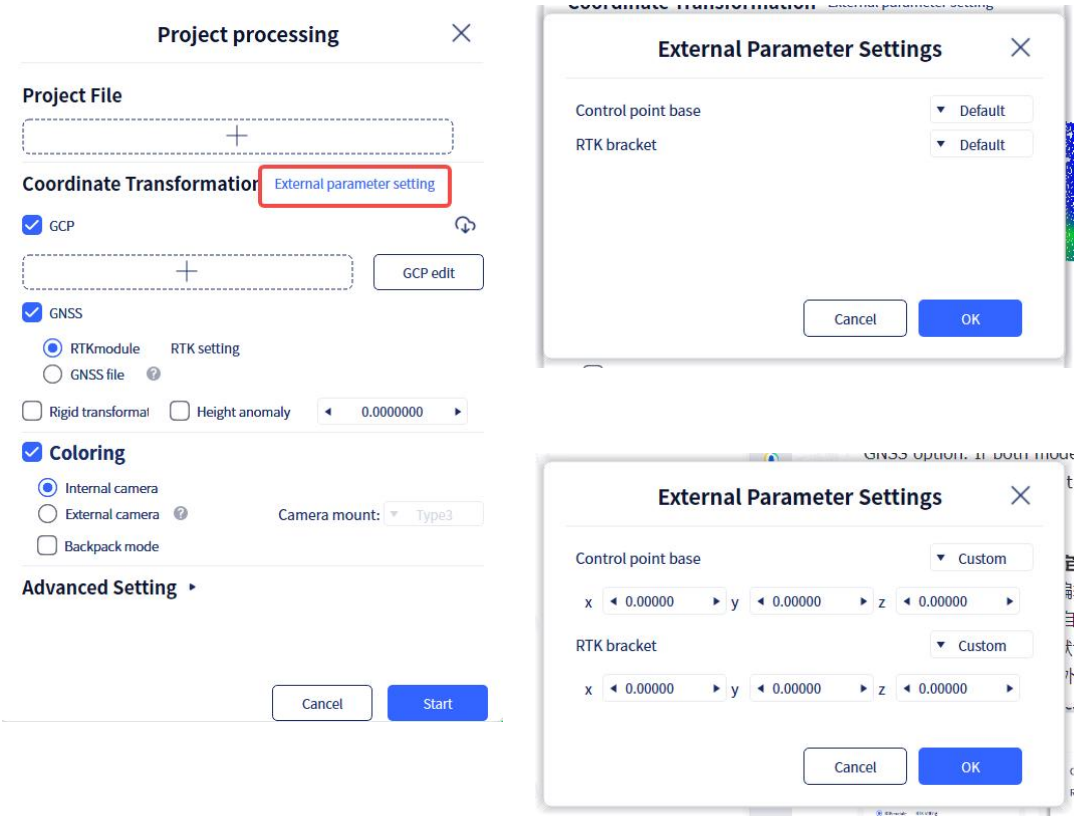
After selecting the project, you can choose the processing options based on specific needs.

1.1 Coordinate Transformation

The coordinate transformation function primarily provides the capability to convert 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.

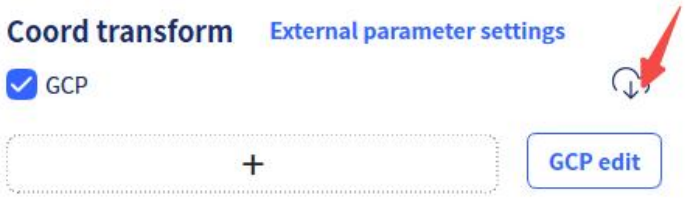


1.1.2 Ground Control Points

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.

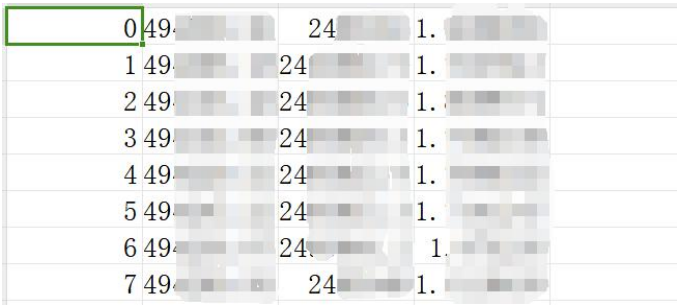
This function not only converts the point cloud data from a relative coordinate system to an absolute coordinate system but also uses the constraint information of the control points to improve the accuracy of SLAM mapping, resulting in higher precision point cloud data.

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.

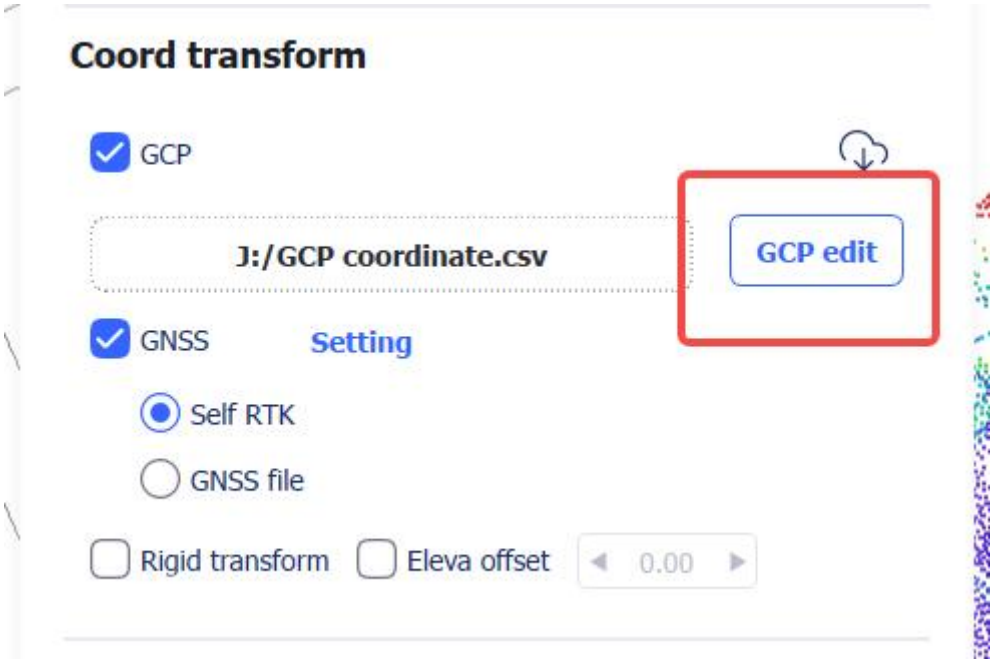


Note:

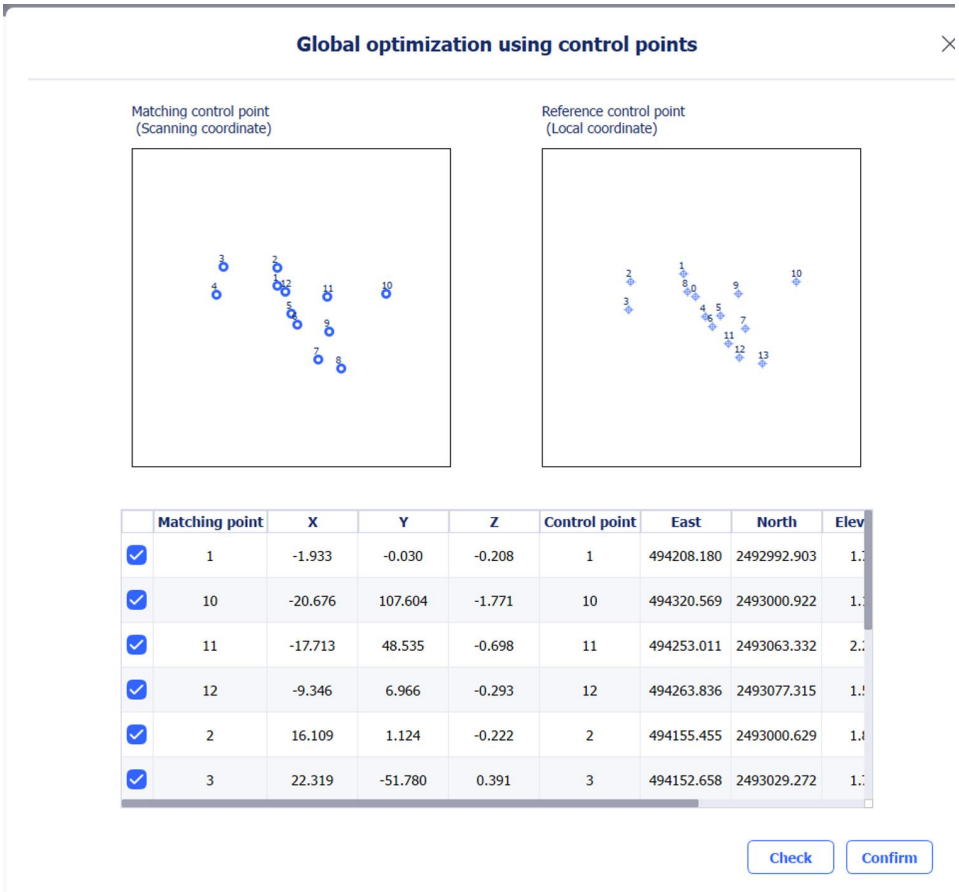
- The extension of the .xls table file cannot be directly modified to .csv . It needs to be saved in csv format, otherwise it will cause the data to be unable to read normally.
- **Note that the point name needs to match the control point number recorded on the LixelGO app, otherwise it will cause control point conversion errors.**



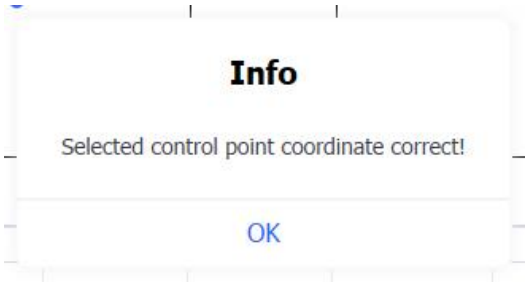
0	49	24	1.
1	49	24	1.
2	49	24	1.
3	49	24	1.
4	49	24	1.
5	49	24	1.
6	49	24	1.
7	49	24	1.

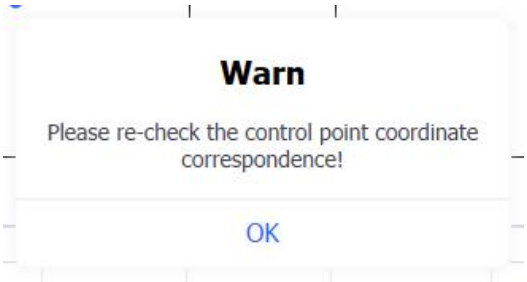


2. Click the GPC edit button on the right to open the control point edit window.The left side of the interface displays the coordinates where your Lixel handheld device marked the points (the default coordinate system is the scanning coordinate system), and the right side shows the true value coordinates 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 which coordinates will be used in the control point transformation.

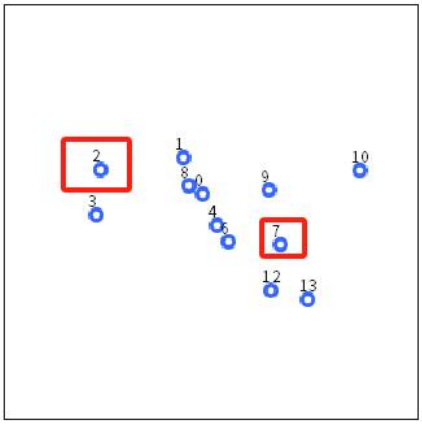


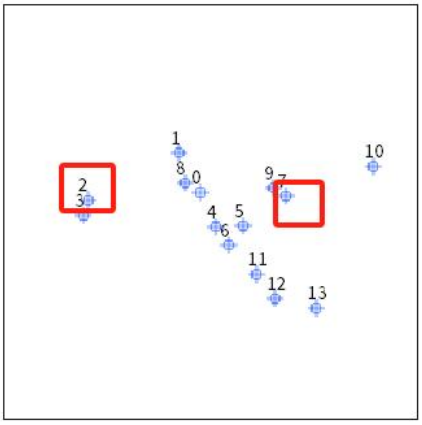
3. Click "Check" and the software will automatically verify the correspondence between the control points. If the control points are correct, it will display "Selected control point coordinates are correct." The user can then click "Confirm" to exit the control point edit window. If there is an error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

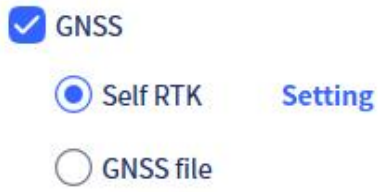
6. After confirmation, click "Confirm" to return to the engineering processing interface. Upon completing the engineering processing, a control point accuracy report will be output in the "Report" folder within the project directory.

XGRIDS

Control point accuracy report

Point name	Error on plane	Error on elevation	Error on space
0_1	0.000	0.000	0.000
0_10	0.000	0.000	0.000
0_11	0.001	0.000	0.001
0_12	0.000	0.000	0.000
0_2	0.005	0.001	0.005
0_3	0.002	0.000	0.002
0_4	0.002	0.000	0.002
0_5	0.002	0.000	0.002
0_6	0.001	0.000	0.001
0_7	0.001	0.000	0.001
0_8	0.001	0.000	0.001
0_9	0.001	0.000	0.001

1.1.3 GNSS



1. XGRIDS RTK

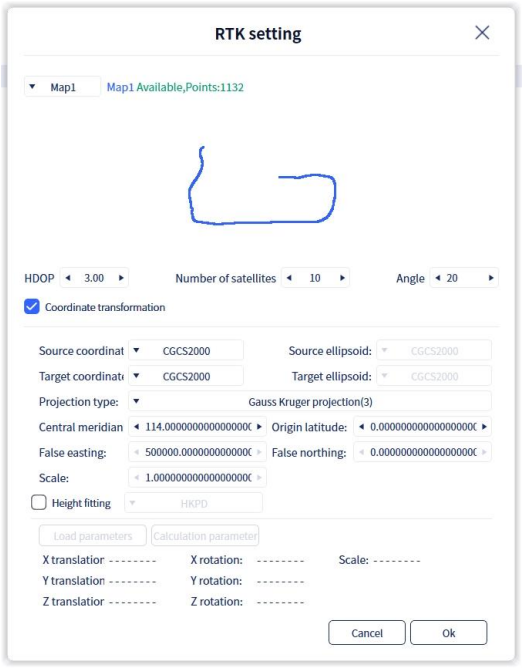
If the RTK module of XGRIDS is used for scanning, you can check the RTK option. After checking, you can click on Settings to enter the RTK setting module and edit the RTK data.

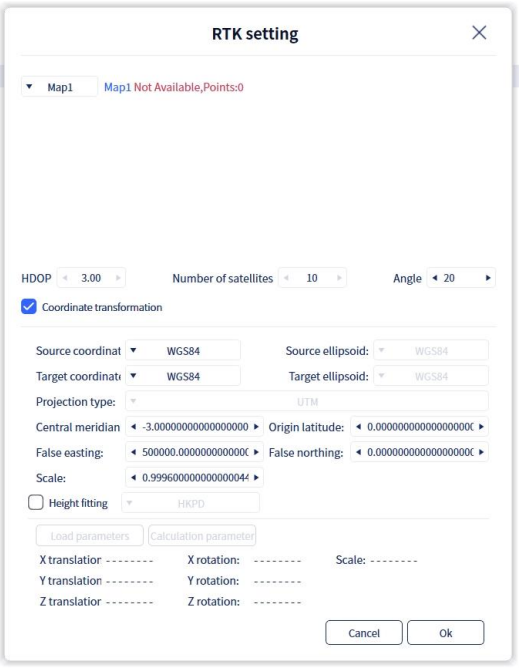
The RTK setting module mainly includes adjusting the parameters of the acquired RTK data to adjust the GNSS data involved in SLAM mapping and coordinate conversion.

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 GNSS data. Try not to affect the distribution, ensuring it remains evenly spread across the entire trajectory. If the GNSS 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.

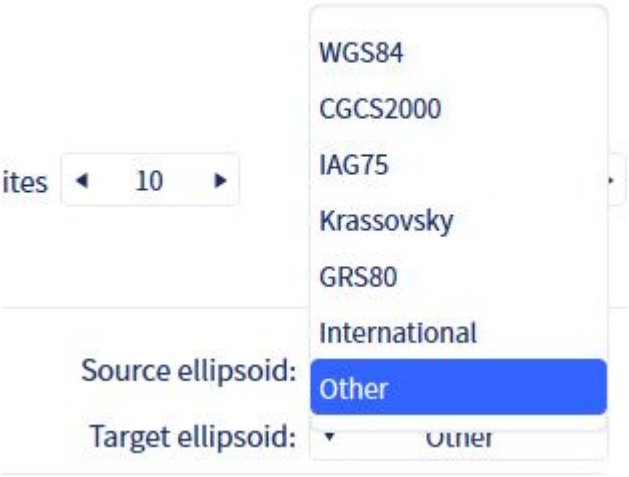
While making adjustments, pay attention to whether the data in the top left corner of the window is in a usable state. If it shows a red unusable state, it indicates that the effective GNSS data under the current parameters is less than what the software requires for calculation. In this case, you need 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, normal coordinate transformation cannot be performed.



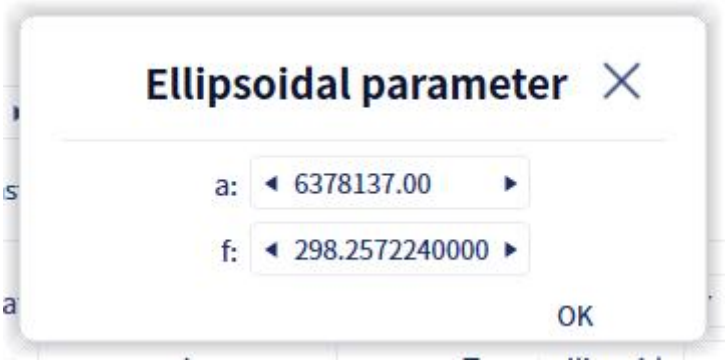


If you need to perform coordinate transformation on the acquired data, make sure to check the coordinate transformation box. Be sure to select the source coordinate system, source ellipsoid, target coordinate system, target ellipsoid, central meridian (degrees), east offset, and latitude origin (degrees) according to the actual situation.

Currently, the supported coordinate systems include CGCS2000, WGS84, ITRF2008, XIAN80, BEIJING54, HK1980, MountEden2000, NZTM2000, JGD2011, KGD2002, and Other. The supported ellipsoids include CGCS2000, WGS84, IAG75, Krassovsky, GRS80, International, and Other ellipsoids.

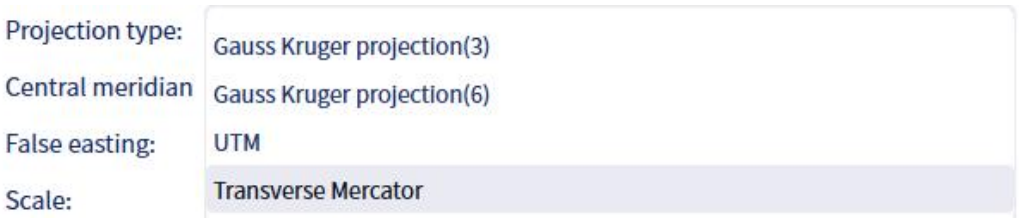


When users select a custom ellipsoid, they need to input the ellipsoid's semi-major axis (a) and 1/f (where f is the ellipsoid flattening).



Note: To ensure the accuracy of the coordinate transformation, be sure to select the correct coordinate system, ellipsoid, and projection.

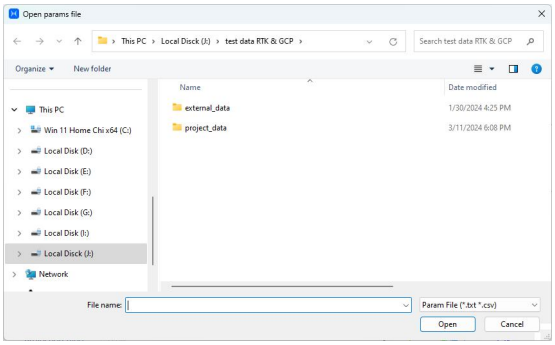
If the coordinate transformation involves the same ellipsoid (i.e. Source ellipsoid and target ellipsoid are the same), the software will perform the projection coordinate transformation based on the projection parameters set by the user. Currently, the software supports Gauss-Kruger 3° and 6° zones, UTM projection, and transverse Mercator projection. Users can select the appropriate option according to their actual situation.

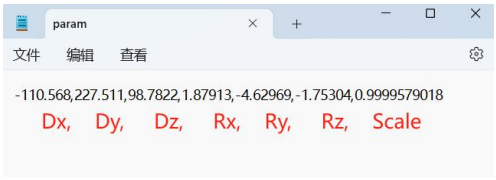


If the transformation involves different ellipsoids, the user needs to input the

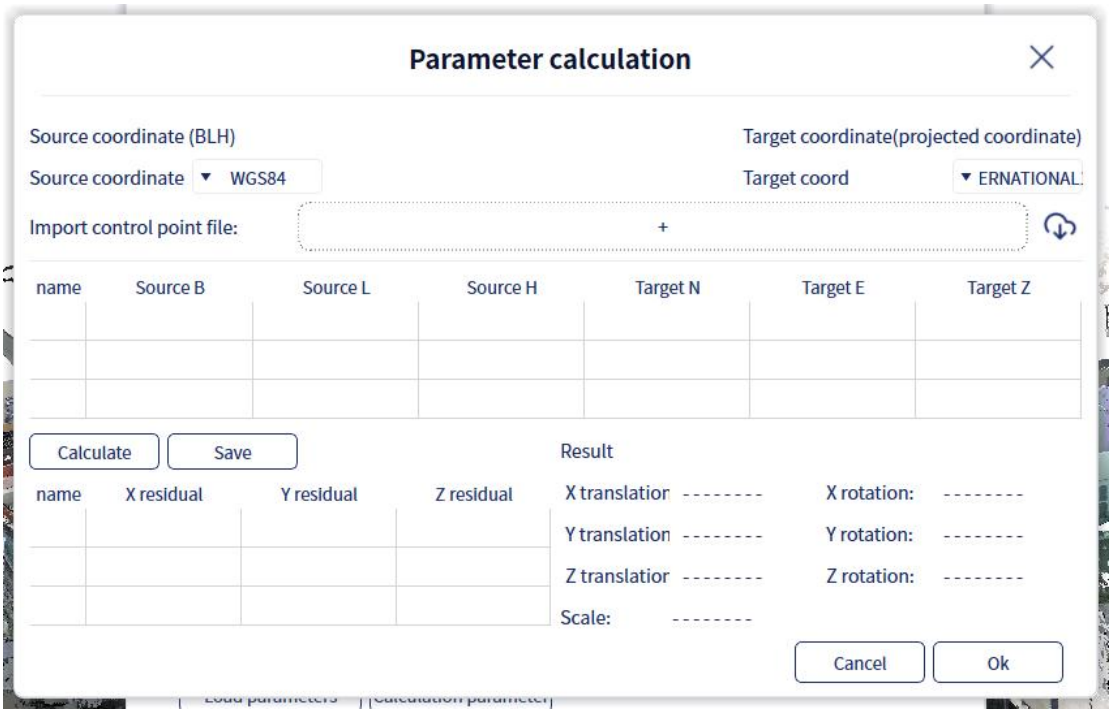
corresponding seven parameters to perform the transformation; otherwise, the coordinate transformation cannot be performed.

If the user has known seven-parameter data, they can click "Load Parameters" and select the corresponding seven-parameter file. Currently, the software supports files in txt or csv format. The data must include seven parameters, namely three translation parameters, three rotation parameters, and one scale parameter: Dx, Dy, Dz, Rx, Ry, Rz, Scale.



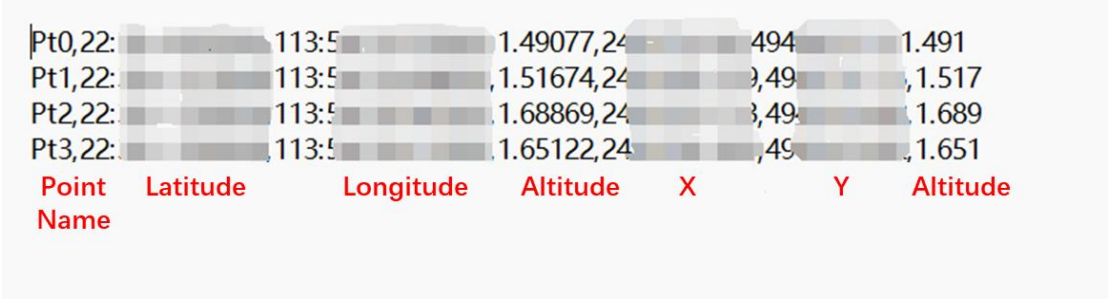


If you do not have the seven parameters, you can calculate them based on the existing control points. Click "Calculate" to open the seven-parameter calculation interface.

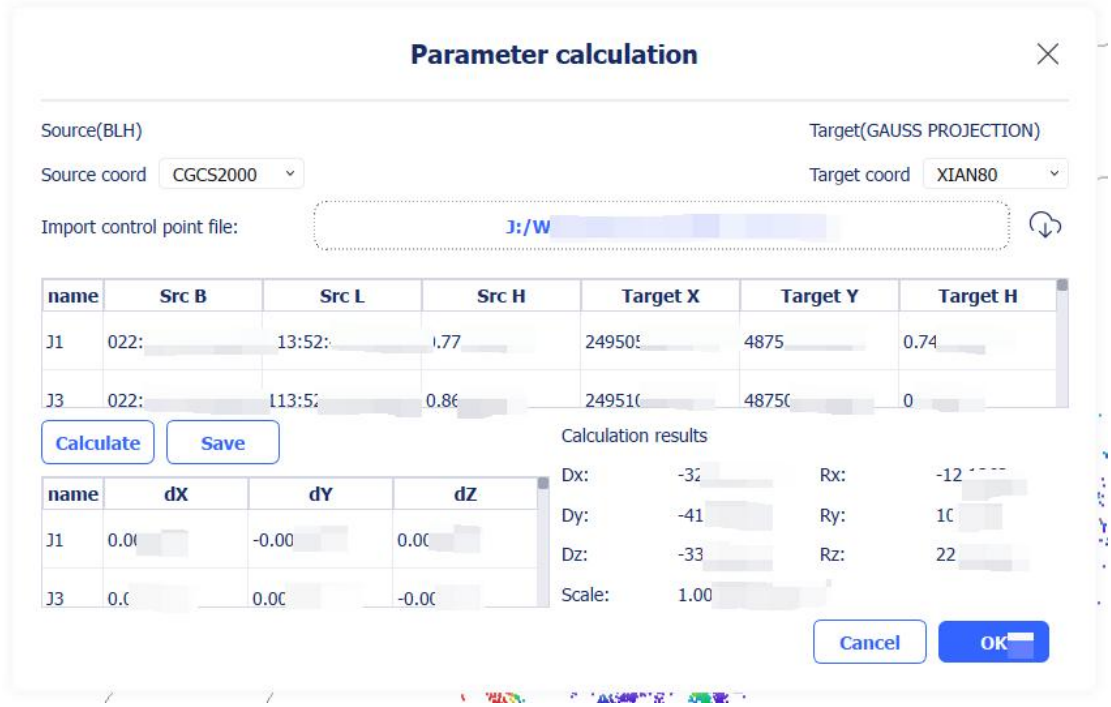


Click the "Import File" button to import the control point file needed for calculating the seven parameters. The file format supports ".csv" or ".txt" formats. The specific data includes: Point Name, Latitude (degrees:minutes:seconds) [e.g., 121:32:11.235], Longitude (degrees:minutes:seconds), Elevation, Projected Plane Coordinate X, Projected Plane Coordinate Y, and Elevation.

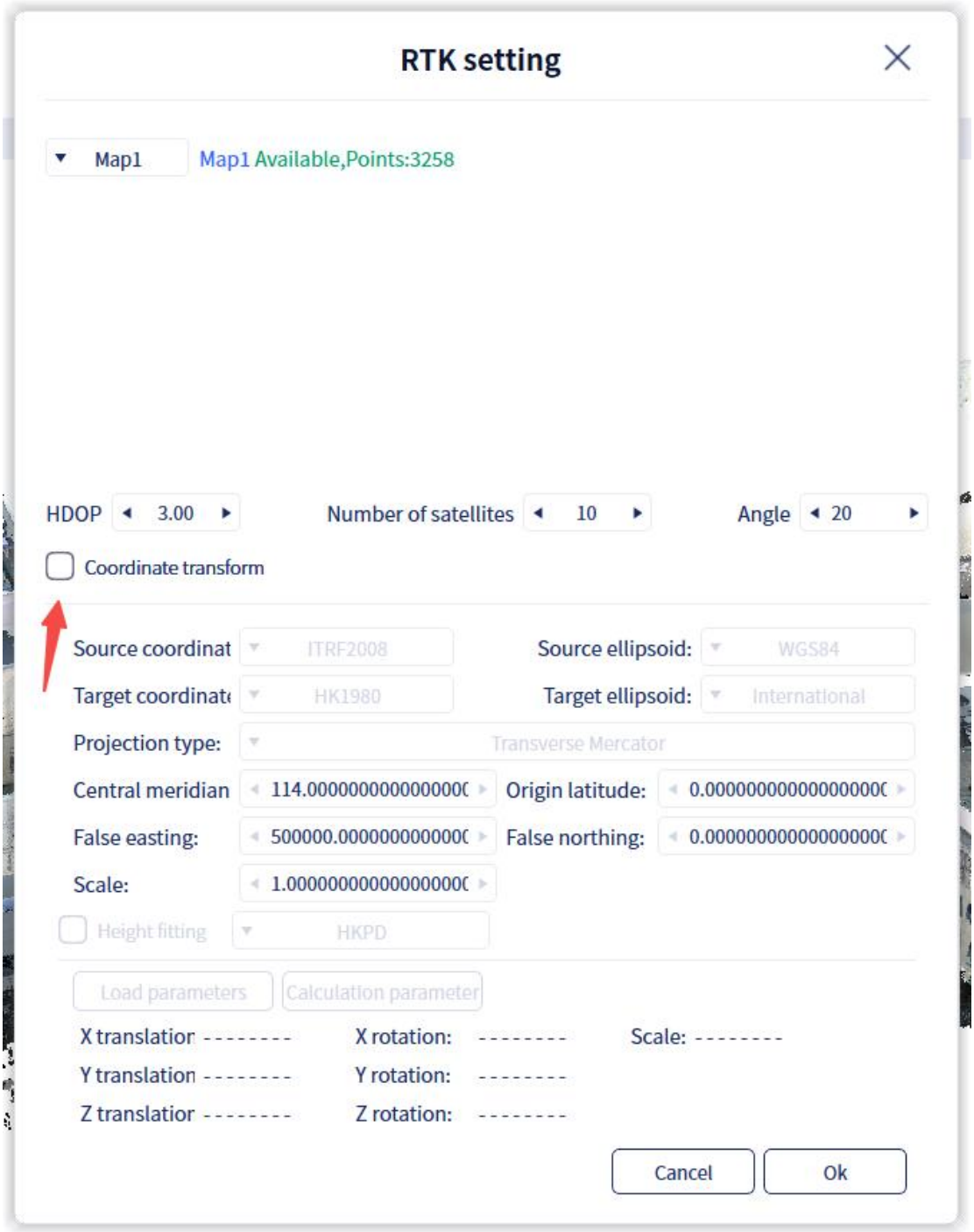
Note: At least three or more valid control points are required to ensure the effectiveness of the seven-parameter calculation. The specific data format is shown below. You can click the button next to it to download the template.



After importing the file, click "Calculate" to perform the seven-parameter calculation. Click "Save" and choose a save path to save the calculated seven parameters. After clicking "OK," the calculated seven parameters will be applied to the coordinate transformation.



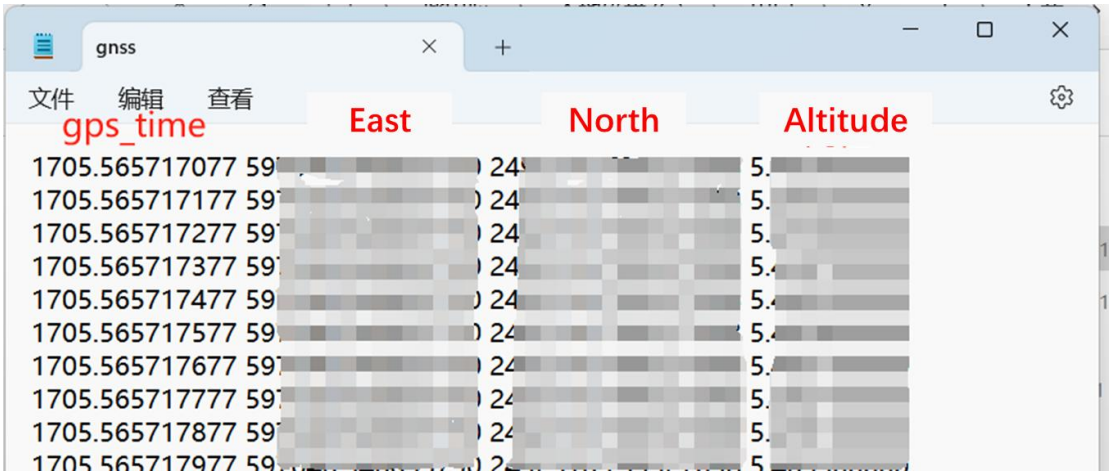
Note: If the conversion option is not selected in the current interface (as shown below), the software will calculate based on the user's RTK account settings. For example, if the account port is selected as CGCS2000, the point cloud result will be projected based on the actual local central meridian. If the account selects WGS84, ITRF2008, or custom, the point cloud result will be projected based on the actual local central meridian using UTM projection.



The height fitting function has added three models: Hong Kong Principal Datum (HKPD) for the Hong Kong area, NZGD2016 and AUCKHT1946 for New Zealand, KNGEOID18 for Korea, and GSIGEO2011 for Japan. Users surveying in these regions can directly obtain latitude, longitude, and ellipsoidal height under the WGS84 ellipsoid using real-time kinematic (RTK) methods. The software can automatically convert ellipsoidal height to orthometric height through elevation fitting. Users from these areas could use this function according to their needs and conditions.

2. **GNSS files**

If users need to convert 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 conversion. After conversion, save the newly converted 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 conversion. The converted gnss.csv format is gps_time east coordinate, north coordinate elevation, as shown in the figure below.

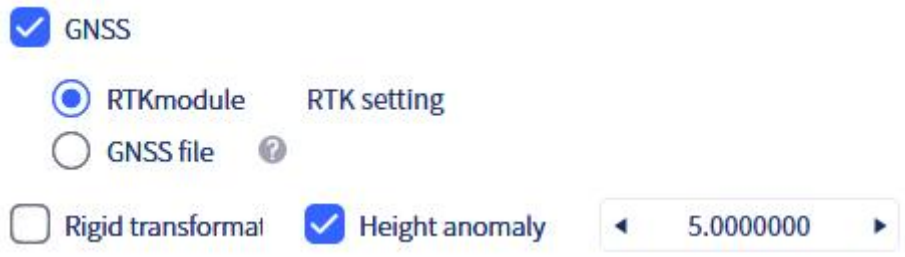


c. **Rigid Transformation**

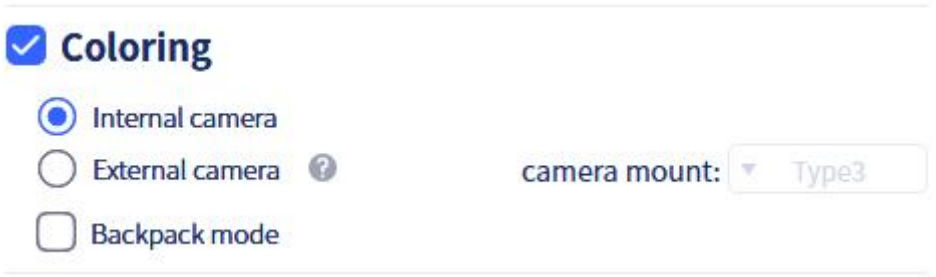
If you check "Rigid Transformation," the external control points or GNSS information will only be used for the rigid transformation of the point cloud and will not be used for SLAM mapping optimization. For those who require high accuracy in point cloud data, it is recommended not to check this option.

d. **Height Anomaly**

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



1.2 Coloring

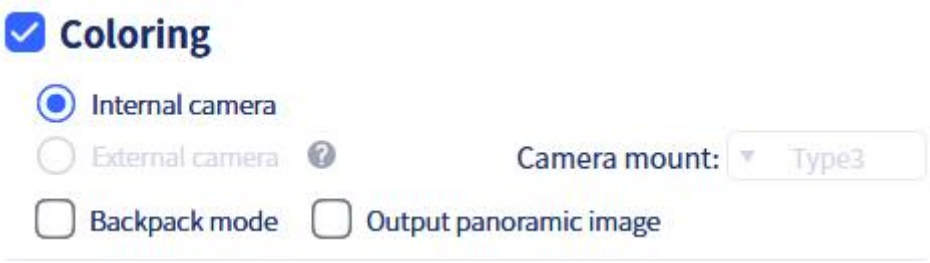


The coloring function mainly uses image data from the built-in camera or external panoramic camera to color the point cloud, obtaining point cloud data with true color information. If you choose external panoramic camera coloring, you need to simultaneously start recording with the external panoramic 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 K1 and L2 Pro devices, if you need to generate panoramic images or use the panorama overlay function, please make sure to check the "Output Panoramic

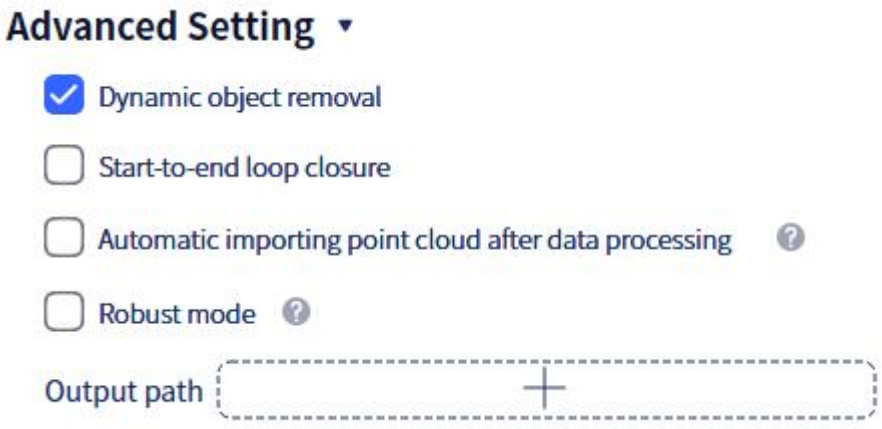
Images" option. After processing, the corresponding panoramic images will be generated in the result folder.



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, Auto Load Point Cloud After Data Processing, and Robust 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 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.

1.3.4 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.

1.3.5 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.

1.3.6 Output path

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

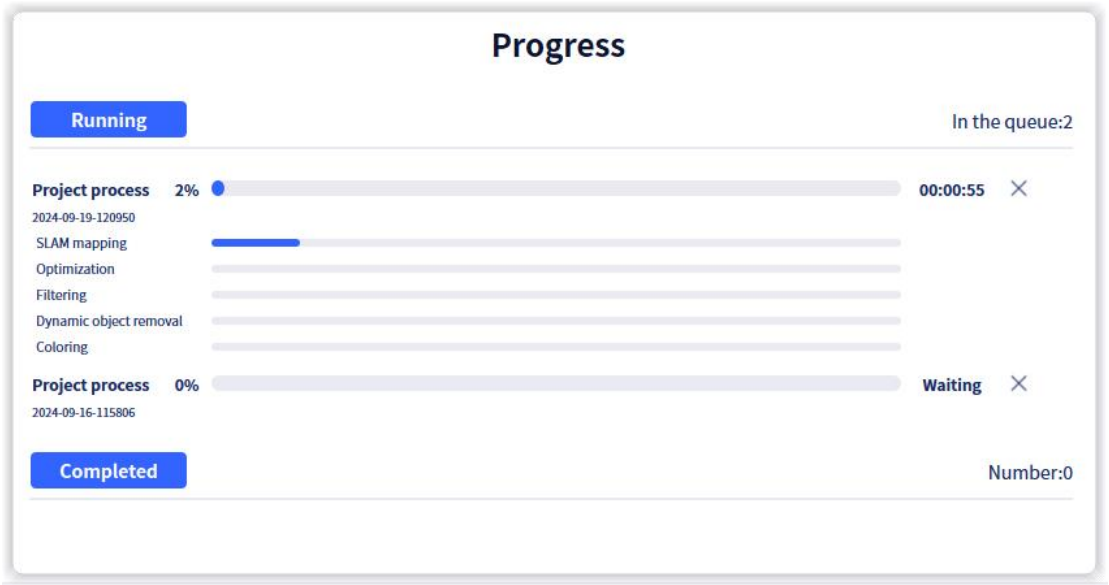
1.3.7 Progress task queue

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).

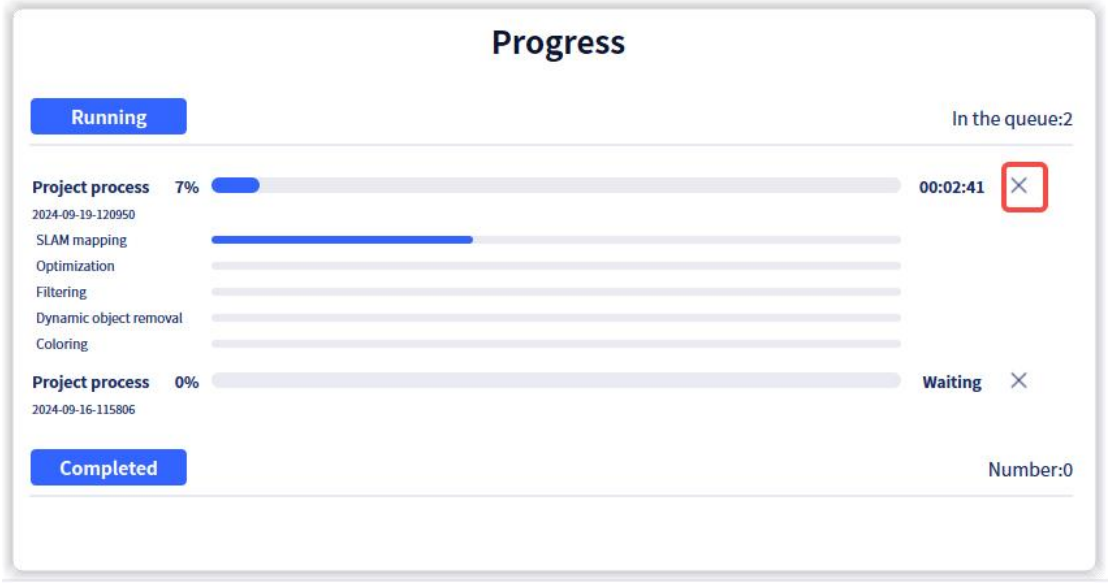
Users can select different options for different processing tasks according to their actual needs. After selecting the options, click "Start," and the software will immediately begin the processing task. The corresponding project processing tasks will be automatically added to the task queue and processed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

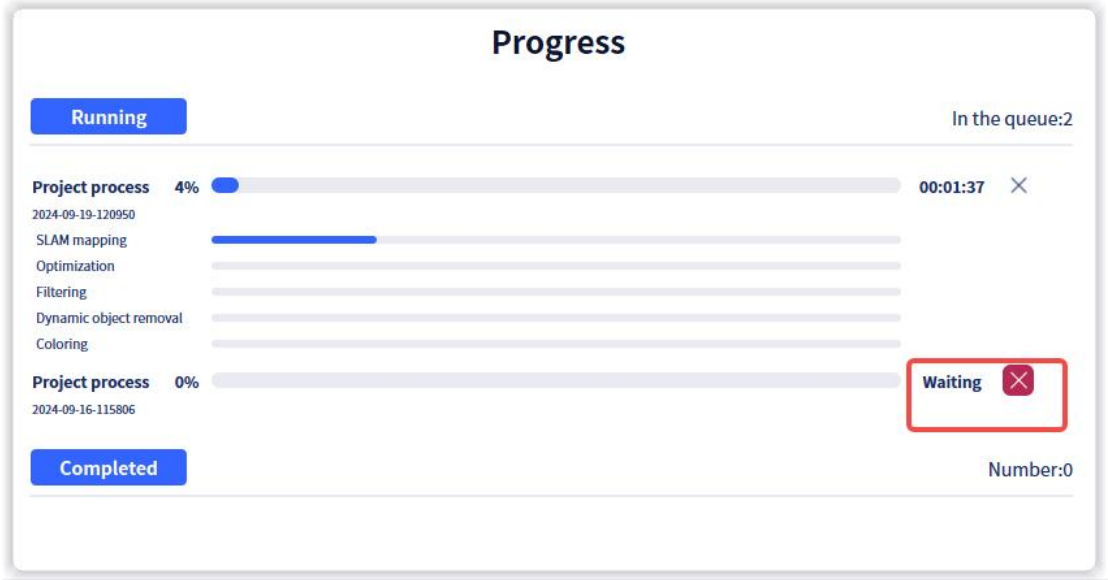


XGRIDS

Projecet Processing Result Report

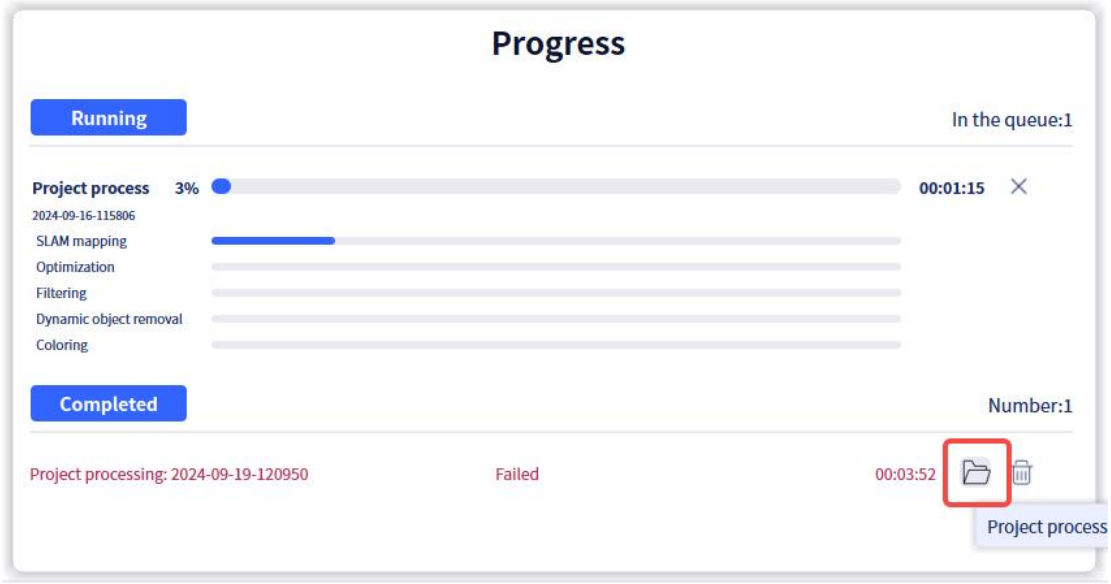
Project name	2024-09-19-120950
Create time	24-09-23:18:22:54
Start time	24-09-23:18:22:54
End time	24-09-23:18:26:46
Processing content	SLAM mapping Optimization Filtering Dynamic object removal Coloring
Result	Fail
Failed step	SLAM mapping
Failed reason	Cancelled by user

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.

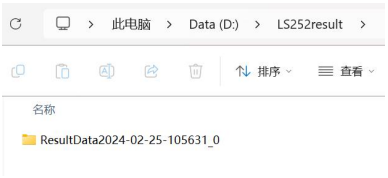
Clicking the folder icon on the right side will open the processing results folder. Clicking the delete icon on the right side will remove the project from the completed list.

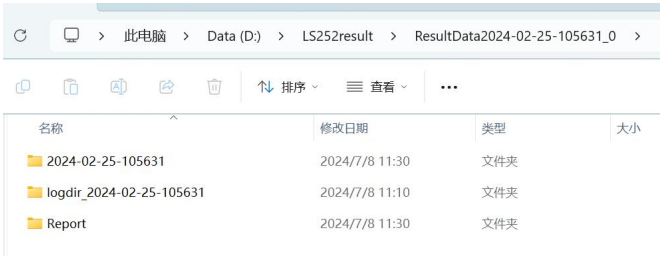


1.3.8 Saving path of project processing

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, 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 conversion accuracy report (if the control point coordinate conversion 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.

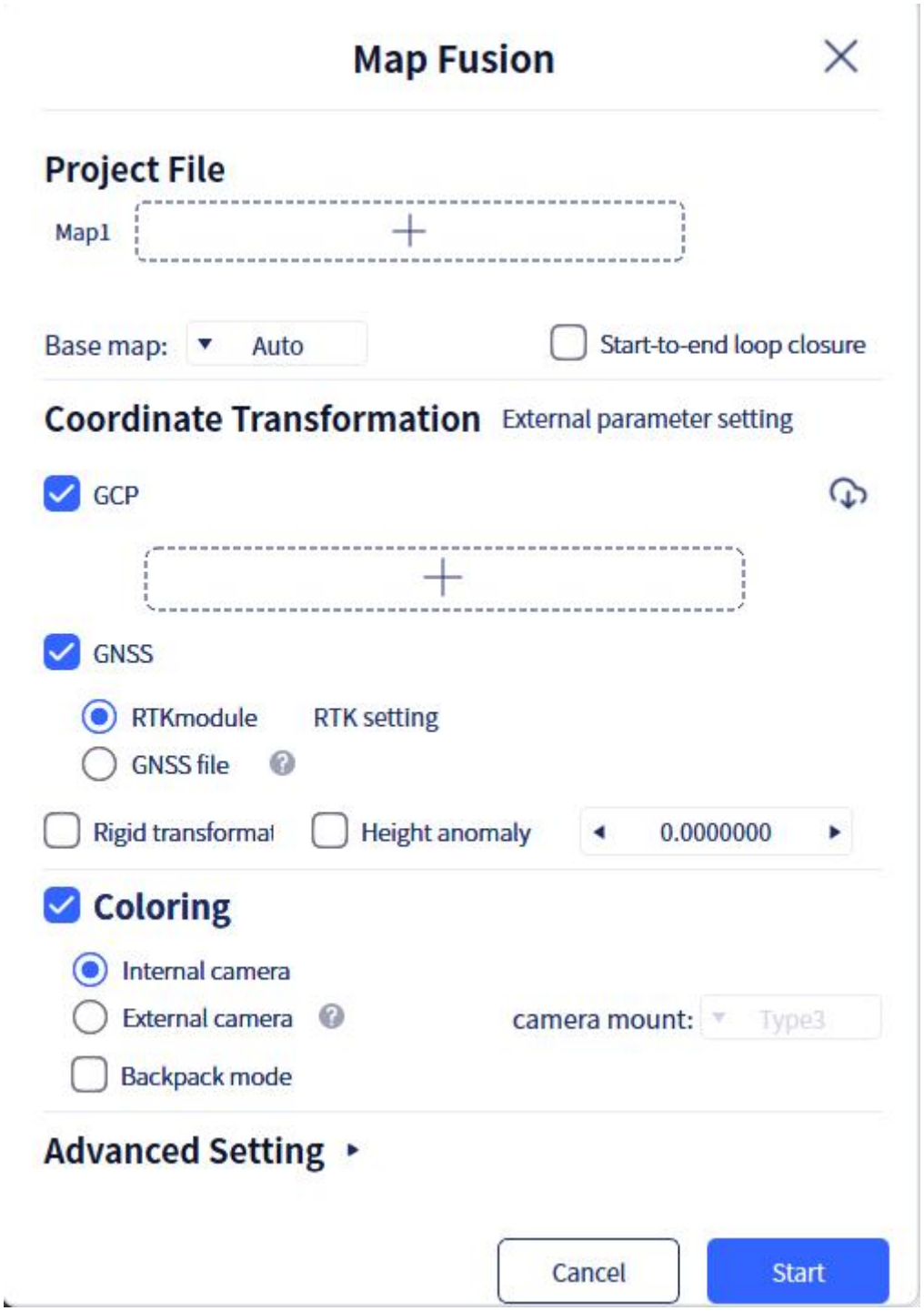
c. If colorization is required, all files to be colorized need to use the same coloring mode. For example, all projects use the internal camera for coloring, and all data use the external panoramic camera for coloring.

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

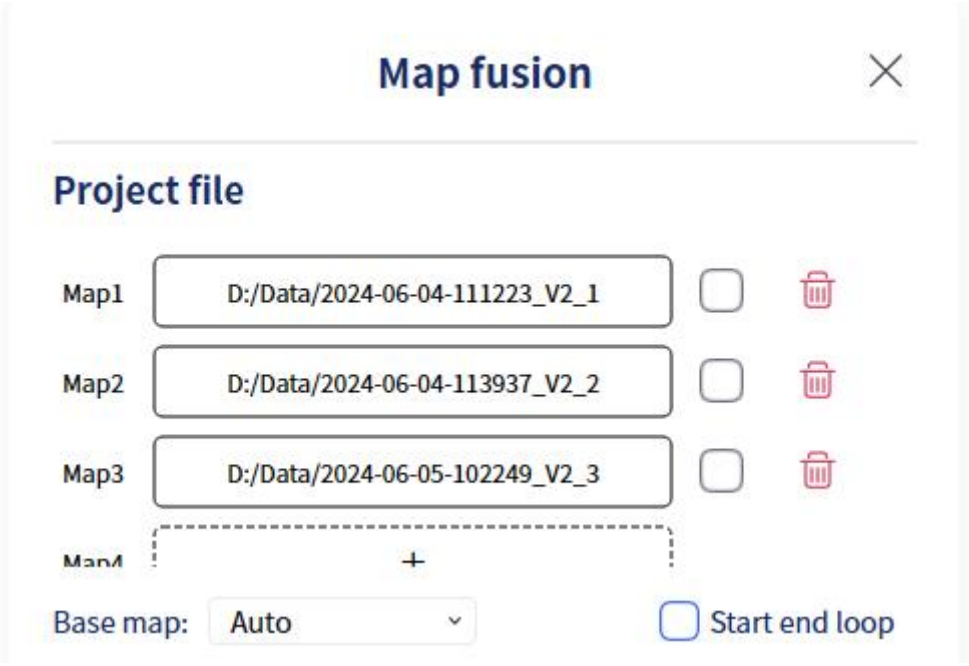
Map fusion supports using the four methods (RTK, GCP, connection point, and resume scanning mode) in a mixed manner, as long as at least one method is used between two projects.

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 much 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.



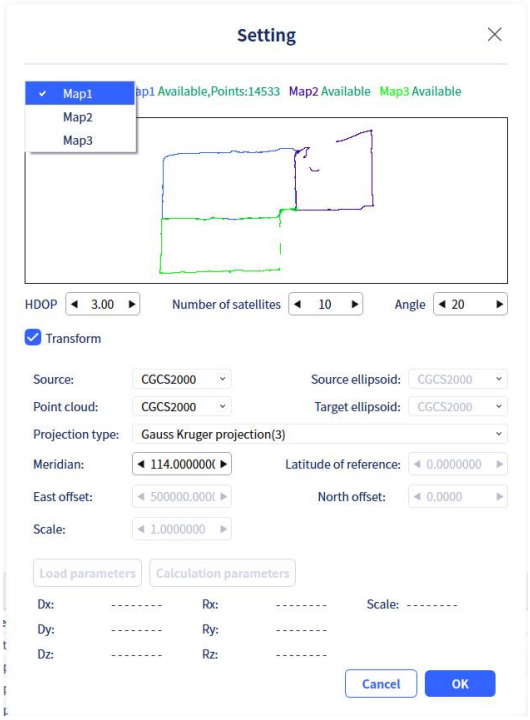
According to the actual situation of the project, check whether each map was scanned in an start-to-end closed loop manner. If so, please check.

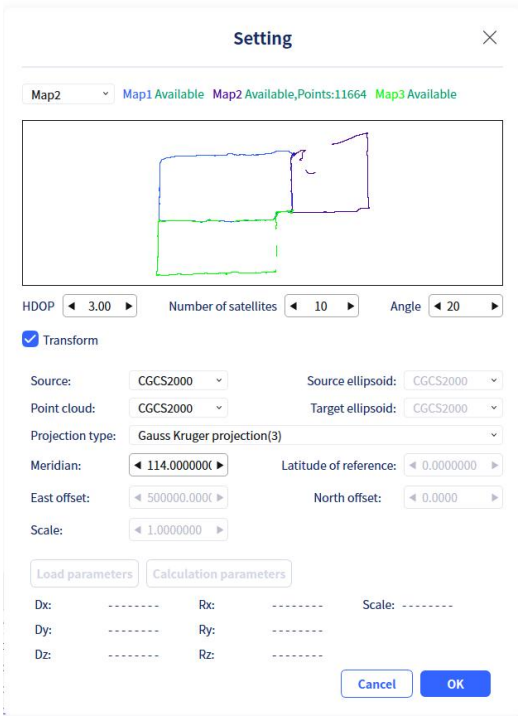
Based on the actual project situation, select the reference map. If "Auto" is selected, the first map in the list will be used as the reference map by default.

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 system conversion 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 conversion 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.

Multi-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 color the collected 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.

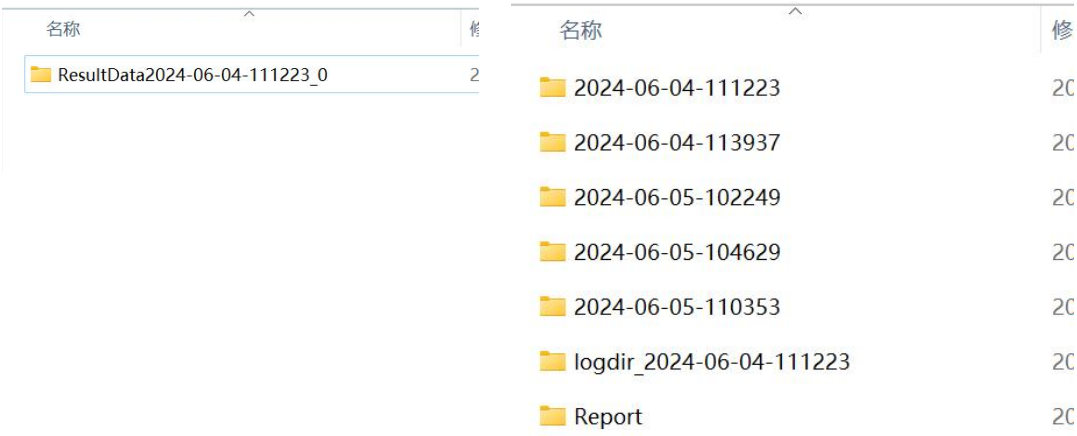
Note: Please select correctly according to the actual collection situation. Incorrect selection will lead to coloring errors or even failure. Therefore, please choose carefully based on the actual situation.

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

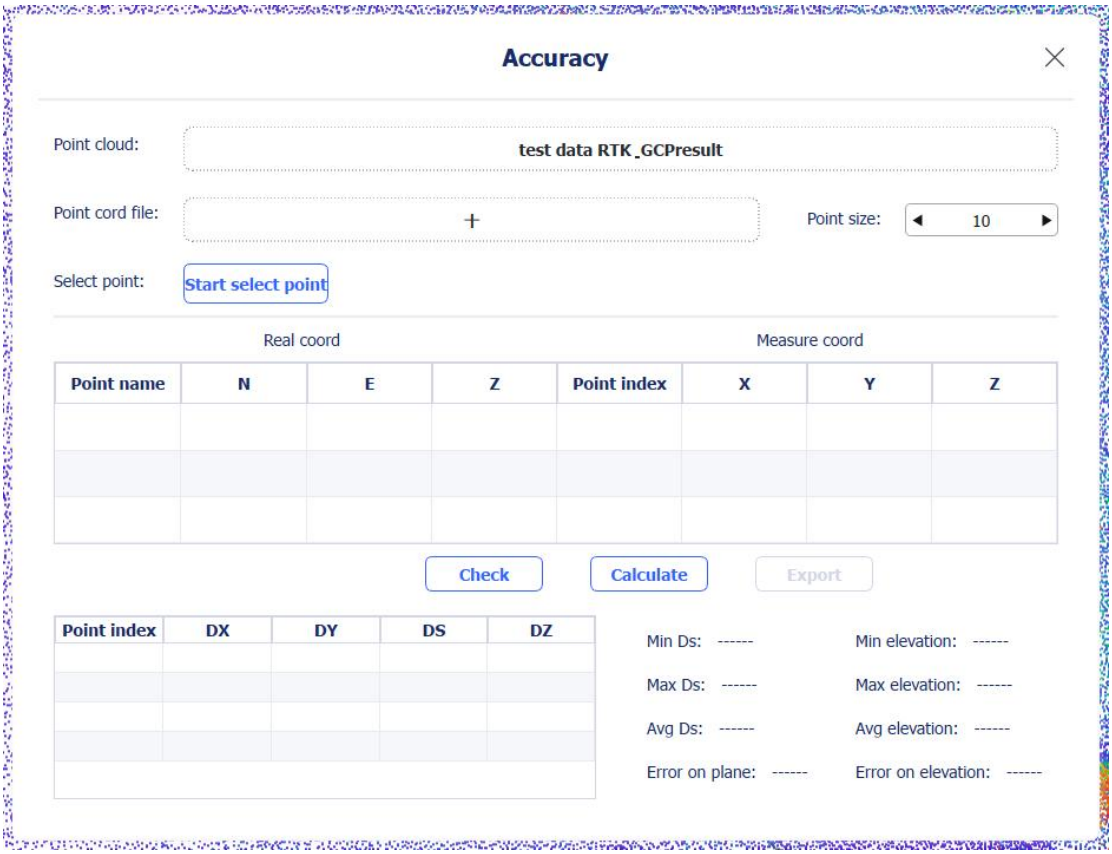
If the output path is not specified in the advanced settings, the map fusion result file will be saved in the current LS project folder by default; if the output path is specified, the result folder will be saved in the corresponding path. The result folder will be saved under the name " **ResultData 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 conversion (if the control point coordinate conversion is checked).



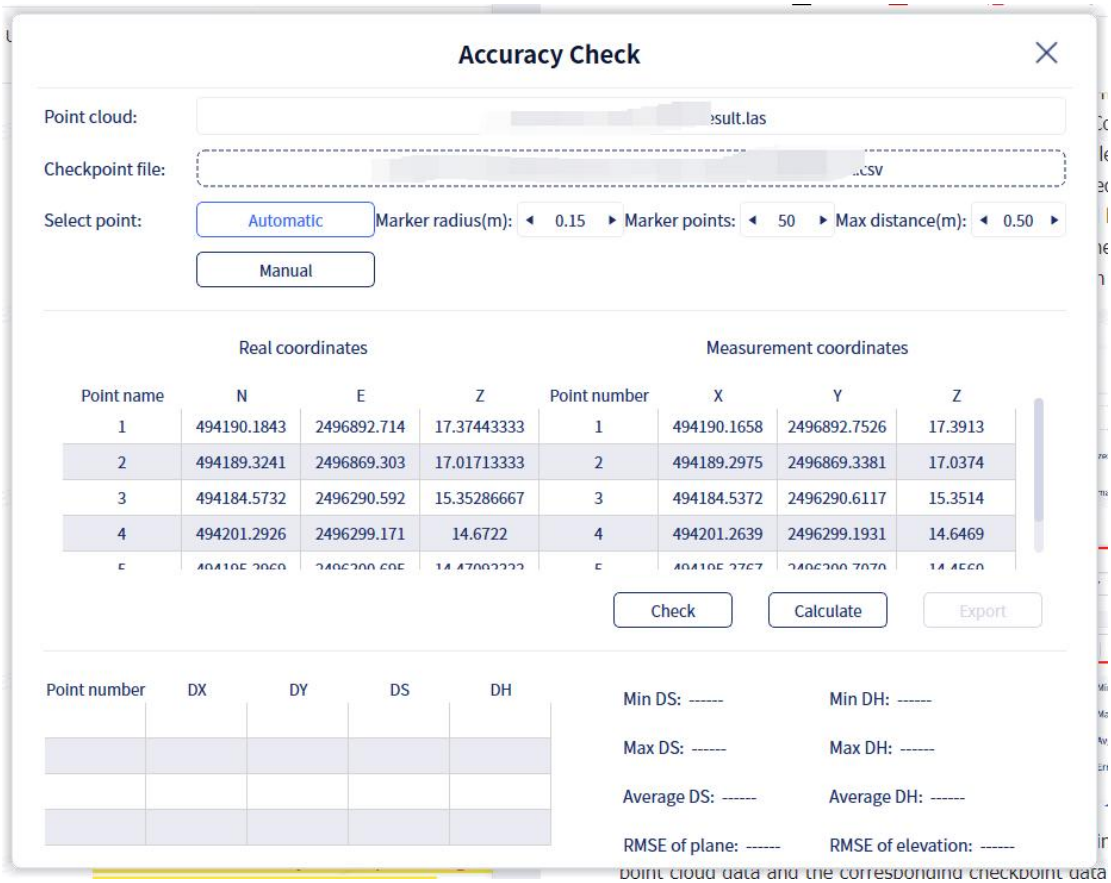
3. Accuracy Check

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:

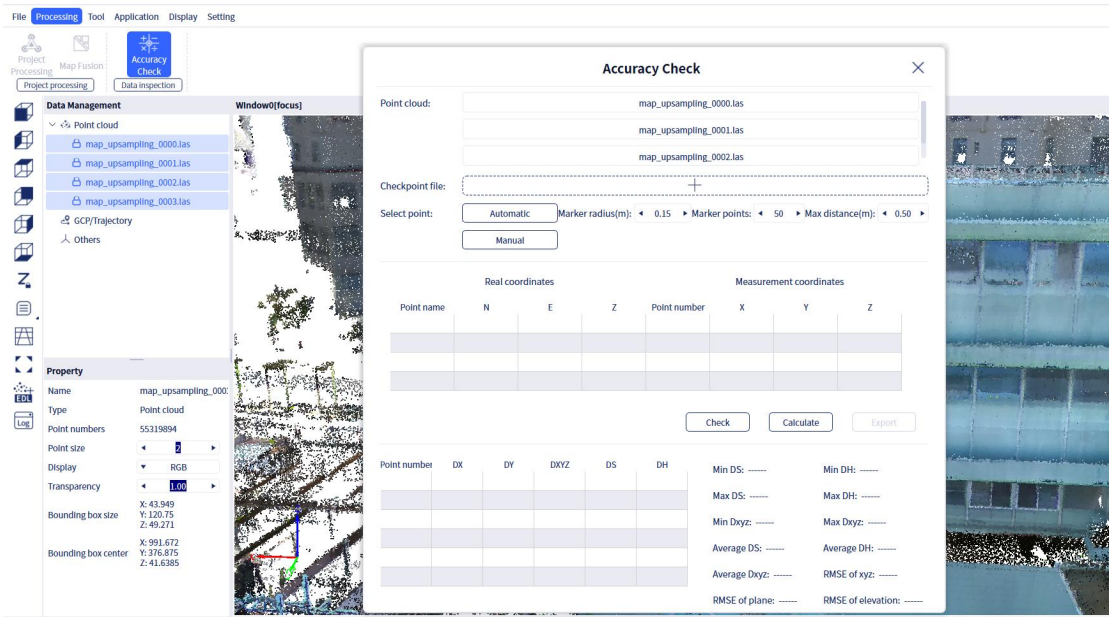


3.1 Automatic Point Selection

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.



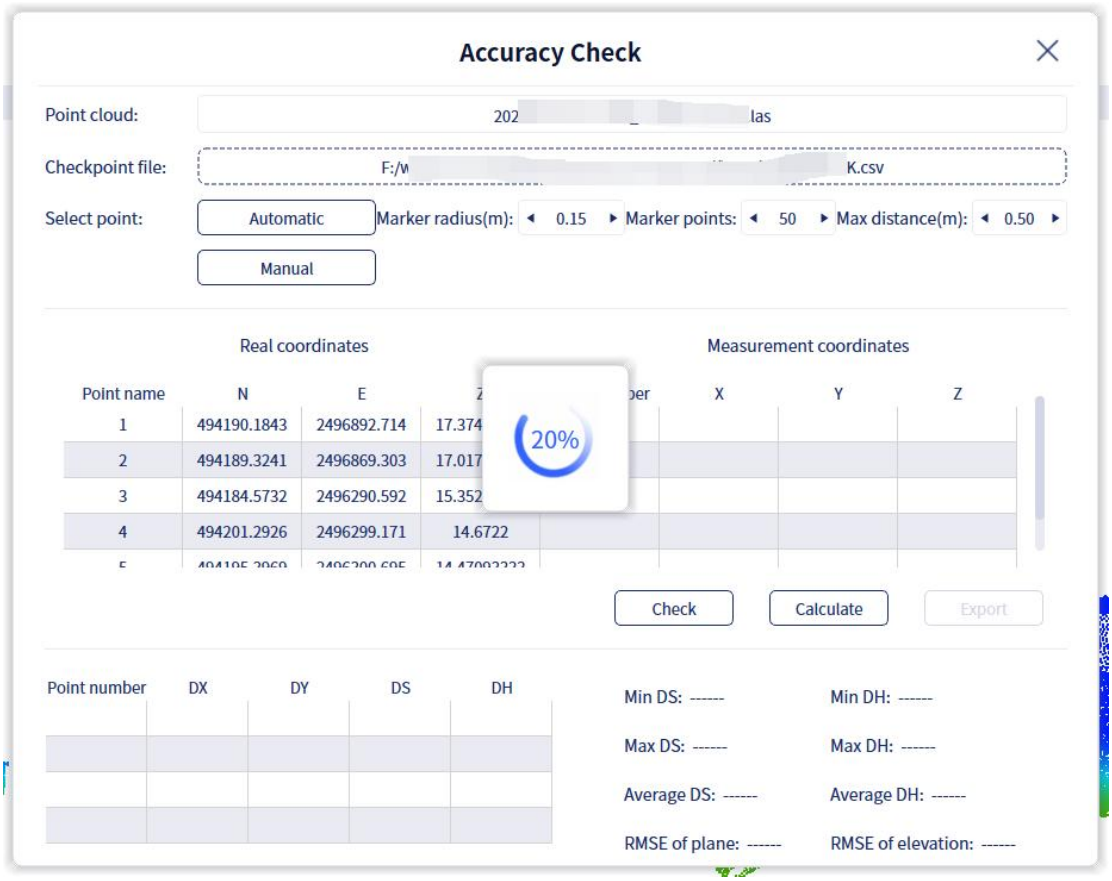
The software supports Accuracy Check for individual point clouds as well as for multiple data sets enhanced by L2 Pro. In the left data panel, select the multiple data sets that need accuracy verification simultaneously, and click "Accuracy Check" in the toolbar to perform verification on multiple data sets.

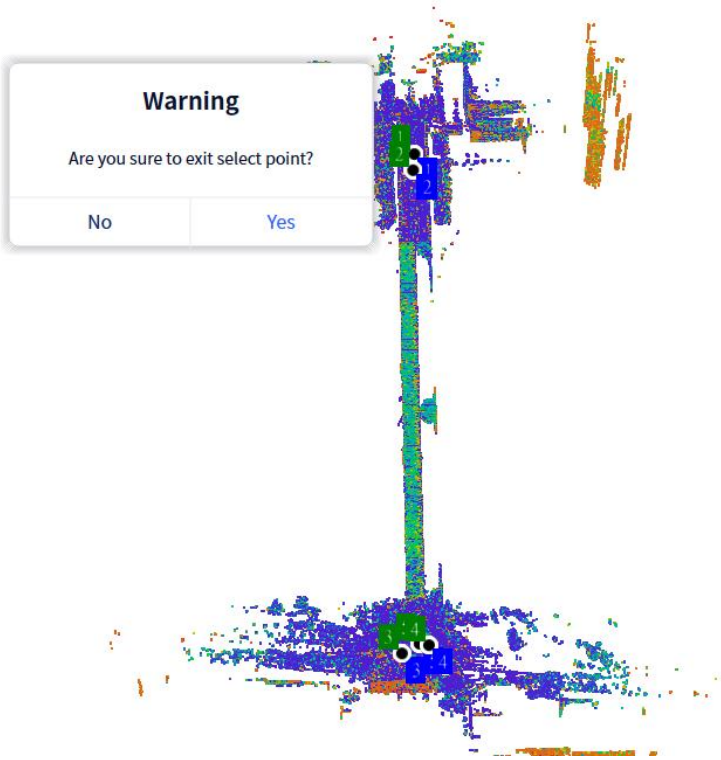


If you have scanned reflective targets (at the checkpoints) during data collection, you can click the auto-selection function, and the software will automatically extract the coordinates of the target center points. The auto-selection function provides three parameters:

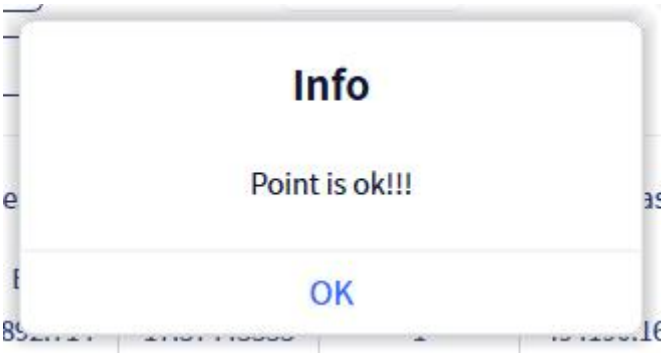
- Target Radius: The radius of the standard circular reflective target specific to the area, default is 0.15m, range: 0.1-1m.
- Target Points: The minimum number of points the software searches for when automatically extracting the target, default is 50, range: 50-200. To ensure extraction accuracy, 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.


Accuracy Check
Point cloud:
las
Checkpoint file:
K.csv
Select point:
Automatic
Marker radius(m):
0.15
Marker points:
50
Max distance(m):
0.50
Manual
Real coordinates
Measurement coordinates
Point name
N
E
X
Y
Z
1
494190.1843
2496892.714
17.374
2
494189.3241
2496869.303
17.017
3
494184.5732
2496290.592
15.352
4
494201.2926
2496299.171
14.6722
20%
Check
Calculate
Export
Point number
DX
DY
DS
DH
Min DS: ------
Min DH: ------
Max DS: ------
Max DH: ------
Average DS: ------
Average DH: ------
RMSE of plane: ------
RMSE of elevation: ------

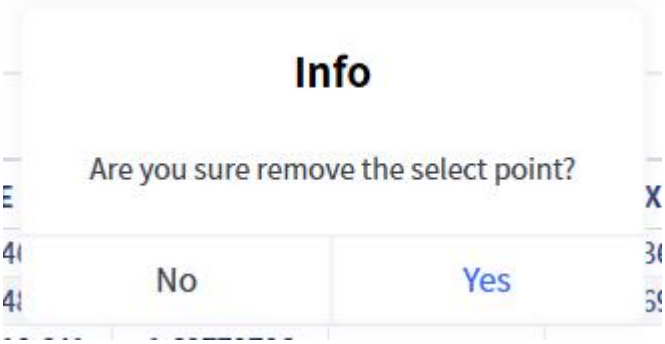

Warning
Are you sure to exit select point?
No
Yes

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.

Accuracy

Point cloud: 2024-01-30-162548-RTK+控制点result

Point cord file: D:/PointCloudData/XGRIDS/云之园真值0920.csv

Point size: 10

Select point: to select poi | Marker radius(m): 0.15 | Marker points: 50 | Match max dis(m): 0.50

Start select point

Real coord / Measure coord

Point name	N	E	Z	Point index	X	Y	Z
6	494236.8685	2493046.225	1.87323499	6	494236.858	2493046.231	1.864
7	494269.9346	2493048.036	1.61104929	7	494269.935	2493048.030	1.593
8	494211.6881	2493010.641	1.69779706				

Check | Calculate | Export

Point index	DX	DY	DS	DZ
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

Report

AccuracyCheck

其域创新 XGRIDS

Accuracy checking report

Unit:meter

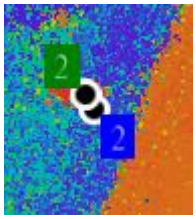
Point index	DX	DY	DS	DZ
10	-0.031	0.036	0.048	0.004
12	-0.007	0.005	0.009	0.006
13	-0.008	0.009	0.012	0.017
3	-0.026	-0.000	0.026	0.039
4	-0.028	0.007	0.029	0.041
6	-0.010	0.006	0.012	0.009
7	0.001	-0.006	0.006	0.019
9	-0.007	0.018	0.020	0.023

Min Ds: 0.006
Max Ds: 0.048
Avg Ds: 0.020
Error on plane: 0.024

Min elevation: 0.004
Max elevation: 0.041
Avg elevation: 0.020
Error on elevation: 0.024

3.2 Manual point selection

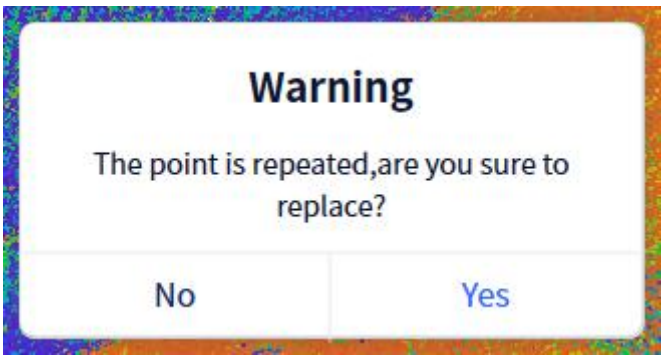
If the feature points do not have reflective targets affixed, the user can manually select points. Click on "Manual Point Selection" to begin selecting checkpoints in the point cloud data. I Click the checkpoint position in Point Cloud with the left mouse button, and select the default green label.



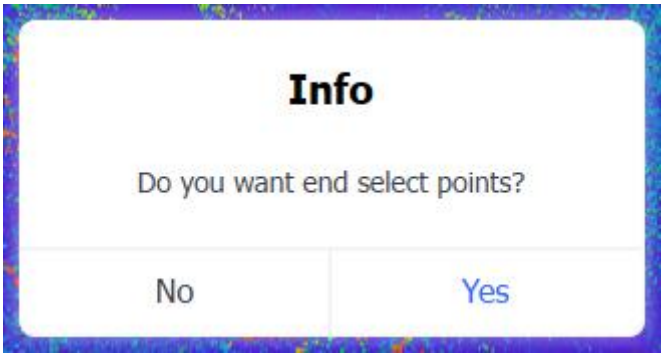
Left-click in the point cloud to select the checkpoint location, and the selected point will be labeled with a green tag by default. [Note: The software will automatically search for the true value points near the selected point and automatically display the tag for that point.]

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 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. 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.

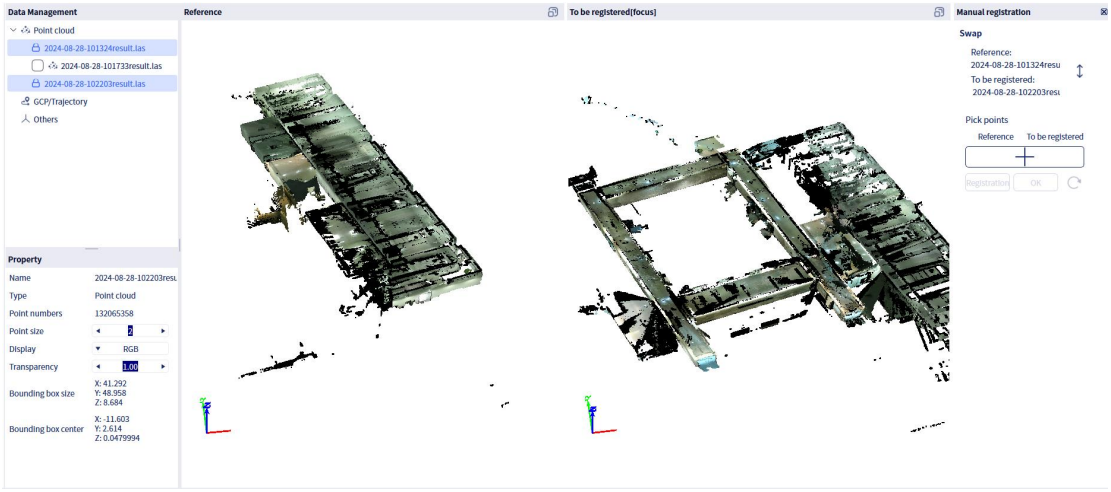
(2) Tools

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 "Register" to perform the registration.



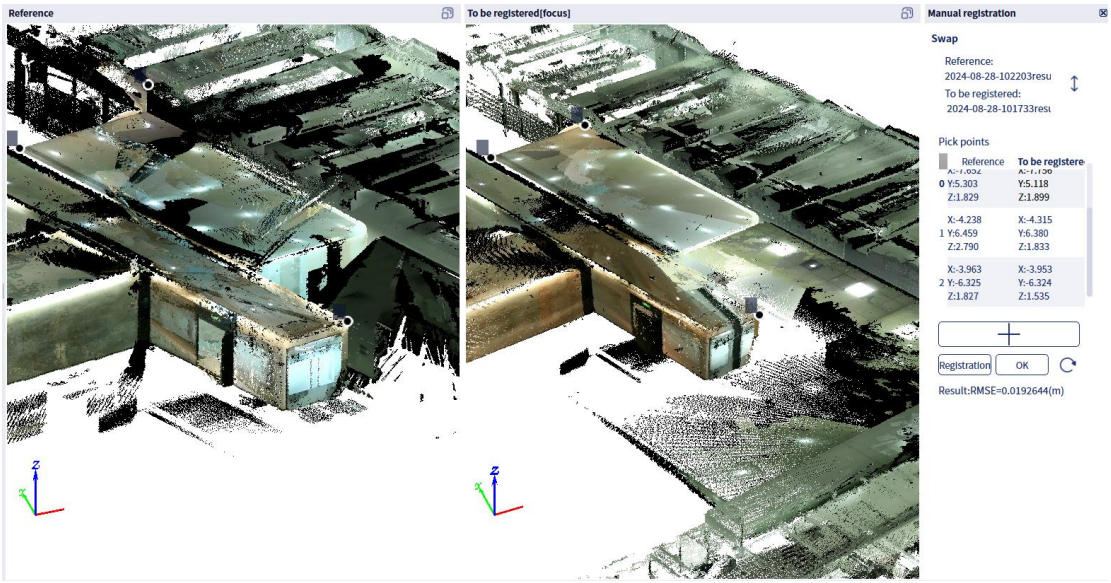
Click "Manual Registration" to open the manual registration window and select the point clouds that need to be registered. You can also click the arrows to swap the roles of the reference and the point cloud to be registered.

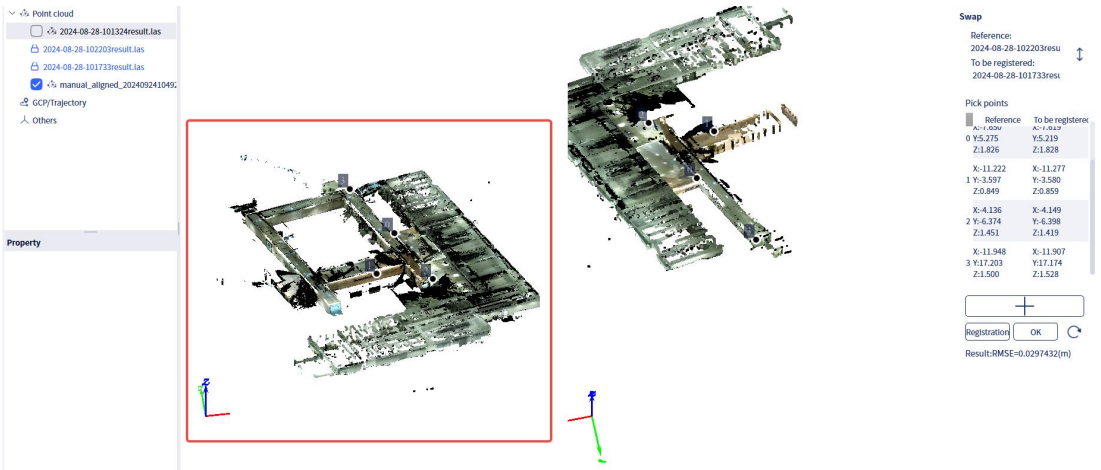
After selecting, click the plus sign to add corresponding points and start the point selection process. Select points in both the reference point cloud window and the point cloud to be registered window to choose corresponding points in each point cloud. Select at least 3 corresponding points.

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.

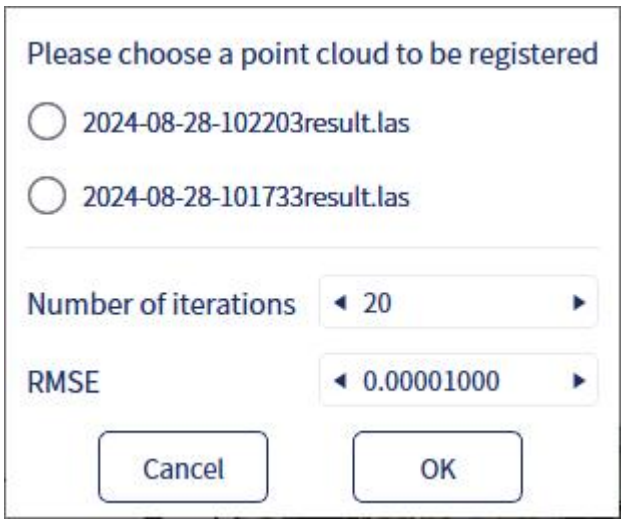




2. ICP Registration

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.

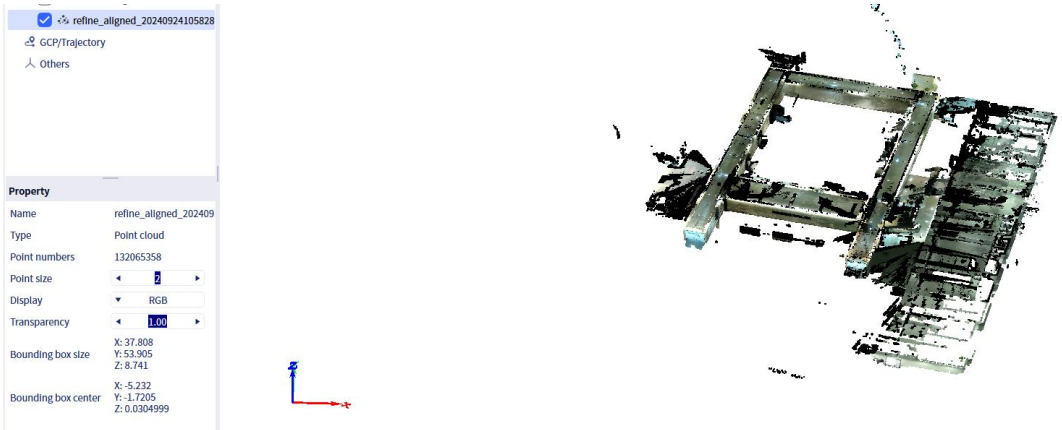
First, select the two point cloud datasets that need to be registered in the data list on the left. Click "ICP Registration" to open the ICP registration interface. Based on the actual project needs, determine the reference point cloud and the point cloud to be registered.



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.

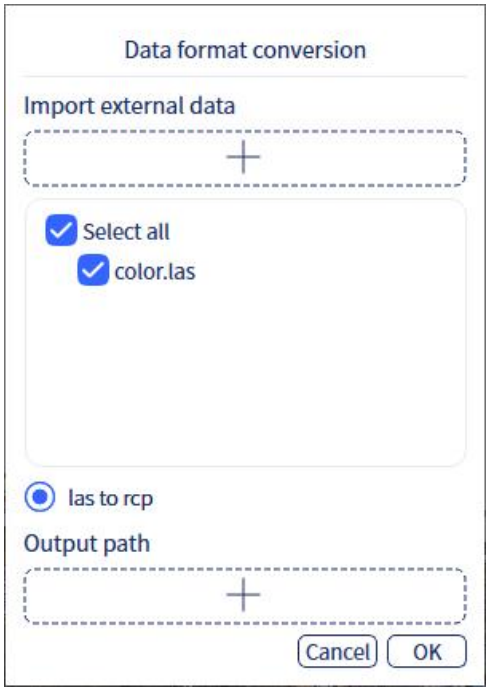


3. **Data Conversion**

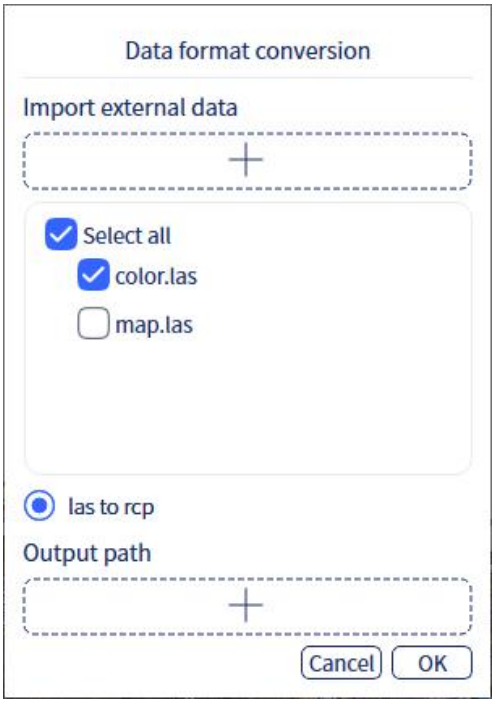
The data conversion feature primarily allows users to convert .las format data into .rcp format. Select the imported point cloud data that needs to be converted, and click on "Data Conversion." A pop-up window will appear displaying the data format conversion interface. This window shows the currently selected point cloud data. Additionally, you can click "Import External Data" to select other .las data that has not been imported yet. The selected point cloud data will be displayed in the window accordingly.

Note: Only .las format point cloud data is supported for conversion, and you can select up to 10 point clouds for conversion at a time. After completing the data selection, users can still make final adjustments by selecting or deselecting point clouds in the checkboxes to confirm the data that needs to be converted.

When performing RCP format conversion, please avoid using other software functions and try to minimize the use of other high-performance applications on your computer.



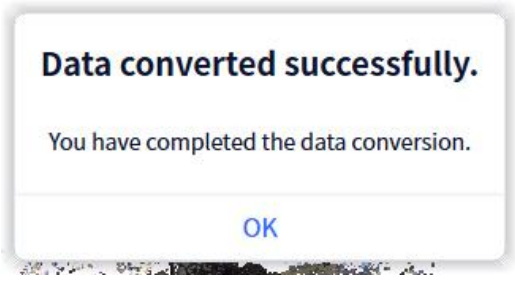
After making your selections, choose the output path. Click "Confirm," and the software will begin the conversion process.

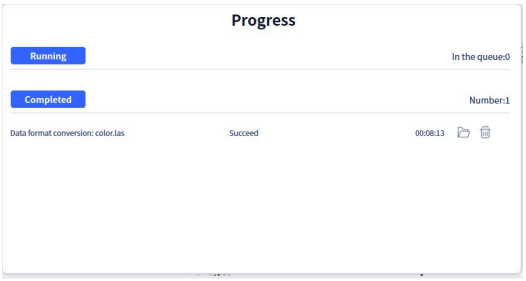


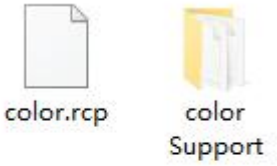
The conversion progress can be monitored in the progress bar.

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

Note: The converted .rcp format data consists of two parts: one part is the .rcp data index, and the other part is the folder containing the corresponding data. If you need to copy the data to another location, make sure to copy both the .rcp file and the folder. The converted .rcp files are supported by AutoCAD and Recap versions from 2020 and later.



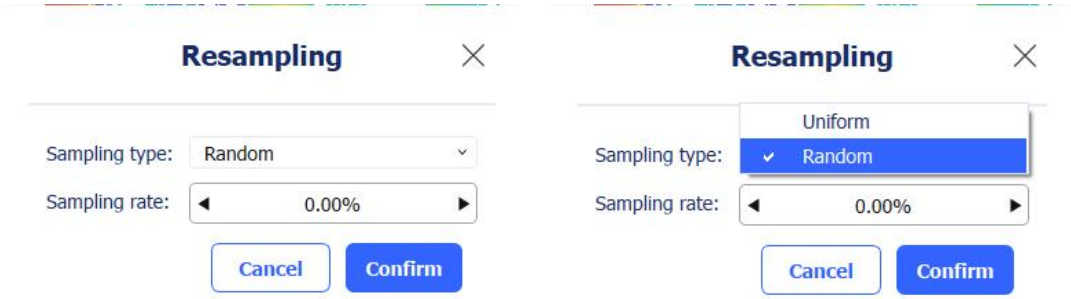




4. Resampling

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.

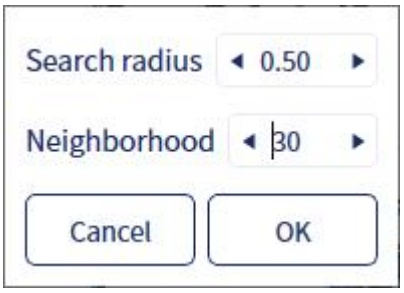
The second method is to sample according to the minimum point spacing (default): you can set the minimum point spacing between two points. After setting, the algorithm will calculate that the spatial 3D distance between any two points within a certain voxel range will not be less than this value. The 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 software's algorithm requires two parameters to be set: search radius （m） and neighborhood value. The algorithm searches for neighboring points within the specified search radius for each point in the point cloud, calculates the average distance from each point to its neighboring points, and also calculates the overall average distance for all points. It then computes the standard deviation and median of these average distances to determine the maximum distance threshold. If a point's average distance to its neighboring points exceeds this maximum distance, it is considered noise.



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

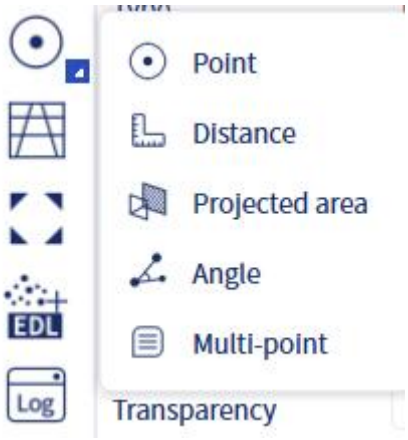
The point cloud smoothing function processes the point cloud data to make the laser points on some surfaces smoother. The algorithm provided by the software requires setting the neighborhood radius. The algorithm searches for neighboring points for each point in the point cloud based on the specified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

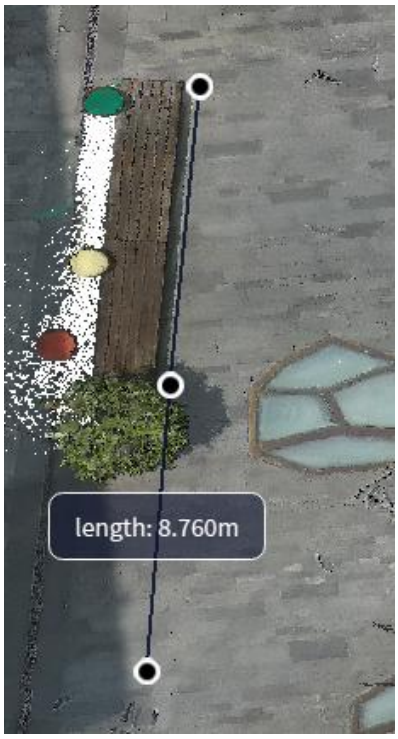
7. Measure

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.

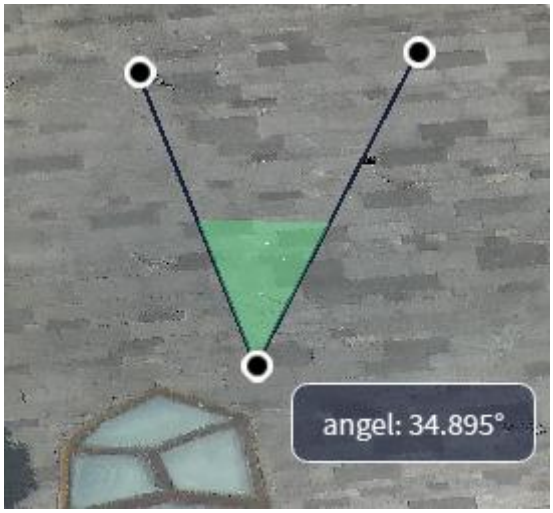


Click "Point Measure", left-click on a point in the point cloud, and the information of the selected point will be displayed, including point coordinates, point cloud color RGB information, intensity signal, etc. Note: Only when the point cloud has the above information during scanning can it be displayed.

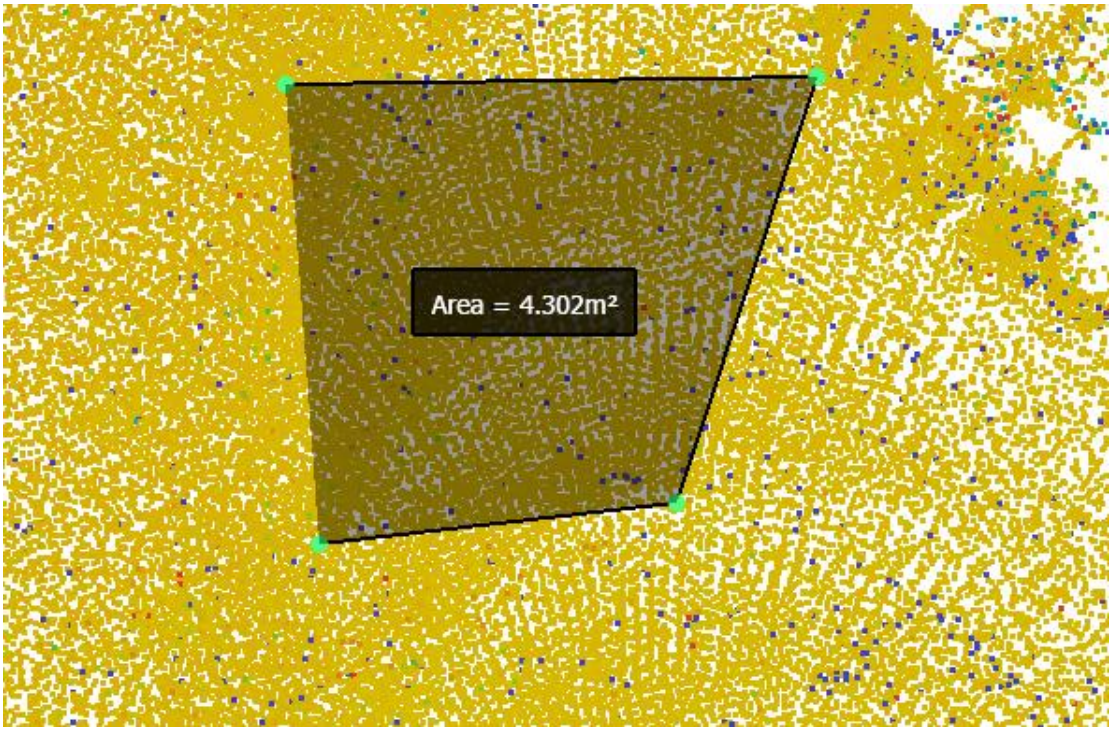
Click "Distance Measure", left-click on two points in the point cloud, and the distance between the selected points will be displayed for measurement. If multiple points are clicked continuously, the distance of continuous line segments between multiple points will be measured. To undo a selection, right-clicking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



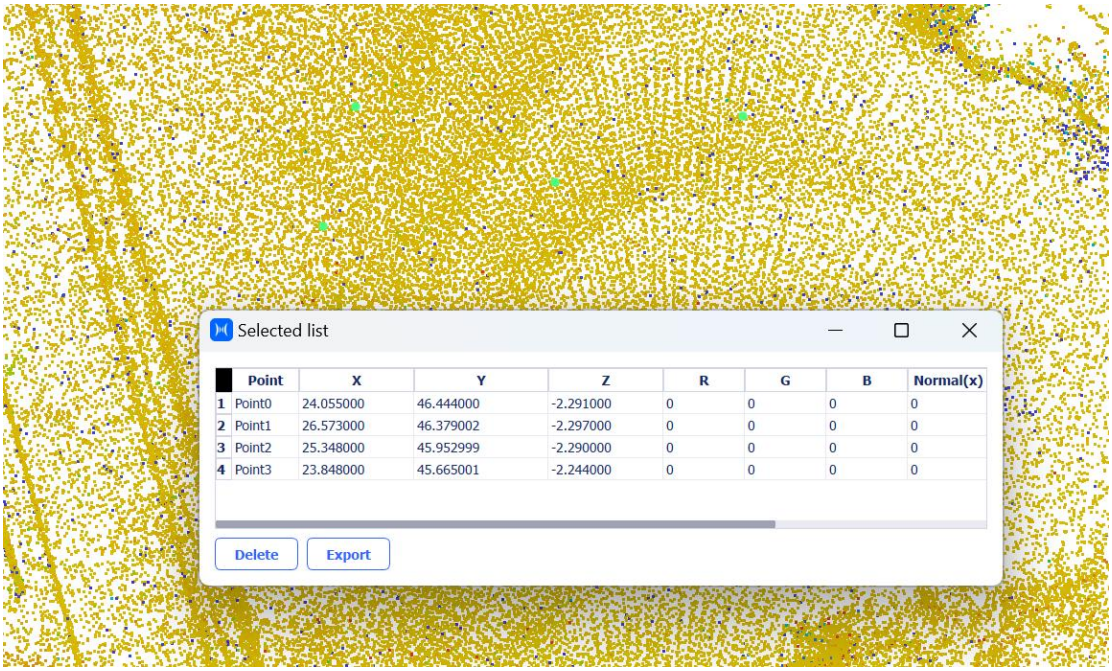
Click "Angle Measure", select three points with the left mouse button, and the degree of angle between the three points will be displayed.



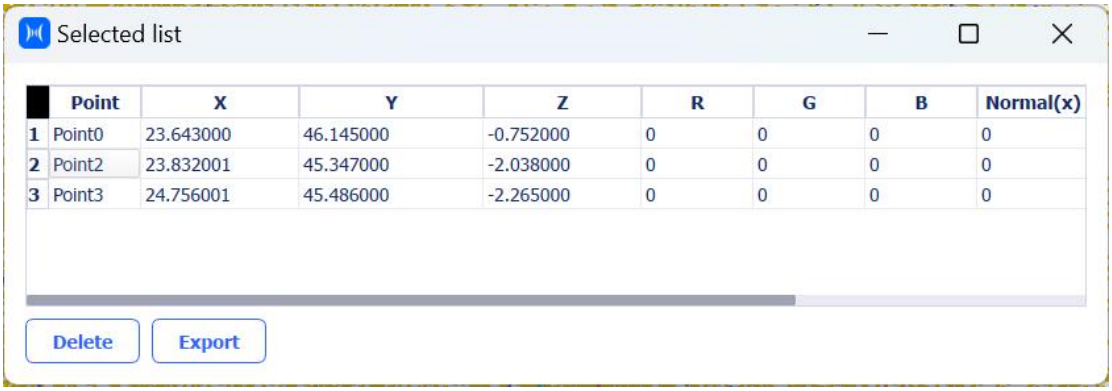
Click "Area Measure", left-click to continuously select the area to be measured, and the area of the selected polygon will be displayed.



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.



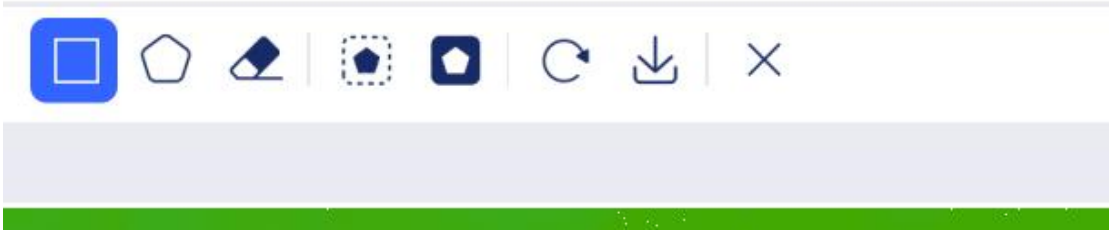
Select a row of point data and click "Delete" to delete the point.



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

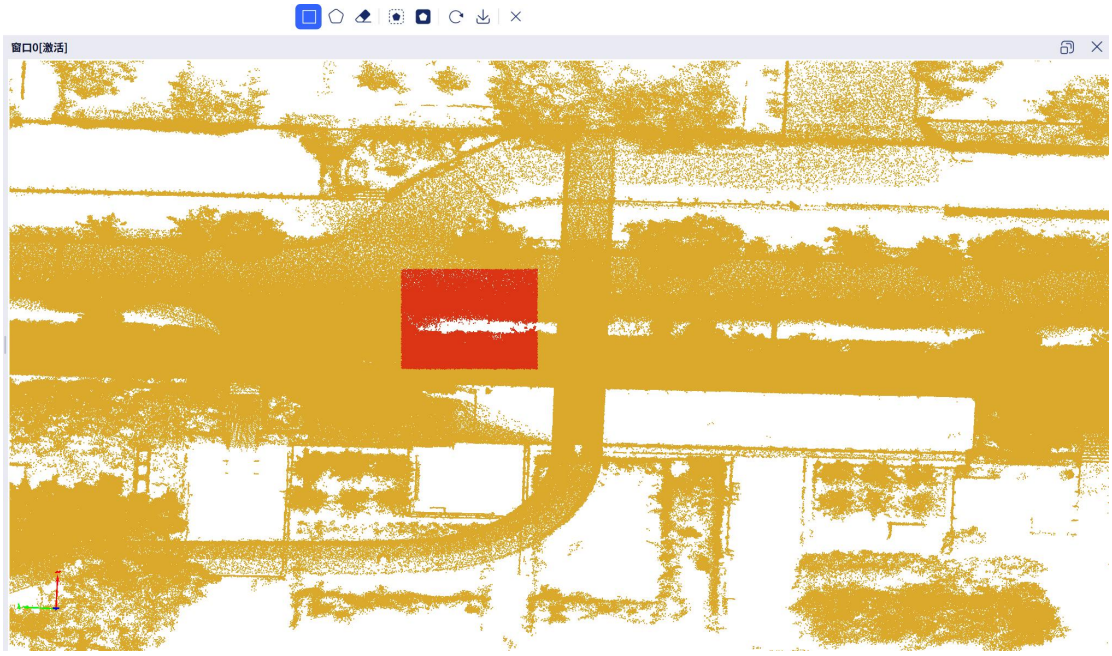
8. Clip

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.



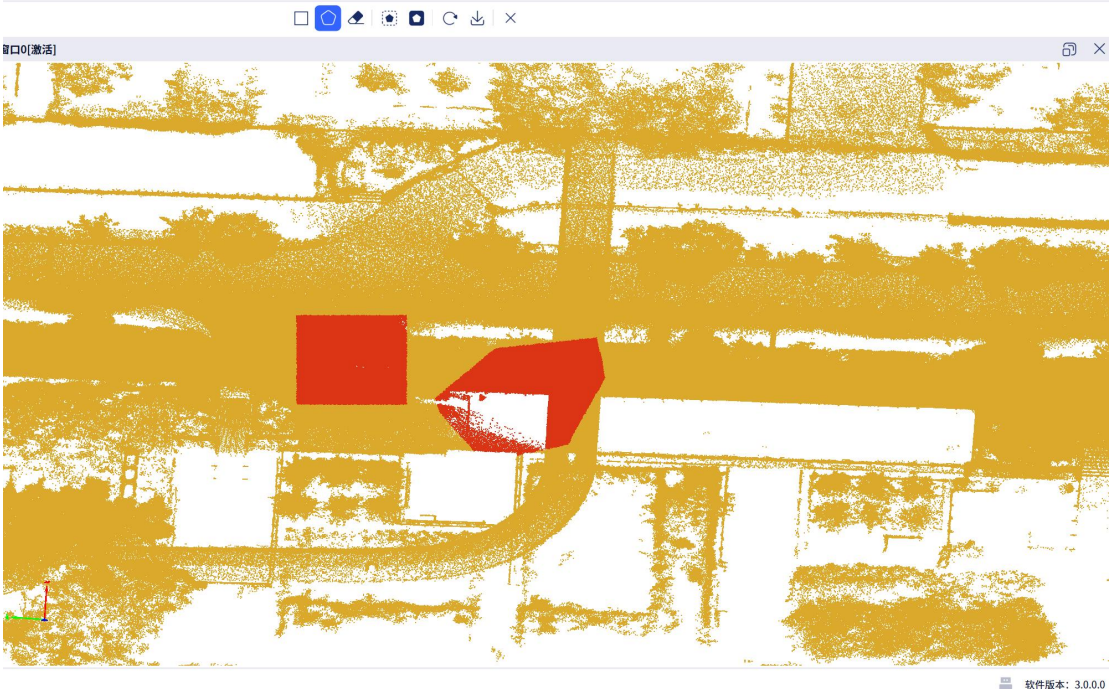
8.1 Select by Rectangle

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.



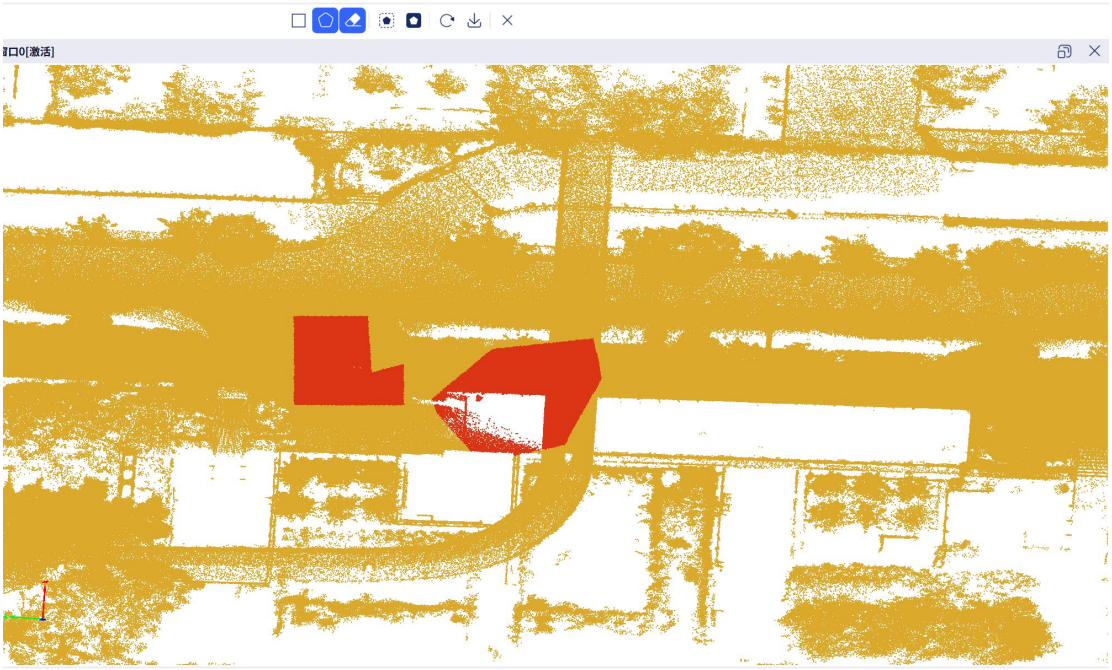
8.2 Select by Polygon

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.



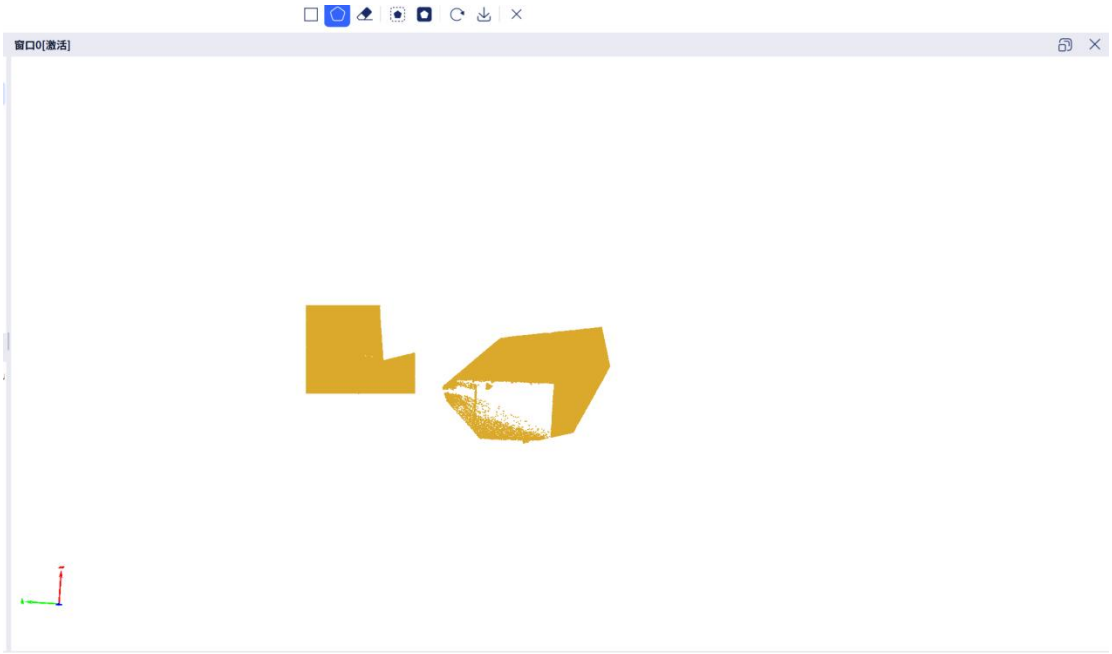
8.3 Unselect

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.



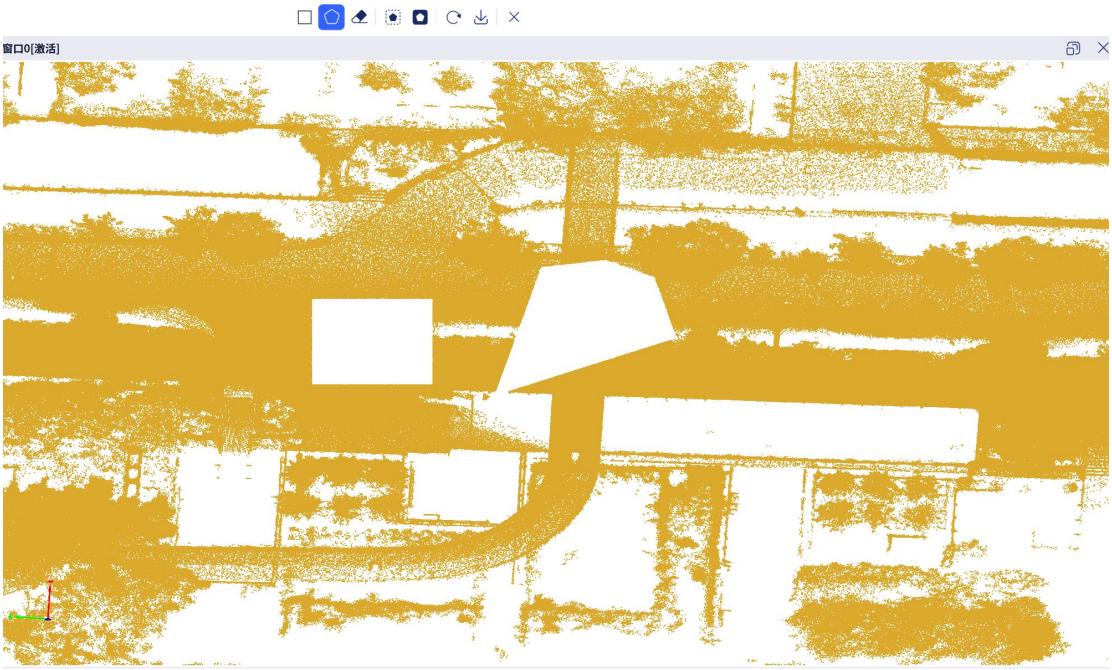
8.4 Inner Clip

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

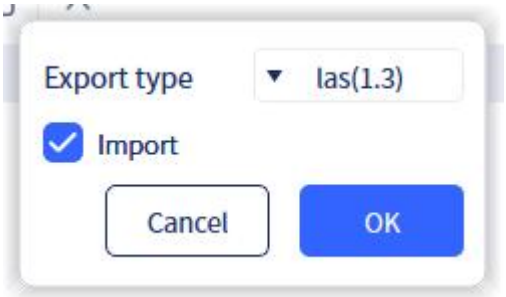
Click the "Outer Clip" button. Unlike the "Inner Clip" function, this will retain the unselected area in the display window and delete the selected point cloud data.



8.6 Save

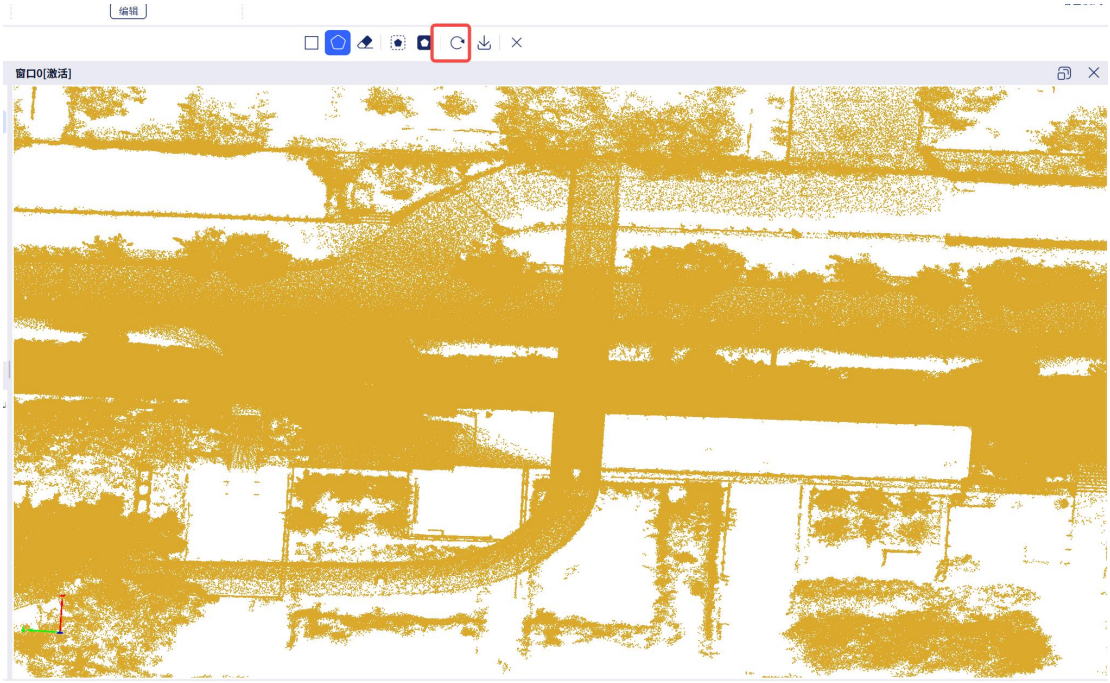
Click "save" to save the cropped results. You can choose the desired data format for saving; currently, las1.1-1.4 versions and ply are supported. You can also choose whether to import the data. If you choose to import, the cropped data will be imported into the software.

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.



8.7 Reset and Close

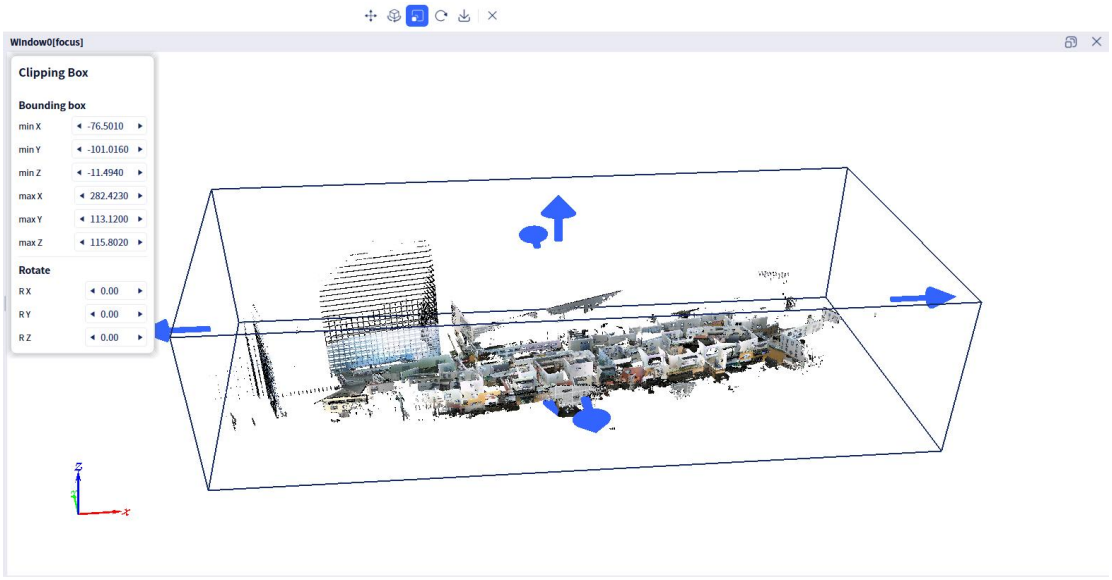
Click "reset" to cancel all seletions. "Close" will exit the Clip tool.



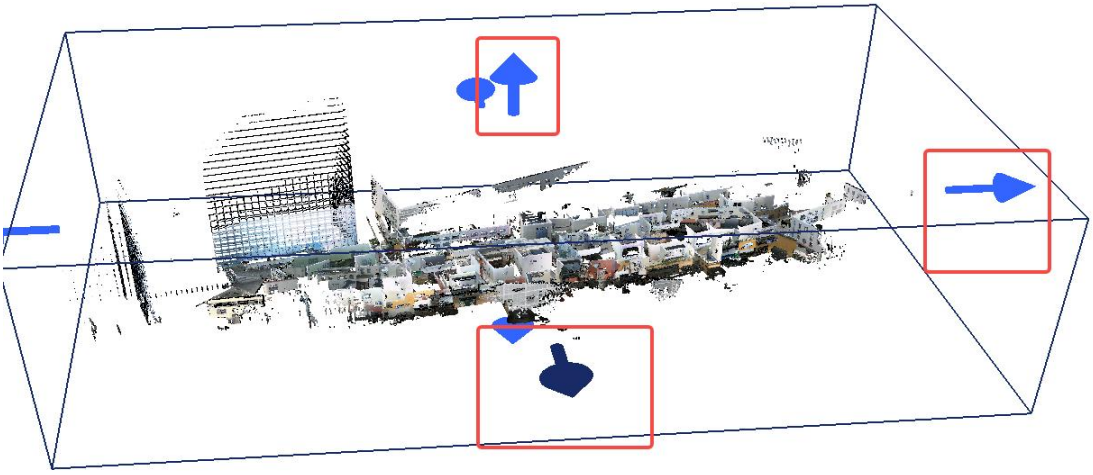
9. Clipping Box

The "Clipping Box" function uses a cutting box to perform cutting operations on the point cloud data. Click the tool and the function bar will appear on the top of the window. From left to right, the buttons are: Pan, Rotate, Zoom, Reset, Save, and Close.

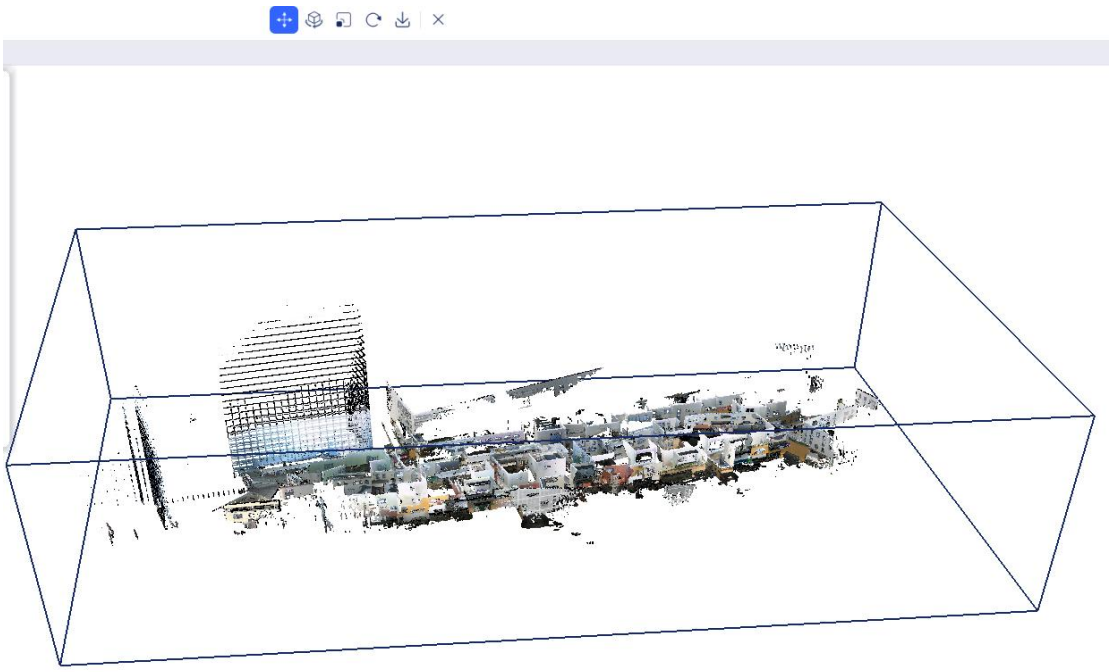
Click the tool and the software will display a bounding box around the current point cloud data, with the scaling arrows for six directions enabled. You can perform clipping option for a single point cloud layer or multiple layers at once.



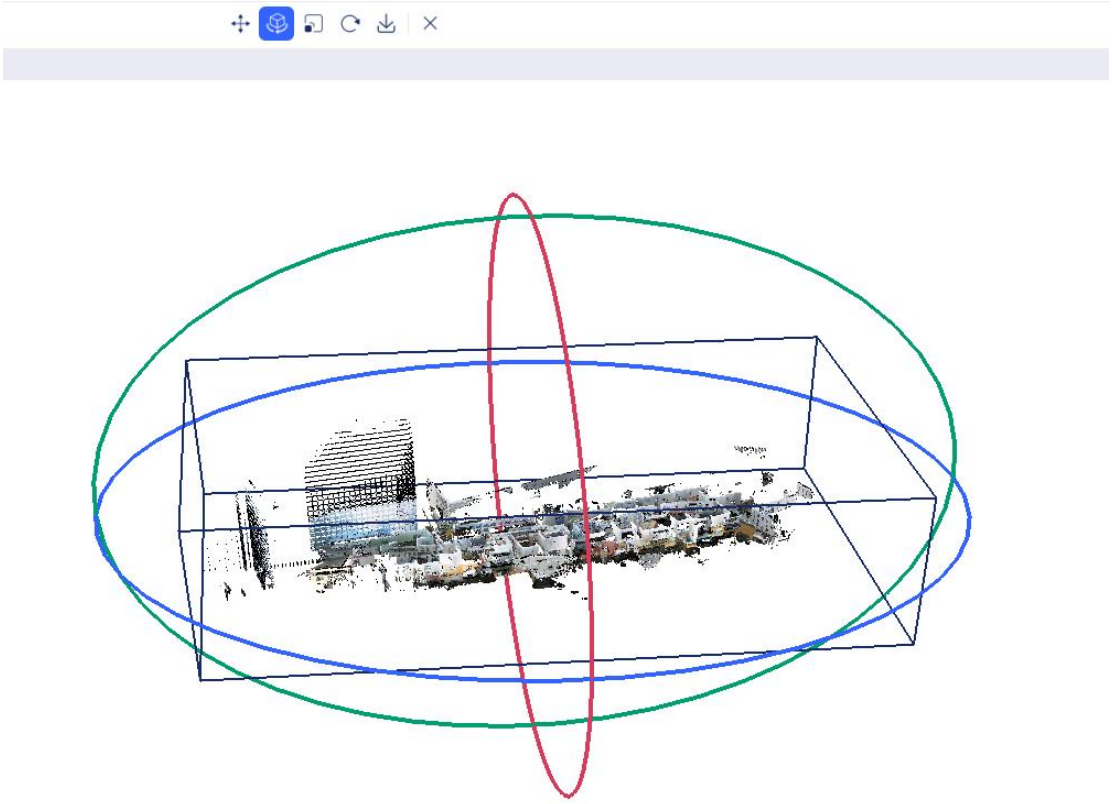
By clicking the six arrows with the left mouse button, you can change the positions of the six planes of the bounding box.



Click "Translate" to move the entire bounding box.



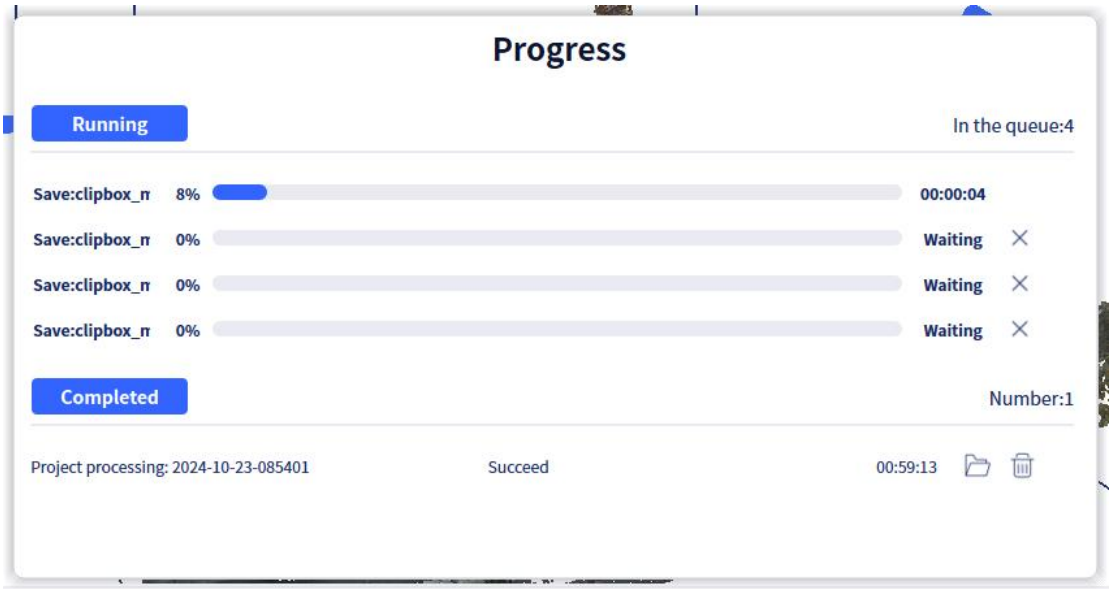
Click "Rotate," then click and select one of the three axes (X, Y, Z axis) and drag the red blue and green lines to rotate the entire bounding box.



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 there are multiple datasets being clipped, they will be saved into separate files.



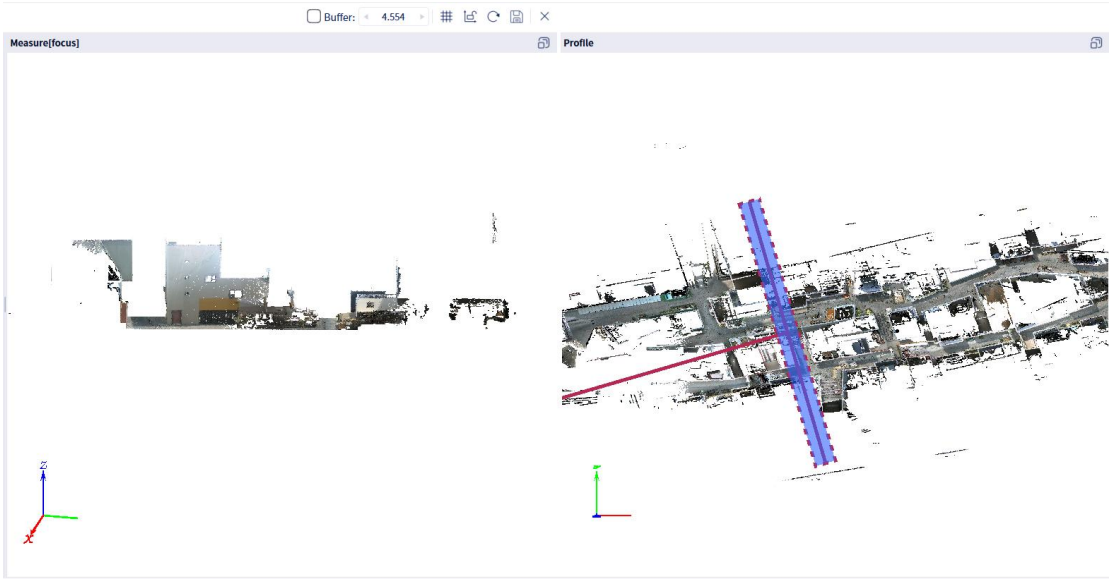
Note: Since the current window contains the 3D-clipped point cloud, the imported 3D-clipped point cloud will not automatically display in the current window. To view the point cloud, exit the 3D clipping function and drag the point cloud into the window.

Click "Close" to exit the clipping box tool.

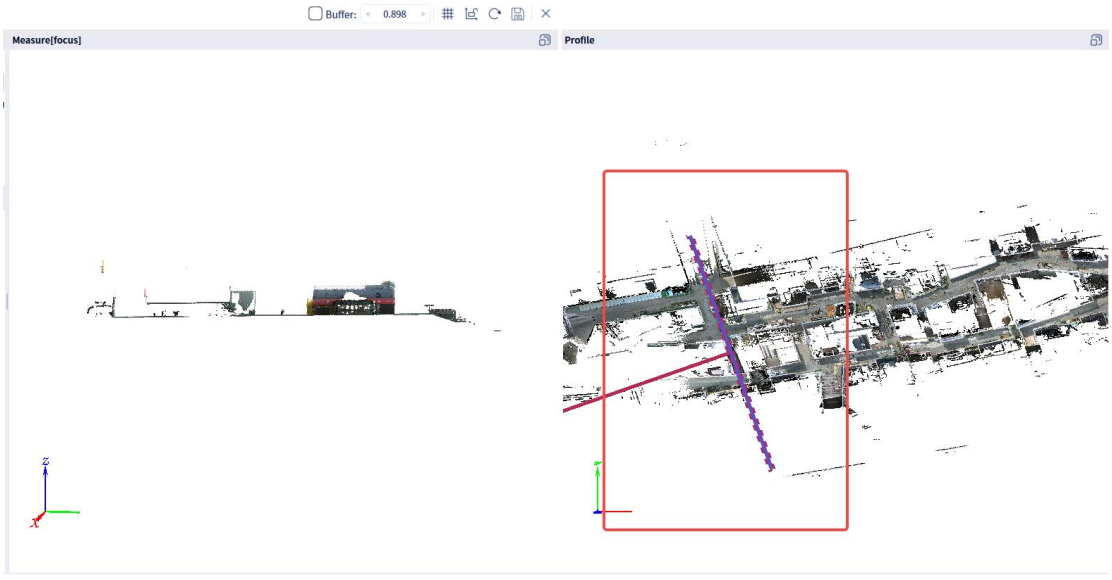
10. Profile Analysis

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.

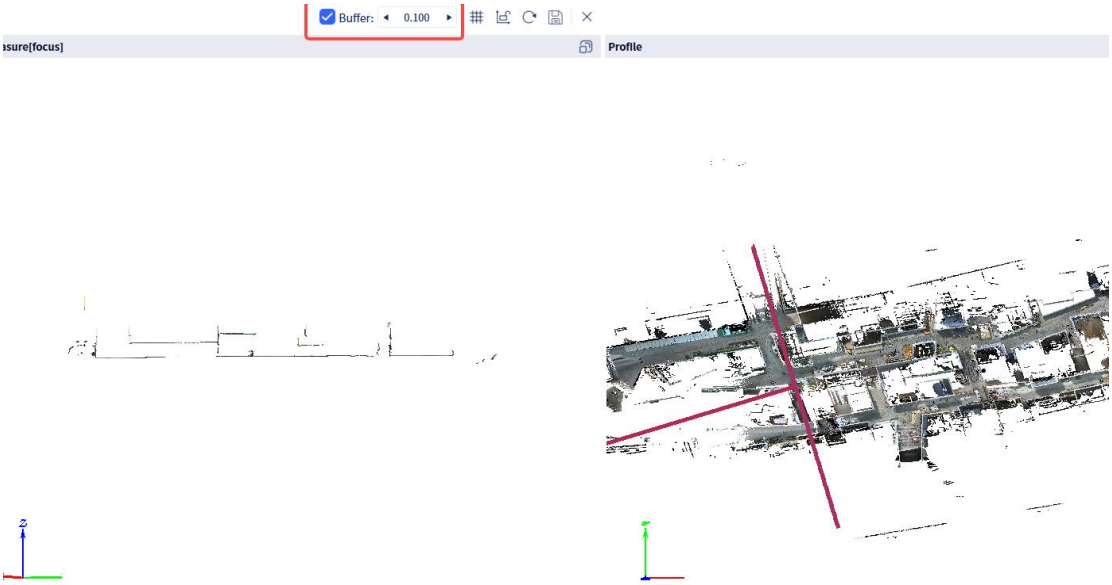
Select the point cloud data you want to view, then click "profile analysis" The software will open a cross-section viewing buffer, add a new cross-section viewing measurement function, and open a new cross-section data viewing window.



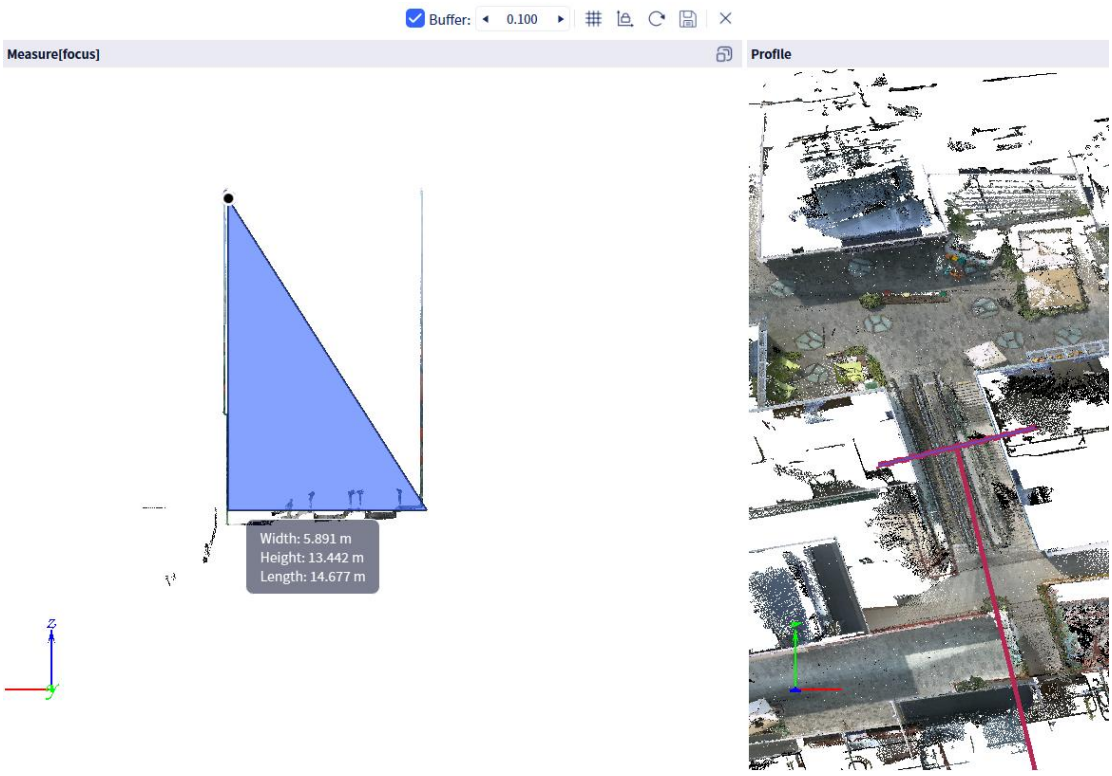
In the main point cloud display window on the right, click and move the mouse to select the point cloud data you want to view in cross-section. Once you have made your selection, double-click to display the selected point cloud data in the cross-section window on the left. While moving the mouse to select 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.



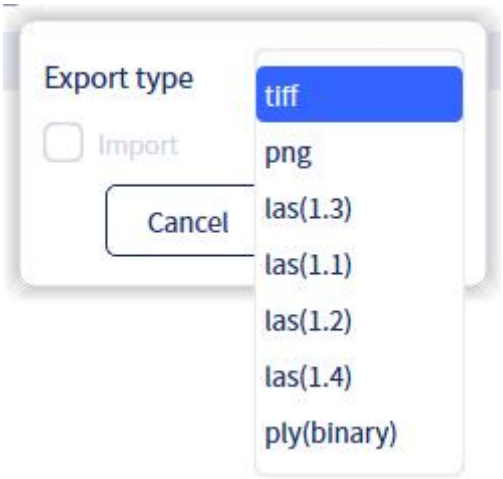
For the data obtained from the cross-section, the software provides corresponding viewing and measurement functions, including view, rotation, and measurement. Users can click the six-view buttons in the left-side quick operations to switch the perspective of the point cloud. Clicking the view button 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.

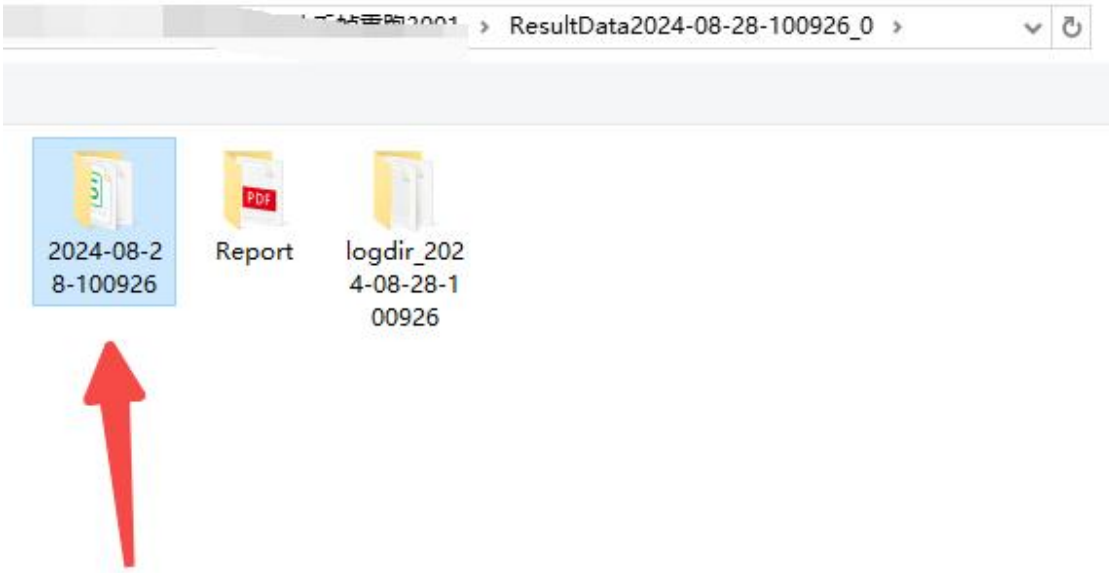
Note: Since the current window contains other point clouds, the imported cross-section point cloud will not automatically display in the current window. To view the point cloud, exit the profile analysis function and drag the point cloud into the window.



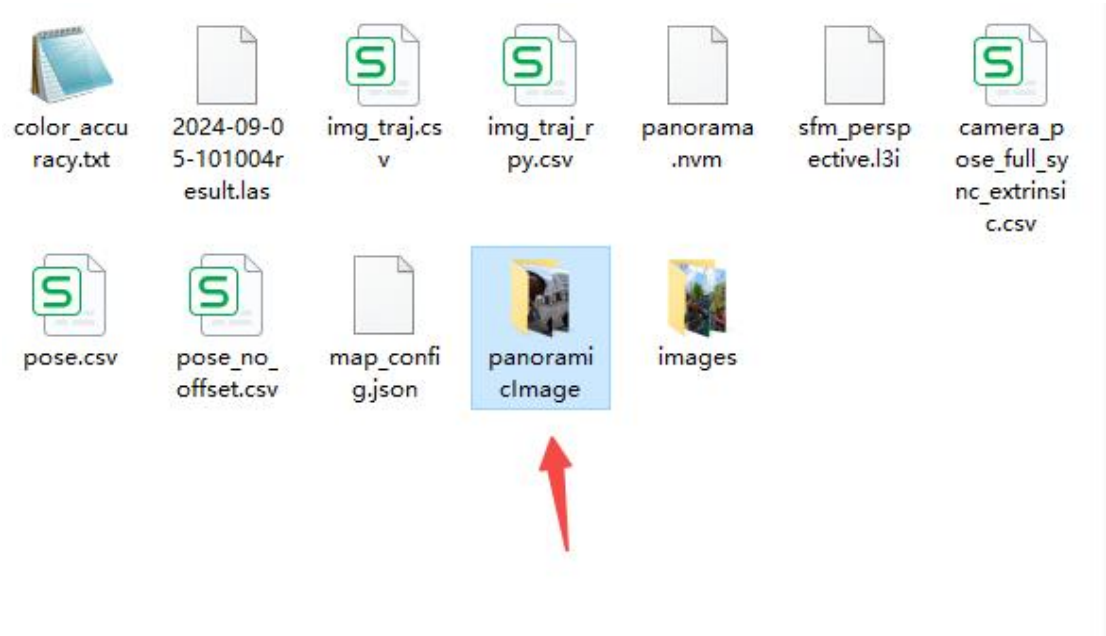
11. Panorama Overlay

The panorama overlay function allows users to measure point cloud data files colored using an panoramic camera. 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.

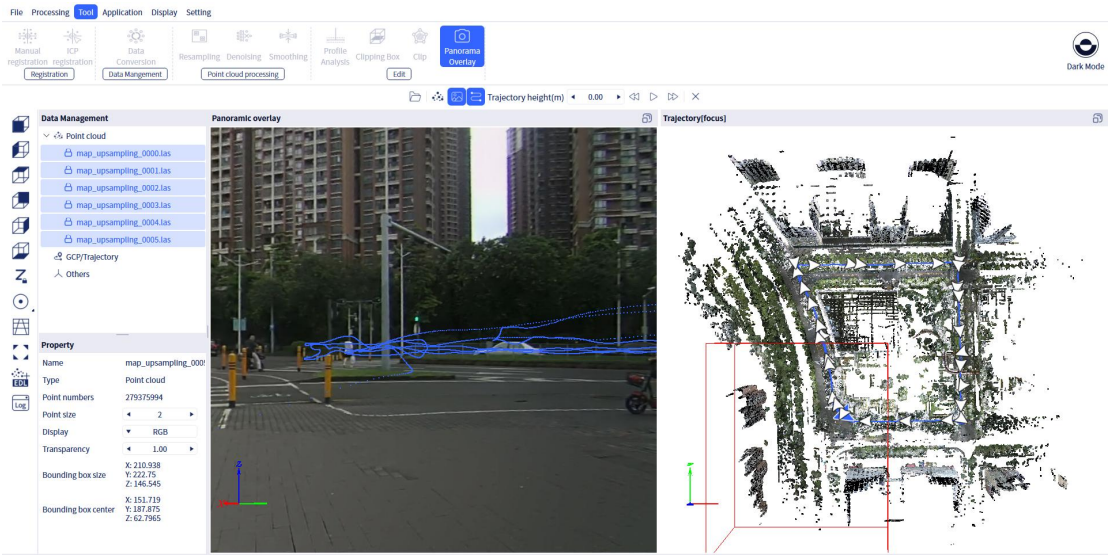
Click on the data from the data list on the left and select the point cloud data for which you need to perform panoramic measurement. Click "Tools" - "Panorama Overlay," and select the data folder (with the same name as the raw data), located in the processed ResultData folder.



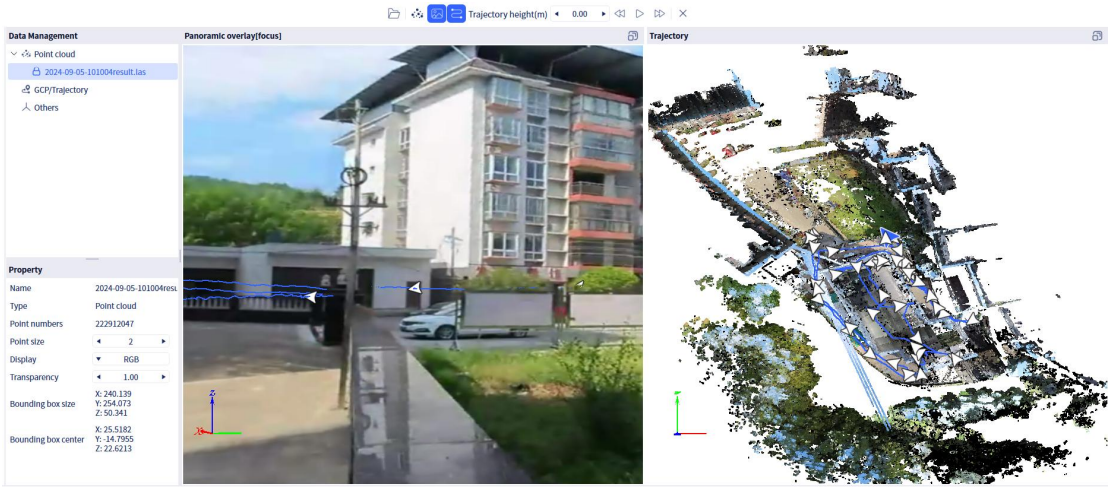
Note, in this folder there must be a PanoramicImage folder. Otherwise this function cannot be used.



In addition to individual point cloud data, the software also supports using multiple data sets enhanced by L2 Pro. In the left data panel, select all the point cloud data for the project and ensure that the data has been dragged into and is displayed in the right window. After selecting the data, click on the "Panoramic Overlay" option in the tools menu. Then, select the corresponding result folder to proceed.



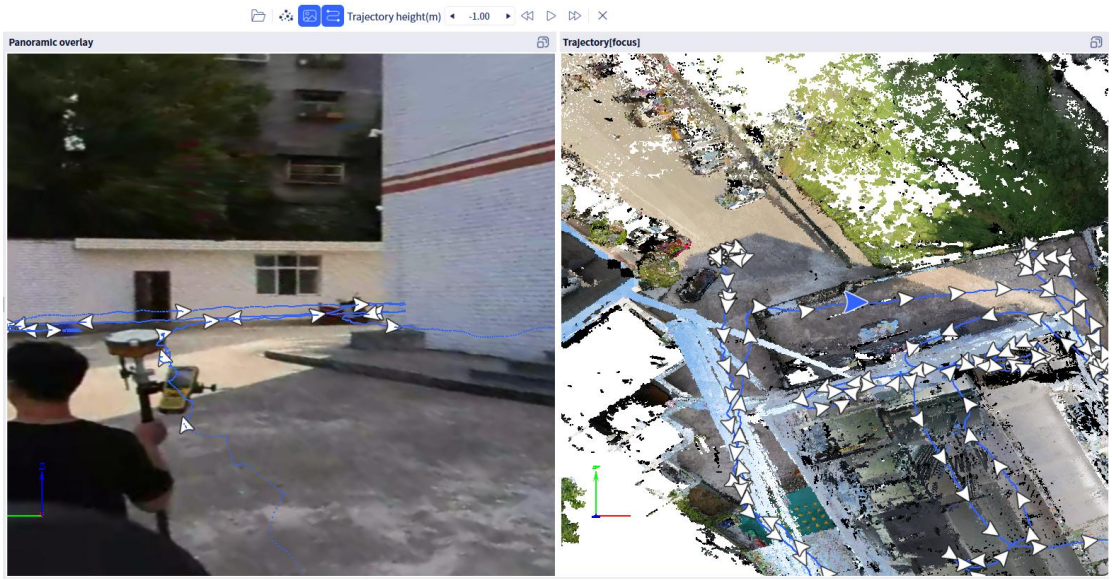
After making your selection, you can proceed to panoramic overlay.



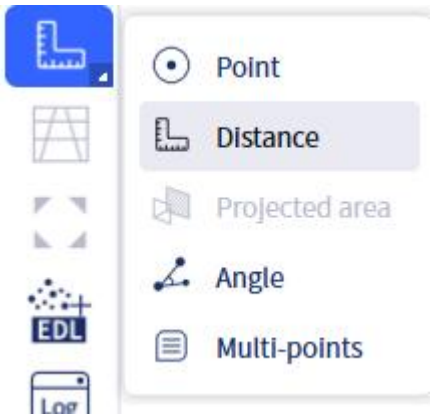
The panoramic overlay function bar includes: point cloud, panoramic photo, trajectory, trajectory height, previous frame, play, next frame.

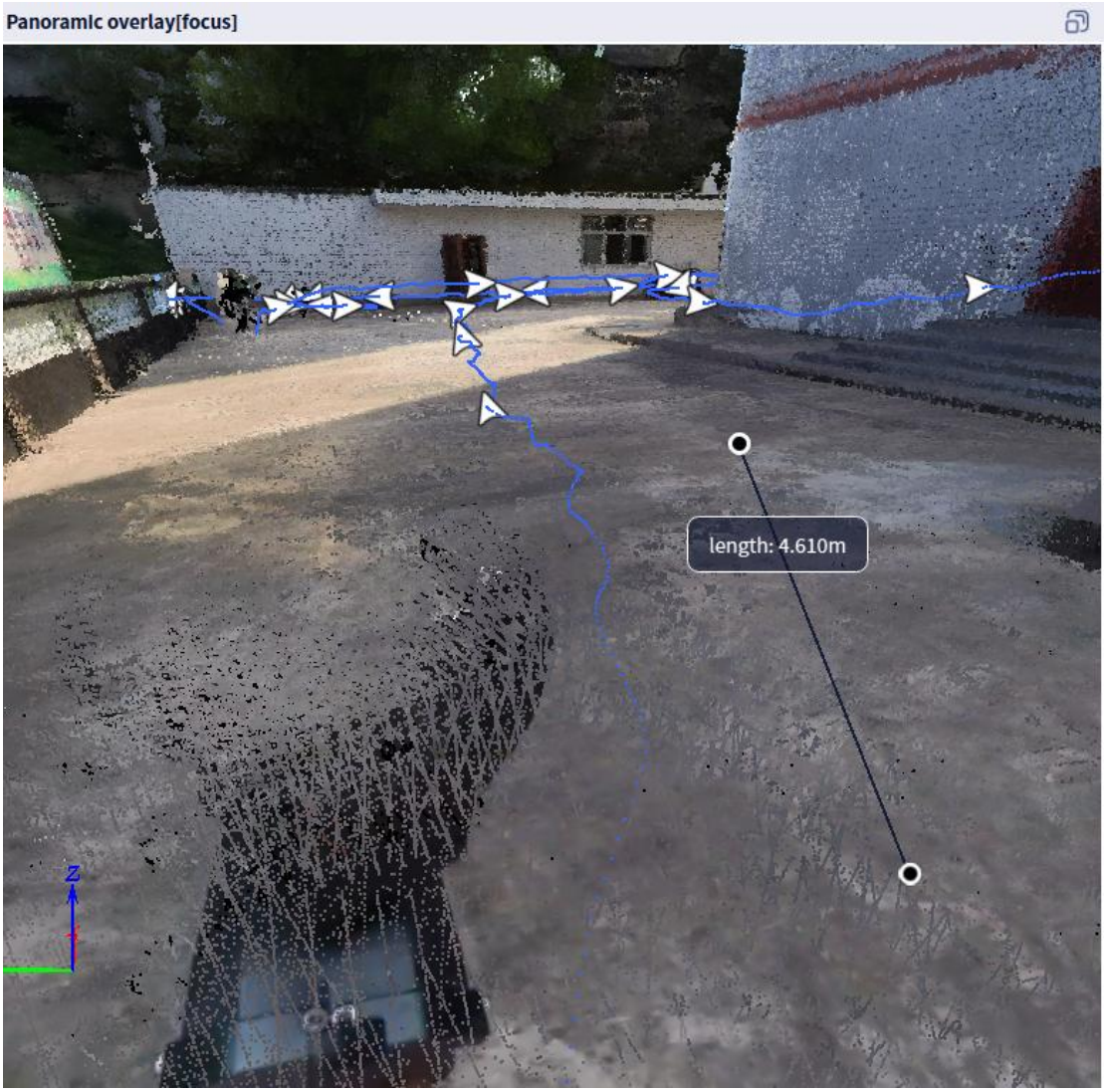
- Point Cloud: Selected by default. If you click to deselect it, only the panoramic photo will be displayed in the left window.
- Panoramic Window: Selected by default. If you click to deselect it, the display of the panoramic photo in the left window will be turned off.
- Trajectory: Selected by default. 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.

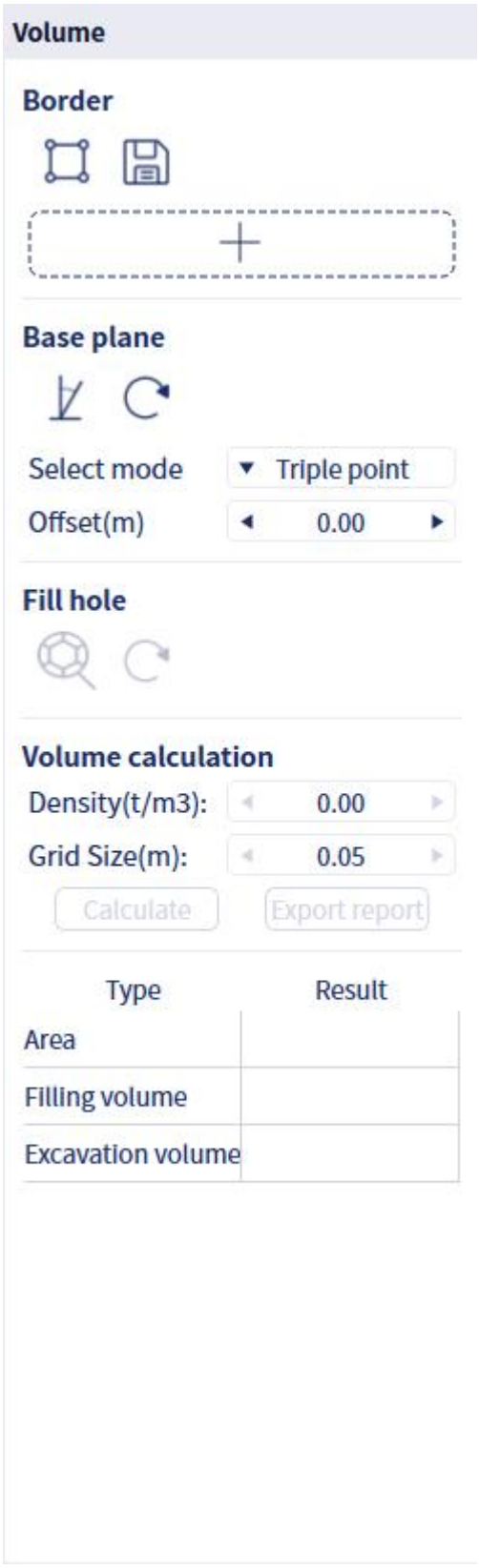
Click on "applications" and select a data from the data list. Selecting one point cloud data will default to the calculation of a single period of point cloud data. Selecting two point cloud data will compare the point cloud data from the two periods.

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.

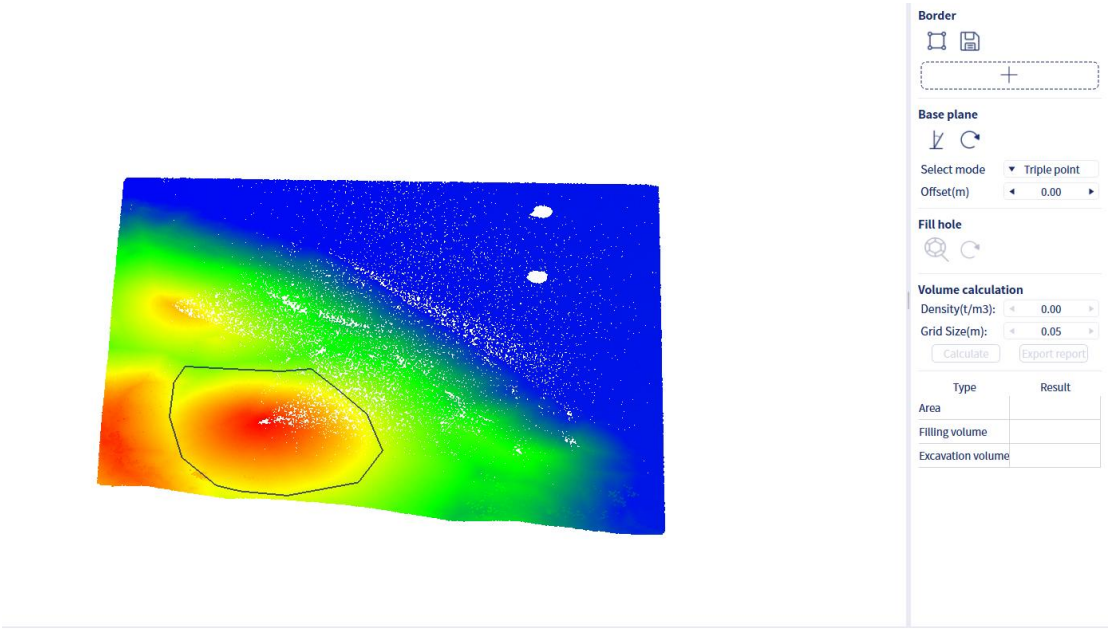
The window for volume calculation pops up on the right side of the interface, including border, base plane, fill hole, volume calculation, and report export.



1.1.1 **Border selection**

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

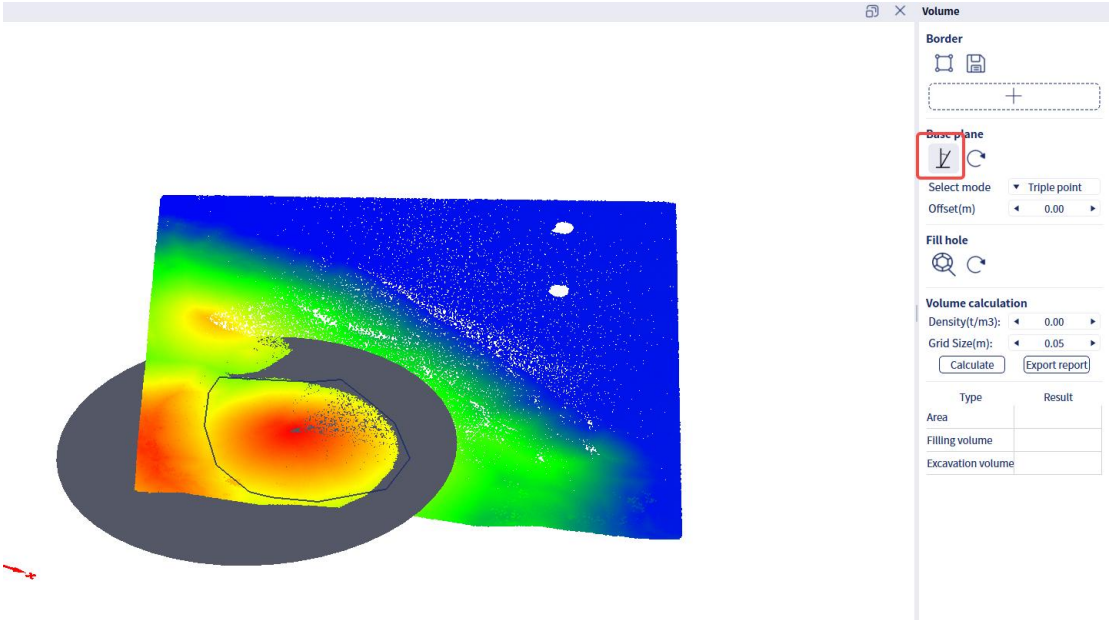
cloud, and double-click to automatically cut out the heap range. Click the reset button to re-select the boundary.



1.1.2 **Base plane selection**

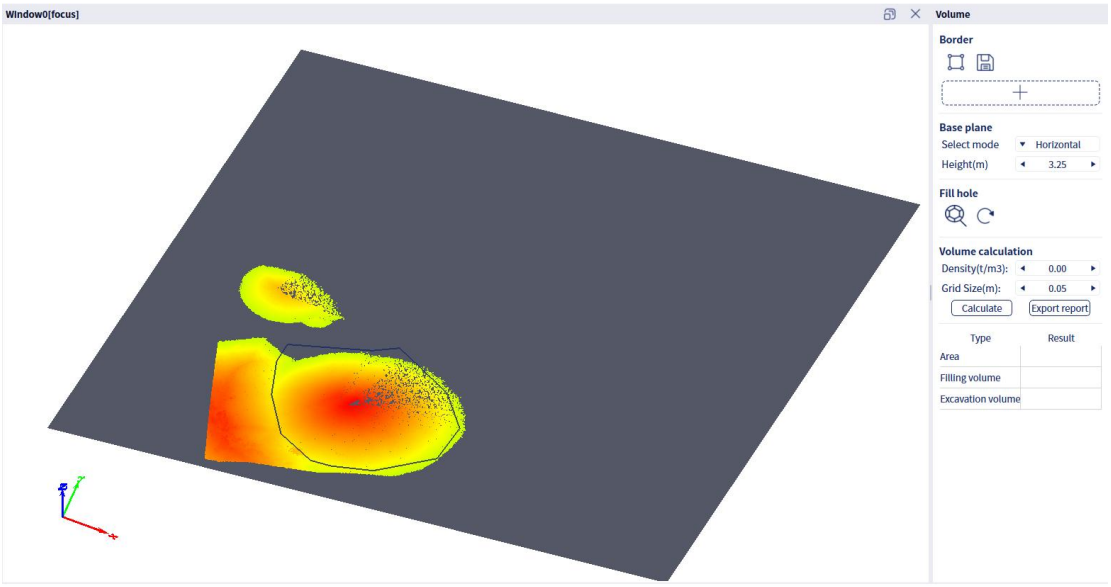
Base plane selection, the software provides three selection modes: three-point selection and horizontal plane.

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**

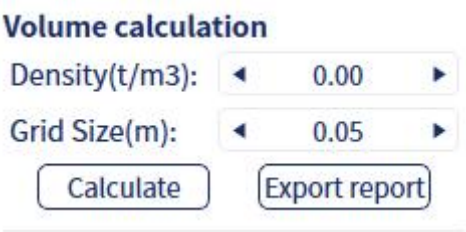
Click the "Fill Holes" button to fill in the point cloud holes in the pile. Left-click to select points, right-click to delete the last point. Double-click to end point selection. If you need to reset, click the reset button to the right of "Fill Holes" to reset the filling results.

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.



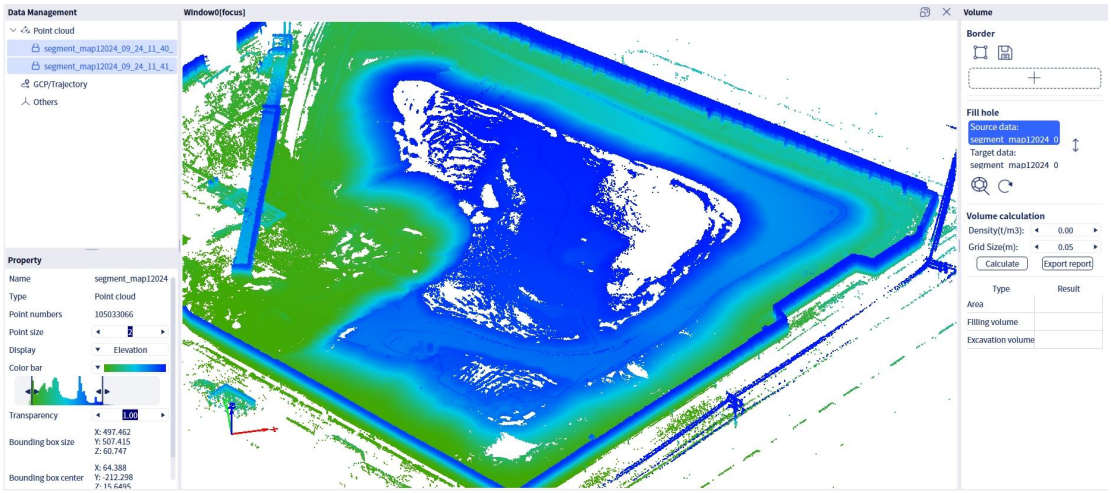
Click the "Calculate" button to start the pile volume calculation. Once the calculation is complete, the corresponding results will be displayed below.

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

1.2 Volume Comparison

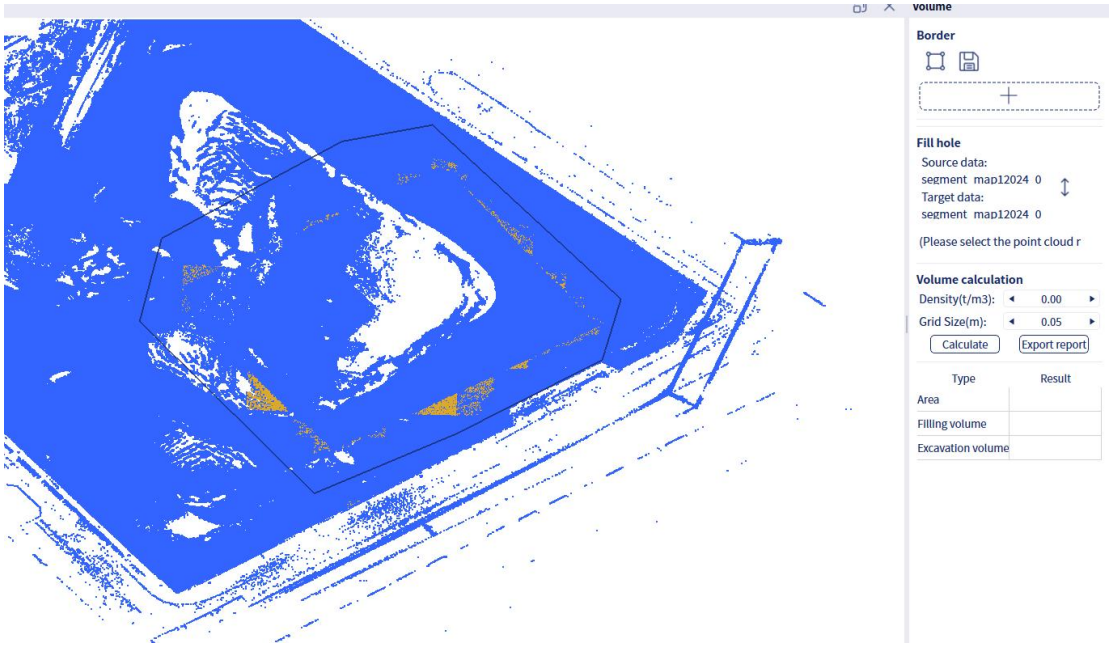
The volume comparison function is similar to the pile calculation function and provides the volume change between two sets of data over different periods. (The two point cloud datasets need to maintain a consistent reference surface, so it is recommended to register the two datasets first.)

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.



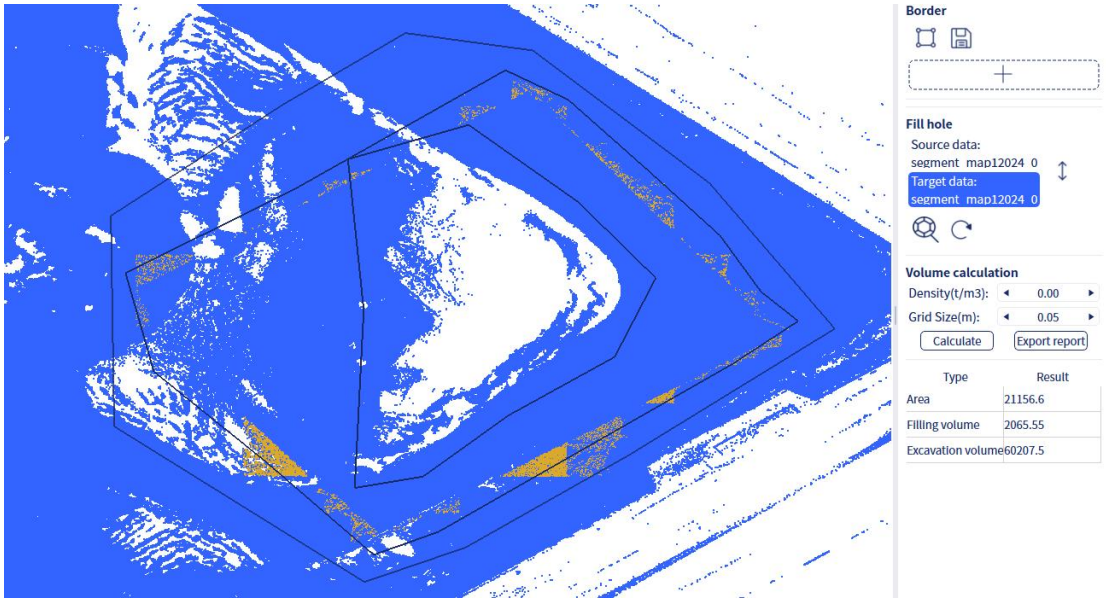
After importing the data, the interface on the left will display the pile calculation window. Similar to the pile calculation function, the pile comparison requires users to perform boundary selection, reference surface setting, meshing, hole filling, and other operations separately for the two sets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



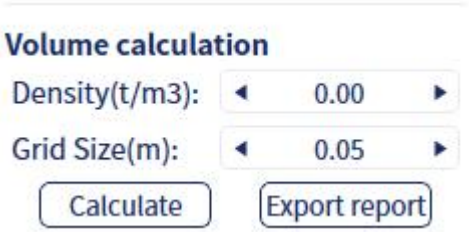
ii. Fill Hole:

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.

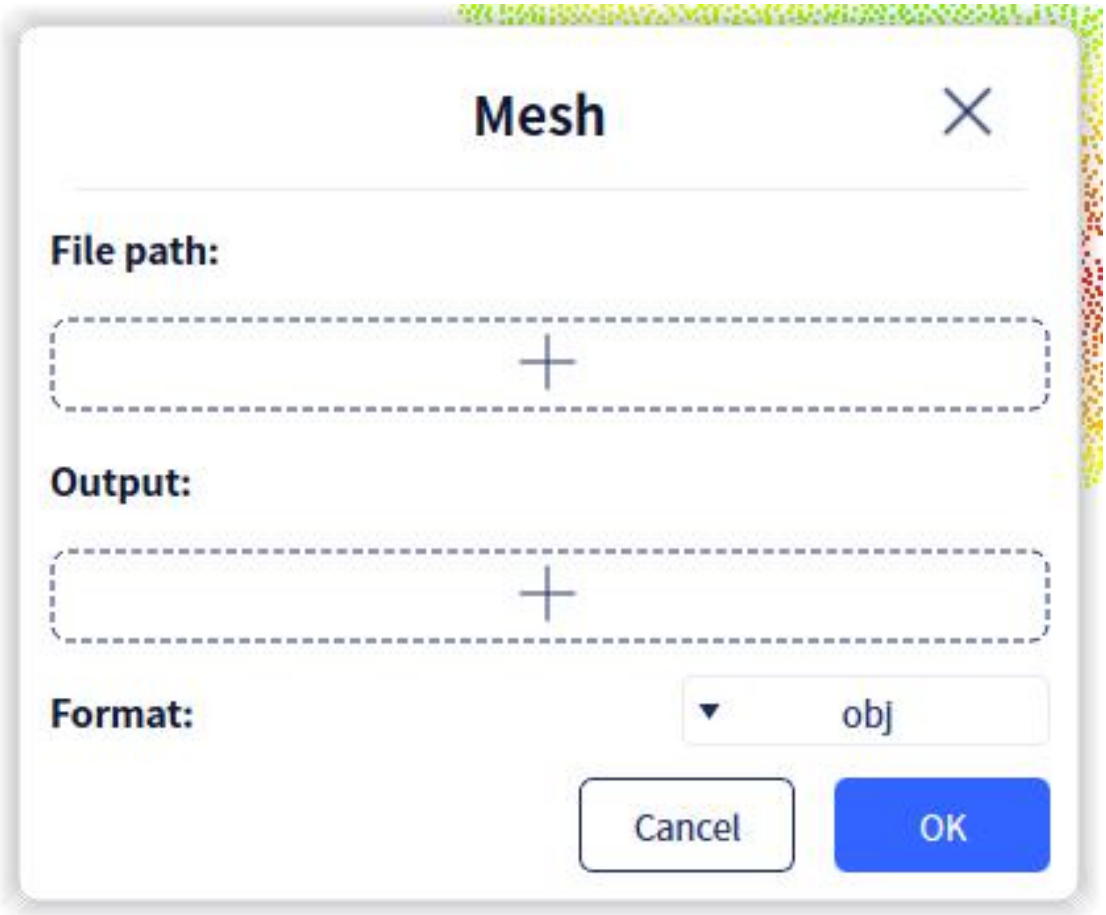
Type	Result
Area	21156.6
Filling volume	2065.55
Excavation volume	60207.5

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

2. **Mesh**

The Mesh function generates textured 3D models based on point cloud and panoramic photo data. For L1 and L2, it uses the external camera, while for K1 and L2 Pro, it uses the panoramic images generated from the coloring stage of project processing.

Click "Mesh," and input the 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:

a. For L1 and L2, you would need to perform coloring with the external camera. For K1 and L2 Pro, you will need to tick the Generate Panoramic Data option for internal camera in the coloring setting.

b. The current version of the Mesh function only supports processing post-processed .las result data that is less than 10GB.