3D Measurement and Inspection User Manual

v1.9.0

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Welcome to the tutorials of the 3D measurement and inspection solution!

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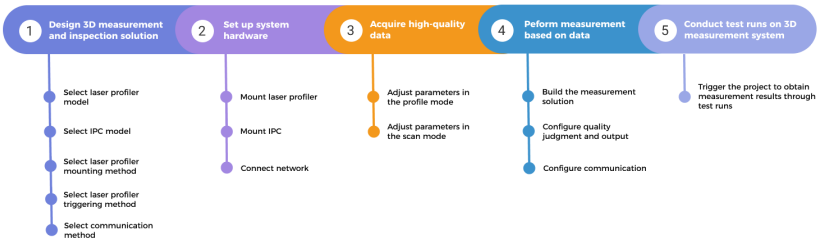
Practical Application Deployment

The approach to deploying a 3D measurement and inspection application in actual projects is shown in the following figure:



Please click the links to view the detailed explanation of each deployment phase.

Solution design:

- Design 3D Measurement and Inspection Solution

Solution deployment:

- Set up System Hardware
- Acquire High-Quality Data
- Perform Measurement Based on Data
- Conduct Test Runs on 3D Measurement System

1.1. Introduction to 3D Measurement and Inspection Solution

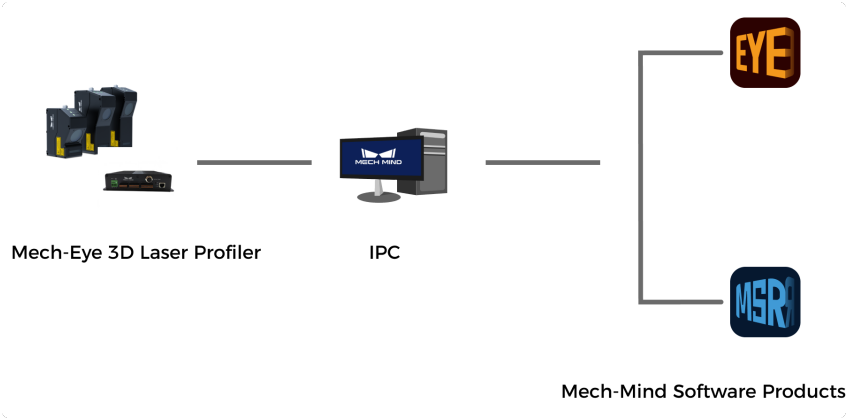
What Is the 3D Measurement and Inspection Solution?

Based on the Mech-Eye 3D Laser Profiler and Mech-MSR 3D measurement and inspection software developed by Mech-Mind, the 3D measurement and inspection solution provides various typical 3D measurement and inspection applications such as 3D geometric measurement, height

measurement, 3D defect inspection, and object counting. This solution is applicable to consumer electronics, EV battery, automobile, photovoltaic and other industries.

System Components of the 3D Measurement and Inspection Solution

The 3D measurement and inspection solution consists of the following components:



3D Laser Profiler

Mech-Eye 3D Laser Profiler ("laser profiler") is the 3D laser profiler developed by Mech-Mind and can output high-quality intensity images, depth maps, and point clouds. Together with Mech-MSR, it can be deployed for various 3D measurement and inspection applications.

- The laser profiler consists of a **controller** and **sensor head**.
- The laser profiler can be powered by a DIN rail power supply.

Industrial Personal Computer (IPC)

The computer that provides the operating environment for the Mech-Mind's software products.

You can use the standard IPC provided by Mech-Mind (recommended) or use your own device as the IPC. For more information about the IPC, refer to Select IPC Model.

Mech-Mind's Software Products

Mech-Mind's software products perform 3D measurement or inspection based on the data (intensity image, depth map, and point cloud) acquired by the laser profiler, and output the measurement or inspection results to an external device.

In this article, the laser profiler, IPC and Mech-Mind software products (Mech-Eye Viewer and Mech-MSR) provided by Mech-Mind constitute the Mech-Mind 3D Measurement System.

The Mech-Mind 3D Measurement System mainly involves the following software:

- Mech-Eye Viewer

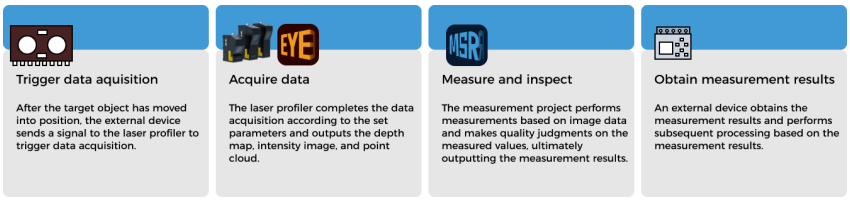
  Mech-Eye Viewer, installed on the IPC, is the configuration and data visualization software for laser profilers. It allows users to adjust the parameters of the laser profiler according to the characteristics of the target object, thus obtaining high-quality intensity images, depth maps, and point clouds simply and quickly.

- Mech-MSR

Mech-MSR, installed on the IPC, is a professional 3D measurement and inspection software. It can work with the laser profiler to deploy various 3D measurement and inspection applications, such as 3D geometric measurement, height measurement, 3D defect inspection, and object counting. The software has various built-in measurement algorithms and features, and it boasts a user-friendly interface. Users can apply the software to rapidly achieve one-stop, end-to-end deployment of applications.

Workflow of 3D Measurement and Inspection Applications

The general workflow of a 3D measurement and inspection application is shown in the figure below:

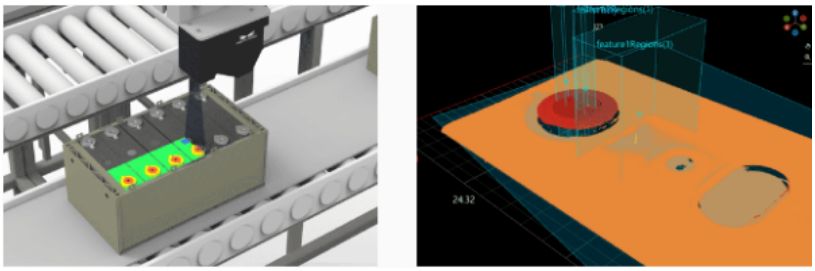


1. When the target object moves in place, an external device (such as a photoelectric sensor) sends a signal to trigger data acquisition.
2. After receiving the signal, the laser profiler acquires data of the object according to the parameters set through Mech-Eye Viewer, and generates the depth map, intensity image, and point cloud.
3. An external device triggers the measurement project to run. Mech-MSR performs measurement based on the acquired data, determines the quality of the measurement, and outputs the measurement result.
4. An external device obtains the measurement result from the 3D measurement system and performs subsequent processing based on the measurement result.

Application Scenarios of the 3D Measurement and Inspection Solution

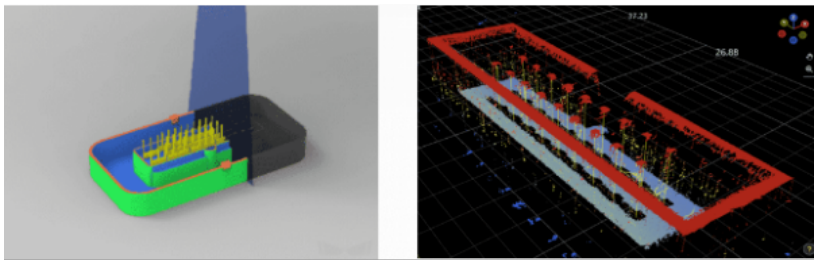
- 3D geometric measurement

  Measure the dimensions, step height, and spacing of the battery cell terminals. Regardless of the texture, reflectivity or color of the target object, the solution can perform stable measurements.



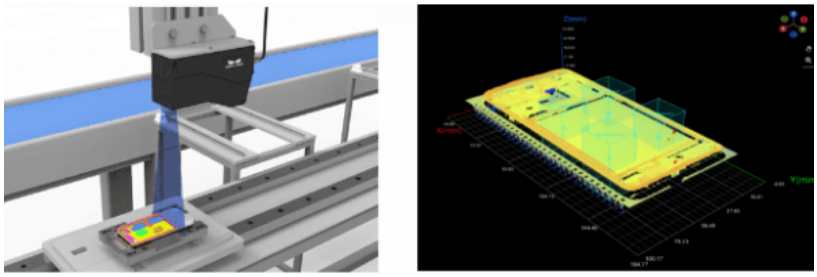
- Height measurement

  Measure the heights of connector pins relative to the surface of the connector. Even though the tip of the pin is extremely small, the solution can perform stable measurements.



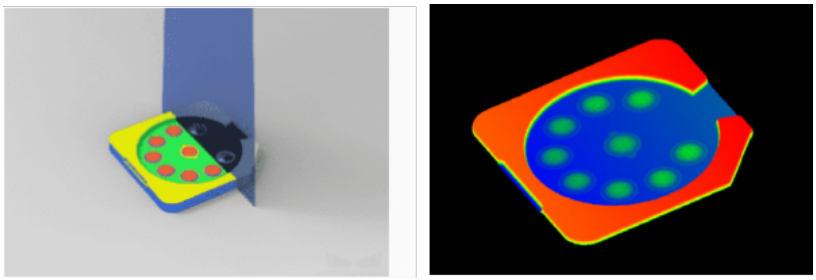
- Flatness inspection

  The flatness of smartphone mid-plates is a key factor in product quality. The solution can rapidly evaluate the flatness of the mid-plates.



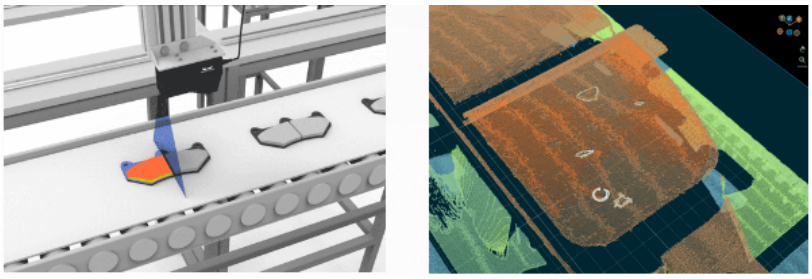
- Hole locating

  Quickly locate the holes on the target objects and measure the hole diameters to ensure that the shape, dimensions, and positions of the mounting holes on stamped parts are correct.



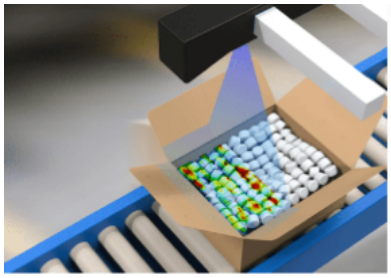
- 3D defect inspection

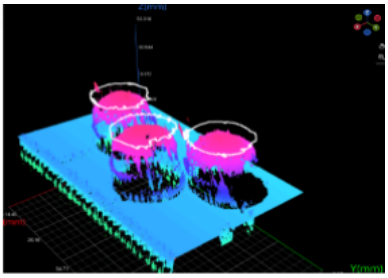
  Extract the change points of height from the depth map, and detect the presence of defects and defect patterns such as skewness, depression, and protrusion on the surface using the height information.



- Object counting

  Count product items of different shapes and sizes in real time on high-speed production lines.





1.2. Practical Application Deployment

1.2.1. Design 3D Measurement and Inspection Solution

Before actual deployment, you need to design a 3D measurement and inspection solution first, including selecting the laser profiler model, the IPC model, the laser profiler mounting method, and the communication method according to the actual requirements of the project.

In this phase, you need to complete:

- Select the Laser Profiler Model
- Select the IPC Model
- Select the Laser Profiler Mounting Method
- Select the Laser Profiler Triggering Method
- Select the Communication Method

Select the Laser Profiler Model

Familiarize yourself with the laser profiler models, their characteristics and applicable scenarios according to Laser Profiler Models, and select the appropriate laser profiler model according to the actual requirements of the project.

Please follow the procedure below to select the laser profiler model:

1. Determine the laser profiler model based on the measured object's dimensions (length, width, and height).

   Selection basis: The X-axis measurement range of the laser profiler should be larger than the length or width of the object to be measured. Usually, the long side of the laser profiler is parallel to the long side of the object to be measured, and the X-axis measurement range is larger than the width of the object to be measured. In addition, the Z-axis measurement range of the laser profiler should be larger than the height of the object to be measured.

   If multiple models of laser profilers meet your requirements, it is recommended to choose the model with a smaller measurement range.

   If the long side of the laser profiler is parallel to the wide side of the object to be measured, the X-axis measurement range should be larger than the length of the object to be measured. If two or more objects are stitched together for measurement, the X-axis measurement range should be greater than the total length or width of the objects after stitching.

2. Confirm that the laser profiler accuracy meets the project accuracy requirements.

The X-axis resolution and Y-axis resolution of the laser profiler should be smaller than the resolution required by the project.

The resolution reflects the minimum size or amount of variation that the laser profiler can resolve. Usually, the higher the laser profiler resolution (the smaller the value), the more accurate the laser profiler.

In a project, usually a measurement area should be represented by at least 5x5 to 10x10 pixels on the acquired depth map. You can calculate the X-axis and Y-axis resolution requirements based on the smallest measurement area. For example, if the smallest area to be measured is 1 mm x 1 mm, and the area is represented by 10 x 10 pixels, then each pixel needs to represent 0.1 mm x 0.1 mm, which means that the X-axis and Y-axis resolutions in the depth data (depth map, point cloud) output by the laser profiler should be less than 0.1 mm.

3. Confirm that the scan rate of the laser profiler meets the project cycle time requirement.

   The required scan rate of the project can be calculated using the following equation:

   Scan rate = Total scan length / Allowable scan time / Y-axis resolution

   For example, if the total scan length is 160 mm, the scan time is 2 s, and the Y-axis resolution is 0.0235 mm, then the needed scan rate of the project is 3.405 kHz.

   The above scan rate is only the image acquisition rate of the laser profiler. In actual projects, project processing time and signal/data transmission time should also be considered.

Select the IPC Model

Mech-Mind IPC STD and Mech-Mind IPC ADV models are recommended for 3D measurement and inspection solutions. Please select the appropriate IPC model according to the technical specifications of the IPC and the actual needs of the project.

Technical specification	Mech-Mind IPC STD	Mech-Mind IPC ADV
Number of Mech-MSR projects that can run simultaneously	≤3	≤5
Number of laser profilers that can be connected simultaneously	≤3	≤5

When the point cloud data of the target object is large (for example, the number of scan lines is close to 20,000) and the surface features are rich, it will place higher requirements on the performance of the IPC if multiple blob analysis and surface preprocessing Steps are required in the same project. Therefore, it is recommended to use the Mech-Mind IPC PRO model to ensure more efficient processing.

Mech-Mind allows you to use your own computer or laptop (“non-standard IPC” for short) as the IPC for installing and running Mech-Mind’s software products. Please note that Mech-Mind does not guarantee that the functions and performance of a non-standard IPC are the same as those of a standard IPC. Your own IPC should meet the system requirements for installing the Mech-MSR software.

Select the Laser Profiler Mounting Method

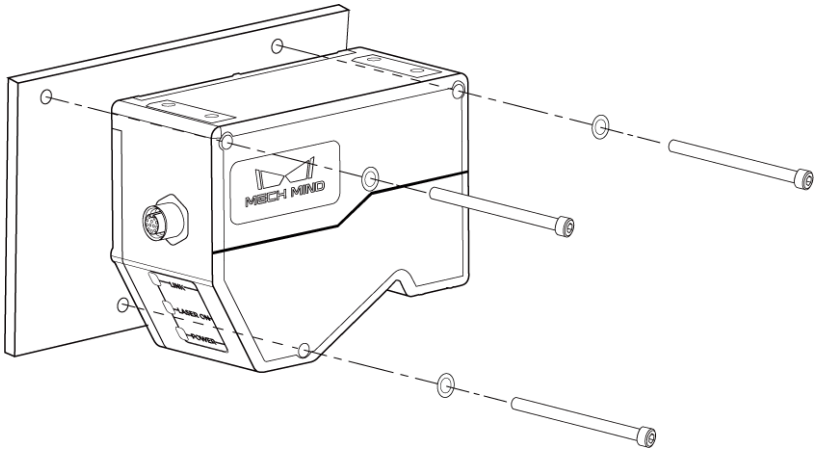
To ensure that the laser profiler can capture data of the target object, you need to maintain the

relative movement of the laser profiler (sensor head) and the object. You can choose any of the following methods according to the actual layout of the production line:

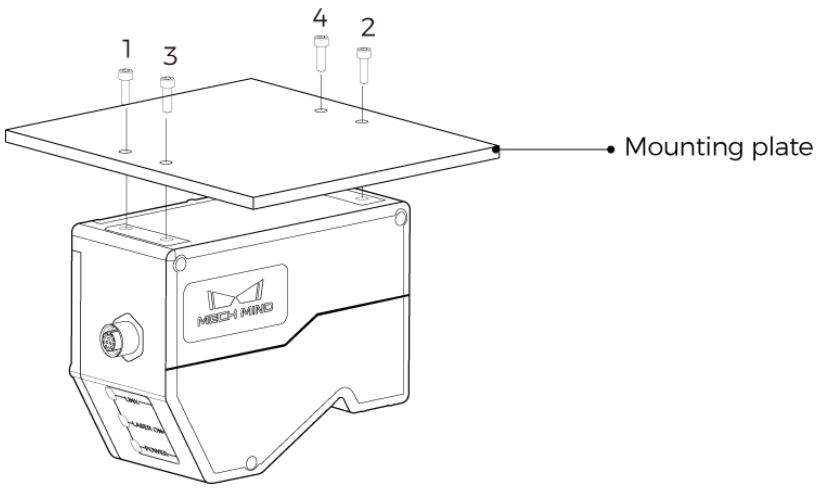
- **Fix the laser profiler and move the target objects**: The laser profiler needs to be securely mounted on a fixed bracket.
- **Fix the target objects and move the laser profiler**: The laser profiler needs to be mounted firmly on the frame of a motion mechanism.

The laser profiler (sensor head) supports two mounting methods:

- Side mounting (recommended)



- Top mounting



Please select the mounting method according to the actual needs of the project. For instructions on mounting the laser profiler, refer to Mounting and Connection.

Select the Laser Profiler Triggering Method

The laser profiler supports multiple methods to trigger data acquisition. The laser profiler supports controlling the triggering method of each round of data acquisition and each line scan separately.

There are two methods each for triggering one round of data acquisition and one line scan.

- Trigger a round of data acquisition:

  - External: Use the signal input from an external device to trigger each round of data acquisition.
  - Software: Use Mech-MSR, Mech-Eye Viewer, Mech-Eye API, or a GenICam client to trigger each round of data acquisition. In a 3D measurement and inspection solution, the "Software" method refers to triggering each round of data acquisition by Mech-MSR.
- Trigger a line scan:
  - Encoder: Use encoder signals to trigger each line scan.
  - Fixed rate: Trigger each line scan at a fixed rate.

Laser profilers support the following combinations of triggering methods. Please select the appropriate combination of triggering methods according to Combination of Triggering Methods and the actual needs of the project.

	External	Software
Encoder	√	√
Fixed rate	√	√

For the workflow of using each combination, refer to Workflow of Triggering Data Acquisition.

Select the Communication Method

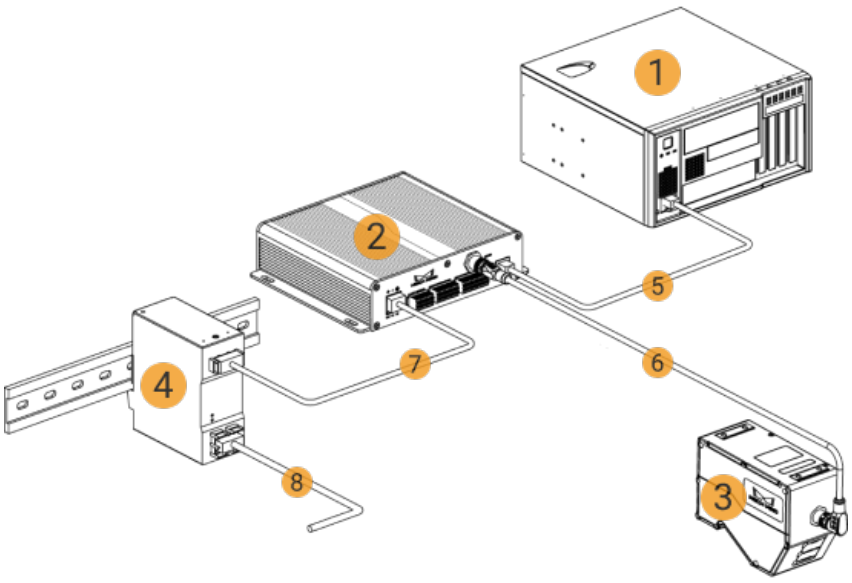
In a 3D measurement and inspection solution, the Mech-MSR project needs to send the measurement or detection result to an external device.

Mech-MSR currently supports only the communication method Transmission Control Protocol (TCP) in ASCII format. To ensure that the Mech-MSR can communicate normally with an external device, make sure that the external device supports TCP ASCII communication.

1.2.2. Set up System Hardware

In this phase, you need to integrate the hardware (laser profiler and IPC) of the 3D measurement system into the actual environment to support the normal operation of the 3D measurement system.

You need to mount and connect the hardware of the 3D measurement system, as shown below.



Prepare Materials

Before setting up the hardware, prepare the following materials.

1	IPC
2	Controller
3	Sensor head
4	DIN rail power supply (optional)
5	Controller Ethernet cable
6	Sensor-head-to-controller cable
7	DC power cable
8	AC power cable (prepared by yourself)

Mount the Laser Profiler

When mounting the laser profiler, follow these steps:

1. Mount the Sensor Head
2. Mount the Controller
3. Connect the Sensor Head and Controller
4. Connect the Controller and IPC
5. Connect the Controller and DIN Rail Power Supply
6. Connect the Controller and External Device
7. Set the Laser Profiler IP Address

For detailed instructions on mounting and connection, refer to Mounting and Connection in the getting started tutorial of the laser profiler.

Mount the IPC

The IPC is normally mounted in the control cabinet. The environment in which the IPC is mounted requires good heat dissipation, ventilation, and dust-proof. It should be mounted at a location where Ethernet cables, HDMI cables, and USB ports can be easily mounted and maintained.

For mounting of the Mech-Mind IPC STD model, refer to Mech-Mind IPC STD User Manual.

For mounting of the Mech-Mind IPC ADV model, refer to Mech-Mind IPC ADV User Manual.

After mounting the IPC, please start it. Make sure that the **Mech-Eye SDK SDK** and **Mech-MSR** software used in the 3D measurement and inspection solution are running the latest versions.

If these software are not running the latest version, refer to the following documents to upgrade the software:

- Mech-Eye SDK Installation Guide.
- Mech-MSR Installation Guide.

Connect the Network

In this section, you need to complete the Ethernet cable connection and network setup between the laser profiler and the IPC, as well as between the IPC and the external device.

Please pay attention to the following requirements when setting up the network:

- The IP addresses of the laser profiler and the IPC's Ethernet port connected to the laser profiler are in the same subnet.
- The IP address of the external device and the IPC's Ethernet port connected to the external device are in the same subnet.

Connect the IPC and External Device

The connection between the laser profiler (controller) and the IPC has been completed during the "Mount the Laser Profiler" step. Here, you need to connect the IPC and the external device.

Use an RJ45-to-RJ45 Ethernet cable to plug one end into the Ethernet port of the IPC and the other end into an Ethernet port of the external interface.

Set the IP Addresses on the IPC

1. Select Control Panel › Network and Internet › Network and Sharing Center › Change adapter settings on the IPC. The **Network Connections** page will be displayed.
2. Right-click the Ethernet port connected to the laser profiler, and select **Rename** to rename the Ethernet port, such as "To_profiler".
3. Right-click the Ethernet port connected to the laser profiler, and select **Properties** to enter the **Ethernet Properties** page.
4. Select the **Internet Protocol Version 4 (TCP/IPv4)** checkbox, and then click the **[Property]** button to enter the **Internet Protocol Version 4 (TCP/IPv4) Properties** page.
5. Select the **Use the following IP address** radio button, set the **IP address** to "192.168.100.10", **Subnet mask** to "255.255.255.0", and **Default gateway** to "192.168.100.1", and then click the **[OK]** button.

6. Repeat steps 2 to 5 to rename the Ethernet port connected to an external device (such as "To_external"), and set the IP address of the Ethernet port. For example, the IP address of this Ethernet port is "192.168.200.10."

Test the Network Connectivity

1. Press `Win` + `R` to open the **Run** dialog box.
2. Type cmd in the **Run** dialog box, and then click **[OK]**.
3. Type **ping XXX.XXX.XX.XX** in the command prompt window and press **[Enter]** to execute the command.

> Replace XXX.XXX.XX.XX with the actual IP address of the laser profiler or external device.

If the network connectivity is normal, you should receive the following response:

```
Pinging XXX.XXX.XX.XX with 32 bytes of data:
Reply from XXX.XXX.XX.XX: bytes=32 time<1ms TTL=128
Reply from XXX.XXX.XX.XX: bytes=32 time<1ms TTL=128
Reply from XXX.XXX.XX.XX: bytes=32 time<1ms TTL=128
Reply from XXX.XXX.XX.XX: bytes=32 time<1ms TTL=128
```

1.2.3. Acquire High-Quality Data

In this phase, you need to adjust the parameters of the laser profiler to ensure that you can acquire high-quality data (intensity images, depth maps, and point clouds).

The general workflow of adjusting parameters is as follows:

1. Create or select a parameter group.

> After setting the parameter group here, you should select this parameter group when connecting to the laser profiler in the "3D Laser Profiler" Step of the Mech-MSR project.

2. Adjust the parameters in the profile mode to obtain the satisfactory profile.
3. Adjust the parameters in the scan mode to obtain the satisfactory intensity image, depth map, and point cloud.
4. Save parameter adjustments to the parameter group.

For more details, refer to General Workflow of Adjusting Parameters.

1.2.4. Perform Measurement Based on Data

In this phase, you need to configure the Mech-MSR project to ensure that the project can accurately measure each measurement item and output the measurement results.

The process of configuring a Mech-MSR project is shown in the figure below.

Build a Solution

A Mech-MSR solution is used to measure and inspect target objects, starting with image acquisition, processing (optional), and then measurement or inspection.

For typical application scenarios, you do not need to build a solution and project from scratch. The Mech-MSR solution library provides a wealth of 3D measurement case solutions. You can directly use these case solutions as your application template to create, configure, and tune a 3D measurement solution quickly.

You can also build a solution from scratch and then configure parameters. To build a solution from scratch, follow the steps below: Create a new solution → Create a new project → Add Steps to the project and connect them → Enable "Autoload Solution" for the new solution.

You can build the project by referring to the following materials:

- Quick Guide to Solutions
- Quick Guide to Projects
- Quick Guide to Steps
- *Typical Case Practices of 3D Measurement and Inspection*

Configure Parameters

After building a solution, you need to adjust the parameters of each Step of the project to ensure that the project can meet the measurement and inspection requirements.

The general workflow of adjusting parameters is as follows:

1. In the graphical programming workspace, select the "3D Laser Profiler" Step and connect to the laser profiler used in the project.

   When connecting to the laser profiler, you should select the parameter group set in Acquire High-Quality Data.

2. Enable **Debug Output** for the project.
3. Select another Step in the graphical programming workspace, and then adjust the parameters as needed in **Step Parameters**.
4. In the **Output** area of **Step parameters** of measurement-type Steps, select the desired measurement items and set the acceptable range (min and max values).
5. Run the project or a single Step, and then check the effect in **Data Viewer**.
6. Save the project and solution after adjusting the parameters of all Steps.

For more information about adjusting Step parameters, please refer to Step Reference Guide. If you have built a solution and project using a case solution, please refer to Typical Case Practices for more guidance on parameter configuration.

Configure Quality Judgment and Output

You can configure quality judgment rules, aggregate the results of multiple measurement items, and output the overall judgment result.

- If the overall result is OK, Mech-MSR will return 0.

- If the overall result is NG, the Mech-MSR will return 1.

For details, refer to [software-overview:output-management:::output-setting].

In addition, you can configure Mech-MSR to output the measured value and measurement result of each measurement item. Measured values and measurement results (OK/NG) of individual measurement items can only be output to external devices by Mech-MSR after the measurement items are added to the output.

Configure the Communication

To ensure that an external device can trigger the project and obtain measurement results from the 3D measurement system, you need to complete the communication configuration.

For the communication configuration on the external device side, refer to the communication configuration guide for the external device.

On the 3D measurement system side, you need to complete the communication configuration on Mech-MSR. For details, refer to Communication Configuration Process.

1.2.5. Conduct Test Runs on 3D Measurement System

In this phase, you need to conduct test runs on the 3D measurement system to make sure that an external device can obtain measurement results normally.

Prerequisites for Test Runs

Before testing the 3D measurement system, the following conditions must be satisfied:

- If the laser profiler uses an external device to trigger each round of data acquisition, make sure that the external device can normally input signals to the laser profiler to trigger one round of data acquisition.
- If the laser profiler uses an encoder to trigger line scans, make sure that the encoder can input the signals that trigger line scans to the laser profiler normally.
- TCP ASCII communication has been enabled for the external device and a TCP connection has been established with the 3D measurement system.

In addition, before testing the 3D measurement system, you need to prepare sample objects (including OK and NG ones) and the values (reference values) measured by other measurement instruments.

Procedure of Test Runs

The procedure for conducting test runs on the 3D measurement system is as follows:

1. After the object is in place, an external device (such as a photoelectric sensor) sends a signal to trigger data acquisition.
2. The laser profiler acquires data.
3. An external device (such as a PLC) sends a command to trigger the Mech-MSR project to run. For example:

```
trigger, 1
```

This command triggers the Mech-MSR project with ID 1 to run. Project ID is the number before the project name in the project list.

4. An external device obtains the measurement result output by the Mech-MSR project.

```
return, 1
```

This command obtains the measurement result output by the Mech-MSR project with ID 1. The format of the result returned by this command is set by the **Data format of return commands** parameter in the **Communication Configuration** window.

5. Confirm that the external device can receive the measurement result normally and parse it.
6. Confirm that the measurement result and measured values of each sample are consistent with the reference values.

If the measurement result and measured values output by the 3D measurement system are consistent with the reference values, the 3D measurement system can be used in the production line.

2. Mech-MSR Software User Manual

Welcome to Mech-MSR Software User Manual!

Mech-MSR is a software designed for 3D measurement and inspection. It can work with the Mech-Eye 3D Laser Profiler to deploy various 3D measurement and inspection applications, such as 3D geometric measurement, height measurement, 3D defect inspection, and object counting. The software has various built-in measurement algorithms and features, and it boasts a user-friendly interface. Users can apply the software to rapidly achieve one-stop, end-to-end deployment of applications.

This manual consists of the following contents:

2.1. Release Notes

Thank you for using Mech-MSR 1.9.0!

Mech-MSR has integrated powerful operators, including dimensional measurement, height measurement, flatness inspection, etc., which makes it suitable for measurement and inspection applications such as 3D geometric measurement, hole locating, 3D defect inspection, object counting and so on. With specialized functionalities such as image acquisition, alignment and correction, 3D measurement, quality judgement, as well as communication protocols, Mech-MSR provides one-stop, end-to-end deployment. Even beginners with no prior experience or knowledge will be able to configure the operators and perform 3D measurements easily by means of the user-friendly interface and the powerful 3D visualization engine built-in.

Thank you for choosing Mech-MSR. Exceptional measurement solutions are now in place!

2.2. Installation Guide

This chapter guides you through the downloading, installation, uninstallation, repair, and installation modification of Mech-MSR.

System Requirements

Mech-MSR can be used only when installed on an industrial personal computer (IPC) or your PC (personal computer). The IPC or PC for installing software should meet the following recommended system requirements:

Operating system	Windows 10 or above
CPU	Support for the AVX2 instruction set, Intel i5-12400 or higher
Memory	16 GB or above

GPU	NVIDIA GeForce GTX 1660 Super or above (if with a discrete graphics card)
Hard disk	256 GB SSD or larger

- Mech-MSR does not support discrete graphics cards other than NVIDIA.
- Ensure that the hard disk where the software will be installed on IPC or PC should have at least 10 GB free space; otherwise, installation may fail.

When Mech-MSR is running, the resolution and scale of the screen should follow the correspondence in the table below. If the resolution and scale of your screen do not match those in the table below, some display problems may occur.

Resolution	Scale
1920 × 1080 (16:9)	100% or 125%
2560 × 1440 (16:9)	125% or 150%
3840 × 2160 (16:9)	150% or 175%

Download Software Installation Package

You can download the software installation package from Mech-Mind Download Center or contact Mech-Mind pre-sales or support engineers.

Install the Software

Verify the Integrity of Software Installation Package

Since the software installation package may be corrupted during transmission or downloading, you need to verify the integrity of the software installation package. The integrity of the installation package can be verified with the CRC-32 value, which is provided on the download page.

Please install and use the 7-Zip software to calculate the CRC-32 value.

To verify the integrity of the software installation package, follow these steps:

1. Copy the installation package to a specified directory on the device that will run the software, such as *D:/*.
2. Unzip the installation package. You will see the installer (`Mech-MSR Installer 1.9.0.exe`) and the **content** folder.

   Do not move the installer and the **content** folder.
3. Open 7-Zip, and use the address bar to navigate to the directory where the software installation package is located.
4. Select the software installation package, and in the context menu, select File › CRC › CRC-32 to calculate the CRC-32 value.
5. Check the calculated CRC-32 value against the one on the download page. The two values should be identical.
6. Repeat Steps 3–5 on the installer and content file after decompression.

   If the calculated values do not match those provided on the download page, please download the installation package again.

Install the Software

To install Mech-MSR, follow these steps:

1. Double-click the executable software installation file and open **Mech-MSR Setup Wizard**. The **Welcome** window will be displayed.
2. In the **Welcome** window, browse the software information and click **[Next]**.
3. In the **License Agreement** window, read the license agreement carefully, check the **[I accept the terms and conditions in the license agreement]** check box, and then click **[Next]**.
4. In the **Select Product** window, select the product to install (Mech-MSR x.x.x). Select the **[Create desktop shortcut(s)]** checkbox (recommended), and then click the **[Next]** button.
5. In the **Set Path** window, change the installation path as required, such as “D:/project”, and then click the **[Next]** button.

   If the installation path is not changed, the path to the default destination folder is as follows: `C:/Mech-Mind/Mech-MSR-1.9.0`

6. In the **Confirm** window, confirm that the installation path is correct and then click the **[Install]** button.
7. In the **Install** window, wait for the installation to complete.
8. After the software is installed, in the **Finish** window, click the **[Finish]** button.

   If the installation fails, refer to the error message in the **Finish** window and the Troubleshoot Common Installation Issues section to troubleshoot the issue.

   When you first open the software, if your IPC or PC displays a security alert, click **[Allow Access]** to add the software to the firewall whitelist. Otherwise, the software may not be able to detect the laser profiler due to the firewall blocking.

Uninstall the Software

If you do not need to use Mech-MSR, you can uninstall it using any of the following ways:

- Uninstall the software using the Setup Wizard (recommended)
- Uninstall the software using Windows Control Panel

Uninstall the Software Using the Setup Wizard

To uninstall the software using the Setup Wizard, follow these steps:

1. Double-click the decompressed software installation file (EXE file) and open **Mech-MSR Setup Wizard**. The **Maintain** window will be displayed.
2. In the **Maintain** window, click the **[Uninstall]** button.
3. In the **Uninstall** window, click either **[Keep user configuration files]** or **[Do not keep user configuration files]**.
4. Wait until the uninstall operation is completed.

Uninstall the software using Windows Control Panel

To uninstall the software using the Windows Control Panel, follow these steps:

1. Open the **Control Panel** on the IPC or PC.
2. Select Program › Uninstall or change a program.
3. Right-click the software to uninstall, and then click **[Uninstall]**.
4. Wait until the uninstall operation is completed.

Repair the Software

If Mech-MSR fails to work normally due to certain exception, you can use the repair function to reinstall the software.

To repair the software, follow these steps:

1. Double-click the executable software installation file and open **Mech-MSR Setup Wizard**. The **Maintain** window will be displayed.
2. In the **Maintain** window, click **[Repair]**.
3. Wait until the repair operation is completed.

Software License Agreement

For the license agreement of Mech-MSR, please refer to End-User License Agreement.

Troubleshoot Common Installation Issues

Failed to Start the Setup Wizard

Symptom:

After a double click on the installation file, the setup wizard could not be started properly or crashed.

Possible Cause:

There is not enough space available on the system drive.

Troubleshooting Procedure:

Check whether the available space on the system drive is larger than the size of the installer.

- If the available space on the system drive is smaller than the size of the installer, delete unnecessary files to free up the space, and then reinstall. If the issue still exists, contact Mech-Mind Technical Support.
- If there is enough space on the system drive, contact Mech-Mind Technical Support.

Installation Failed

Symptom:

An error message saying “Installation failed.” appeared during the installation.

Possible Cause:

- Corrupted installer or missing files.

- The current user does not have administrator access.
- Another Wizard is performing the installation or the Windows system is being upgraded.
- Other reasons.

Troubleshooting Procedure:

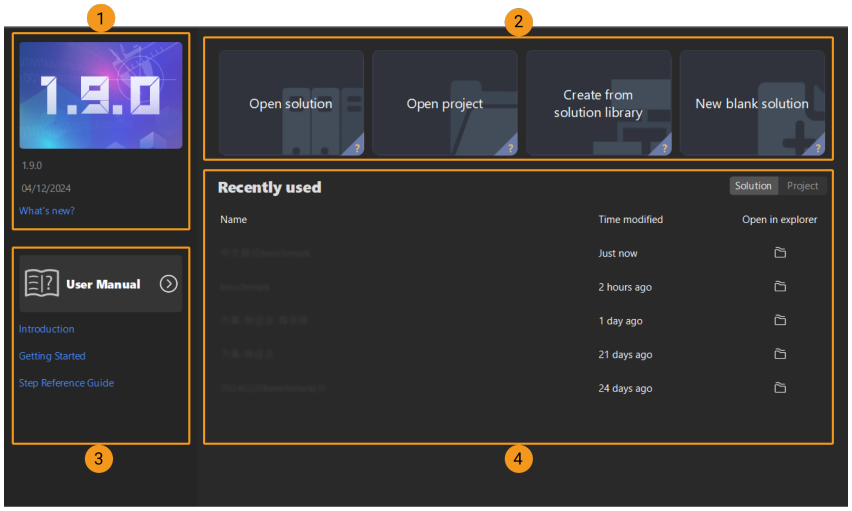
1. Obtain a new installer and check its integrity, and then try the installation again.
   - If the problem is resolved, the troubleshooting is completed.
   - Otherwise, proceed to Step 2.
2. Right-click the installer and select “Run as administrator” to reinstall.
   - If the problem is resolved, the troubleshooting is completed.
   - Otherwise, proceed to Step 3.
3. Try the installation again after the installation of other software completes or after the Windows system upgrade completes.
   - If the problem is resolved, the troubleshooting is completed.
   - Otherwise, proceed to Step 4.
4. Restart your IPC or computer and try the installation again.
   - If the issue is resolved, the troubleshooting is completed.
   - If the issue still exists, click the “installation log” link in the **Finish** window to collect installation logs and send them to Mech-Mind Technical Support.

2.3. User Interface

This part introduces Mech-MSR’s Welcome interface and Home interface.

Welcome Interface

If there is no autoloaded solution or project, Mech-MSR will display the Welcome interface when you open it, as shown below.



Hover the mouse cursor over the “?” in lower right corner of a quick entry card to check induction to this card .

The Welcome interface of Mech-MSR consists of the following parts.

No.	Area	Description
1	Version information	Check version information and release notes.
2	Quick entry	Quick access for the user to open a solution, open a project, create a solution from solution library, and create a new blank solution.
3	User Manual	Click the button to view Mech-MSR's user manual.
4	Recently used	Quickly open recently used solutions or projects.

Home Interface

Leave the Welcome interface and you will enter the Mech-MSR Home interface, as shown below.

The Home interface of Mech-MSR consists of the following parts.

No.	Area	Description
1	Menu Bar	Includes File, Edit, Communication, Settings, and Help.
2	Toolbar	Includes buttons to quickly access tools and functions.
3	Project List	Displays opened solution, project name, and their status, including communication status and autoload status.
4	Step Library	Includes all the Steps needed to create a project.
5	Graphical Programming Workspace	Edit the processing or logical flows of a vision project.
6	Parameter configuration panel	Used to configure the input, parameters, and output of a Step.
7	Data Viewer	Used to visualize various input data, set feature regions, and view the execution results of some Steps.

No.	Area	Description
8	Result display area	Displays the execution results of a Step according to the selected output items.
9	Log panel	Displays the logs in real-time while a project is running for user to find the execution record of a certain moment in this panel.

2.4. Quick Guide of Mech-MSR

As you learn to use Mech-MSR, mastering the basic procedures will help you deploy 3D measurement and inspection applications faster and more efficiently.

Quick Guide for Solution Library

In the Solution Library, you can find case solutions with example data for different industries.

Here are some common operations related to the Solution Library:

Quick Guide for Solution Library	Open the Solution Library
	View Solution Information
	Create a Solution from the Solution Library

Quick Guide for Solutions and Projects

“Solution” is the solution to a 3D measurement project; “project” refers to the Mech-MSR measurement project. A project must belong to a solution, or else it cannot be used. In addition, a solution may include multiple projects. The data and configurations for measurement, such as project data, communication configuration, and output management, are stored in the directory of the solution.

Basic procedures of using solutions and projects are as follows:

Quick Guide for Solutions	Create Solution
	Save Solution
	Autoload Solution
	Rename Solution
	Close Solution
Quick Guide for Projects	Create and Save Project
	Save Project
	Rename Project
	Open Project
	Run project
	Close Project
	Adjust Project ID

Quick Guide for Steps

A Step is a minimum algorithm unit for data processing. By connecting different Steps in a project, you can construct a complete measurement procedure.

Basic procedures of using Steps are as follows:

Quick Guide for Steps	Search/Add/Delete Steps
	Create/Delete Connections
	Run Steps
	View Outputs

Others

- Quick Guide for Output Management
- Quick Guide for Communication Configuration

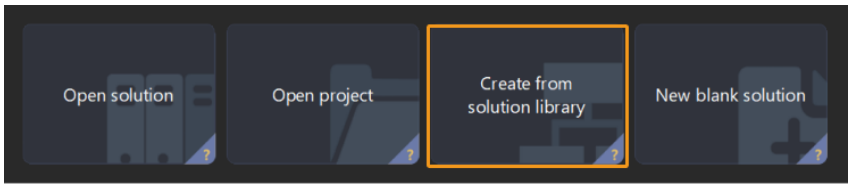
2.4.1. Quick Guide to Solution Library

Open the Solution Library

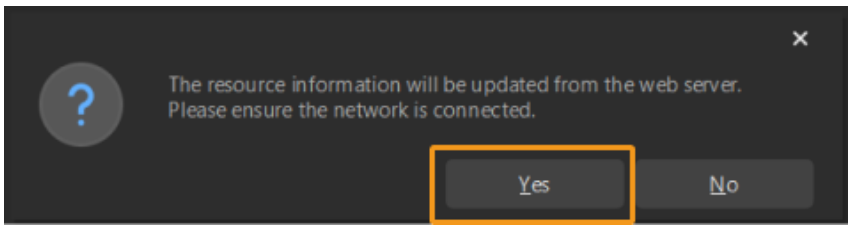
This section introduces how to open the Solution Library.

Open from the Welcome Interface

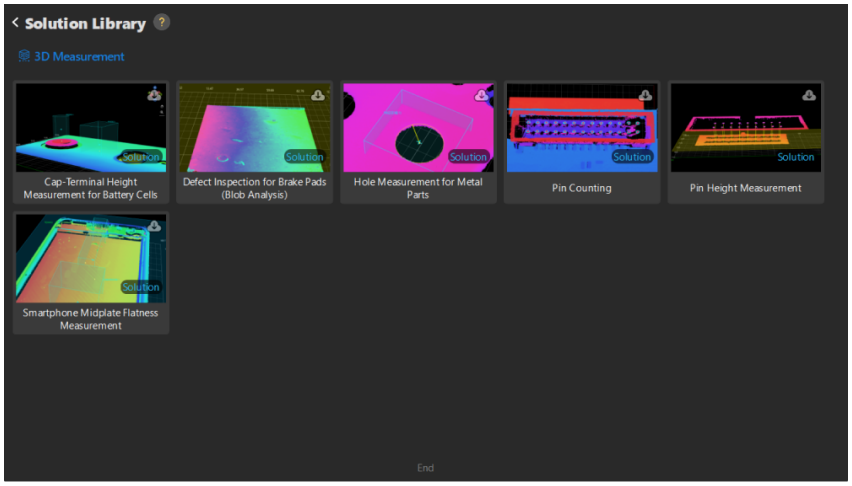
After you open Mech-MSR, click **[Create from solution library]** in the Welcome interface to open the Solution Library.



There are some built-in resources in the Solution Library. If you want to view more solutions, click **[More]** at the bottom of the interface. Click **[Yes]** in the pop-up window to start loading.



After the resources are loaded, you can see more solutions displayed in the Solution Library, as shown below.



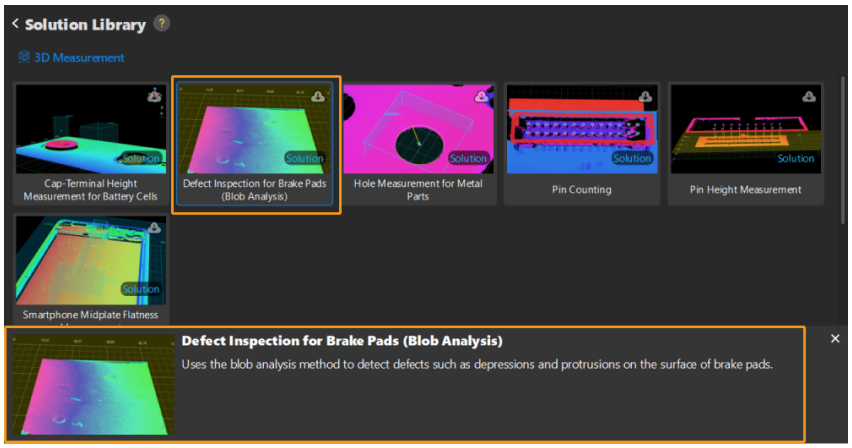
Open from the Main Interface

If you have already entered the main interface, you can open the Solution Library in either of the following ways.

- Click **[Create from Solution Library]** in the toolbar.
- Select File › Create from Solution Library in the menu bar.

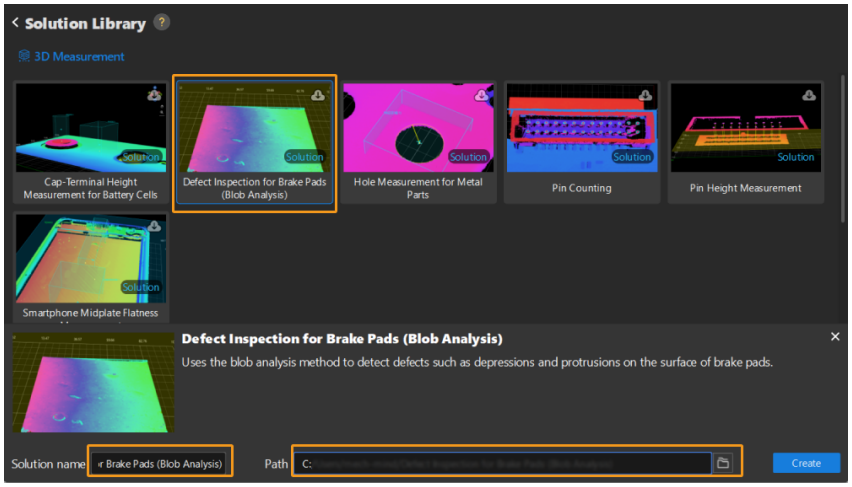
Check the Brief Introduction to Solutions

If you want to know more about a solution, click the solution in the Solution Library, and a brief introduction will appear at the bottom of the interface.

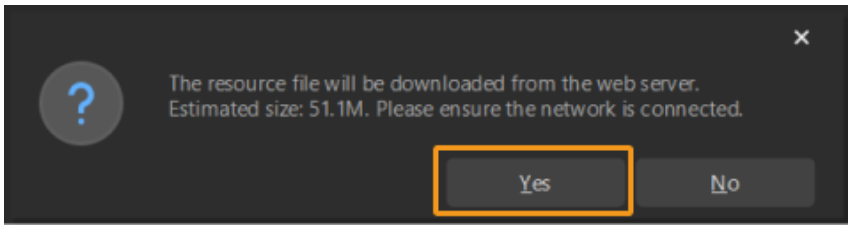


Create a Solution from the Solution Library

To create a solution from the Solution Library, open the Solution Library first. Then, select the solution, enter a **Solution name**, and specify the **Path** to store the solution. Click **[Create]** in the end.



Click **[Yes]** in the pop-up window to create the solution to the specified path.



2.4.2. Quick Guide to Solutions

Create a New Solution

Create a New Blank Solution

There are three ways to create a new blank solution:

- Click **[New blank solution]** on the Welcome interface.
- Select File › New Solution in the menu bar of the main interface.
- If no solution or project is opened, click **[New solution]** in the middle of the interface.

Create a Solution from the Solution Library

See Create a Solution from the Solution Library.

Save the Solution

After a new solution is created, it is recommended to specify a directory to save the solution in time. Select File › Save Solution in the menu bar (or press `Ctrl` + `Shift` + `S` on the keyboard).

Autoload a Solution

Right-click the solution in the Project List and select **Autoload Solution**.

When **Autoload Solution** is selected, all the projects belonging to the solution will be auto-loaded. Therefore, the next time you open the software, you will enter the main interface of the software directly, instead of the Welcome interface.

Rename the Solution

1. Right-click the solution in the **Project List** and select **[Rename Solution]**.
2. Enter a new solution name and then press `Enter` to confirm.

Close the Solution

There are two ways to close a solution:

- Right-click the solution in the Project List and select **[Close Solution]**.
- Select File › Close Solution in the menu bar.

- If there are unsaved changes in the project, a pop-up window will appear. You can make a choice based on actual needs.
- Once you close the solution, all the projects in the solution will be closed as well.

2.4.3. Quick Guide to Projects

Create and Save Project

Create from Solution Library

New Blank Project

You can only create a new project after creating a new solution.

There are three ways to create a new blank project:

- After a new solution is created, a new blank project will automatically be created within that solution.
- Select File › New Project in the menu bar to create a new blank project.
- Press `Ctrl` + `N` on the keyboard to create a new blank project.

Save Project

You can choose to save a single project or all projects in the solution.

Save a Single Project

There are three ways to save a single project:

- Select File › Save Project in the menu bar to save a single project.
- Click  on the left end of the project toolbar.
- Press `Ctrl` + `S` on the keyboard.

Save all Projects in the Solution

Select File › Save Solution in the menu bar to save all projects in the solution.

Rename Project

Right-click the project in the Project List, and select **[Rename Project]**. Enter a new project name and press `Enter` to confirm.

Open Project

Open an Existing Project

There are three ways to open an existing project:

- Click **[Open project]** on the Welcome interface, and select the project folder in the pop-up window. You do NOT need to open the folder and select the MSR file.
- Click File › Open Project in the menu bar of the main interface (or press `Ctrl` + `O` on the keyboard), and select the project folder in the pop-up window. You do NOT need to open the folder and select the MSR file.
- Double-click the MSR file in the project folder to open Mech-MSRand autoload the project.

Open a Recently Opened Project

- Find the Solution/Project button on the Welcome interface, switch to **Project** and double-click the project you want to open.
- Click File › Open Recent… in the menu bar of the main interface, and then select the project recently opened from the context menu.

Run Project

Click **[Run]** in the project toolbar or press `Ctrl` + `R` on the keyboard to run the current project.

Close Project

You cannot close a single project within a solution. Instead, you can close the solution to close all the projects within it. The detailed instructions are as follows.

Right-click the corresponding solution in the Project List, and select **[Close Solution]** to close the solution and all the projects within it.

If there are unsaved changes in the project, a pop-up window will appear. You can make a choice based on actual needs.

Adjust Project ID

When **Autoload Solution** is selected, the projects belonging to the solution will be auto-loaded as well. Each project will be assigned a project ID.

To adjust the project ID, follow these instructions:

1. Select a project and drag it up and down to adjust its order.
2. To reset the project ID, right-click the solution or one of the projects, and select **[Reset Project IDs]**. The disordered project IDs will be re-sorted in ascending order, while the order of the projects remains the same.

2.4.4. Quick Guide to Steps

Search/Add/Delete Steps

Search for a Step

There are two ways to search for a Step:

- In the search box of the Step Library, enter the name of the Step directly (or a keyword in the name).
- Click the corresponding Step category to expand the list.

Add Steps

You can add Steps only after you have created a new project or opened an existing one.

Press and hold the left mouse button to select a Step, drag it to any position in the graphical programming workspace and release it.

Delete Steps

There are two ways to delete a Step:

- Left-click a Step and press `Delete` on the keyboard.
- Right-click a Step and click **[Delete]** in the context menu.

Create/Delete Connections

Create Connections

- Connections can only be created among ports of the same data type.
- An output port can be connected to multiple input ports, but an input port can only be connected to one output port.

There are two ways to connect Steps:

- Hover over an output port of a Step, press and hold the left mouse button and drag to the input port of a succeeding Step, then release the left button.
- Click a Step, and configure the inputs under **Input** in the parameter configuration panel.

Delete Connections

There are three ways to delete connections:

- After left-clicking the connection, the connection will be highlighted. Press `Delete` on the keyboard to delete it.
- After right-clicking the connection, the connection will be highlighted, and a context menu will pop up. Then, click **[Delete]**.
- Click a Step, and select “No Input” from the drop-down menu under **Input**.

Run Steps

- Click **[Run]** in the project toolbar to run the entire project.
- Click  to run the project down from the current Step.
- Click  to run the current Step independently.

View Outputs

The data output from Step "3D Laser Profiler" is used for the entire project.

1. Enable **Debug Output** in the project toolbar.
2. Run the Steps.
   - For Step "3D Laser Profiler": Click  on the Step, then the visualized output will be displayed in Data Viewer.
   - For the other Steps: Run the entire project or click  on Step "3D Laser Profiler" to pass the data down. Then, click the Step for which you want to view the results, and its visualized output will be displayed in Data Viewer.

In debugging phase, there is no need to re-pass data every time. After running Step "3D Laser Profiler" once to pass data down, you can click  to view the visualized output.

2.4.5. Quick Guide to Output Management

This section introduces the operations related to output management.

Output management provides two main functions:

- **Quality judgment**: Evaluate the measurement data of the project to determine whether the target object meets predefined quality standards or specifications. Quality judgment can be used to evaluate all the measurement items as a whole and finally obtain the overall quality judgment result of the project. You can configure the comprehensive judgment rule or custom judgment rules for quality judgment.
- **Communication output**: Can be used to customize the output content. By default, the Mech-MSR software outputs only the overall quality judgment result of the project. This function allows you to customize the output of the project. For example, you can add the measurement result (judgment result and measured value) of a specific measurement item to the output.

- **Quality judgment** and **communication output** should be set per project.
- After running the project, the overall quality judgment result (OK or NG) of the project will be displayed on the top of the **graphical programming workspace**. If **quality judgment** has not been set for the project, the overall quality judgment result of the project will be OK by default.

The following operations are mainly introduced:

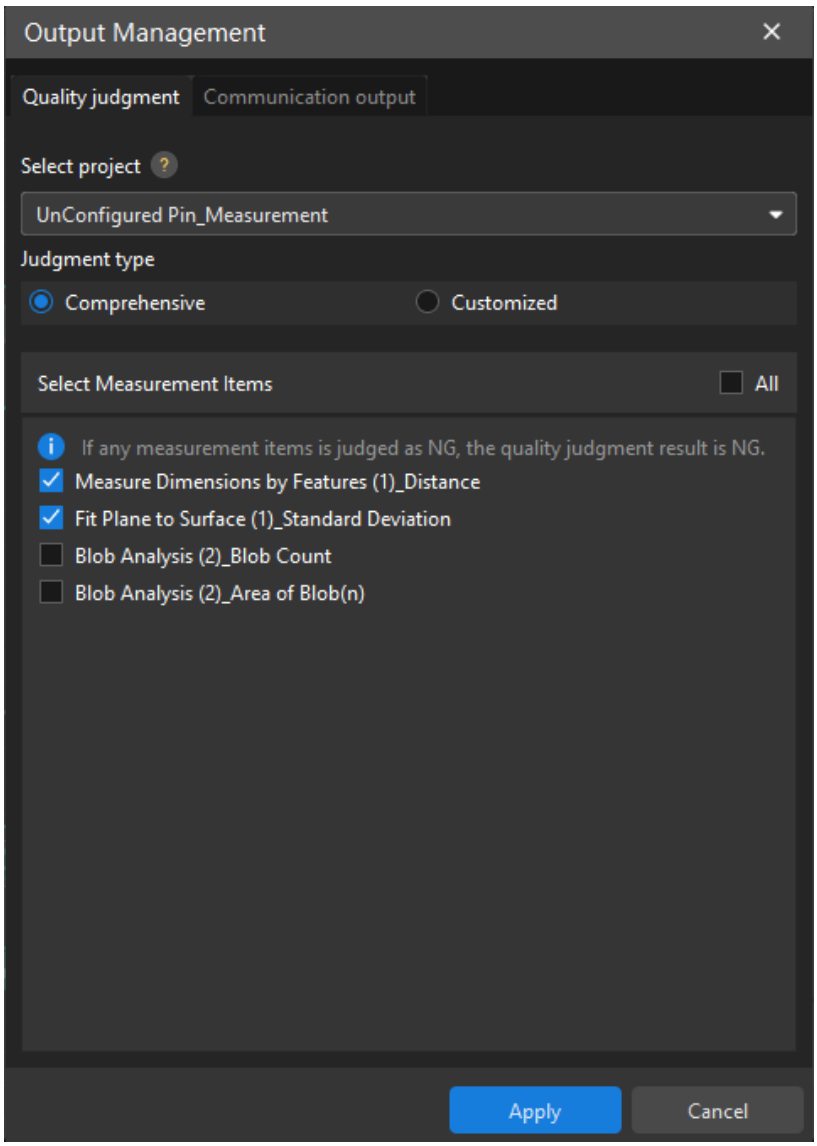
- Configure the Comprehensive Judgment Rule for the Project
- Configure Custom Judgment Rules for the Project
- Add Measurement Items to the Project Output

Configure the Comprehensive Judgment Rule for the Project

The comprehensive judgment rule can be used to evaluate the measurement data of multiple measurement items as a whole. If the result of any measurement item is unqualified (NG), the result of the whole project is NG. Only if the results of all measurement items are OK, the judgment result of the whole project is OK.

To configure the comprehensive judgment rule, follow these steps:

1. On the toolbar of Mech-MSR, select Output Management › Quality judgment .
2. In the **Quality judgment** tab, set the **Select project** parameter to the desired project, and then select the **Comprehensive** option.
3. In the **Select Measurement Items** area, select the measurement items to be used for comprehensive judgment, and then click the **[Apply]** button.



- After configuration, the status of the project set by the **Select project** parameter changes from “Unconfigured” to “Configured”.
- The above procedure can also be used to modify the measurement items involved in the comprehensive judgment.

Configure Custom Judgment Rules for the Project

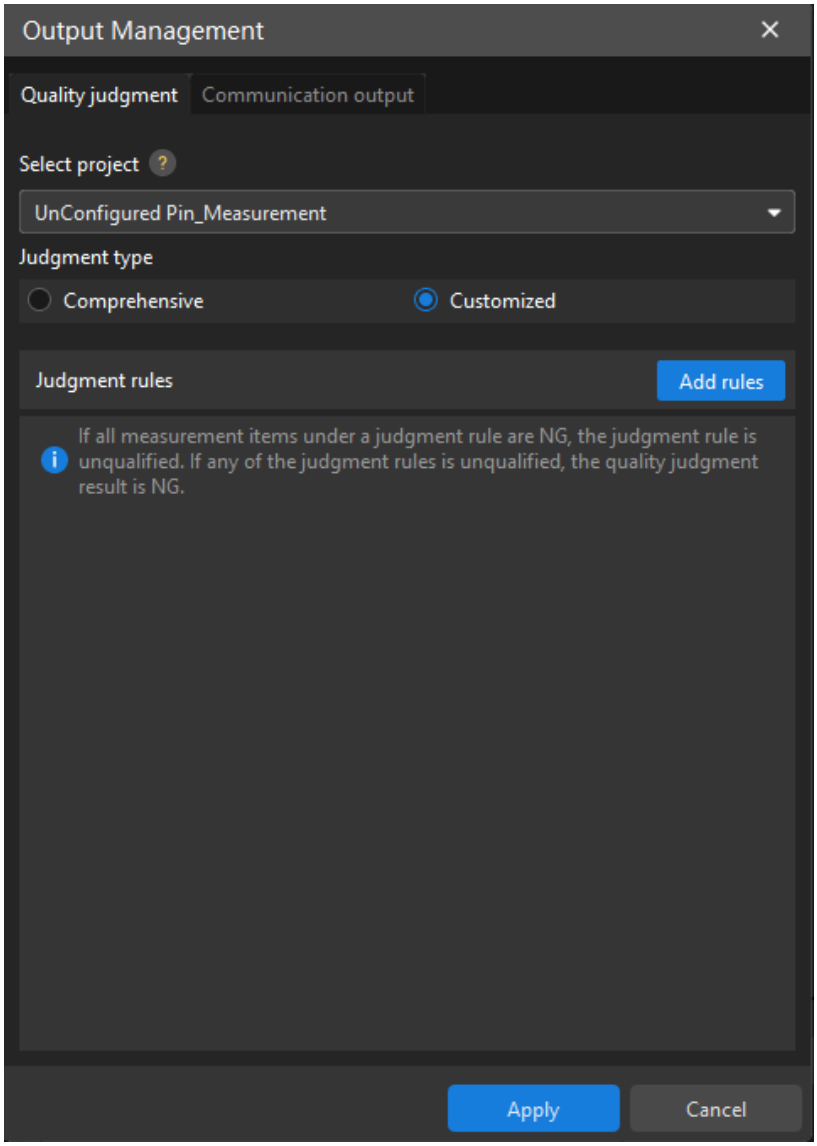
Custom judgment rules are used to meet complex quality judgment needs. You can configure multiple custom judgment rules, and each rule can contain multiple measurement items.

The fit relationship between the judgment rules and measurement items is as follows:

- If all measurement items under a judgment rule are unqualified (NG), the judgment rule is NG.
- If any of the judgment rules is unqualified (NG), the quality judgment result of the whole project is NG.

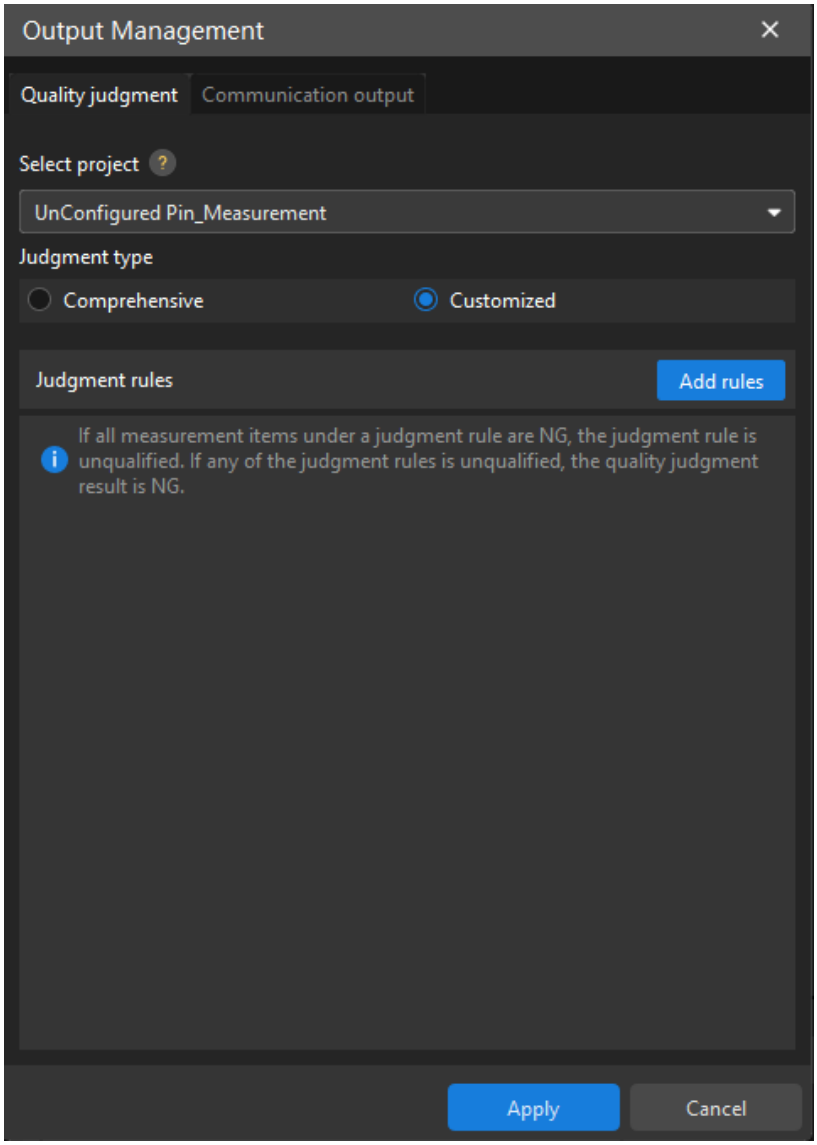
To configure custom judgment rules for the project, follow these steps:

1. On the toolbar of Mech-MSR, select Output Management › Quality judgment .
2. In the **Quality judgment** tab, set the **Select project** parameter to the desired project, and select the **Customized** option.

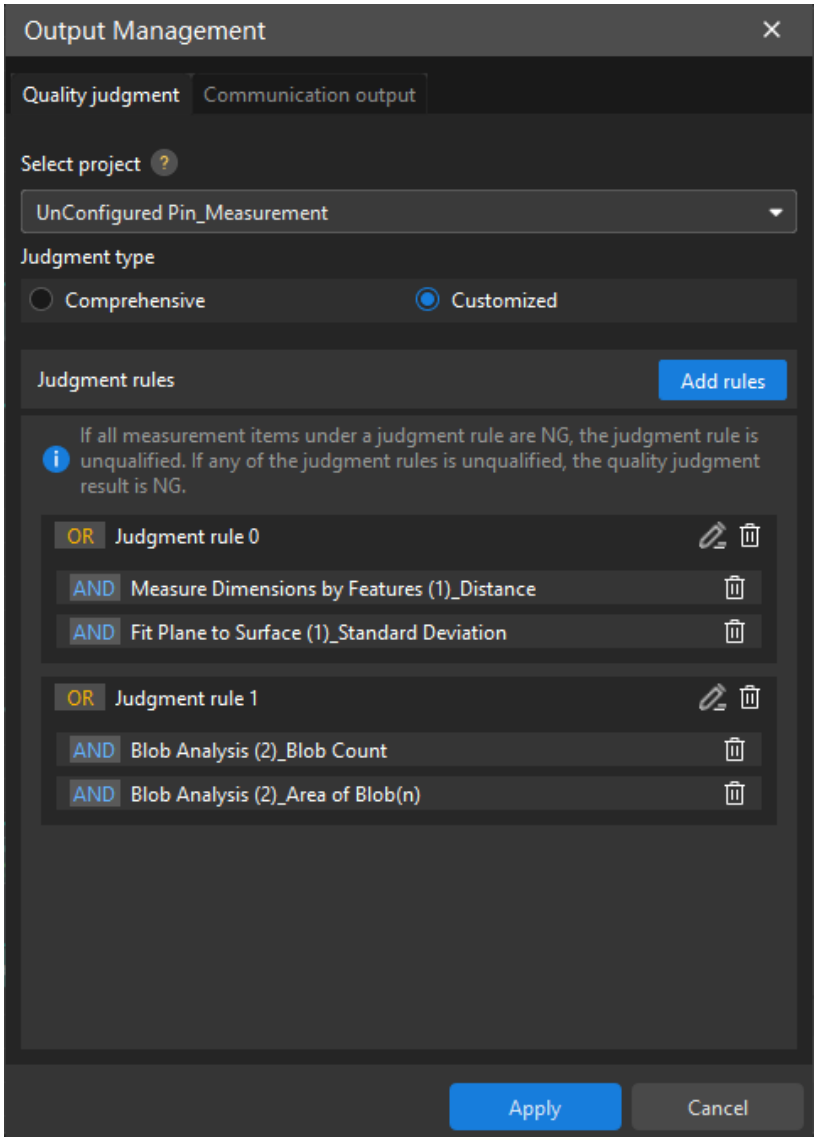


3. In the **Judgment rules** area, click the **[Add rules]** button.
4. In the pop-up **Select Measurement Items** dialog box, select the measurement items you need,

and then click the [OK] button.



5. Repeat the previous two steps to add more judgment rules, and then click the [Apply] button.



To delete a custom judgment rule, click behind the custom judgment rule in the **Judgment rules** area, and then click the **[Apply]** button.

In a project, one measurement item can be included in only one custom judgment rule. If you want to add a measurement item to another custom judgment rule, you need to delete the measurement item from the current custom judgment rule before adding it to another rule.

To delete a measurement item from a custom judgment rule, in the **Judgment rules** area, click the behind the measurement item, and then click the **[Apply]** button.

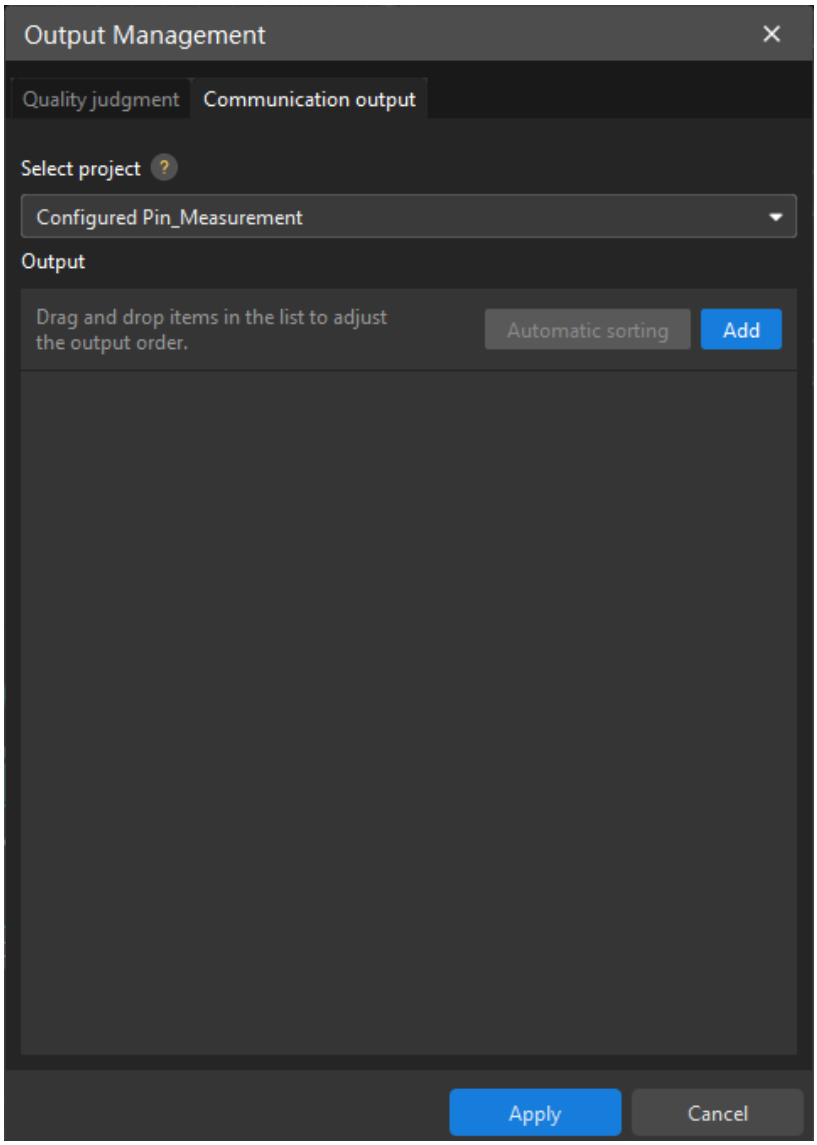
To add a measurement item to a custom judgment rule, follow these steps:

1. In the **Judgment rules** area, click behind the custom judgment rule.
2. In the pop-up **Select Measurement Items** dialog box, select the measurement items you want to add, and then click the **[OK]** button.
3. Click the **[Apply]** button.

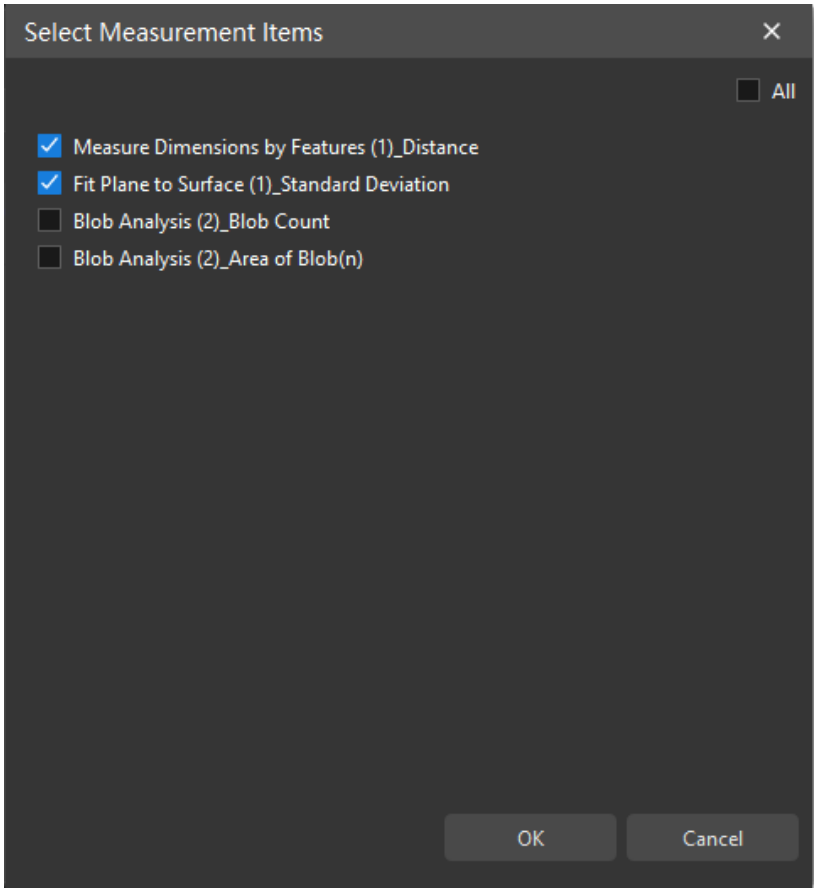
Add Measurement Items to the Project Output

To add measurement items to the output of the project, follow these steps:

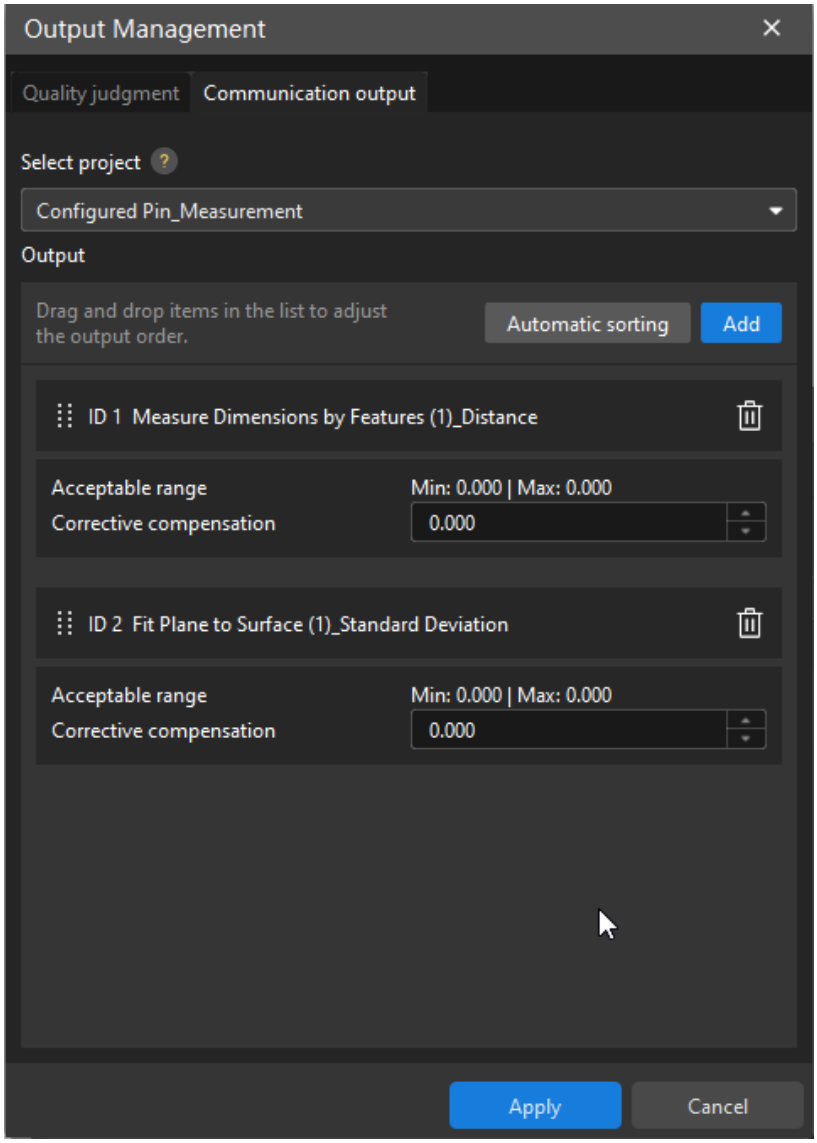
1. On the toolbar of Mech-MSR, select Output Management › Communication output .
2. On the **Communication output** tab, set the **Select project** parameter to the desired project, and then click the **Add** button in the **[Output]** area.



3. In the pop-up **Select Measurement Items** dialog box, select the measurement items you need, and then click the **[OK]** button.



4. In **Output** area, set the **Corrective compensation** parameter for the measurement item according to the actual needs, and then click the **[Apply]** button.



- In the **Output** area, the ID before the measurement item name is the order of the measurement items in the output of the current project.
- After **Corrective compensation** is set for a measurement item, the **Output Results** panel of the relevant Step will display the measured values before and after correction of the measurement item.

To delete a measurement item from the output of the project, in the **Output** area, click 🗑 behind the measurement item, and then click the **[Apply]** button.

2.4.6. Quick Guide to Communication Configuration

This section introduces the operations related to communication configuration.

After completing the communication configuration and enabling the communication service, you can trigger the Mech-MSR project to run and obtain measurement results with external devices (such as PLC).

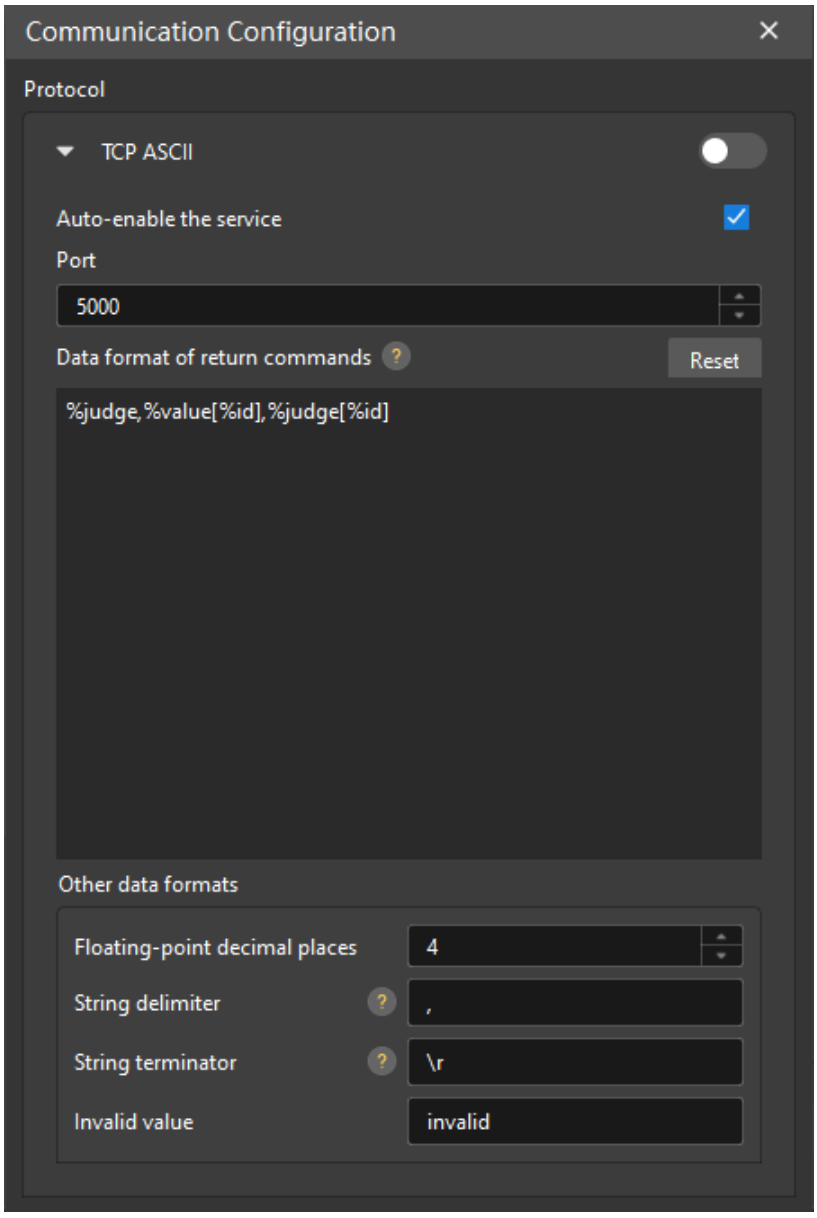
The Mech-Mind 3D Measurement System supports TCP ASCII communication with external devices.

Configure TCP ASCII Communication

Follow these steps to configure TCP ASCII communication:

1. On the toolbar of Mech-MSR, click **Communication Configuration**.
2. (Optional) In the **Communication Configuration** window, set the **Port** parameter as required.

   The default value of the **Port** parameter is 5000. After the TCP ASCII communication service is enabled, the software listens to TCP ASCII commands sent by external devices at the specified port.



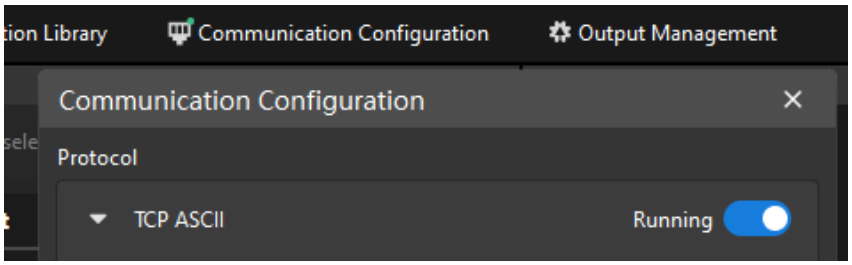
3. (Optional) Set the **Data format of return commands** parameter by referring to Set Data Format of Return Commands.

   The **Data format of return commands** parameter is used to customize the format of the data returned by the software to the return commands.

4. (Optional) Set other data formats by referring to Set Other Data Format.

5. (Optional) Select the **Auto-enable the service** option according to your actual needs. If the option is selected, the software automatically enables the TCP ASCII communication service every time the software is started.
6. Click  to start the TCP ASCII communication service.

After the TCP ASCII communication service is started successfully, the status of TCP ASCII is displayed as “Running.”



The previous procedure can also be used to modify the configuration of TCP ASCII communication. Note that the current communication configuration modification only takes effect for subsequent command requests.

Set Data Format of Return Commands

The **Data format of return commands** parameter is used to customize the format of the data returned by the software to the return commands.

Format Description

The returned data for the “return” command supports the following fields:

Field	Description
%time	Outputs image acquisition time in the format of 202001010101100 (01:01:01 sec, 100 ms, 01/01/2020).
%judge	Outputs the overall quality judgment result of the project. 0 is OK, and 1 is NG.
%value[#]	Outputs the measured value of the specified measurement item. “#” should be replaced with the ID of the specific measurement item. If it is set to 1, the measured value of the measurement item with an ID of 1 in the Communication output tab will be output.
%value[%id]	Outputs the measured values of all configured measurement items in the Communication output tab.
%judge[#]	Outputs the judgment result of the specified measurement item. 0 is OK, and 1 is NG. “#” should be replaced with the ID of the specific measurement item. If it is set to 1, the judgment result of the measurement item with an ID of 1 in the Communication output tab will be output.
%judge[%id]	Outputs the judgment results of all configured measurement items in the Communication output tab.

Setting Example

Suppose that the **Communication output** tab contains three measurement items, whose IDs are 1, 2, and 3.

Example 1	Data format	%judge,%value[%id],%judge[%id]
	Returned result	0,100,0,200,0,300,0
	Mapping relationship	%judge,%value[1],%judge[1],%value[2],%judge[2],%value[3],%judge[3]
Example 2	Data format	%judge, M%id, %value[%id], %judge[%id]
	Returned result	0,M1,100,0,M2,200,0,M3,300,0
	Mapping relationship	%judge,M1,%value[1],%judge[1],M2,%value[2],%judge[2],M3,%value[3],%judge[3]
Example 3	Data format	%judge, V%value[%id], J%judge[%id]
	Returned result	0,V100,J0,V200,J0,V300,J0
	Mapping relationship	%judge,V%value[1],J%judge[1],V%value[2],J%judge[2],V%value[3],J%judge[3]

Examples 2 and 3 are examples of adding character prefixes. In example 2, M%id stitches the character M together with the ID of the measurement item in the output. In example 3, V%value[%id] and J%judge[%id] add the characters V and J before the measured value and judgment result of each measurement item respectively.

Set Other Data Formats

Parameter	Description
Floating-point decimal places	Specifies the number of decimal places to keep when the software outputs the measured values. The value ranges from 0 to 20. The default value is 4.
String delimiter	Specifies the delimiter used to separate data (between the command name and parameter, and between parameters) in TCP command requests. Common string delimiters include the English comma (,) and semicolon (;). By default, the string delimiter is the English comma.
String terminator	Specifies the string terminator of commands. Common string terminators are \n and \r. By default, the terminator is \r.
Invalid value	Specifies the data format when there are no measured values or no judgment results. The default value is invalid.

2.5. Step Reference Guide

This section provides reference information for Steps in Mech-MSR.

For better use of the Steps, you can first read

- Quick Guide to Steps
- Instructions on Data Viewer

Steps

Click the links of the corresponding Steps to view their usage instructions and parameter details.

Camera	3D Laser Profiler

General Processing	Extract Surface Section
	Filter Surface Points By Normals
	Process Profile by Filter
	Process Surface by Filter
General Locating	Alignment
	Blob Analysis
Geometric Locating	Fit Line to Profile
	Fit Circle to Profile
	Fit Plane to Surface
	Locate Feature Point of Profile
	Locate Feature Point of Surface
Basic Measurement	Measure Dimensions by Features
	Measure Dimensions by Profile Features
	Measure Dimensions by Surface Features
Advanced Measurement	Measure Feature Point Height
	Measure Surface Flatness
Object Measurement	Detect and Measure Hole on Surface
Meta	Extract Data
	Merge Data
Scripting Engine	Calc Results by Python

2.5.1. Camera

2.5.1.1. 3D Laser Profiler

Description

This Step is generally used to acquire the scan data, which is generally the first step in a measurement project. With this Step, you can connect to Mech-Eye 3D Laser Profiler (hereinafter referred to as “laser profiler”) to acquire data, or read saved data in the virtual mode.

Connect to Laser Profiler to Acquire Data

Preparation

1. Complete hardware setup of the 3D measurement system.
2. Complete relevant settings in Mech-Eye Viewer:
   a. Connect to laser profiler in Mech-Eye Viewer;
   b. Adjust parameters and save parameter groups in Profile Mode and Scan Mode.

> The version of Mech-Eye Viewer should be 2.3.1 or above.

Workflow

1. Drag the Step to the graphical programming workspace.
2. Under **Parameters**, find **Camera ID**, click **[Open the editor]** to open the **Choose the camera and calibration parameter group to use** window.

   In this context, camera refers to the laser profiler.

3. Find the camera to connect in the list, hover the cursor over the target camera ID, and click to connect to the camera.

   If becomes , the camera is connected successfully.

4. After the camera is connected successfully, you can select the calibration parameter group in the drop-down list of **Calibration Parameter Group** and then click **[OK]** in the lower right corner of the window. Parameters will be automatically updated in the **Parameters** section.
5. Run this Step to connect to the laser profiler and acquire data.

Reading Saved Data

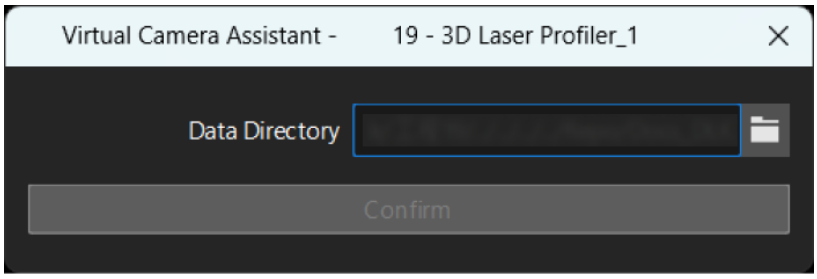
Preparation

Acquire and save data with a laser profiler. For related operations, refer to Acquire and View Data and Save Data instructions.

Workflow

1. Drag the Step to the graphical programming workspace and enable **Virtual Mode** under **Parameters** in the parameter configuration panel.
2. Click under **Data Path**.
3. In the pop-up window, browse to and select the folder where the data is saved and then click **[Select Folder]**.

   If the selected folder does not contain valid data of the virtual camera, a **Virtual Camera Assistant** window will pop up. You need to manually select the path to the folder that contains the MRAW files of the virtual camera. Note that you should use Mech-Eye Viewer (version 2.3.1 or above) to save the MRAW files of the virtual camera.



4. Run this Step to read the saved data.

Parameter Description

Camera Type

Select the type of laser profiler you want to use. Currently, only **LNXCamera** is supported, i.e., Mech-Eye 3D Laser Profilers.

Basic Settings

Calibration Parameter Group

The parameter group used by the selected laser profiler.

Configuration Parameter Group

The laser profiler acquires data according to the parameters in the parameter group configured in the Mech-Eye Viewer.

IP Address

The IP address of the laser profiler.

This parameter will be automatically updated after the laser profiler is connected. Do not make any modification, otherwise the laser profiler will be disconnected.

Num of Reconnection Attempts

Use this parameter to specify the maximum number of attempts to reconnect the camera if the software fails to connect to the camera within the timeout period. The default value is 3.

Trigger Settings

Data Acquisition Status

When **Data Acquisition Trigger Source** is **External**, this parameter determines whether the laser profiler will be triggered by externally input signals to acquire data. Once this parameter is enabled, the laser profiler will be in the data acquisition status, and the parameter groups cannot be modified.

Auto-Filled Parameters

After a camera is connected, the following parameters are automatically updated according to the actual situation and cannot be modified in Mech-MSR. If you do need to adjust the parameters, however, you can connect the corresponding laser profiler in Mech-Eye Viewer and configure these parameters.

Parameter	Description	Instructions on adjustment in Mech-Eye Viewer
Data Acquisition Trigger Source	Select the method for triggering a round of data acquisition, **External** or **Software**.	See Methods for Triggering Data Acquisition for detailed instructions.
Line Scan Trigger Source	Select the method for triggering one line scan, **Encoder** or **Fixed rate**.	See Methods for Triggering Data Acquisition for detailed instructions.
Scan Line Count	The number of profiles needed to generate one intensity image or depth map.	See Scan Settings for detailed instructions.
Timeout Period	The timeout period for data acquisition. After data acquisition is triggered, if the software does not receive data within the set timeout period, the current round of data acquisition is automatically stopped.	See Timeout Period for detailed instructions.
Y-Axis Resolution	The resolution in the Y direction, which is the distance between two neighboring points along the travel direction of the target object.	See Point Cloud Resolutions for detailed instructions.

Parameter	Description	Instructions on adjustment in Mech-Eye Viewer
Trigger Interval	The number of trigger signals needed for scanning one line. Only visible when **Line Scan Trigger Source** is set to **Encoder**.	See Trigger Settings for detailed instructions.

Virtual Settings (Displayed after "Virtual Mode" is Enabled)

Playback Mode

This parameter is used to specify the order to read the images.

Options:

- Sequential (default): Read the images in the order of the images in the folder.
- Repeat one: Read the current image repeatedly.
- Repeat all: Read all images in the order of the images in the folder and then read them from the beginning after all images are read.
- Random: Read images randomly.

Tuning recommendation: Please select the mode according to image reading order you need.

Current Frame Name

Description: This parameter is used to display the serial number and timestamp of the currently read image.

Cache Settings

This group of parameters is displayed only when **Data Acquisition Trigger Source** is **External**.

Maximum Cached Data

This parameter is used to show the maximum data volume that can be cached. With each scan, the cached data can generate depth maps, intensity images, and point clouds. When this value is exceeded, you can process the cached data using the **Cache Overflow Solution** or manually clear the cache.

Cache Overflow Solution

This parameter is used to select the solution to the cache overflow.

Options: DiscardOldest, DiscardNewest.

Clear Cache

This parameter is used to clear cached image data manually.

Other Settings

This parameter group is displayed differently under different settings. Refer to the descriptions according to your specific situation.

Use Initial Encoder Value

Once this option is enabled, the initial encoder value will be used to generate the point cloud.

Save Encoder Values to JSON

Once this option is enabled, the encoder values will be saved to a JSON file.

Data Transfer Wait Time

The time for the laser profiler to transfer data to Mech-MSR after the scan is completed.

Heartbeat Interval

The interval between heartbeat signals sent by the laser profiler to ensure a stable and real-time connection.

2.5.2. General Processing

2.5.2.1. Extract Surface Section

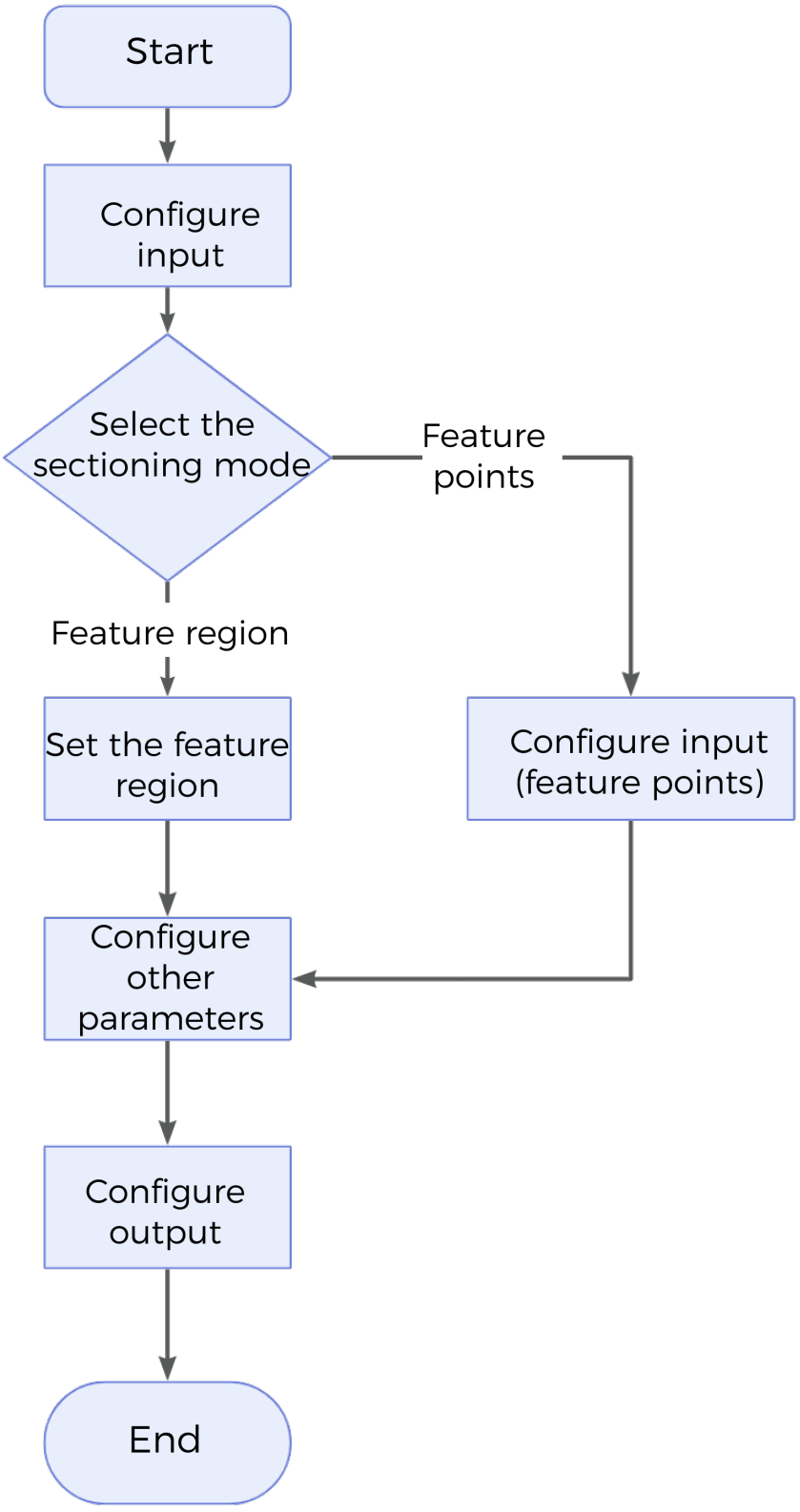
Description

This Step extracts a profile from the surface data. A section perpendicular to the XOY plane is formed using the line connecting the two feature points or the center line of the feature region. The intersection between the section and the surface data is extracted to generate the profile.

The direction of the intersection extracted from the surface is variable, but the final output profile of this Step is on the XOZ plane.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Set the sectioning mode.
3. Set other parameters.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and

configure the **Min** and **Max** values of the acceptable range.

5. Run the Step and view output.

Parameter Description

Sectioning Mode

The method of extracting profile from the surface data.

Options: Feature region, Feature points

- Feature region: Once this is selected, the section perpendicular to the XOY plane where the center line of the feature region is located will intersect the surface, generating the profile.

  The center line of a feature region is the line connecting the midpoints of two edges along the Y-axis at the initial position of the feature region.

  For more information on how to set the feature region, please refer to Set the Feature Region.

- Feature points: Two data points are selected as feature points on the surface. The section perpendicular to the XOY plane where the line connecting the two feature points is located intersects the surface, generating the profile. The endpoints of the profile are the two selected feature points.

  Once this is selected, two more inputs will be displayed. You need to connect the ports manually or configure the input under **Input**.

Feature points provide precise positional information, specifying the endpoints of an intersection to form a section perpendicular to the surface. It is preferable to use feature points when you already know exactly where the endpoints are located.

Using the feature region, you can define the position of the section more flexibly. If you want to extract the profile from a wider region and do not need to specify endpoints, a feature region may be more appropriate.

Average Profiles

The profile is generated by averaging the data points along the direction perpendicular to the center line of the feature region or the line connecting the two feature points.

- **Selected**:
  - When **Sectioning Mode** is set to **Feature region**, the average Z value of the data points is calculated within the length of the feature region, along the direction perpendicular to the center line of the feature region. The averaged data points (which may be empty) form a profile.
  - When **Sectioning Mode** is set to **Feature points**, the average Z value of the data points is calculated within **Averaging Width**, along the direction perpendicular to the line connecting the two feature points. The averaged data points (which may be empty) form a profile.

    This takes into account not only the data points covered by the line connecting the two feature points or the center line of the feature region, but also the neighboring data points, for a more comprehensive characterization of the region.

- **Unselected** (default):

Use the raw data points (which may be empty) on the intersection directly without averaging. This will only consider the data points covered by the line connecting the two feature points or the center line of the feature region, reflecting more local features.

Min Valid Points

Only valid when **Average Profiles** is selected. This parameter is used to specify the percentage of valid points within **Averaging Width** or the length of the feature region. When the actual percentage of valid points is lower than this value, the data point on the profile will be judged as non-existent.

If certain data points on the profile are judged as non-existent, the region may be too sparse.

Show Detail

Once this is selected, the generated profile will be displayed on the raw data.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Profile	The resulting profile.
Start X	The X coordinate of the start point of the profile.
End X	The X coordinate of the end point of the profile.
Start Y	The Y coordinate of the start point of the profile.
End Y	The Y coordinate of the end point of the profile.
Rotation Angle	The rotation of the profile around the Z-axis (angle relative to the X-axis).

Troubleshooting

Invalid Parameter

No.	Error	Possible Causes	Solution
1	Inappropriate min valid points	The set value of min valid points is not within [0, 1].	Reset Min Valid Points and ensure that the value is within [0, 1].

Invalid Input

No.	Error	Possible Causes	Solution
1	Invalid input “Feature Point 1”		Check and adjust the input “Feature Point 1” to ensure that it is a valid feature point.
2	Invalid input “Feature Point 2”		Check and adjust the input “Feature Point 2” to ensure that it is a valid feature point.

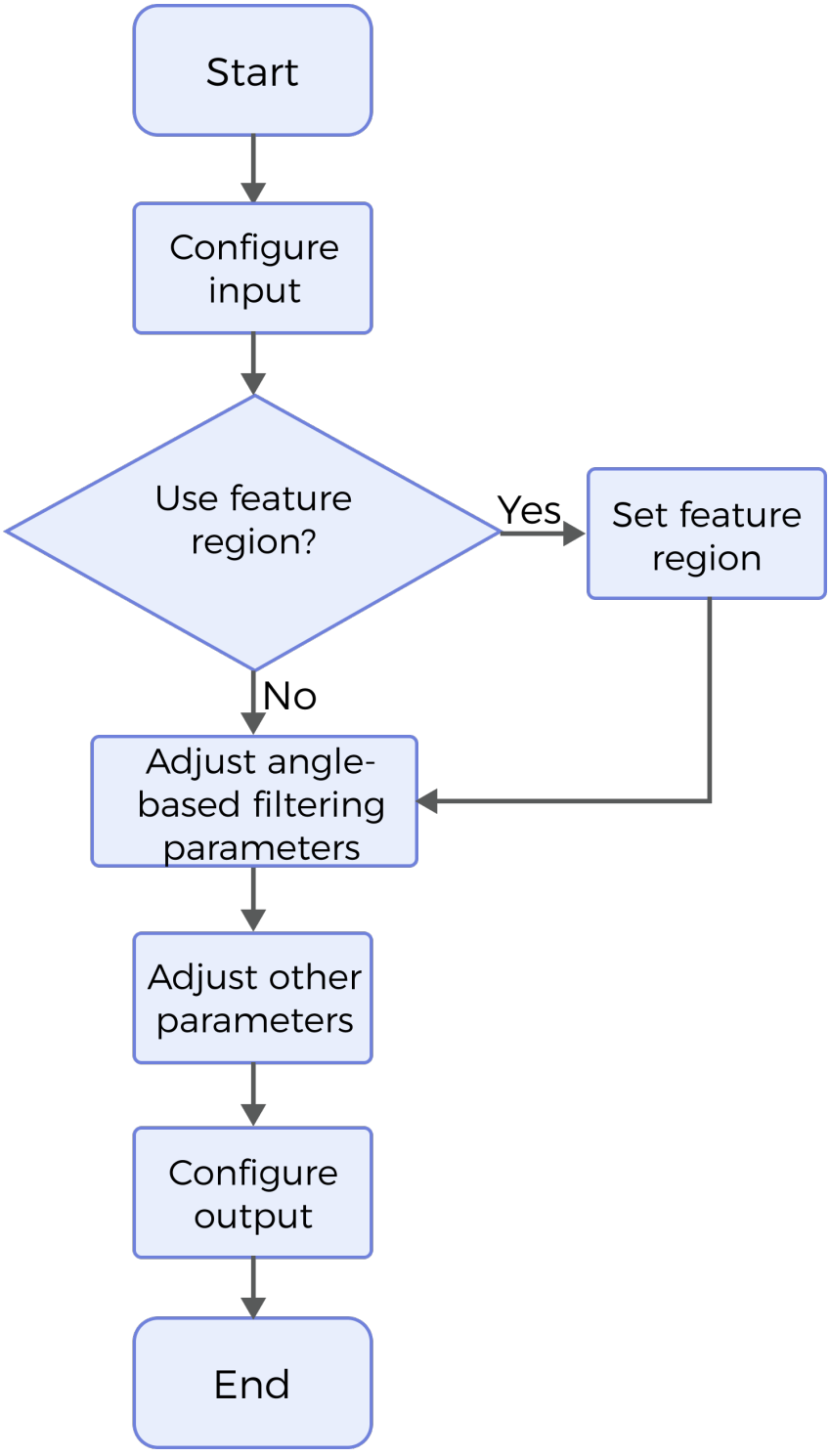
2.5.2.2. Filter Surface Points By Normals

Description

This Step is used to exclude unwanted surface points based on their normals so that a better surface can be obtained.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region. For more information, please refer to Use Feature Region.
3. Set the angle parameters.
4. Set other parameters.
5. Select the output item Depth Map (selected by default).

6. Run the Step and view output.

Parameter Description

Use Feature Region

Feature region defines the area to be filtered. When this option is selected, this Step will only process data within or outside the feature region.

Default setting: Unselected

Instruction: Please set the parameter according to the actual requirement.

Feature Region Mode

Once **Use Feature Region** is selected, this parameter is used to set the mode of the feature region, that is, to select whether to filter the surface data within the feature region or the data outside the feature region.

Options: Include data in Region, Exclude data in Region

Default setting: Include data in Region

Instruction: To filter surface data within the feature region, select **Include data in Region**; otherwise, select **Exclude data in Region**.

For more information on how to set the feature region, please refer to Set the Feature Region.

Angle-Based Filtering

The relevant parameters are explained as follows:

- **Min Polar Angle**: The minimum acceptable angle of the normals with respect to the Z-axis.
- **Max Polar Angle**: The maximum acceptable angle of the normals with respect to the Z-axis.
- **Min Z Angle**: The minimum acceptable angle of the XOY projection of normals clockwise around the Z-axis and relative to the positive X direction.
- **Max Z Angle**: The maximum acceptable angle of the XOY projection of normals clockwise around the Z-axis and relative to the positive X direction.

[filter surface points by normals angle filter] | *filter-surface-points-by-normals/filter-surface-points-by-normals-angle-filter.png*

As shown in the figure above, OA is the normal, OB is the XOY projection of normal, ∠a is the polar angle of normal, and ∠b is the Z angle of normal.

The parameters **Min / Max Z Angle** and **Min / Max Polar Angle** specify the angle filtering range for normals. Data points with normal's polar angle or Z angle **outside** the range will be excluded.

Remove Noise

This parameter eliminates noise that can be introduced by normal calculation. Please select the level according to the tolerance to noise.

Options: None, Small, Medium, Large

Default setting: None

Smooth Size

The size of the filter window.

Apply a mean filter to the surface data before calculating the normals to avoid abrupt normal changes due to noise. The default value is 1.

Normal Vector Calculation

Normal Search Radius

For surface processing, points within a circle with a set radius are used to calculate normals. The unit is millimeters (mm).

Default setting: 1.000 mm

Half Kernel Size

For depth map processing, points within a square with a side length of twice the set value will be used to calculate the normals. The unit is pixels.

Default setting: 1 pixel

Output Description

The output of this Step is a processed depth map that can be used as input to other Steps.

Troubleshooting

Invalid Parameter

No.	Error	Possible Causes	Solution
1	Inappropriate smooth size	The set smooth size is less than 1.	Reset Smooth Size and ensure that the value exceeds 1.
2	Inappropriate polar angle	The set polar angle is not within the range of 0–90°.	Reset Min / Max Polar Angle to ensure that the polar angle is within the range of 0–90°.
3	Inappropriate Z angle	The set Z angle is not within the range of 0–360°.	Reset Min / Max Z Angle to ensure that the Z angle is within the range of 0–360°.
4	Inappropriate normal search radius	The set normal search radius is not greater than 0.	Reset Normal Search Radius and ensure that the value exceeds 0.
5	Inappropriate half kernel size	The set half kernel size is not greater than 0.	Reset Half Kernel Size and ensure that the value exceeds 0.

2.5.2.3. Process Profile by Filter

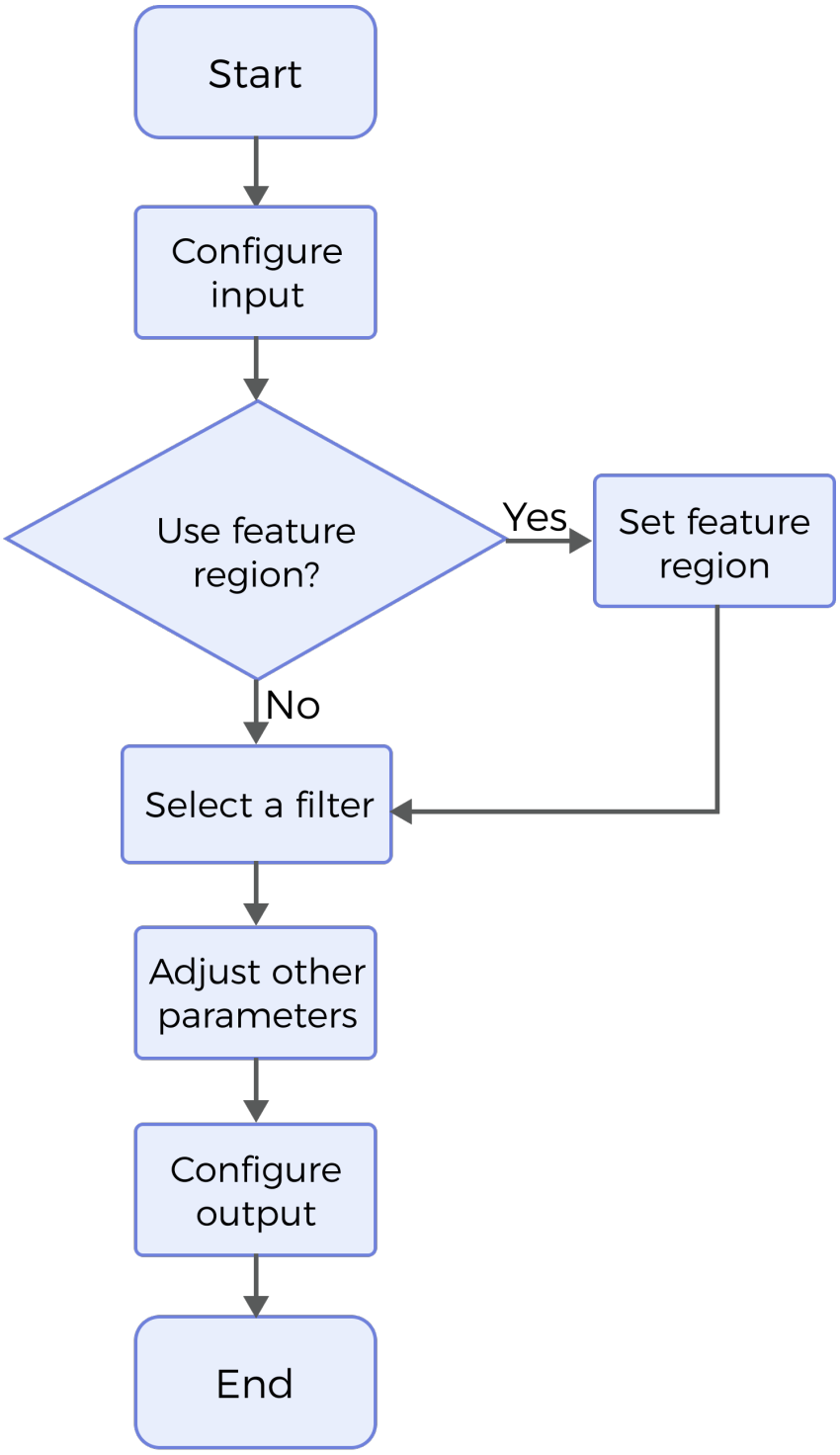
Description

This Step is used to process the profile by a filter to obtain a better profile. The optional filters

include Gaussian, median, mean, decimation, and gap filling.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region. For more information, please refer to Use Feature Region.

3. Select the filter type and complete the configuration. For more information on the available filters, please refer to Filter Type.
4. Select the output item **Profile** (selected by default).
5. Run the Step and view output.

Parameter Description

Use Feature Region

Feature region defines the area to be preprocessed. When this option is selected, this Step will only process data within or outside the feature region.

Default setting: Unselected

Instruction: Please set the parameter according to the actual requirement.

> For more information on how to set the feature region, please refer to Set the Feature Region.

Filter Type

The filter type for profile preprocessing.

Options: Mean, Gaussian, Median, GapFilling, Decimation.

- Mean

  The mean filter can smooth the image by calculating the neighbors of pixels in the image and replacing the pixel values in the original image with the calculated average.

  - X-Direction Window Size

    The number of points in the window along the X direction. It defines how many neighboring data points along the X direction are considered for Gaussian filtering.

    Instruction: The larger the window size, the smoother the profile, but the profile details may be lost.

- Gaussian

  Gaussian filtering is used to remove the noise in the profile, smoothing the profile without losing major details.

  - X-Direction Window Size

    The number of points in the window along the X direction. It defines how many neighboring data points along the X direction are considered for Gaussian filtering.

  - Sigma

    Sigma, the standard deviation, is used to control the shape of the Gaussian distribution. A larger sigma is accompanied by a flatter Gaussian distribution curve and a better smoothing effect.

- Median

  Median filtering is used to smooth and sharpen the profile by removing unwanted fluctuations and outliers.

- X-Direction Window Size

  The number of points in the window along the X direction. It defines how many neighboring data points along the X direction are considered for median filtering.

  Instruction: As the window size increases, the filtering effect becomes more pronounced, resulting in greater noise reduction. However, this also leads to longer computing time.

- GapFilling

  With the maximum or minimum Z values of the nearest neighbors or linear interpolation between neighboring values, this filter fills in missing data in the specified window.

  - Gap Filling Type

Option	Description
Min Z point filling	Use the minimum Z value of the nearest neighbors to fill the gap.
Max Z point filling	Use the maximum Z value of the nearest neighbors to fill the gap.
Linear interpolation filling	Use the Z values of the nearest neighbors for linear interpolation to fill the gap.

  - X-Direction Window Size

    Maximum gap width along the X direction. Only gaps equal to or narrower than this width will be filled.

    Instruction: Gap filling may distort features with abrupt depth variations, such as object edges. Adjust this parameter according to the size of the gap to be filled.

- Decimation

  Decimation reduces the size or resolution of the image. During decimation, some pixels in the raw image will be discarded or merged to generate a small-sized image.

  - X-Direction Window Size

    The sampling interval along the X direction. For instance, if the value is set to 2, the filter will begin selecting data points from the leftmost end of the profile and move in step size of 2 away from that starting point.

Output Description

The output of this Step is a processed profile that can be used as input to other Steps.

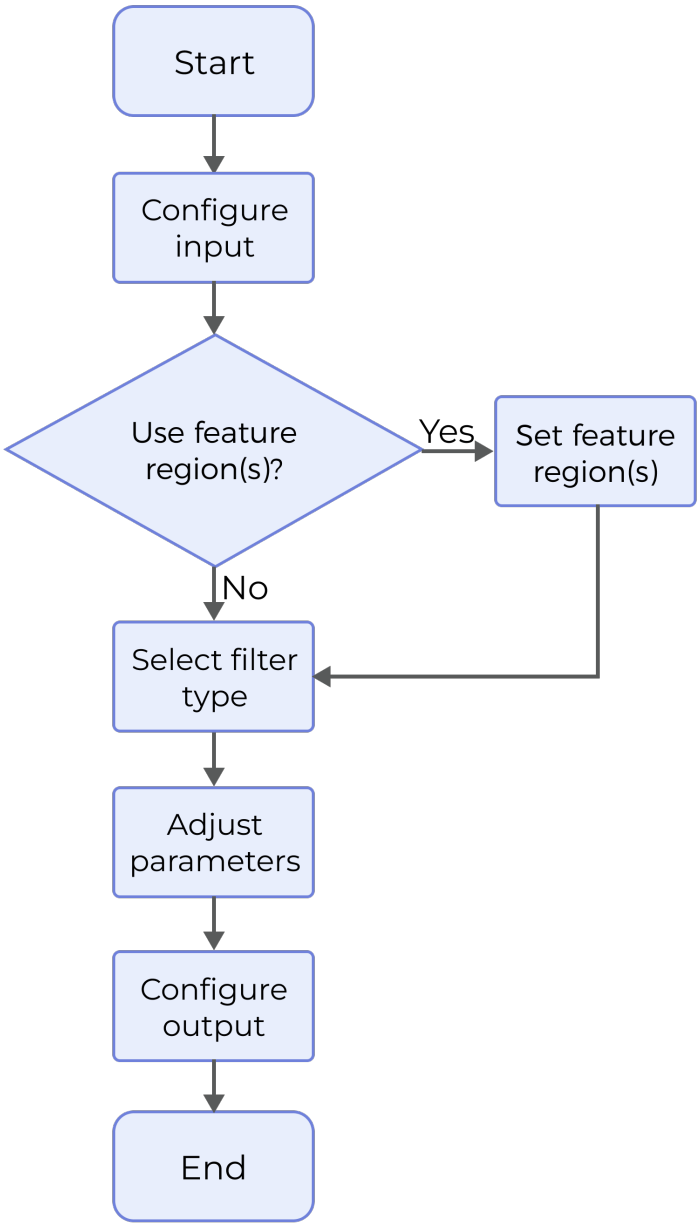
2.5.2.4. Process Surface by Filter

Description

This Step is used to preprocess the surface with a specific filter to obtain a better surface.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use the feature region, select the **Filter Type**, and set the filter parameters.
3. Select the output item **Depth Map** (selected by default).
4. Run the Step and view output.

Parameter Description

Show Advanced Filters

Once this parameter is selected, more advanced filters will be listed in the drop-down menu of Filter Type.

Default setting: Unselected

Instruction: Please set the parameter according to the actual requirement.

Use Feature Region

Feature region defines the area to be preprocessed. When this option is selected, this Step will only process data within or outside the feature region.

Default setting: Unselected

Instruction: Please set the parameter according to the actual requirement.

Feature Region Mode

Once **Use Feature Region** is selected, this parameter is used to set the mode of the feature region, that is, to select whether to preprocess the data within the feature region or the data outside the feature region.

Options: Include data in Region, Exclude data in Region

Default setting: Include data in Region

Instruction: To preprocess data within the feature region, select **Include data in Region**; otherwise, select **Exclude data in Region**.

For more information on how to set the feature region, please refer to Set the Feature Region.

Keep Unfiltered Data

Once this parameter is selected, the unfiltered data will be retained in the output.

Default setting: Unselected

Filter Type

This parameter is used to select the filter type for feature region preprocessing.

Options: The filters are listed below. Please refer to Filter Type for detailed information.

- Standard filter: Gap filling, Mean, Median, Decimation
- Advanced filter: Dilation, Erosion, Opening, Closing, Morph gradient, Gaussian, Sobel, Laplacian, Negative, Normalization, Binarization, Percentile, Relative threshold, Crop

Default setting: Gap filling

Instruction: Please select the filter according to the actual requirement and data features.

Suggestions	Description
Understand data characteristics	Understand the features of the data: Familiarize yourself with your original data. Understand the noise types and the data processing tasks to be performed.

Suggestions	Description
Check the available filters	Gain insight into the available filters. Different filters are applicable to different situations, such as the mean filter for smoothing and the median filter for noise removal.
Determine processing goal	When selecting a filter, consider the processing goals, such as noise removal, smoothing the curve, highlighting certain specific features, etc.
Test and compare	Use multiple filters to process the input data, and compare the results of each filter to see if the filtered data can meet the processing goals while preserving features.
Adjust parameters incrementally	Adjust the filter parameters incrementally for the best processing result.
Check filtering effect	Pay attention to the effect of each filter on the data. Ensure that the selected filter does not eliminate important features of the data.

Output Description

The output of this Step is a processed depth map that can be used as input to other Steps.

Appendix

Filter Type

- Gap filling:

  With the maximum or minimum Z values of the nearest neighbors or linear interpolation between neighboring values, this filter fills in missing data in the specified window.

Parameter	Parameter Description
Gap Filling Type	This parameter is used to select the method to fill the gaps. • Min Z point filling: Use the minimum Z value of the nearest neighbors to fill the gap. • Max Z point filling: Use the maximum Z value of the nearest neighbors to fill the gap. • Linear interpolation filling: Use linear interpolations of the Z values of the nearest neighbors to fill the gap.
Filter in X Direction	This parameter is used to determine whether to filter in the X-direction.
X-Direction Window Size	This parameter specifies the window size for X-direction filtering.
Filter in Y Direction	This parameter is used to determine whether to filter in the Y-direction.
Y-Direction Window Size	This parameter specifies the window size for Y-direction filtering.

- Mean:

  The mean filter can smooth the image by calculating the neighbors of pixels in the image and

replacing the pixel values in the original image with the calculated average.

Parameter	Parameter Description
Filter in X Direction	This parameter is used to determine whether to filter in the X-direction.
X-Direction Window Size	This parameter specifies the window size for X-direction filtering.
Filter in Y Direction	This parameter is used to determine whether to filter in the Y-direction.
Y-Direction Window Size	This parameter specifies the window size for Y-direction filtering.

- Median:

  The median filter can reduce noise in images, especially salt and pepper noise. The filter substitutes the value of a certain point in the image with the median calculated within a specified window around the point, so that the surrounding pixel values are close to the real values, eliminating isolated noise points.

Parameter	Parameter Description
Filter in X Direction	This parameter is used to determine whether to filter in the X-direction.
X-Direction Window Size	This parameter specifies the window size for X-direction filtering.
Filter in Y Direction	This parameter is used to determine whether to filter in the Y-direction.
Y-Direction Window Size	This parameter specifies the window size for Y-direction filtering.

- Decimation:

  The decimation filter can reduce the image resolution. During decimation, some pixels in the raw image will be discarded.

  Once this type of filter is selected, data outside the feature region cannot be retained during preprocessing of the feature region, i.e., **Keep Unfiltered Data** cannot be selected.

Parameter	Parameter Description
Filter in X Direction	This parameter is used to determine whether to filter in the X-direction.
X-Direction Window Size	This parameter specifies the window size for X-direction filtering.
Filter in Y Direction	This parameter is used to determine whether to filter in the Y-direction.
Y-Direction Window Size	This parameter specifies the window size for Y-direction filtering.

- Dilation:

  This type of filter can be used to remove small holes and smooth object edges to make the image more complete.

  Note that dilation may magnify the noise in the image. Therefore, when dilating images, you should set a proper kernel size and symmetry to ensure that the dilation can achieve the

desired result.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during dilation.
Symmetry	This parameter is used to set the applied method for dilation. • Horizontal symmetry: Use the kernel to dilate the image horizontally. • Vertical symmetry: Use the kernel to dilate the image vertically. • Center symmetry: Use the square kernel to dilate the image.

- Erosion:

  This type of filter can be used to remove small objects or noises in the image to make the image clearer.

  Note that erosion may lead to loss of image details, so you should set a proper kernel size and symmetry for erosion.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during erosion.
Symmetry	This parameter is used to set the applied method for erosion. • Horizontal symmetry: Use the kernel to erode the image horizontally. • Vertical symmetry: Use the kernel to erode the image vertically. • Center symmetry: Use the square kernel to erode the image.

- Opening:

  Opening is essentially erosion followed by dilation. This type of filter can be used to remove the noise in the details of the image while preserving the main features of the image.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during erosion and dilation.

- Closing:

  Closing is essentially dilation followed by erosion. This type of filter can be used to fill small holes in objects and smooth edges without significantly altering their areas. Secondly, the closing operation can effectively improve the issue of uneven object edges caused by noise.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during dilation and erosion.

- Morph gradient:

  Morphological gradient is an operation in image morphological processing. It highlights the edge information in an image with the difference between dilation and erosion. This type of filter can enhance the object edges in the image and make the edges more prominent.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during dilation and erosion.

- Gaussian:

  Gaussian filter can remove a certain amount of noise in the image. This type of filter can be used to effectively smooth the object edges while preserving the edges and details of the image. Therefore, it is usually used for image smoothing, removing high-frequency noise, and preprocessing before edge detection.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size in the process of smoothing the image.

- Sobel:

  Sobel is capable of performing operations within a certain range around pixels and is often used for image edge detection.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during edge detection.
Symmetry	This parameter is used to set the applied method for edge detection. • Horizontal symmetry: Use the kernel to detect edges in the image horizontally. • Vertical symmetry: Use the kernel to detect edges in the image vertically. • Center symmetry: Use the square kernel to detect edges in the image.
Min Threshold	After filtering, points with Z values greater than this threshold will be considered edge points.
Max Threshold	Limit the Z values of the filtered points to this threshold or below.

- Laplacian:

  Laplacian can effectively detect edge and regions where grayscale changes abruptly in images.

Parameter	Parameter Description
Kernel Size	This parameter is used to set the kernel size during edge detection.
Min Threshold	After filtering, points with Z values greater than this threshold will be considered edge points.
Max Threshold	This parameter is used to limit the Z values of the filtered points to this threshold or below.

- Negative:

  During image processing, each pixel of the image can be inverted to achieve a visual effect similar to that of a negative film.

- Normalization:

  Normalization is a method for enhancing image contrast, which can improve the local contrast of an image without affecting the overall contrast.

Parameter	Parameter Description
Min Threshold	This parameter is used to normalize the filtered points to the range [Min Threshold, Max Threshold].
Max Threshold	This parameter is used to normalize the filtered points to the range [Min Threshold, Max Threshold].

- Binarization:

  This type of filter sets the pixel values of the grayscale image to two custom values. If the custom values are 0 and 255, pixels with depth values greater than or equal to the specified depth threshold are set to 255 (white), while pixels with depth values smaller than the threshold are set to 0 (black).

Parameter	Parameter Description
Min Threshold	This parameter is used to set the pixels whose values are smaller than or equal to Depth Threshold to the specified Min Threshold.
Max Threshold	This parameter is used to set the pixels whose values are greater than or equal to Depth Threshold to the specified Min Threshold.
Depth Threshold	Pixels with values smaller than the “Min/Max Threshold” will be set to the “Min/Max Threshold.”

- Percentile:

  After sorting the points in the feature region according to the depth values, each point has its own percentile. By setting **Low Threshold Percentile** and **High Threshold Percentile**, the points that do not meet the requirements can be removed. This type of filter can be used to analyze and process image data to extract useful information or improve image quality.

Parameter	Parameter Description
Low Threshold Percentile	Points with percentiles within the range of [Low Threshold Percent, High Threshold Percent] will be retained.

Parameter	Parameter Description
High Threshold Percentile	Points with percentiles within the range of [Low Threshold Percent, High Threshold Percent] will be retained.

- Relative threshold:

  Based on the specified minimum and maximum heights, set the height of the feature region relative to the reference region.

Parameter	Parameter Description
Low Threshold	Points with Z values within the range [Low Threshold, High Threshold] will be retained.
High Threshold	Points with Z values within the range [Low Threshold, High Threshold] will be retained.

- Crop:

  This type of filter can remove unqualified data in the feature region.

Troubleshooting

Invalid Type

No.	Error	Error Description	Possible Causes	Solution
1	The selected filter type is invalid.	The selected filter type is invalid and cannot be used for filtering.	The filter type was not selected properly.	Select Filter Type again in the drop-down list.
2	The selected gap filling type is invalid.	When Filter Type is set to “Gap filling,” the selected Gap Filling Type is invalid.	A valid gap filling type was not selected.	Select Gap Filling Type again in the drop-down list.

Invalid Parameter

No.	Error	Error Description	Possible Causes	Solution
1	The “Kernel Size” value is not set properly.	After selecting a filter, the kernel size used for filtering is not set properly.	“Kernel Size” was not greater than 0.	Adjust the “Kernel Size” to ensure that it is greater than 0.
2	The X-direction window size or Y-direction window size is not set properly.	When Filter Type was set to “Gap filling,” the set value of “X/Y-Direction Window Size” is not appropriate.	The “X/Y-Direction Window Size” was no greater than 0.	Adjust the value of “X/Y-Direction Window Size” to ensure that it is greater than 0.

No.	Error	Error Description	Possible Causes	Solution
3	Incorrect threshold setting.	When Filter Type was set to “Relative threshold,” the threshold setting is incorrect.	“Low Threshold” was not lower than “High Threshold” or was not within the range of 0–1.	Adjust the thresholds again to ensure that the “Low Threshold” is smaller than the “High Threshold” and that both the “High Threshold” and “Low Threshold” are within the range of 0–1.

2.5.3. General Locating

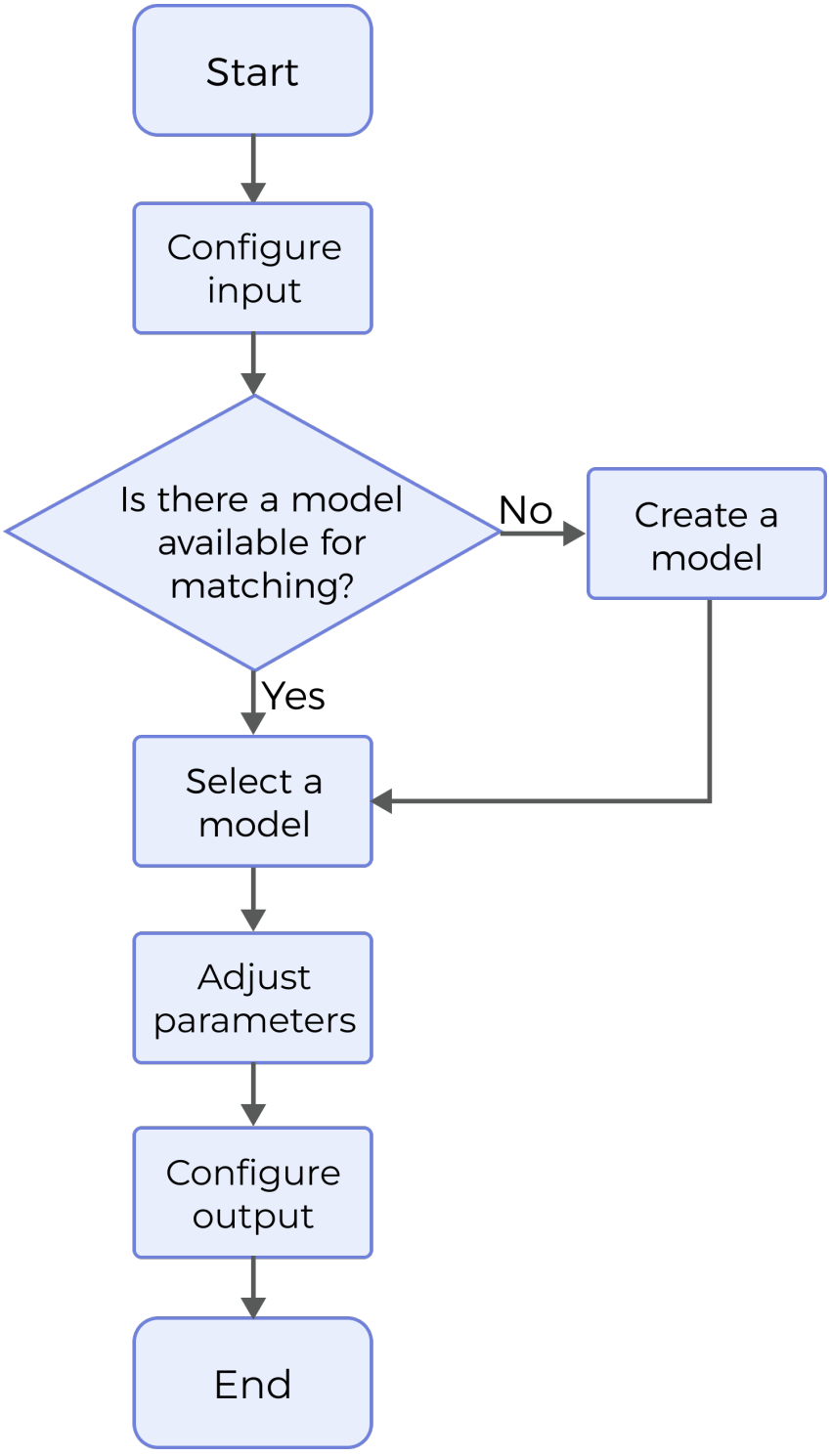
2.5.3.1. Alignment

Description

This Step is used to match the model features to the features in the image. Transform the input image by scaling, rotation, or translation to eliminate its differences from the model.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Make and select a model. For more information on how to make a model, please refer to 2D Model Editor.
3. Complete the matching settings.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Use Intensity Image

This parameter determines whether to use intensity image. Once it is selected, an Intensity Image input will be added to the Step.

Default setting: Unselected

Use Feature Region

Feature region defines the area to be processed by the algorithm. When this option is selected, this Step will only process data within the feature region.

Default setting: Unselected

Instruction: Complete the configuration according to the actual requirement.

For more information on how to set the feature region, please refer to Set the Feature Region.

Model Settings

Select Model

This parameter is used to configure and select the model for matching.

Instruction: Click **[Edit Model]** to open 2D Model Editor, where you can edit the model for alignment. After setting and saving the model, click **[▼]** and select the model in the drop-down menu. For instructions on how to use the editor, please refer to 2D Model Editor.

Matching Settings

Pyramid Level

This parameter determines from which level of the pyramid to start for downward model matching.

Instruction: This parameter should be set according to the size of the object and the image resolution. Generally, for larger objects and higher-resolution images, a higher pyramid level is required.

Matching Score Threshold

This parameter is used to determine whether a matching result is valid. Result with a matching score below this threshold will be discarded.

Default setting: 50.0

Max Padding Size

This parameter determines the maximum number of pixels to be padded.

Default setting: 0

Instruction: When a part of the object to be matched is outside the image, padding is required. If the number of pixels of the object outside the image after matching is above the set value, a matching failure will occur.

Max Overlap Ratio

This parameter defines the upper limit of the overlap ratio if there is an overlap between two matching results. If the overlap ratio is above the set value, the result with the higher matching

score will be retained, while the result with the lower score will be discarded.

Default setting: 0.40

Skip Lowest Level

This parameter is used to determine whether to ignore the lowest level of the pyramid during matching. Selecting this option will accelerate matching.

Default setting: Selected

Min Grayscale Value for Tiles

This parameter is used to optimize the matching strategy. It dictates that matching will be conducted within tiles of the image where the grayscale value is above the set value.

Default setting: 10

Max Grayscale Value for Tiles

This parameter is used to optimize the matching strategy. It dictates that matching will be conducted within tiles of the image where the grayscale value is below the set value.

Default setting: 255

Refinement Setting

Use Non Rigid Refinement

Once this option is selected, a non-rigid method for pose refinement will be used. This is suitable for scenes where there is object deformation.

Default setting: Selected

Search Radius

This parameter is used to set the radius when searching for the corresponding point in pose refinement.

Default setting: 10

Instruction: When the matching effect is poor, increase the value appropriately.

Canny Low Threshold

This parameter determines the minimum number of edge pixels to be extracted during pose refinement. A lower value implies a greater number of pixels recognized as edges.

Default setting: 30

Canny High Threshold

This parameter determines the maximum number of edge pixels to be extracted during pose refinement. A higher value implies a greater number of pixels recognized as edges.

Default setting: 60

ICP Model Downsampling Step

This parameter specifies the step size for model downsampling, accelerating the matching. Increasing this value will help speed up pose refinement but may decrease the accuracy.

Default setting: 1

ICP Scene Downsampling Step

This parameter specifies the step size for scene downsampling, accelerating the matching. Increasing this value will help speed up pose refinement but may decrease the accuracy.

Default setting: 1

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Aligned Image	The depth map after alignment.
Confidence	The confidence of the matching result or the accuracy of the match.

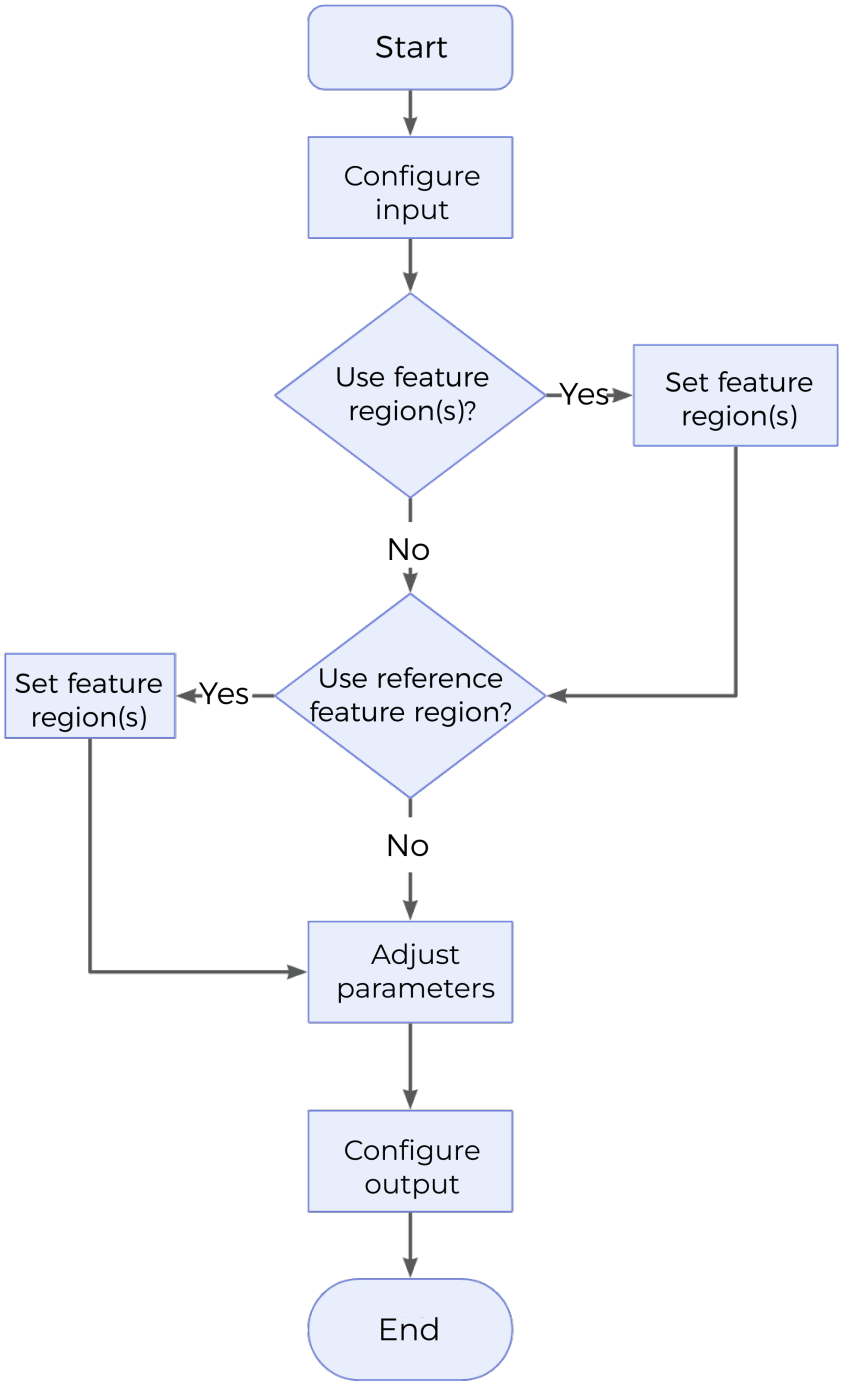
2.5.3.2. Blob Analysis

Description

This Step is used to detect defects on a surface based on a depth map or an intensity image. In addition, it can extract targets from the surface.

Workflow

The process of configuring this Step is shown below.



Instructions:

1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature regions.
3. Determine whether to use reference region.
4. Set other parameters.
5. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
6. Run the Step and view output.

Parameter Description

Use Intensity Image

Once this option is selected, the intensity image will be used together with the depth map for Blob analysis.

Default setting: Unselected

Use Feature Regions

Feature region defines the area where Blob analysis is performed. When this option is selected, this Step will only process data within or outside the feature region.

Default setting: Unselected

Instruction: Complete the configuration according to the actual requirement.

Feature Region Mode

Once **Use Feature Regions** is selected, this parameter is used to select whether to process the data within the feature region or outside it.

Options: Include data in Region, Exclude data in Region

Default setting: Include data in Region

Instruction: To process data within the feature region, select **Include data in Region**; otherwise, select **Exclude data in Region**.

For more information on how to set the feature region, please refer to Set the Feature Region.

Reference Type

This parameter determines the reference region, within which the average height or intensity of the data will be calculated.

Options: None, Reference feature region, Reference plane

- None: No reference region used.
- Reference feature region: Once this is selected, several feature regions can be added. The average height or intensity of the data in the feature region will be calculated.
- Reference plane: Selecting this will add an input to the Step. The reference plane is used to correct the tilt of the target. However, please note that correcting the tilt using the reference plane may introduce shear deformation.

Default setting: None

Threshold Settings

Threshold Filter

This parameter determines whether data above or below the threshold is considered a blob.

Options: Above, Below

- Above: Data above the threshold will be considered blobs.
- Below: Data below the threshold will be considered blobs.

Default setting: Above

Height Threshold

This parameter defines the threshold above or below which data is considered for being a blob. The set value is the minimum or the maximum of data points that will be considered part of a blob.

- With **Reference plane** as the reference type, the average height of the input data to the reference plane will be calculated and compared with **Height Threshold**. Data above or below the threshold is considered a blob.
- With **Reference feature region** as the reference type, the height of the input data to the average height of points within the region will be calculated and then compared with **Height Threshold**. Data above or below the threshold is considered a blob.

Default setting: 0.000 mm

Intensity Threshold

This parameter defines the threshold above or below which data is considered for being a blob. The set value is the minimum or the maximum of data points that will be considered part of a blob. This parameter will be displayed and then requires configuration when **Use Intensity Image** is selected.

Default setting: 0

Open or Close Kernel Operation

Open Kernel X / Y

The X and Y kernel size, respectively, for morphological opening to remove small areas of data. Use these settings, for example, to remove bridges between areas to properly isolate them or to remove small areas entirely.

Default setting: 3 pixels

Instruction: By adjusting the X / Y values, a non-rectangle filter can be used to adapt the kernel to the kinds of unwanted data you see in the scan data.

Close Kernel X / Y

The X and Y kernel size, respectively, for morphological closing to fill in holes smaller than the specified kernel size. Use these settings, for example, to fill small areas within potential blobs that may be caused by drop-outs.

Default setting: 3 pixels

Instruction: By adjusting the X / Y values, a non-rectangle filter can be used to adapt the kernel to the kinds of holes you see in the scan data.

Use Area Filter

Once this is selected, only blobs with areas between **Min Area** and **Max Area** will be retained.

Default setting: Selected

Max Area

The set value is the maximum possible area for retaining the blob.

Default setting: 999.0000 mm²

Min Area

The set value is the minimum possible area for retaining the blob.

Default setting: 0.5000 mm²

Use Aspect Ratio Filter

Once this option is selected, only blobs with aspect ratios between **Min Aspect Ratio** and **Max Aspect Ratio** will be retained.

Default setting: Unselected

Use Circularity Filter

Once this option is selected, only blobs with circularity between **Min Circularity** and **Max Circularity** will be retained.

Default setting: Unselected

Use Convexity Filter

Once this option is selected, only blobs with convexity between **Min Convexity** and **Max Convexity** will be retained.

Default setting: Unselected

Ordering By

This parameter specifies the rules for ordering the output blobs.

Options: Position (X increasing), Position (X decreasing), Position (Y increasing), Position (Y decreasing), Area (Large to small), Area (Small to large)

Default setting: Area (Large to small)

Blob Search Mode

This parameter defines the mode of searching the blobs.

Options: External blobs, External and internal blobs

- External blobs: Ignore the internal blob of a larger blob and return only the external blob. This means that only the external blobs will be retained, while the internal blobs will be ignored.
- External and internal blobs: Include internal blobs in larger blobs. This means that the internal blobs in addition to the external blobs will be retained in the returned result.

Default setting: External and internal blobs

Merge Blob Image

This parameter determines whether to merge blobs in the output.

- Selected: Output the blobs in an array called Blob Surface.
- Unselected: Output each blob as an individual surface output.

Default setting: Unselected

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Blob Count	The number of identified blobs.
Center X of Blob(n)	The X position of the center of mass of each blob.
Center Y of Blob(n)	The Y position of the center of mass of each blob.
Mean Height of Blob(n)	The mean height of data points in each blob.
Min Height of Blob(n)	The minimum height of data points in each blob.
Max Height of Blob(n)	The maximum height of data points in each blob.
Width of Blob(n)	The width of the bounding box that encapsulates each blob, i.e., the short edge.
Length of Blob(n)	The length of the bounding box that encapsulates each blob, i.e., the long edge.
Area of Blob(n)	The area of each blob.
Center of Blob(n)	The center of mass of each blob.
Blob(n) Surface	The surface data corresponding to each blob.

Troubleshooting

Invalid Parameter

No.	Error	Possible Causes	Solution
1	Invalid height threshold		Reset Height Threshold to make sure it works.
2	Inappropriate kernel size of the selected filter	The set kernel size is not greater than 0.	Reset the kernel size and ensure the value exceeds 0.
3	No blobs detected.	• No blob exists within the feature region. • Height Threshold is not set properly.	• Check and adjust the feature region to ensure that blobs are present in it. • Reset Height Threshold to ensure that the number of blobs above or below (as configured) the threshold is not 0.

Invalid Type

No.	Error	Possible Causes	Solution
1	Invalid reference type	• Reference Type is not configured properly. • Reference plane cannot be used in the grayscale mode.	• Configure Reference Type correctly. • Use the depth map mode, or use other reference types in the grayscale mode.

Invalid Input

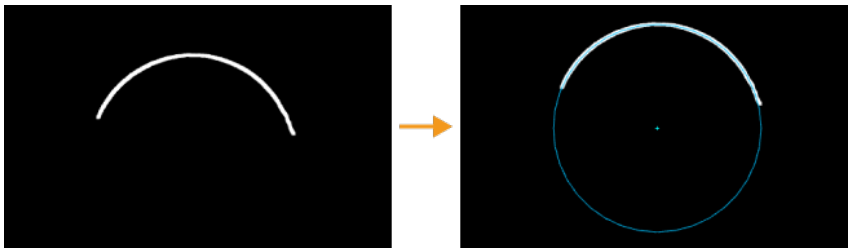
No.	Error	Error Description	Possible Causes	Solution
1	Invalid reference plane	When Reference Type is set to Reference plane, the input reference plane is invalid.	The parameters related to the reference plane is not set properly.	Check the parameters related to the reference plane and ensure that the input reference plane is valid.

2.5.4. Geometric Locating

2.5.4.1. Fit Circle to Profile

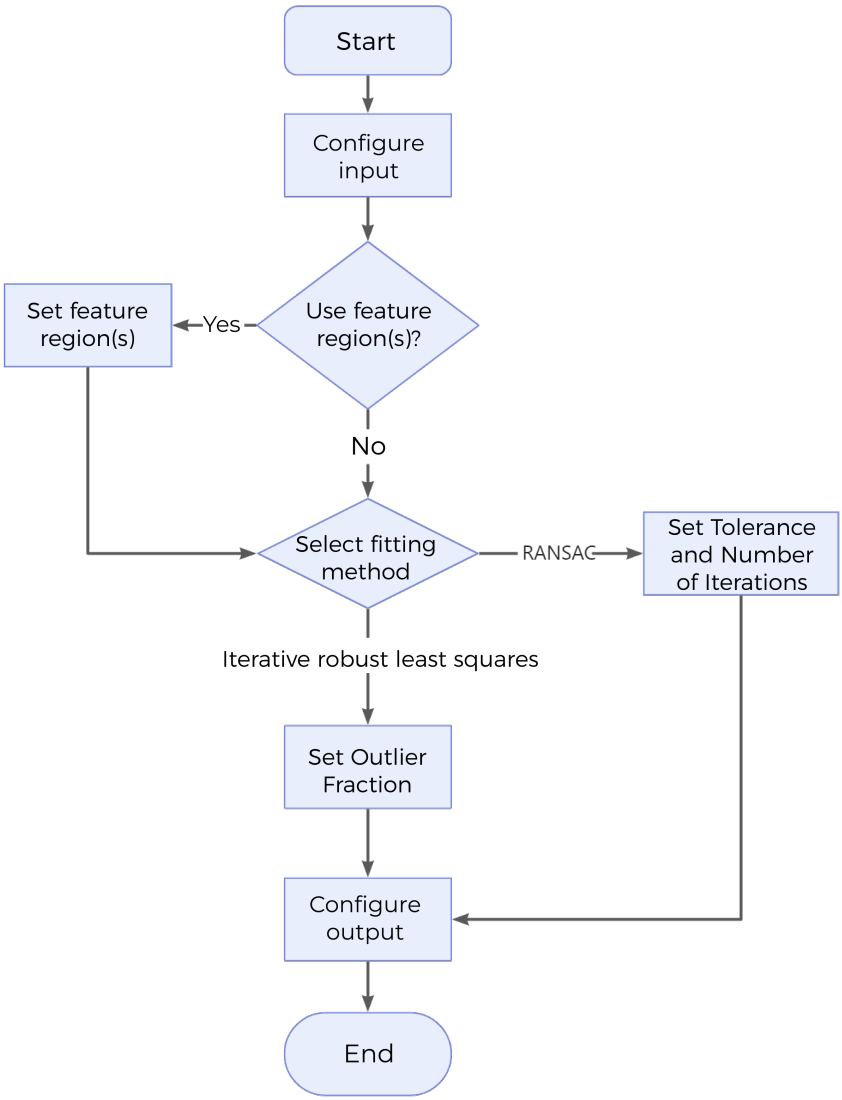
Description

This Step is used to fit a circle to the input profile and output various features of the fitted circle.



Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region. For a feature region used, complete the related settings. For more information, please refer to Use Feature Region.
3. Select the fitting method and set relevant parameters. For detailed description, please refer to Fitting Method.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Fitting Method

This parameter specifies the method of fitting the circle to the profile.

Options: Iterative robust least squares, RANSAC

- Iterative robust least squares: More robust, able to reduce the effect of noise or outliers, but requires longer computational time.

- RANSAC: Finds the best-fitted circle to the data through a random algorithm. The more iterations, the more accurate and stable the result, but the longer the computational time.

Default setting: Iterative robust least squares

Instruction: Iterative robust least squares is usually more suitable for cases with fewer outliers, whereas RANSAC is more appropriate for cases with more outliers because it can mitigate the effects of outliers effectively through random sampling.

Outlier Fraction

This parameter defines the proportion of outliers to be removed during circle fitting, thus resulting in a better result.

Default setting: 0.0%

Tolerance

This parameter refers to the distance threshold used in the RANSAC algorithm when determining the adequacy of a data point for fitting a model. A data point is considered an inlier if its distance to the fitted circle is less than the specified value, otherwise it is considered an outlier. By adjusting Tolerance, it is possible to control the sensitivity of the RANSAC algorithm to noise and outliers. The larger the value, the more easily the noise are recognized as inliers, and vice versa.

Default setting: 0.001 mm

Number of Iterations

This parameter refers to the number of times random sampling and model fitting are performed in the RANSAC algorithm. Due to the stochastic nature of the RANSAC algorithm, the randomly selected subset of data may be different for each iteration. To this end, multiple iterations need to be executed for a robust result. This parameter can be set empirically or based on the characteristics of the problem. Typically, the more iterations, the more robust the result, but with increased computational cost.

Default setting: 1000

Use Feature Region

Feature region defines the area where the circle is fitted. When this option is selected, this Step will only process data within the feature region.

Default setting: Unselected

Instruction: Complete the configuration according to the actual requirement.

For parameter settings of the feature region, please refer to Set the Feature Region.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Circle Center X	X value of the center of the fitted circle.
Circle Center Z	Z value of the center of the fitted circle.
Radius	The radius of the fitted circle.
Standard Deviation	The standard deviation of the data points with respect to the fitted circle.
Min Error	The minimum error of the data points with respect to the fitted circle.
Max Error	The maximum error of the data points with respect to the fitted circle.
Min Error X	The X value of the point with the minimum error.
Min Error Z	The Z value of the point with the minimum error.
Max Error X	The X value of the point with the maximum error.
Max Error Z	The Z value of the point with the maximum error.
Center of Fitted Circle	The center point of the fitted circle.
Fitted Circle	The fitted circle obtained.

Troubleshooting

Invalid Parameter

No.	Error	Error Description	Possible Causes	Solution
1	Inappropriate outlier fraction	When Fitting Method is set to Iterative robust least squares, Outlier Fraction is not set properly.	The set outlier fraction is not within [0, 1].	Reset Outlier Fraction to ensure that the value is within [0, 1].
2	Inappropriate number of iterations (RANSAC used)	When Fitting Method is set to RANSAC, Number of Iterations is not set properly.	The set number of iterations is not greater than 0.	Reset Number of Iterations and ensure that it exceeds 0.
3	Inappropriate tolerance (RANSAC used)	When Fitting Method is set to RANSAC, Tolerance is not set properly.	The set tolerance is not greater than 0.	Reset Tolerance and ensure that it exceeds 0.

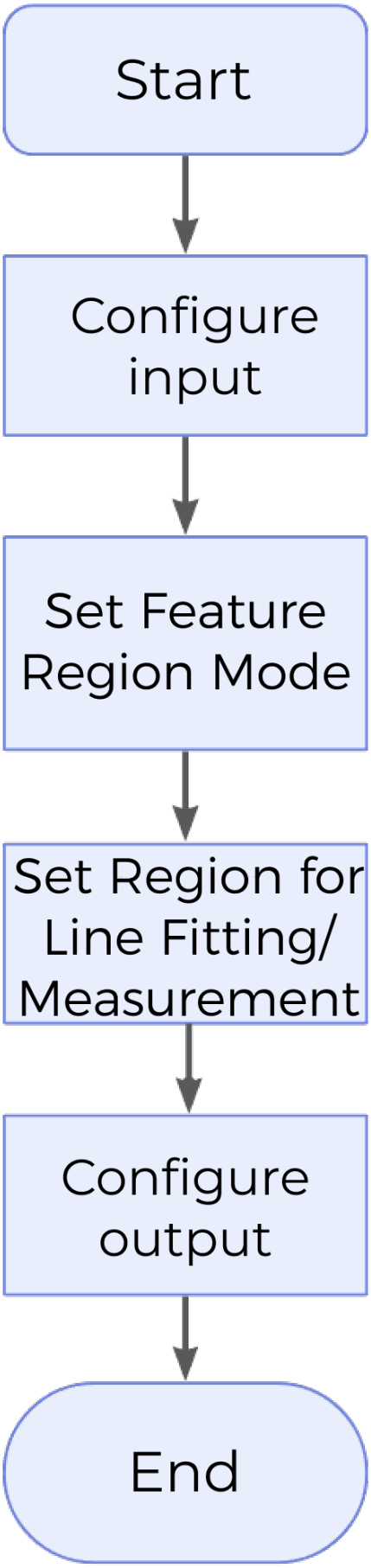
2.5.4.2. Fit Line to Profile

Description

This Step is used to fit a line to the input profile and measure the deviations from the fitted line.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Set the feature region mode.
3. Set the region for line fitting.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Feature Region Mode

This parameter determines whether the region for fitting and the region for measurement are the same.

Options: None, Combined, Separated

- Combined: The fitting region and measurement region are the same.
- Separated: The fitting region and measurement region are different.

Default setting: Combined

Fitting Method

This parameter specifies the method of fitting the line to the profile.

Options: Simple, Robust

- Simple: High speed, but low accuracy.
- Robust: Low speed, but high accuracy.

Default setting: Simple

Outlier Fraction

This parameter defines the proportion of outliers to be removed during line fitting, thus resulting in a better result. It will be displayed when **Fitting Method** is set to **Robust**.

Default setting: 30.000%

Measurements Percentage

This parameter specifies percentile of the nearest point to the line that is referenced when calculating the error in fitting the line.

Default setting: 50.000%

In statistics, percentiles are found by taking a large set of numerical data, arranging it in ascending order, and then dividing it into 100 groups with an equal number of data points. Each of the 99 dividing points is called a percentile of the data set.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Standard Deviation	The standard deviation of the data points with respect to the fitted line.
Min Error	The minimum error of the data points from the fitted line.
Max Error	The maximum error of the data points from the fitted line.
Error at Percentile	The maximum error from points within Measurements Percentage to the fitted line.
Offset	The Z value of the intersection of the fitted line with the Z-axis.
Angle	The angle of the fitted line with respect to the X-axis.
Min Error X	The X value of the point with the minimum error.
Min Error Z	The Z value of the point with the minimum error.
Max Error X	The X value of the point with the maximum error.
Max Error Z	The Z value of the point with the maximum error.
Arithmetic Mean	The mean of the distances from the data points to the fitted line.
Error Range	The range of error of the data points from the fitted line.
Fitted Line	The fitted line obtained.

Troubleshooting

Invalid Parameter

No.	Error	Error Description	Possible Causes	Solution
1	Inappropriate outlier fraction	When Fitting Method is set to Robust, Outlier Fraction is not set properly.	The set outlier fraction is not within [0, 1].	Reset Outlier Fraction to ensure that the value is within [0, 1].
2	Inappropriate measurements percentage	Measurements Percentage is not set properly.	The set measurements percentage is not within [0, 1].	Reset Measurements Percentage to ensure that the value is within [0, 1].

Invalid Feature Region

No.	Error	Error Description	Possible Causes	Solution
1	Insufficient data points in the region for measurement	There are not enough points in the measurement region for the measurement to be completed.	Data points are not included in the region for measurement.	Check and adjust the region for measurement to ensure that data points are included.

No.	Error	Error Description	Possible Causes	Solution
2	Insufficient data points in the region for line fitting	There are not enough points in the fitting region for the fitting to be completed.	The number of points in the region for line fitting is less than 2.	Check and adjust the region for line fitting to ensure that the number of points in it is no less than 2.

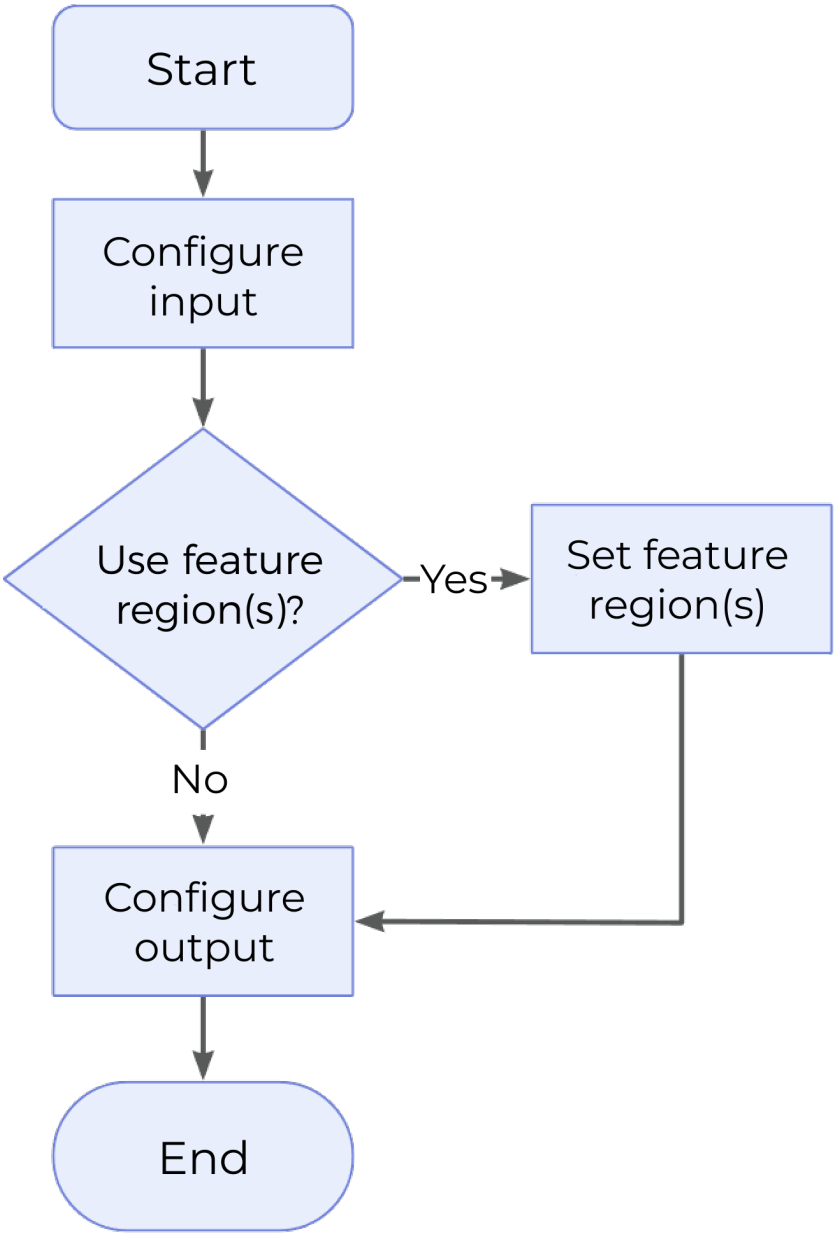
2.5.4.3. Fit Plane to Surface

Description

This Step is used to fit a plane based on a selected region or all data. The fitted plane often serves as the reference plane for other Steps.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region. For a feature region used, you need to set **Feature Region Mode**. For more information, please refer to Use Feature Region.
3. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
4. Run the Step and view output.

Parameter Description

Use Feature Region

Feature region defines the area to be processed by the algorithm. When this option is selected, this Step will only process data within or outside the feature region.

Default setting: Unselected

Instruction: Complete the configuration according to the actual requirement.

Feature Region Mode

Once **Use Feature Region** is selected, this parameter is used to select whether to process the data within the feature region or outside it.

Options: Include data in Region, Exclude data in Region

Default setting: Include data in Region

Instruction: To process data within the feature region, select **Include data in Region**; otherwise, select **Exclude data in Region**.

For other parameter settings of the feature region, please refer to Set the Feature Region.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Standard Deviation	The standard deviation of the points used to fit the plane from the plane.
Min Error	The minimum error of the points used to fit the plane from the plane. The distance is positive for points above the plane and negative for points below the plane.
Max Error	The maximum error of the points used to fit the plane from the plane. The distance is positive for points above the plane and negative for points below the plane.
Distance	The distance from the origin to the plane.
Fitted Plane	The plane fitted to the selected surface.

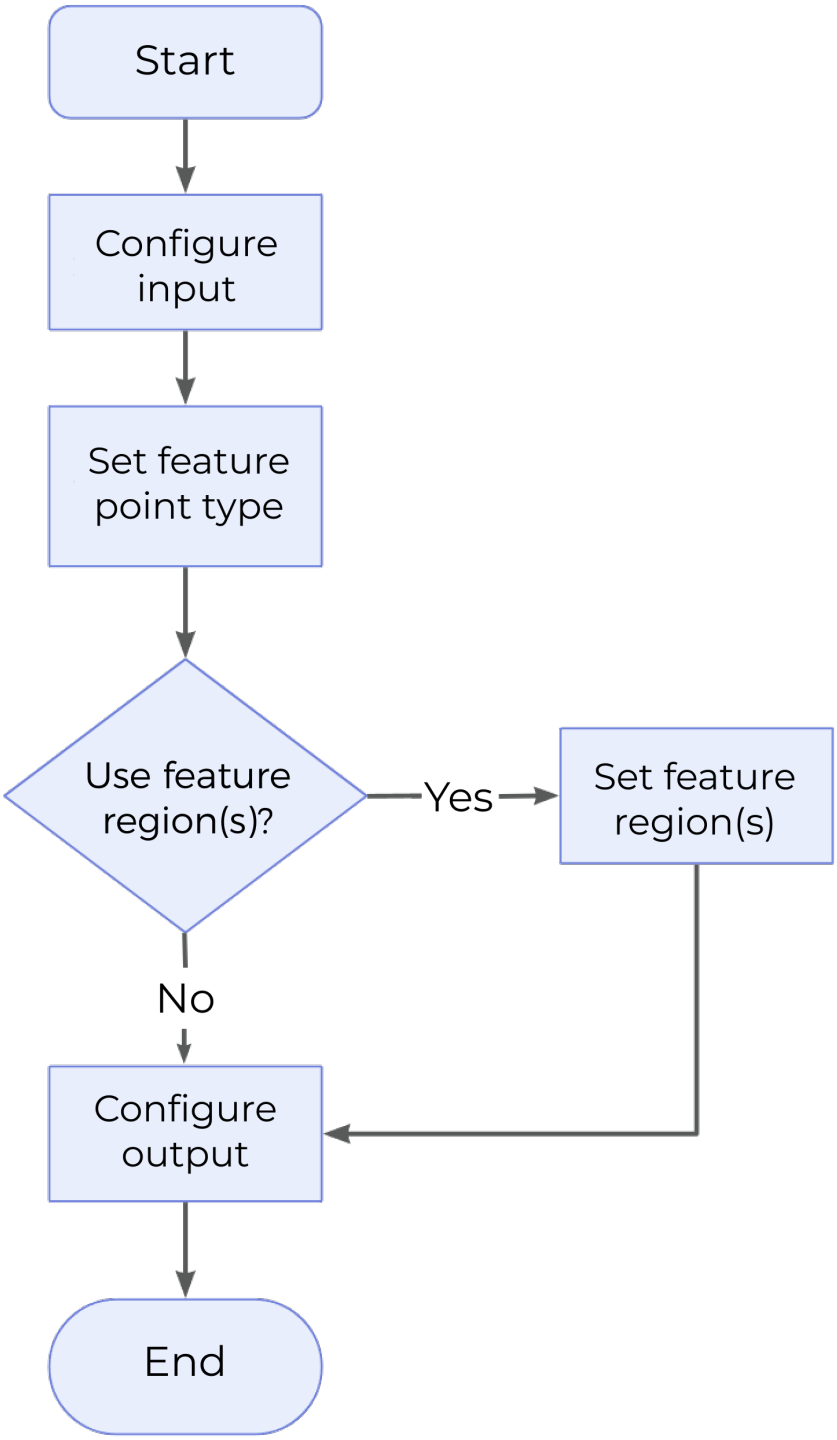
2.5.4.4. Locate Feature Point of Profile

Description

This Step is used to locate a feature point from the input profile, such as a point with a maximum or minimum Z value.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region. For more information on the configuration of feature region, please refer to Instructions on Feature Region.
3. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
4. Run the Step and view output.

Parameter Description

Feature Point Type

This parameter determines the type of the feature point to be located from the profile.

For more information on feature point types, please refer to Feature Points.

Use Feature Region

This parameter defines the region within which the feature point can be selected. For more information on how to set the feature region, please refer to Set the Feature Region.

Default setting: Unselected

Instruction: Please set the parameter according to the actual requirement.

Epsilon

This parameter specifies the sensitivity to profile shape changes. Generally, the smaller the Epsilon value, the more candidate feature points are calculated in the feature region, indicating higher sensitivity to profile shape changes. Conversely, the larger the Epsilon value, the fewer candidate feature points are calculated in the feature region, indicating lower sensitivity to profile shape changes.

This parameter can be used only when the feature point is of corner- or edge-related type.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
X-Coordinate	The X value of the feature point located from the profile.
Z-Coordinate	The Z value of the feature point located from the profile.
Feature Point	The feature point located from the profile.

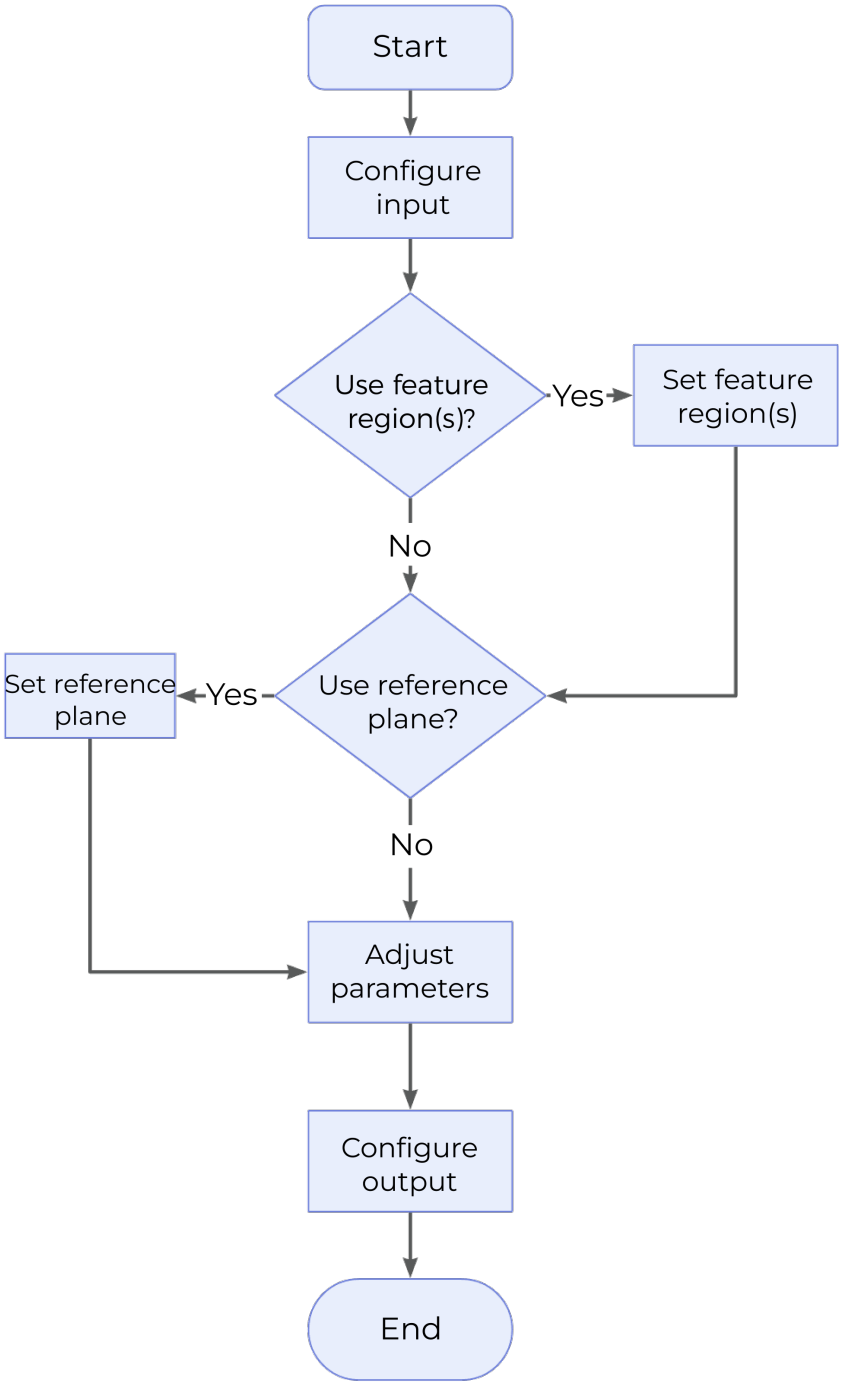
2.5.4.5. Locate Feature Point of Surface

Description

This Step is used to locate a feature point on the surface, such as a point with a maximum or minimum Z value.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region. For a feature region used, you need to set **Feature Region Mode**. For more information, please refer to Use Feature Region.
3. Determine whether to use reference plane. If a reference plane is used, an additional input will be displayed. You can manually connect the corresponding ports in the graphical programming workspace or configure the input under **Input**.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Feature Point Type

This parameter is used to determine the type of the feature point. For more detailed information, please refer to Feature Points.

Options: Min X, Max X, Min Y, Max Y, Min Z, Max Z, Average, Centroid, Median

Default setting: Average

Instruction: Complete the configuration according to the actual requirement. Notably, only a few of the above types are available when a reference plane is used.

Use Feature Region

Feature region defines the area to be processed by the algorithm. When this option is selected, this Step will only process data within or outside the feature region.

Default setting: Selected

Instruction: Complete the configuration according to the actual requirement.

Feature Region Mode

Once **Use Feature Region** is selected, this parameter is used to select whether to process the data within the feature region or outside it.

Options: Include data in Region, Exclude data in Region

Default setting: Include data in Region

Instruction: To process data within the feature region, select **Include data in Region**; otherwise, select **Exclude data in Region**.

For other parameter settings of the feature region, please refer to Set the Feature Region.

Use Reference Plane

Once this option is selected, a feature point will be located according to its distance to the reference plane.

Default setting: Unselected

Instruction: Once this option is selected, please reset **Feature Point Type**.

Feature Point Type (Use Reference Plane selected)

This parameter is used to select the type of the feature point when a reference plane is used.

Options: Min Z, Max Z, Average Z, Median Z (Z is the distance of points in the region to the reference plane)

- Max Z: The point in the region with the largest distance to the reference plane.
- Min Z: The point in the region with the smallest distance to the reference plane.
- Average Z: The point in the region whose distance to the reference plane is on average.
- Median Z: The point in the region whose distance to the reference plane is the median.

Default setting: Average Z

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
X-Coordinate	The X value of the feature point.
Y-Coordinate	The Y value of the feature point.
Z-Coordinate	The Z value of the feature point.
Feature Point	The located feature point.

Troubleshooting

Invalid Type

No.	Error	Error Description	Possible Causes	Solution
1	Invalid feature point type	The feature point type selected is invalid and Use Reference Plane is unselected.	The feature point type is not selected properly.	Adjust Feature Point Type.
2	Invalid feature point type	The feature point type selected is invalid and Use Reference Plane is selected.	The feature point type is not selected properly.	Adjust Feature Point Type.

Invalid Input

No.	Error	Error Description	Possible Causes	Solution
1	Invalid reference plane	When a reference plane is used, the input reference plane is invalid.	The parameters related to the reference plane is not set properly.	Check the parameters related to the reference plane and ensure that the input reference plane is valid.

2.5.5. Basic Measurement

2.5.5.1. Measure Dimensions by Features

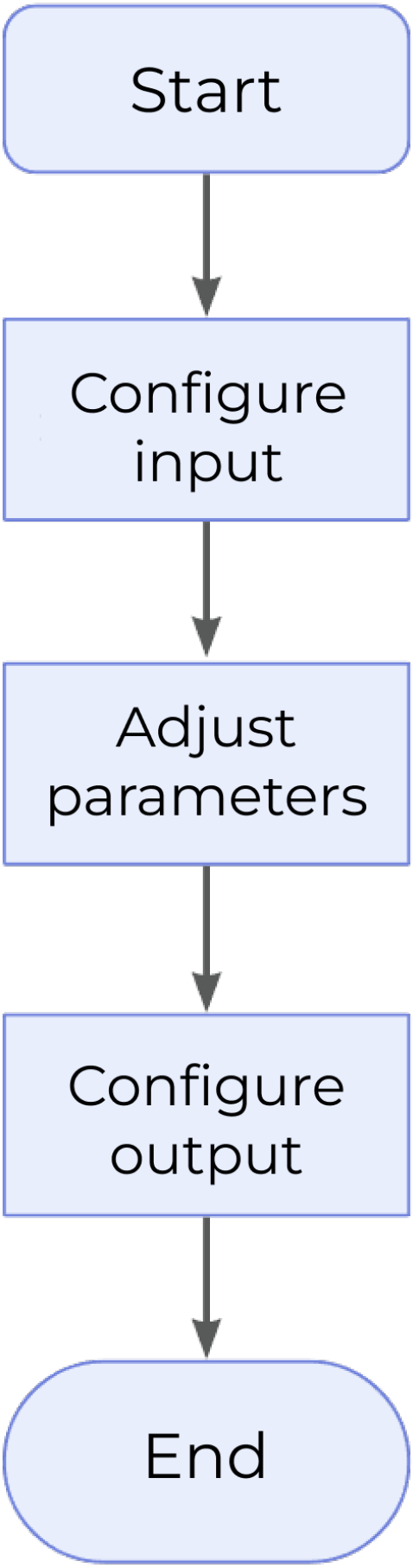
Description

This Step is used to perform dimensional measurements from a feature point to a reference

feature (reference point, reference line, or reference plane). It measures the distance between a point and a geometric feature such as a point or a plane.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Set the parameters according to the actual requirements.
3. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
4. Run the Step and view output.

Parameter Description

Output Absolute Width / Length / Height

- **Output Absolute Width**: When this is selected, the absolute value of the width (along the X-axis) between features will be output. Otherwise, a signed number will be output.
- **Output Absolute Length**: When this is selected, the absolute value of the length (along the Y-axis) between features will be output. Otherwise, a signed number will be output.
- **Output Absolute Height**: When this is selected, the absolute value of the height (along the Z-axis) between features will be output. Otherwise, a signed number will be output.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the qualified range, the measurement is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Width	• **Point-point**: The difference on the X-axis between the points. • **Point-plane**: The difference on the X-axis between the point and a point on the plane with the same Y and Z values as the first point.
Length	• **Point-point**: The difference on the Y-axis between the points. • **Point-plane**: The difference on the Y-axis between the point and a point on the plane with the same X and Z values as the first point.
Height	• **Point-point**: The difference on the Z-axis between the points. • **Point-plane**: The difference on the Z-axis between the point and a point on the plane with the same X and Y values as the first point.
Distance	• **Point-point**: The Euclidean distance between two points. • **Point-plane**: The direct, Euclidean distance between the point and the nearest point on the plane.
Plane Distance	• **Point-point**: The distance between two points. For profile data, the points are projected onto the XOZ plane. For surface data, the points are projected onto the XOY plane. • **Point-plane**: The distance between the point and a plane. For profile data, the distance is projected onto the XOZ plane. For surface data, the distance is projected onto the XOY plane.

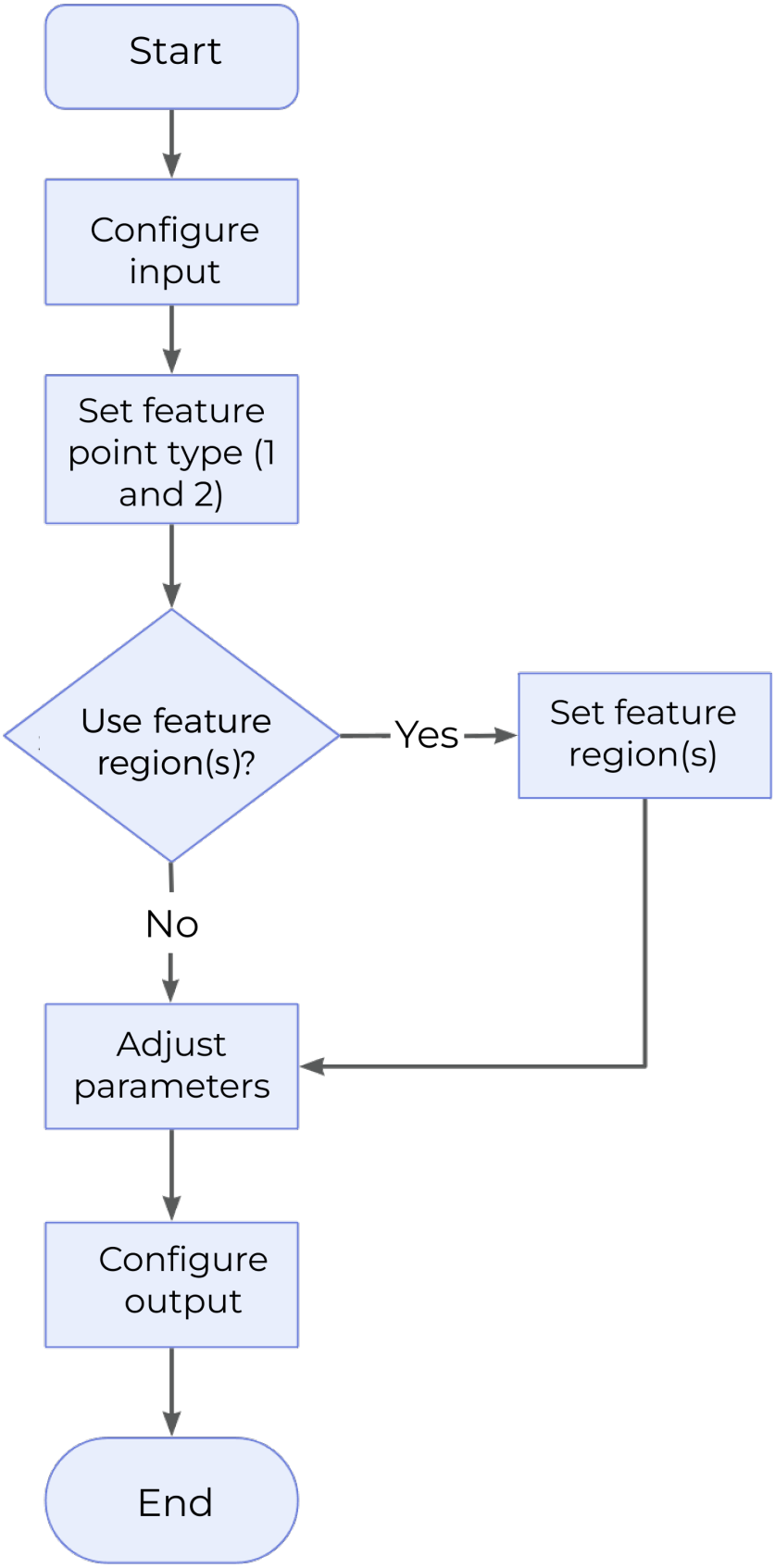
2.5.5.2. Measure Dimensions by Profile Features

Description

This Step is used to locate two feature points of the input profile and make measurements on this basis, including width (X-axis), height (Z-axis), distance, and X / Z values of the center point.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Identify two feature points. Specify two feature point types separately. Define the regions for

the selected feature points by selecting **Use Feature Region 1** and **Use Feature Region 2** as well as completing the configuration.

3. Set other parameters according to the actual requirements.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Use Feature Region 1 / Use Feature Region 2

- **Selected** (default): By setting the feature regions separately, further define the region within which the feature point can be selected.

  For more information on how to set the feature region, please refer to Set the Feature Region.

- **Unselected**: The feature points will be selected from the input profile.

Feature Point Type 1 / Feature Point Type 2

Specify the type of the feature point from the drop-down menu. For more detailed information, please refer to Feature Points.

Output Absolute Width / Height

- **Output Absolute Width**: When this is selected, the absolute value of the width between features will be output. Otherwise, a signed number will be output.
- **Output Absolute Height**: When this is selected, the absolute value of the height between features will be output. Otherwise, a signed number will be output.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the qualified range, the measurement is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Width	The difference along the X-axis between two feature points.
Height	The difference along the Z-axis between two feature points.
Distance	The Euclidean distance between two feature points.
Center X	The X value of the center point of the line connecting the two feature points.
Center Z	The Z value of the center point of the line connecting the two feature points.

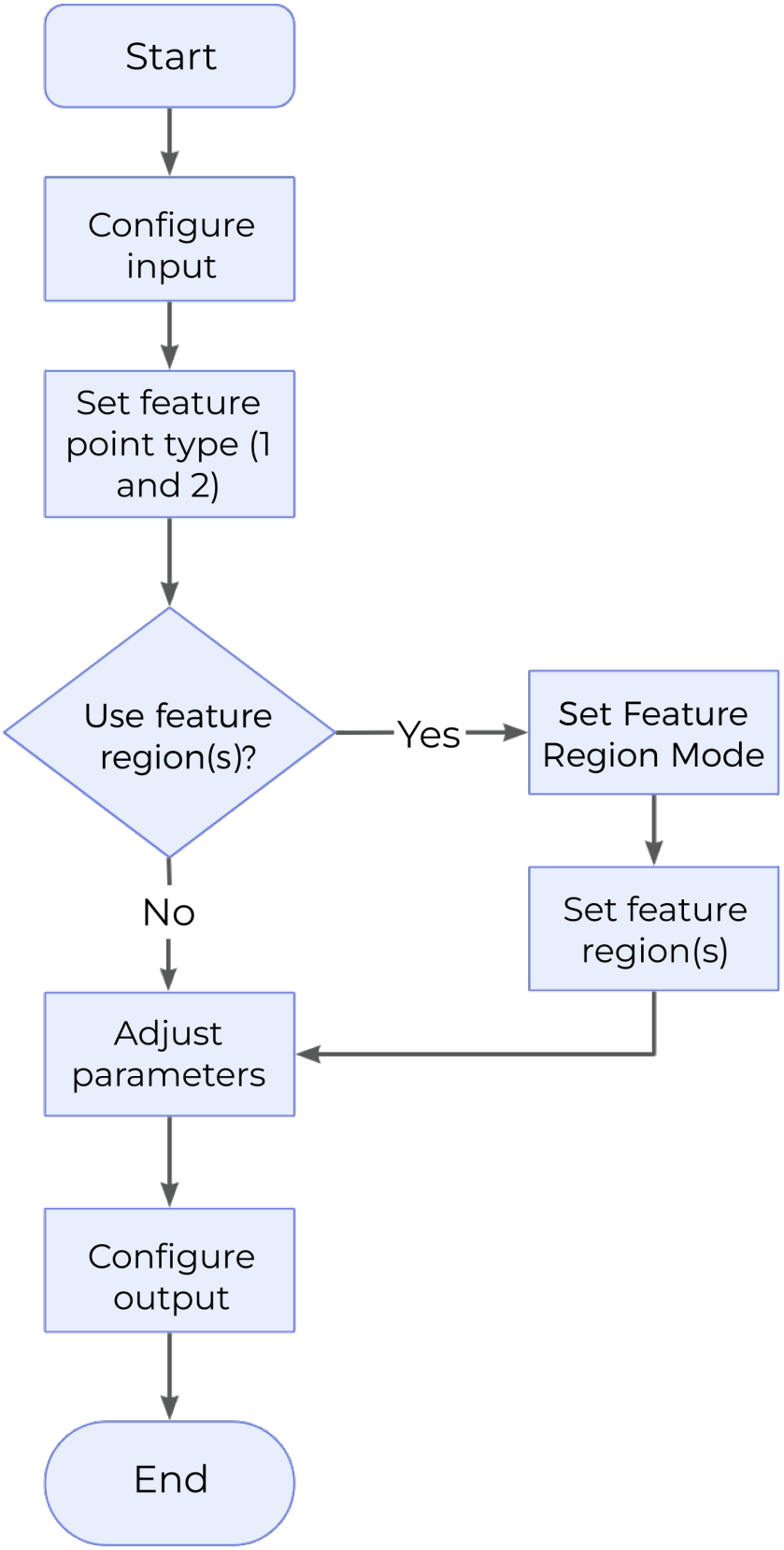
2.5.5.3. Measure Dimensions by Surface Features

Description

This Step is used to locate two feature points on a surface and make measurements on this basis, including width (X-axis), length (Y-axis), height (Z-axis), distance, and X / Y / Z values of the center point.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Identify two feature points. Specify two feature point types under **Type of Feature Point 1** and **Type of Feature Point 2**, respectively. Define the regions for the selected feature points by

selecting **Use Feature Region 1** and **Use Feature Region 2** as well as completing the configuration.

3. Set other parameters according to the actual requirements.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Use Feature Region 1 / Use Feature Region 2

Selected (default): By setting the feature regions separately, you can further define the region within which the feature point can be selected.

For more information on how to set the feature region, please refer to Set the Feature Region.

- **Feature Region Mode 1 / Feature Region Mode 2**: Select whether to **Include data in Region** or **Exclude data in Region**. Correspondingly, the feature points will fall within the set regions.

Unselected: The feature points can be selected over the entire surface.

Type of Feature Point 1 / Type of Feature Point 2

Specify the type of the feature point from the drop-down menu. For more detailed information, please refer to Feature Points.

Output Absolute Width / Length / Height

- **Output Absolute Width**: When this is selected, the absolute value of the width between features will be output. Otherwise, a signed number will be output.
- **Output Absolute Length**: When this is selected, the absolute value of the length between features will be output. Otherwise, a signed number will be output.
- **Output Absolute Height**: When this is selected, the absolute value of the height between features will be output. Otherwise, a signed number will be output.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the qualified range, the measurement is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Width	The distance between two feature points along the X-axis.
Length	The distance between two feature points along the Y-axis.
Height	The distance between two feature points along the Z-axis.
Distance	The Euclidean distance between two feature points.

Output Item	Description
Plane Distance	The distance between two feature points. The point with the lower Z-value is projected onto the XOY plane where the other point is located, and then the distance in the XOY plane is calculated.
Center X / Center Y / Center Z	X, Y, and Z values of the center point of the line connecting the two points, respectively.

2.5.6. Advanced Measurement

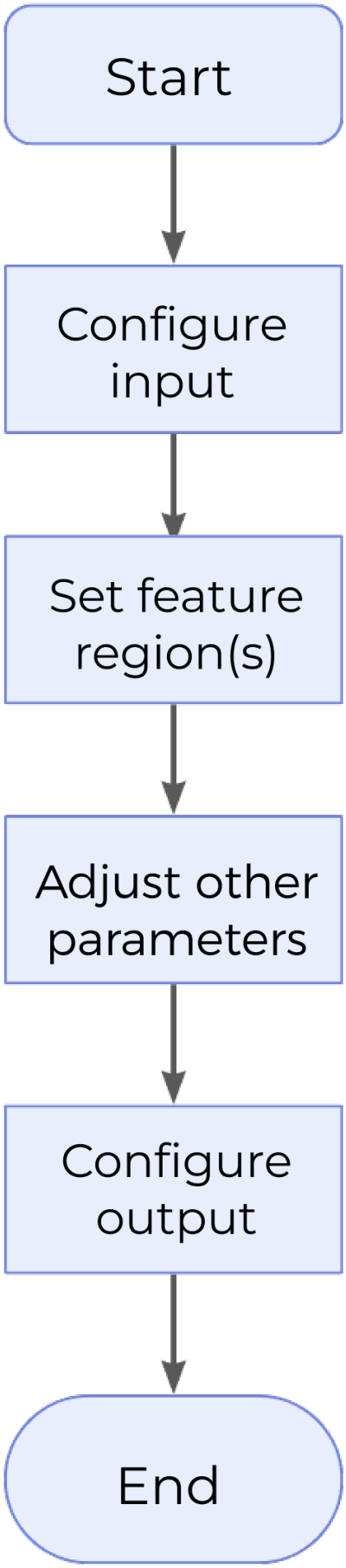
2.5.6.1. Measure Feature Point Height

Description

This Step is used to locate the feature point(s) of the profile and measure the height of feature point(s) relative to a reference line or a base point.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Set the feature region.
3. Set other parameters.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Feature Region

This parameter is used to add feature regions (1–16) for locating feature points on the profile.

- For more information on how to set the feature region, please refer to Set the Feature Region.
- For more information on feature point types, please refer to Feature Point Types.

Reference Line

When this parameter is selected, a reference line will be fitted using the data within the set line region(s).

- Line Regions (1–2): This parameter defines a region on the profile, and the data points within the region will be used to fit the reference line.
- Fitting Method: The method of fitting a reference line with the defined reference region. Choose between **Simple** and **Robust**.
  - Simple: High speed, but low accuracy.
  - Robust: An iterative fitting method. High accuracy, but low speed.
    - Outlier Fraction: The proportion of outliers to be removed during line fitting, thus resulting in a better result.

Use Base Point

This parameter defines a region for locating a base point, which facilitates the measurement of feature point height.

- Base Point Region: Configure the base point region by adjusting Center X / Z, Width, and Height of the base point region.
- Feature Point Type: Select a type of feature points within the region as the base point. For more information, please refer to Feature Point Types.

Height Measurement Method

There are four ways to measure feature point height, corresponding to the following four calculation methods. You can choose among them according to the actual measurement requirements.

Feature Region Only

It is possible to set 1–16 feature region(s), and the 1–16 feature point height(s) can be measured at once. In this case, take the line with Z = 0 as the reference line, and calculate the distance from the feature point to this line as the feature point height. The height is positive for points above the line and negative for points below the line.

[only feature regions] | *measure-feature-point-height/only-feature-regions.png*

Feature Region + Reference Line

Calculate the distance from the feature point to the reference line as the feature point height. The height is positive for points above the line and negative for points below the line.

[feature regions plus line] | *measure-feature-point-height/feature-regions-plus-line.png*

Feature Region + Base Point

Make a reference line parallel to the X-axis through the base point, and calculate the distance from the feature point to the line. The height is positive for points above the line and negative for points below the line.

In this case, the base point height is the distance from the base point to the line with Z = 0.

[feature regions plus base point] | *measure-feature-point-height/feature-regions-plus-base-point.png*

Feature Region + Reference Line + Base Point

Make a line parallel to the reference line through the base point, and calculate the distance from the feature point to the line. The height is positive for points above the line and negative for points below the line.

In this case, the base point height is the distance from the base point to the reference line. The height is positive for points above the line and negative for points below the line.

[feature regions plus line plus base point] | *measure-feature-point-height/feature-regions-plus-line-plus-base-point.png*

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Height of Feature Point	The height of a feature point to the reference line or that of a feature point to the base point. The height is positive for feature points above the reference line or base point, and negative for feature points below the reference line or base point. Without reference line and base point, the feature point height is the distance from the feature point to the line with Z = 0.
Height of Base Point	Without reference line, the base point height is the distance from the base point to the line with Z = 0. With a reference line set, the base point height is the distance from the base point to the reference line. The height is positive for points above the line and negative for points below the line.

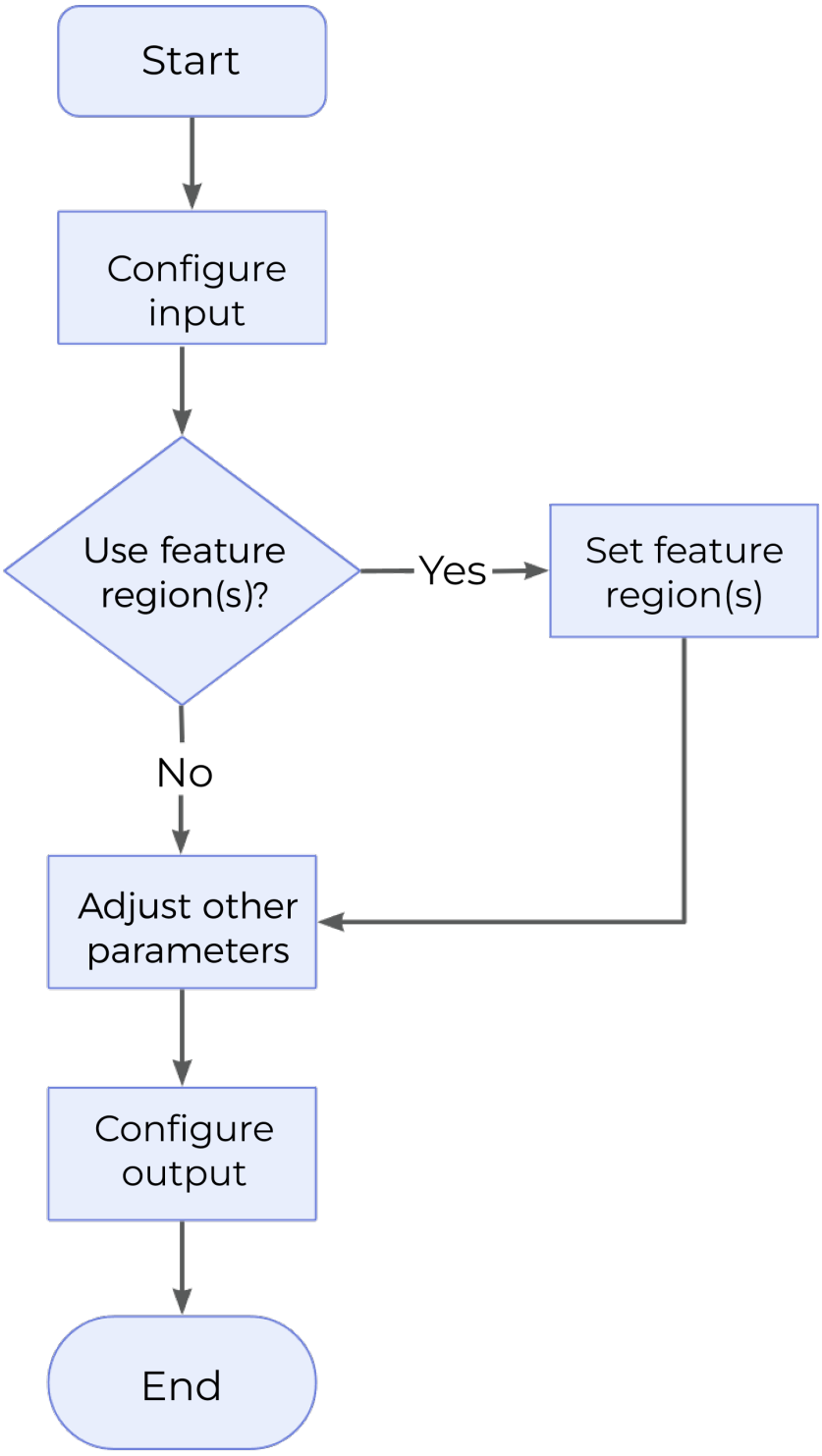
2.5.6.2. Measure Surface Flatness

Description

This Step is used to measure the flatness of a specified surface region.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Determine whether to use feature region.
3. Set other parameters.
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Use Feature Region

Feature region defines the processing area to facilitate fitting the optimal plane. Once this parameter is selected, only data within or outside the feature region will be processed.

Default setting: Unselected

Instruction: Please set the parameter according to the actual requirement.

Feature Region Mode

Once **Use Feature Region** is selected, this parameter is used to set the mode of the feature region, i.e., to choose whether to use the data within the feature region to fit the plane and calculate the flatness, or to use the data outside the feature region to fit the plane and calculate the flatness.

Options: Include data in Region, Exclude data in Region

Default setting: Include data in Region

Instruction: To use the data within the feature region to fit the plane and calculate flatness, select **Include data in Region**; otherwise, select **Exclude data in Region**.

For other parameter settings of the feature region, please refer to Set the Feature Region.

Global Flatness Mode

This parameter determines which points on the surface are used to calculate global flatness.

Options: All points, Single average point

All points:

When no feature region is set, all data points on the surface will be used to fit the global plane and calculate flatness.

- When a feature region is set, the global plane is fitted and flatness is calculated according to the feature region.
  - **Single average point**: Use an average of data points in the measurement area to fit the global plane and calculate flatness.

This option is only available when at least 3 feature regions are set, or else the Step will fail.

Data Filtering Mode

This parameter specifies the data filtering method. Filter the data points according to the actual

Z values before fitting the plane and calculating flatness.

Options: None, Local percentile, Global percentile

- **None**: No data filtering is performed.
- **Local percentile** filters data according to the feature region; **Global percentile** filters global data. In both cases, percentiles must be set to define the range of Z values of data points. Data points outside the range will be filtered out.
  - High Percentile: the percentile corresponding to the upper limit of the Z value of the data point.
  - Low Percentile: the percentile corresponding to the lower limit of the Z value of the data point.

When no feature region is set, both **Local percentile** and **Global percentile** indicate that the global data will be filtered.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the acceptable range, the measurement item is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Global Min	The minimum distance from the data points involved in global plane fitting to the fitted global plane. The distance is positive for points above the plane and negative for points below the plane.
Global Max	The maximum distance from the data points involved in global plane fitting to the fitted global plane. The distance is positive for points above the plane and negative for points below the plane.
Global Flatness	The flatness of the globally fitted plane, which is the difference between Global Max and Global Min.
Global Min Point	The point representing Global Min.
Global Max Point	The point representing Global Max.
Global Average Point	The average point of all data points involved in global plane fitting.
Global Median Point	The median point of all data points involved in global plane fitting.
Global Plane	The fitted global plane.
Local Min	The minimum distance from the data points involved in local plane fitting to the fitted local plane. The distance is positive for points above the plane and negative for points below the plane. The number of output Local Min matches that of fitted local planes.

Output Item	Description
Local Max	The maximum distance from the data points involved in local plane fitting to the locally fitted plane. The distance is positive for points above the plane and negative for points below the plane. The number of output Local Max matches that of fitted local planes.
Local Flatness	The flatness of each fitted local plane, which is the difference between Local Max and Local Min.
Local Min Points	The points representing Local Min.
Local Max Points	The points representing Local Max.
Local Average Points	The average point of data points involved in the fitting of each local plane.
Local Median Points	The median point of data points involved in the fitting of each local plane.
Local Planes	Fitted local planes.

Troubleshooting

Invalid Type

No.	Error	Possible Causes	Solution
1	Invalid data filtering mode	The data filtering mode is not selected properly.	Adjust Data Filtering Mode.

Invalid Parameter

No.	Error	Possible Causes	Solution
1	The percentile for data filtering is not set properly.	The value of Low Percentile is greater than that of High Percentile, or either of them is not within [0, 1].	Reset the percentile to ensure that the percentile is within [0, 1] and that the value of Low Percentile is lower than that of High Percentile.
2	Failure to fit the global plane.	• The number of points in the feature region is less than 3 and Global Flatness Mode is set to Single average point. • The number of points in the feature region is less than 3 and Global Flatness Mode is set to All points.	• Adjust or add feature regions to ensure that the number of points in the feature region is equal to or greater than 3. • Adjust the feature region to ensure that the number of points in the feature region is greater than 3.

2.5.7. Object Measurement

2.5.7.1. Detect and Measure Hole on Surface

Description

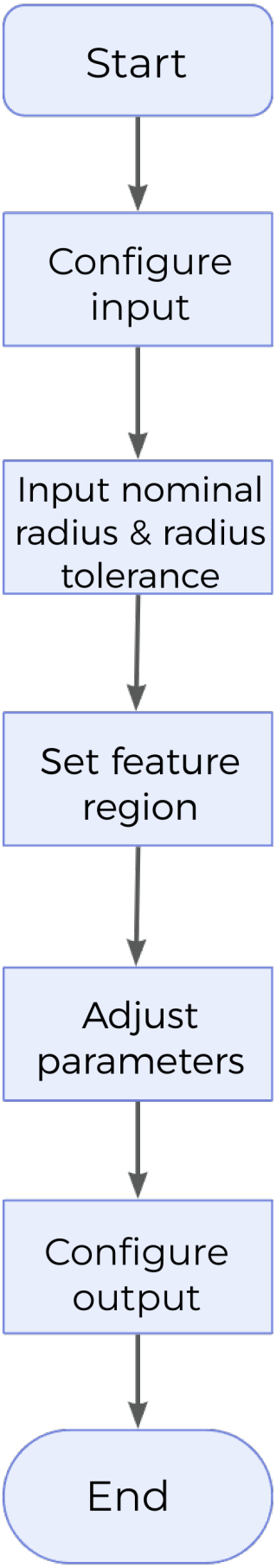
This Step is used to detect the hole on a surface and output the location and radius of the detected hole.

Usage Scenario

Quality inspection, equipment calibration, object recognition, and positioning can be performed by locating and measuring holes on the surface of the workpiece.

Workflow

The process of configuring this Step is shown below.



1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Set **Nominal Radius** and **Radius Tolerance** under **Parameters**.
3. Configure the feature region and reference plane (optional).
4. Select the desired output(s) under **Output**. For an expandable output item, click ▶ and configure the **Min** and **Max** values of the acceptable range.
5. Run the Step and view output.

Parameter Description

Nominal Radius

The expected radius of the hole, i.e. the standard radius of the hole.

Radius Tolerance

The allowable maximum variation of measured radius from the nominal radius (+ / - from the nominal radius).

Use Local Detection

The center of the hole to be detected must be within the feature region. For **Use Local Detection** to be selected, this condition must be met, otherwise no measurement can be performed effectively.

- **Unselected** (default): The hole to be detected is completely within the feature region.
- **Selected**: Only part of the hole is within the feature region.

Use Depth Limit

Once this option is selected, set **Depth Threshold** for data points. Points with depth values (relative to the measurement plane or reference plane) above the set threshold will be removed from hole calculation.

Feature Region

Configure the feature region to ensure that the hole to be detected is within the feature region. For more information on how to set the feature region, please refer to Set the Feature Region.

The data in the feature region can be used to fit a measurement plane as a reference. Once set, the reference plane will be used as reference.

Use Reference Plane

In cases where the surface around the hole is not flat, you can set a **Reference Region** to fit the reference plane so that the detected hole is on the reference plane.

- **Unselected**: All data points in the feature region will be used to fit a measurement plane.
- **Selected**: Once the option is selected, you can set **One** or **Two** reference region(s) to fit a reference plane aligned with the hole to be detected.

Tilt Correction

The plane where the detected hole is located may be tilted compared to the actual plane, which can corrected in one of the following ways:

Options: Autoset, Custom

- **Autoset**: The tilt of the hole relative to the measurement plane or reference plane is automatically detected and corrected.
- **Custom**: Set **X Angle** and **Y Angle** manually to correct the tilt of the hole.

Output Description

Select the output item(s) according to the actual measurement requirements. Then the corresponding data will be output after the Step is run.

If you select an expandable output item, you must expand it by clicking ▶, and then set the **Min** and **Max** values to determine the acceptable range. If the output value falls within the qualified range, the measurement is judged as passing (OK), or else it is judged as failing (NG).

Output Item	Description
Hole Center X	The X value of the hole center.
Hole Center Y	The Y value of the hole center.
Hole Center Z	The Z value of the hole center.
Radius	The radius of the hole.
Hole Center	The center point of the hole.

Troubleshooting

Invalid Feature Region

No.	Error	Possible Causes	Solution
1	Insufficient data points defined by the feature region	-	Adjust the feature region so that sufficient data points are included.
2	Insufficient data points defined by reference region(s)	-	Adjust the reference region so that sufficient data points are included.
3	No hole detected	• The hole is not included in the feature region. • Tilt Correction is not set properly.	• Adjust the feature region so that the hole is included. • Reset Tilt Correction.
4	Failure to reproject	• The feature region is not set properly. • Tilt Correction is not set properly.	• Adjust the feature region. • Reset Tilt Correction.
5	Insufficient data points involved in hole detection in the feature region	• The set depth threshold is too low. • The reference plane is not set properly, i.e., the hole to be measured is not coplanar with the reference plane.	• Increase the value of Depth Threshold appropriately. • Reset the parameters related to the reference plane.

Invalid Parameter

No.	Error	Possible Causes	Solution
1	Unreasonable nominal radius	The set nominal radius is too large or too small.	Reset Nominal Radius appropriately.
2	Large difference between the measured radius and the set nominal radius	-	Reset Nominal Radius, Radius Tolerance, or adjust the feature region.
3	Unreasonable radius tolerance	The set radius tolerance is too large or too small.	Reset Radius Tolerance appropriately.

2.5.8. Meta

2.5.8.1. Extract Data

Description

This Step is used to extract the data at a specified index or in a specified range of an array or a list.

Workflow

The process of configuring this Step is shown below.

1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Configure the index value or index range for data extraction under **Parameters**.
3. Run the Step and view output.

Parameter Description

Dimension

The dimension of the input. The dimension of an array refers to the number of dimensions or axes in the array.

Use Range

This parameter determines whether to use the index range to define the elements to be extracted. An index value of 0 indicates the first element.

- **Unselected**: Extract the element at the specified **Index**.
- **Selected**: Extract elements within the specified index range. For this, you need to set **Begin Index** and **End Index**.

Default setting: Unselected

Index

The index value of the element to be extracted, which is the position of the element in an array or a list. Index values are incremented from 0.

Output Description

The output of this Step is the processed lists.

2.5.8.2. Merge Data

Description

This Step is used to merge data outputs of the same format from different Steps and output a new array or list.

Workflow

The process of configuring this Step is shown below.

1. Configure the input. Connect the ports manually or select the input(s) under **Input** in the parameter configuration panel.
2. Set the number of input ports and the dimension of the input data under **Parameters**.
3. Run the Step and view output.

Parameter Description

Number of Input Ports

The number of input ports of the same format from different Steps, i.e., the number of arrays or lists to be merged.

Instruction: Set the value according to the actual situation.

Dimension

The dimension of the input. The dimension of an array refers to the number of dimensions or axes in the array.

Output Description

The output of this Step is an array or a list after merging.

2.5.9. Scripting Engine

2.5.9.1. Calc Results by Python

Description

This Step runs a user-defined script through Python and outputs the calculation results to Mech-MSR.

The characteristics of this Step are as follows:

- Support multi-threading.
- Load Python script in real time.
- Support various data type conversions when transferring data between C++ and Python.
- Allow for the display of the Python's log in the log panel of Mech-MSR.

Usage Scenario

When a custom calculation is required, this Step can be used to run the user-defined Python script and the measurement solution can be simplified.

Input and Output

- **Input**: determined by the data type input in the **Input Ports** parameter.
- **Output**: determined by the data type input in the **Output Ports** parameter.

You can specify the data type of the input/output ports according to the data type of the previous or subsequent Steps' input/output ports.

Installation and Usage

Installation

Python 3.9.13 is built into Mech-MSR, and thus this Step will use the built-in Python environment of the software. If there is any missing Python library when you use this Step, you need to install the library in the Mech-MSR's built-in Python environment. The procedures for installation are as follows:

1. Open the command prompt window.
2. Use the `cd` command to go to the directory where Python is stored in Mech-MSR.
3. Type `python -m pip install Python name of the library` on the command line to install the missing Python library.

Two commonly used Python libraries, NumPy and OpenCV, are built into the Mech-MSR.

Usage Instructions

After preparing the Python script, please follow the procedure below to use the Step. For detailed description of the parameters, refer to Parameter Description.

1. Set the data type for the input and output ports. Enter the data type for **Input Ports** and **Output Ports** according to the data type of the previous or subsequent Steps' input/output ports.
2. Specify the file path to the Python script. Select the file path to the script to be loaded in the **Script File Path** parameter.
3. Set the name of the function to be called. Once the Script File Path has been specified, this Step will retrieve the function names in the script automatically, and you can select the name of the function to be called in the drop-down list of **Func Name**.
4. Run the Step.

- When writing the Python scripts, you can directly write the functions to process data without writing the statements in the scripts to obtain Mech-MSR data.
- When the Python script is modified, and you want to use the new script to run this Step in real time, click **Reload File** in the **Execution Flags** parameter group.

Notes

Please pay attention to the following issues when you write the Python script and run the script in this Step.

Third-Party Library is Recommended

Because running a Python script in Mech-MSR differs from running the script in Python directly, some Python libraries could not be installed successfully or they cannot function properly after being installed, it is recommended to use third-party libraries.

Use the NumPy Library

The NumPy library is used to support some complicated formats of data. If a parameter type is ndarray, but the NumPy has not been imported, an error may occur. Therefore, you should add the **import numpy** statement at the beginning of the script.

Pay Attention to the Data Dimension when Writing the Script

When writing the Python script, please note the dimension of data corresponding to each port of the Step.

- 0 dimension by default: Image; Cloud(XYZ); Cloud(XYZ-Normal)
- 1 dimension by default: NumberList; BoolList; IndexList; StringList; Point2DList
- 2 dimensions by default: PoseList; Pose2DList; Size3DList

Use "[]" after the data type to add a dimension.

For example, the data dimension of NumberList is 1, while the data dimension of NumberList[] is 2.

Parameter Description

Input Ports

This parameter is used to specify the data type(s) of the input port(s). The input data types will be passed to the called function as parameters in the corresponding order.

Default value: Null.

Output Ports

Description: This parameter is used to specify the data type(s) of the output port(s). Data returned by the function will be returned to the Step in the corresponding order and will be parsed according to the corresponding data type.

Default value: Null.

The currently supported data types are as follows:

Step port type	Data type used in Python	Input data example
PoseList	List	[[10, 20, 30, 0.951, 0.255, 0.168, 0.045]], [10, 20, 30, 0.951, 0.255, 0.168, 0.045]] (In each array, the first three values are the coordinates, and the following four values are quaternions.)

Step port type	Data type used in Python	Input data example
Pose2DList	List	[[0, 0, 0]], [2, 0, 120]] (In each array, the first two values are X and Y values of the coordinates respectively, and the third value is the angle.)
NumberList	List	[1.1, 2, 999.9, -22]
StringList	String	['string_1', 'string_2', 'string_3']
Image	8-bit unsigned integer/64-bit floating point number	Image data
Cloud(XYZ)	Array	Point cloud data
Cloud(XYZ-Normal)	Array	Point cloud data with normals
Cloud(XYZ-RGB)	Array	Data of textured point cloud
Size3DList	64-bit floating point number	[[2.5, 5, 0.001]], [6, 5, 0.02]] (In each array, the first two values are the width and height, and the third value is the length of each pixel.)
IndexList	Integer	[45, 10, 90]
BoolList	Boolean	[True, False, True]
Point2DList	List	Profile data

Script File Path

This parameter is used to select the file path of the script to be loaded.

Func Name

This parameter is used to set the name of the function to be called.

2.6. Tool User Guide

Click the corresponding link to view the detailed usage instructions of the corresponding tool.

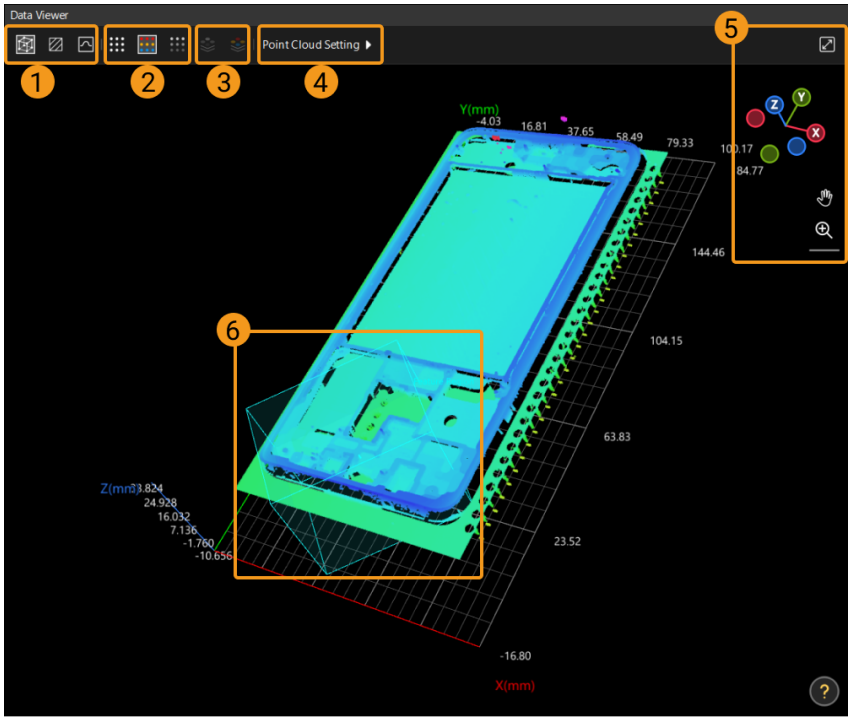
- Data Viewer
- 2D Model Editor

2.6.1. Data Viewer

Data Viewer can be used to display the acquired data, adjust feature regions, and view the data processed by each Step, such as profile, planes, feature points, and distance.

You can use **Data Viewer** only after **Debug Output** is enabled in the graphical programming workspace.

The interface is shown below.



Switch the Display Mode (①)

Use the following icons to switch the display mode:

- Click to switch to the **perspective mode** and view the data in a 3D perspective.
- Click to switch to the **surface mode** and view the data on the XOY plane.
- Click to switch to the **profile mode** and view the data on the XOZ plane. Profiles are usually processed in this view.

Switch the Point Cloud Mode (②)

Use the following icons to switch the point cloud mode:

- Click to switch to the **Monochrome point cloud**.
- Click to switch to the **Color point cloud**.
- Click to switch to the **Grayscale point cloud**.

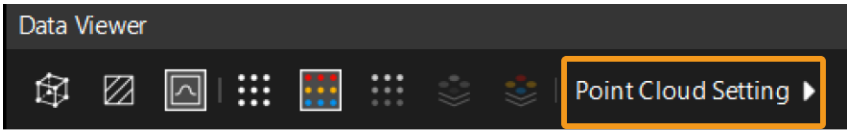
Switch the Intensity Image Mode (③)

Use the following icons to switch the intensity image mode:

- Click to switch to the **intensity image**.
- Click to switch to the **Color intensity image**.

Point Cloud Setting (④)

Only visible in the developer mode. In the menu bar, go to Settings › Options, select **Developer mode** in the **Common** tab, and then click **[OK]** to close the window. This setting will take effect once the software has been restarted.



1. Click **Point Cloud Setting**.
2. In the pop-up window, you can adjust the depth range of the color rendering to conveniently observe the depth variation of the data within a certain range.

- **Auto** is selected by default, namely that the software automatically adjusts the color rendering according to the depth range of the obtained data.
- Once **Auto** is unselected, you can adjust the ends of the slider to set the minimum and maximum depth values to set the depth range of the data. When the depth value of a data point is outside this range, the color of the point will be rendered as the color corresponding to the minimum or maximum value.

Adjust View (⑤)

Use the following buttons or shortcuts to adjust the view:

View adjustment	Instructions
Rotate the view	Press and hold the left mouse button and drag in any direction.
Pan the view	Press and hold and drag in any direction, or press and hold `Shift` + left scroll wheel and drag in any direction.
Zoom in/out	Press and hold and drag, or scroll the mouse wheel.
Fit the view	Click .

The navigation gizmo shows the orientation of the current view. Click the icon of each axis (X, Y, Z, -X, -Y, -Z) to align the view with the axis.

Set the Feature Region (⑥)

Feature regions define the target regions of algorithm processing. In some Steps, you can adjust the feature regions directly, while in others, you need to select the **Use Feature Region** option first.

You can set the feature region in the following ways:

- Adjust Feature Region in Data Viewer Area
  - Adjust the position of feature region(s) intuitively
  - Adjust the size of feature region(s) intuitively
- Set Feature Region Parameters in the Parameter Configuration Panel
  - Set the feature region type
  - Adjust the position of feature region(s) precisely
  - Adjust the size of feature region(s) precisely
  - Add or delete feature region(s)

Adjust Feature Region in Data Viewer Area

This method is used to roughly adjust the feature region(s).

- Adjust the position of a feature region
  1. Press and hold the `Ctrl` key to activate the feature region. Green squares will be displayed on each edge of the feature region.
  2. Long press the left mouse button on any plane of the feature region to be moved. Yellow arrows will appear on each side.
  3. Move the mouse in any direction to move the feature region. Release the left mouse button to complete the adjustment.
- Adjust the size of a feature region
  1. Press and hold the `Ctrl` key to activate the feature region. Green squares will be displayed on each edge of the feature region.
  2. Press and hold the left mouse button on any green square, and the square will turn yellow.
  3. Move the mouse in any direction to adjust the size of the feature region. Release the left mouse button to complete the adjustment.

Set Feature Region Parameters in the Parameter Configuration Panel

This method is used to fine-tune a feature region. In some Steps, you can set a feature region only when the **Use Feature Region** option is selected.

- Feature Region
  - Add a feature region: Click **[+ Add a region]** to add a new feature region.

    If this button is greyed out in a Step, it means that the Step does not support the creation of a new feature region or the number of created feature regions has reached the upper limit.

  - Expand Region1 (example): Click ▶ to expand **Region1**.
    - Region Type: The type of the feature region. The options are Cuboid, Cylinder, and Elliptic cylinder.
    - Center X/Y/Z: The center position of the feature region.
    - Width (X) / Length (Z) / Height (Z): The dimensions of the feature region.
    - Rotation Angle: The angle at which the feature region rotates counterclockwise around the Z-axis of the spatial reference frame in its initial position.
  - Delete a feature region: Click 🗑 to the right of **Region2** (example) to delete this feature region. If the delete icon is grayed out, the feature region cannot be deleted.

The parameters of a feature region may differ from Step to Step. Please adjust the relevant parameters according to the actual display of the interface.

2.6.2. 2D Model Editor

This tool is used to generate and edit the models for 2D matching. These models can be used in the **Alignment** Step to align the input images with the selected model.

Preparation

1. Make sure that the **Alignment** Step has normal input.
2. Under **Parameters** in the parameter configuration panel of the **Alignment** Step, click the **[Edit Model]** button to open the **2D Model Editor**. This tool will automatically obtain the input image of the Step.

> Click **[Get Step input]** in the parameter panel of **2D Model Editor** to update the image.

Usage Workflow

1. Rename the default model or click **[+ New]** to create a new model.

> After selecting a model from in the model list, right-click and select the **Rename** option, enter a custom name, and click **[OK]** to modify the model name.

2. Select feature points. The selected feature points should be representative, and the quantity should be appropriate.

   Instruction: Click the icon on the toolbar to select the appropriate ROI tools and label the image.

> - In the **ROI list** section at the bottom left of the interface, right-click an ROI and select **Enable**, **Disable**, etc., to set the drawn ROI. For overlapped regions, the **Disable** option is more effective than **Enable**. In other words, when two overlapped regions are set to **Enable** and **Disable** separately, the actual status of the overlapped region is **Disable**, and the feature points in the overlapped region do not take effect.
> - You can use the **ROI Eraser** to erase unwanted feature points in the created ROI.

3. Set the center point. The center point determines the position of the model in the image to be matched, thus determining the search range for model matching.
4. Set Feature parameters.
5. Click **[Generate model]** in the lower-right corner to generate and preview the model.
6. Click **[Save]**.

> If you only clicked **[Save]** in the lower-right corner and did not generate a model, the edited content would be saved but would not work.

After configuration, close the tool. Click **[▼]** under the **[Edit Model]** button in the **Parameters** section of the **Alignment** Step and then select the corresponding model in the drop-down menu.

Feature Parameters

Gradient magnitude threshold

Points with gradient magnitude greater than the threshold will be considered feature points. Set this parameter to filter out feature points with small gradient magnitude.

Instruction: When a high threshold is set, only points with large gradient magnitude, i.e., points that vary significantly in the image, will be kept. When a low threshold is set, some noise or insignificant feature points may be kept.

Number of feature points

The expected number of feature points extracted from the model image. A greater value means a larger feature point count.

Instruction: Adding more feature points can improve the matching accuracy, but also increase the calculation complexity and reduce the matching speed.

If the number of feature points in the generated model is smaller than the set one, the number of feature points in the model is subject to the actual one.

Kernel size of NMS

The kernel size of non-maximum suppression (NMS). This parameter is used to regulate the distribution density of the feature points. The larger the value, the sparser the feature points.

Instruction: Set the parameter according to actual situation.

Set angle

Set the angle-related parameters to define the allowable rotation angle range of the image to be aligned.

- Range (°): Set this parameter to determine the possible rotation angle range of the target object in the image relative to the model during model matching.
- Step size (°): The angle interval during matching. Setting a small step size will improve the search accuracy but slow down the search process.
- Attempt count: The number of matching attempts within the given angle range.

Set scale

Set the scale-related parameters to define the allowable scale range of the image to be aligned.

- Range: Set this parameter to determine the scale range that the target object will appear in the image during model matching.
- Step size: The scale interval during matching.
- Attempt count: The number of matching attempts within the given scale range.

3. Typical Case Practices of 3D Measurement and Inspection

Mech-Mind typical case practices are practical application guides derived from numerous successful use cases in various application scenarios. This manual will guide you step by step to easily deploy typical 3D measurement and inspection applications.

Overview of a Typical Application Deployment Process

The solution library of Mech-Mind provides a wealth of typical solutions. You can select suitable typical applications according to application scenarios, and then quickly complete the deployment of 3D measurement and inspection applications.

The following figure shows the general process of typical application deployment.

During the solution design stage, you need to assess the risks a 3D measurement and inspection application might encounter in actual project deployment, then design a solution that meets the project's requirements.

The deployment of the 3D measurement and inspection solution refers to applying the typical application cases to your actual project according to the solution design, including the entire process from the hardware setup to the final measurement and inspection.

For more information about each stage of application deployment, see Learning Guidance for 3D Measurement and Inspection.

Guidance on Typical Case Practices

Cap-Terminal Height Measurement for Battery Cells

This solution measures the height of terminals relative to the cap of battery cells.

Acquire guidance on solution design and deployment

Defect Inspection for Brake Pads (Blob Analysis)

This solution uses the blob analysis method to detect defects such as depressions and protrusions on the surface of brake pads.

Acquire guidance on solution design and deployment

Hole Measurement for Metal Parts

This solution measures the dimensions of the target hole, such as the location of the hole center and radius.

Acquire guidance on solution design and deployment

Pin Counting

This solution counts connector pins.

Acquire guidance on solution design and deployment

Pin Height Measurement

This solution measures the height of connector pins relative to the base plane.

Acquire guidance on solution design and deployment

Smartphone Midplate Flatness Measurement

This solution measures the flatness of smartphone midplates.

Acquire guidance on solution design and deployment

3.1. Cap–Terminal Height Measurement for Battery Cells

This section introduces the basic information, design, and deployment of the Cap–Terminal Height Measurement for Battery Cells solution.

Basics

Application Scenario Description

Measuring the height difference between the cap and terminal of the battery cell is an important step in quality control, which is crucial for ensuring the performance and safety of the battery cell. The application scenarios for measuring the height difference between the cap and terminal of the battery cell are as follows.

- Quality control during manufacturing process: During the battery cell manufacturing process, measuring the height difference can help manufacturers monitor the consistency and integrity of the battery cells. Inconsistent height between the cap and the terminal may lead to uneven battery pack height, affecting battery performance and lifespan. Precise measurement of the height difference enables timely detection and correction of deviations during the manufacturing process.
- Battery performance evaluation: The height difference between the cap and the terminal of a battery cell may affect the internal structure and electrochemical reactions of the battery, thus impacting its performance. Measuring the height difference of battery cells helps assess key performance indicators such as discharge rate, charging speed, and cycle life.
- Safety inspection: A large height difference between the cap and the terminal can cause uneven stress during charging and discharging processes, potentially leading to cell rupture or leakage and resulting in safety issues. Therefore, by measuring the height difference between the cap and the terminal, potential safety hazards can be identified in advance to ensure the safe use of battery cells.

In summary, measuring the height difference between the cap and the terminal plays a crucial role

in battery manufacturing, performance evaluation, safety inspection, and other processes. Accurate height difference measurement contributes to improving battery performance and safety, aligning with the requirements of sustainable development and green manufacturing.

Target Object Example

The cap of the battery cell used in this solution is shown in the figure below.

Key Technical Specifications

The technical specifications of the Cap–Terminal Height Measurement for Battery Cells solution are as follows.

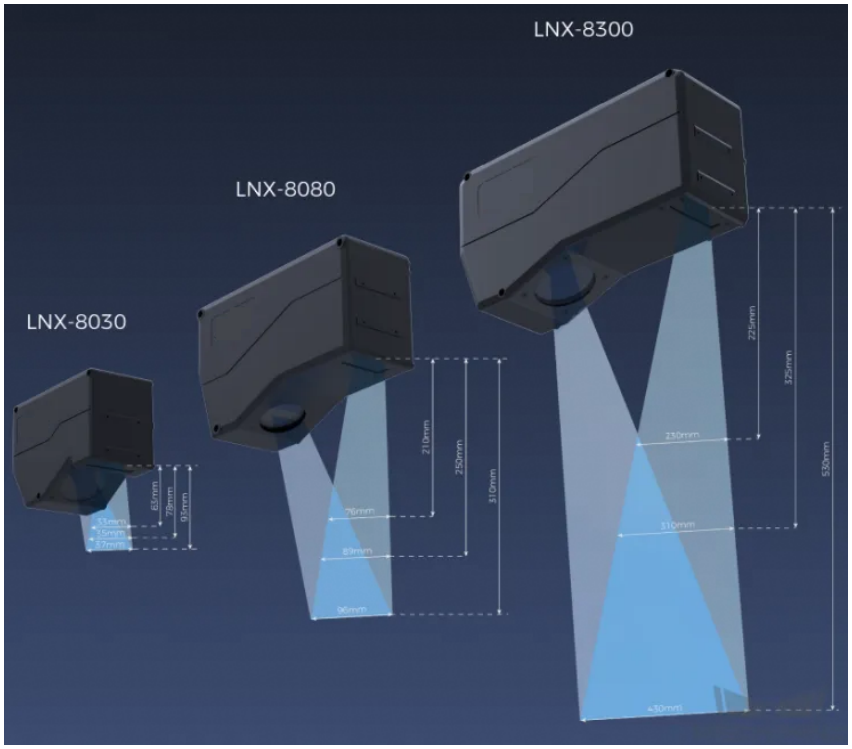
- Repeatability: 0.05 mm
- Vision cycle time: ＜2 s

Solution Design

Select the Laser Profiler Model

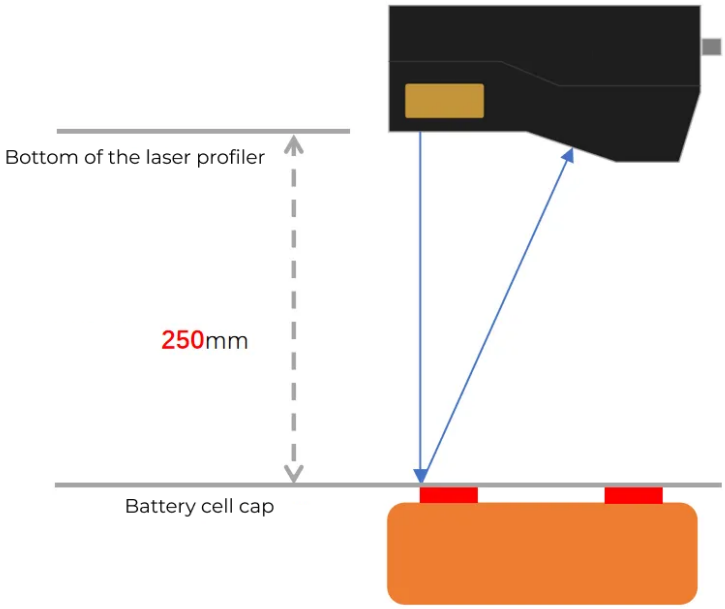
When selecting a laser profiler, the laser profiler's X-axis measurement range should be greater than the length or width of the object to be measured, and the long side of the laser profiler typically aligns with the long side of the object to be measured.

The following figure illustrates the field of view for various models of sensor heads in the LNX-8000 series. Since the dimensions of the target object to be measured are 175 mm × 72 mm, to ensure that the laser profiler's field of view can completely cover the target object, model LNX-8080 is recommended.



Mounting Method of Laser Profiler

You can mount the laser profiler at a fixed location or mount it on a moving rail. Please select the mounting method according to the actual situation. For this solution, the laser profiler is mounted at a fixed location.



Laser Profiler Triggering

The laser profiler supports multiple triggering methods, allowing it to be integrated into a system and work with other devices flexibly to obtain the intensity image, depth map, and point cloud. In this solution, the external + encoder method is used to trigger data acquisition. The detailed

instructions are as follows.

1. Set parameters in Mech-Eye Viewer.
   a. Set the **Data Acquisition Trigger Source** parameter to **External**.
   b. Set the **Line Scan Trigger Source** parameter to **Encoder**.
   c. Based on actual needs, adjust other parameters in the **scan mode**.
2. Set the parameters of the 3D Laser Profiler Step.
   a. In the **Parameters** section, click **[Open the editor]** to select and connect the laser profiler you want.
   b. Activate **Data Acquisition Status** to enable the laser profiler to receive external signals, triggering data acquisition once the signal is received.
3. Run the measurement project, and the external signal triggers the laser profiler to acquire data.
4. Once data acquisition is complete, the data will be transferred to Mech-MSR.

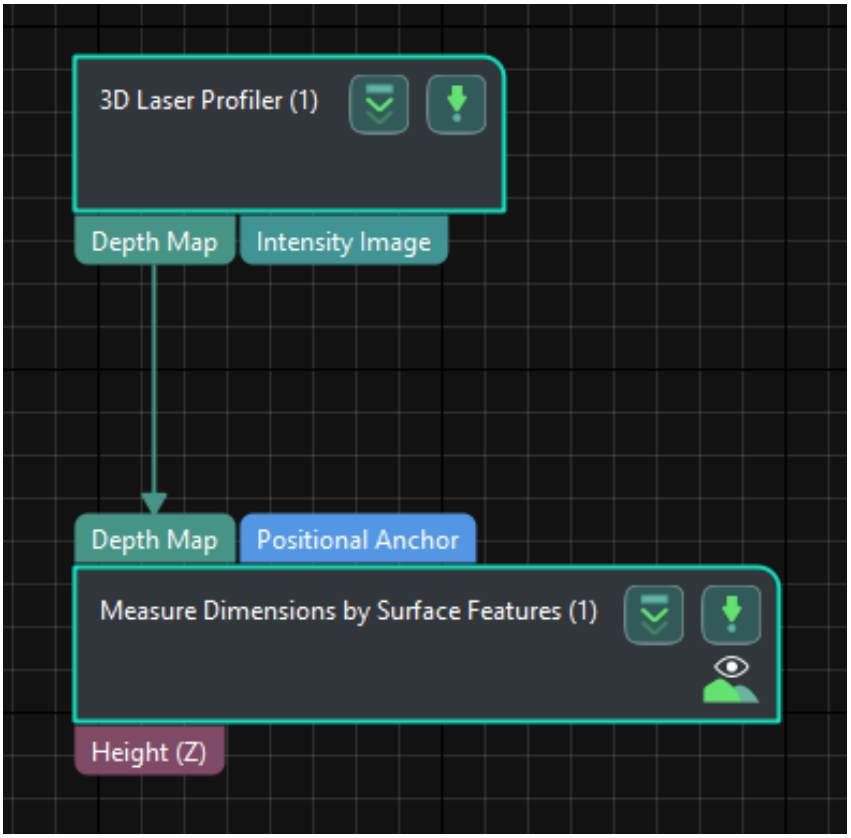
Solution Deployment

Measurement Project Configuration

Workflow Overview

In this solution, the laser profiler is used to acquire the depth map first. Then the acquired depth map will be input to the Measure Dimensions by Surface Features Step for accurate height difference measurement. Once the measurement is complete, the corresponding inspection result will be output.

The following figure shows the overall workflow.



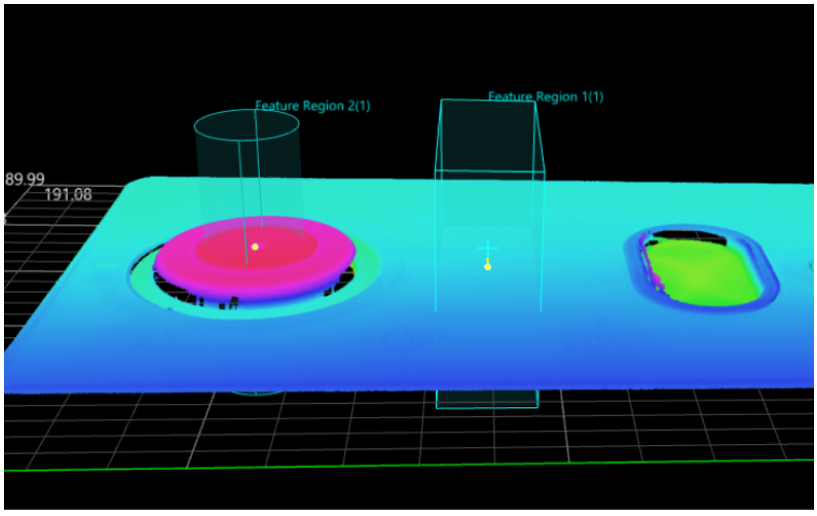
The key Steps in the workflow are described below.

Step Description

Measure Dimensions by Surface Features

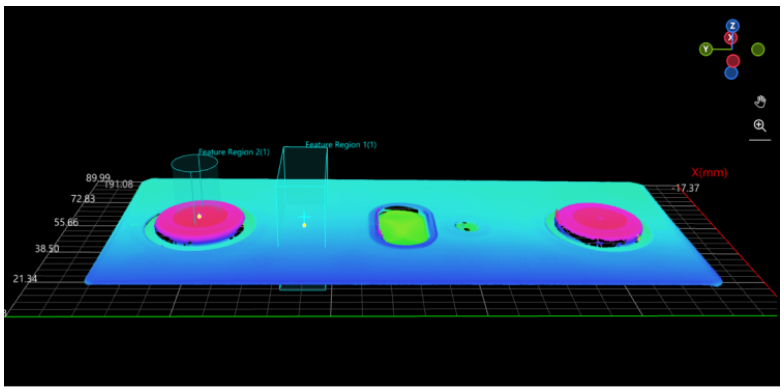
- Function:

  This Step measures and outputs the distance between two feature points in the vertical direction. As shown in the figure below, this Step can measure the distance from feature point 1 to feature point 2.



- Usage Procedure:

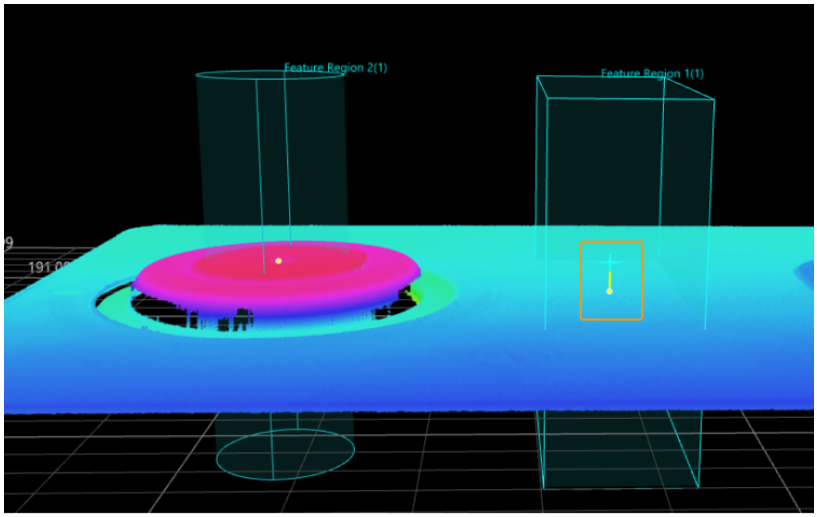
1. Add a feature region.
2. Move the feature region to the desired measurement region.



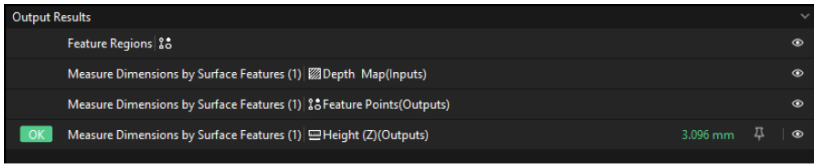
3. Select **Feature Point Type** in the **Parameters** section according to the actual situation.
4. Select **Height** in the **Output** section.

- **Check Output Result:**

  The output result of this Step is shown in the figure below. The yellow line indicates the measured height difference.



  The height difference measured by this Step is **3.096 mm**.



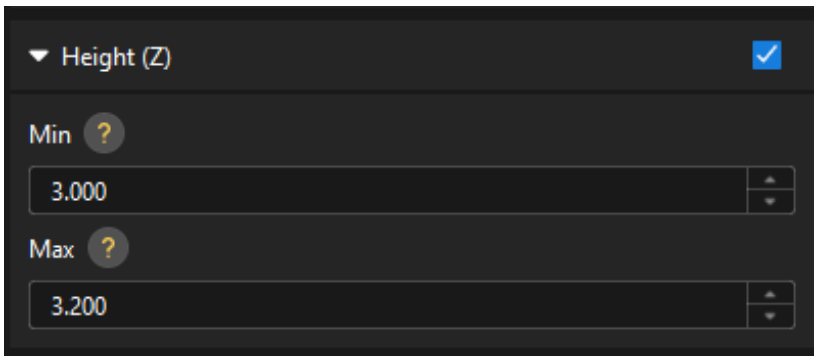
Configure Quality Judgment Rules

After adjusting the Step parameters, you need to configure the quality judgment rules for outputting the measurement and inspection results.

1. In the **Output** section, set the acceptable range for **Height**.

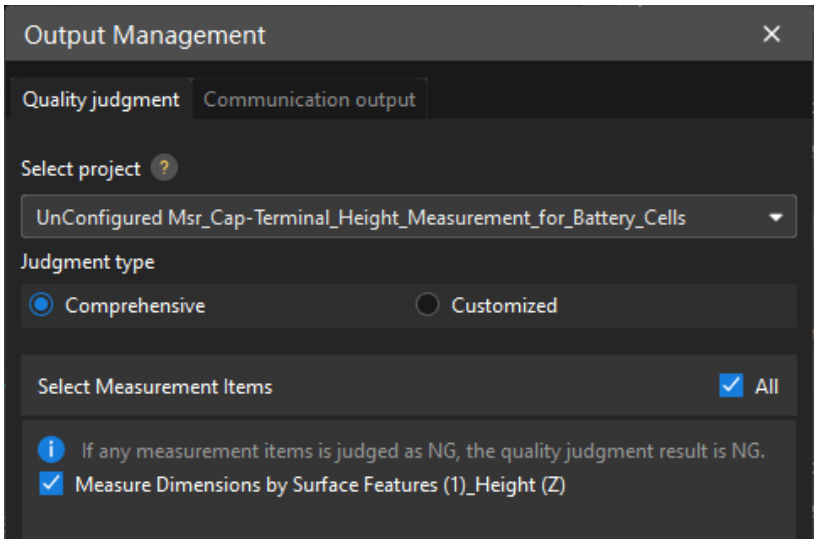
   In the collapsible tab of **Height**, set the maximum and minimum values allowed for the

measurement results. When the measured value is within the acceptable range, the inspection result is OK. Maximum and minimum values need to be set according to the drawing and process requirements of the target object.



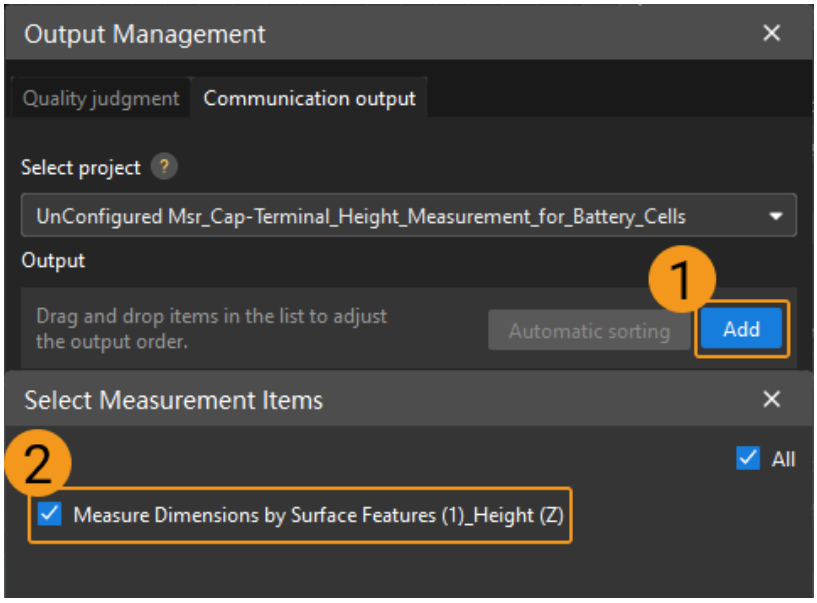
2. Go to **Output Management** and set the Judgment type to Comprehensive.

   Since only the height is inspected in this solution, "0" (OK) will be sent to the external device when all inspection results are OK.



3. Output measurement results (optional).

   If external devices require access to measurement results, the measurement items need to be added as output. To do so, go to Output Management › Communication output to add the measurement item as shown below.



Communication Configuration

To ensure smooth communication between Mech-MSR and external devices (PLC or other production line equipment), allowing them to trigger Mech-MSR project executions and retrieve measurement results, communication configuration is also required. For detailed instructions, please refer to Communication Configuration.

Now you have completed configurations related to the measurement project.

3.2. Defect Inspection for Brake Pads (Blob Analysis)

This section introduces the basic information, design, and deployment of the Defect Inspection for Brake Pads (Blob Analysis) solution.

Basics

Application Scenario Description

In the process of automobile manufacturing, brake pad defect inspection is employed to ensure the quality of the braking system, meeting relevant safety standards and regulations. By automatically inspecting the surface quality and dimensions of brake pads on the production line, defects or non-compliant products can be detected early and repaired or replaced promptly.

Target Object Example

The brake pad used in this solution is shown in the figure below.

Key Technical Specifications

The technical specifications of the Defect Inspection for Brake Pads (Blob Analysis) solution are as follows.

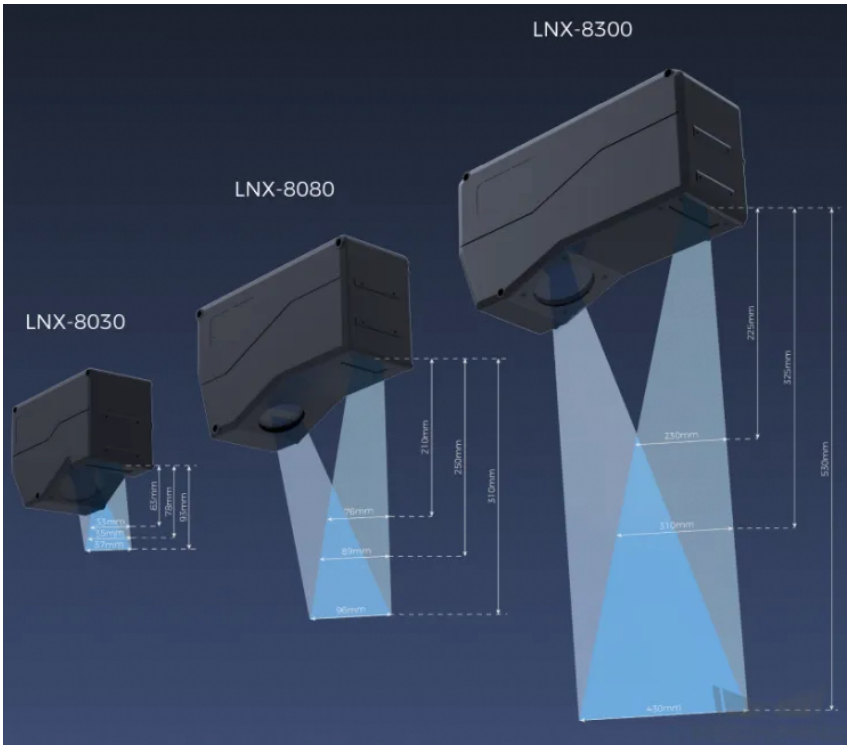
- Repeatability: ＜ 20 μm
- Vision cycle time ＜2 s

Solution Design

Select the Laser Profiler Model

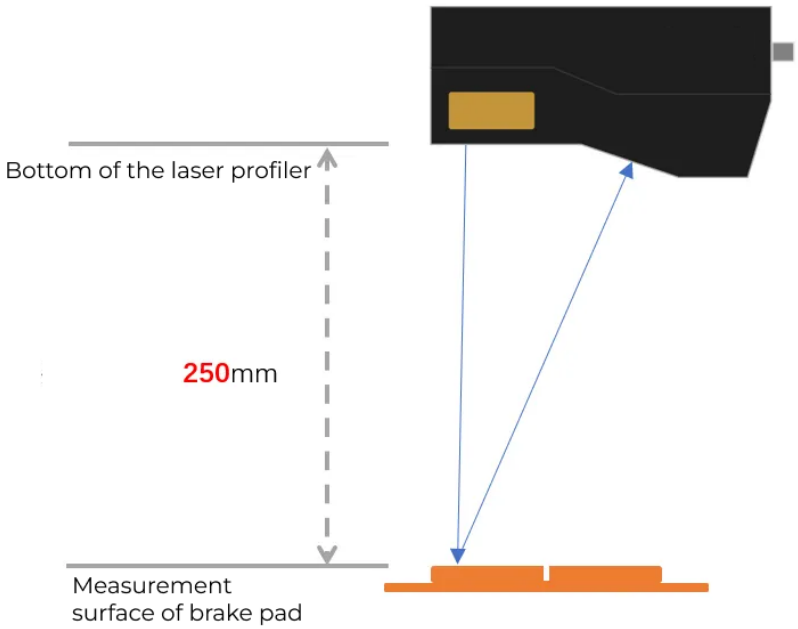
When selecting a laser profiler, the laser profiler's X-axis measurement range should be greater than the length or width of the object to be measured, and the long side of the laser profiler typically aligns with the long side of the object to be measured.

The following figure illustrates the field of view for various models of sensor heads in the LNX-8000 series. Since the dimensions of the target object to be measured are 150 mm × 60 mm, to ensure that the laser profiler's field of view can completely cover the target object, model LNX-8080 is recommended.



Mounting Method of Laser Profiler

You can mount the laser profiler at a fixed location or mount it on a moving rail. Please select the mounting method according to the actual situation. For this solution, the laser profiler is mounted at a fixed location.



Laser Profiler Triggering

The laser profiler supports multiple triggering methods, allowing it to be integrated into a system and work with other devices flexibly to obtain the intensity image, depth map, and point cloud. In this solution, the external + encoder method is used to trigger data acquisition. The detailed

instructions are as follows.

1. Set parameters in Mech-Eye Viewer.
   a. Set the **Data Acquisition Trigger Source** parameter to **External**.
   b. Set the **Line Scan Trigger Source** parameter to **Encoder**.
   c. Based on actual needs, adjust other parameters in the **scan mode**.
2. Set the parameters of the 3D Laser Profiler Step.
   a. In the Parameters section, click **[Open the editor]** to select and connect the laser profiler you want.
   b. Activate **Data Acquisition Status** to enable the laser profiler to receive external signals, triggering data acquisition once the signal is received.
3. Run the measurement project, and the external signal triggers the laser profiler to acquire data.
4. Once data acquisition is complete, the data will be transferred to Mech-MSR.

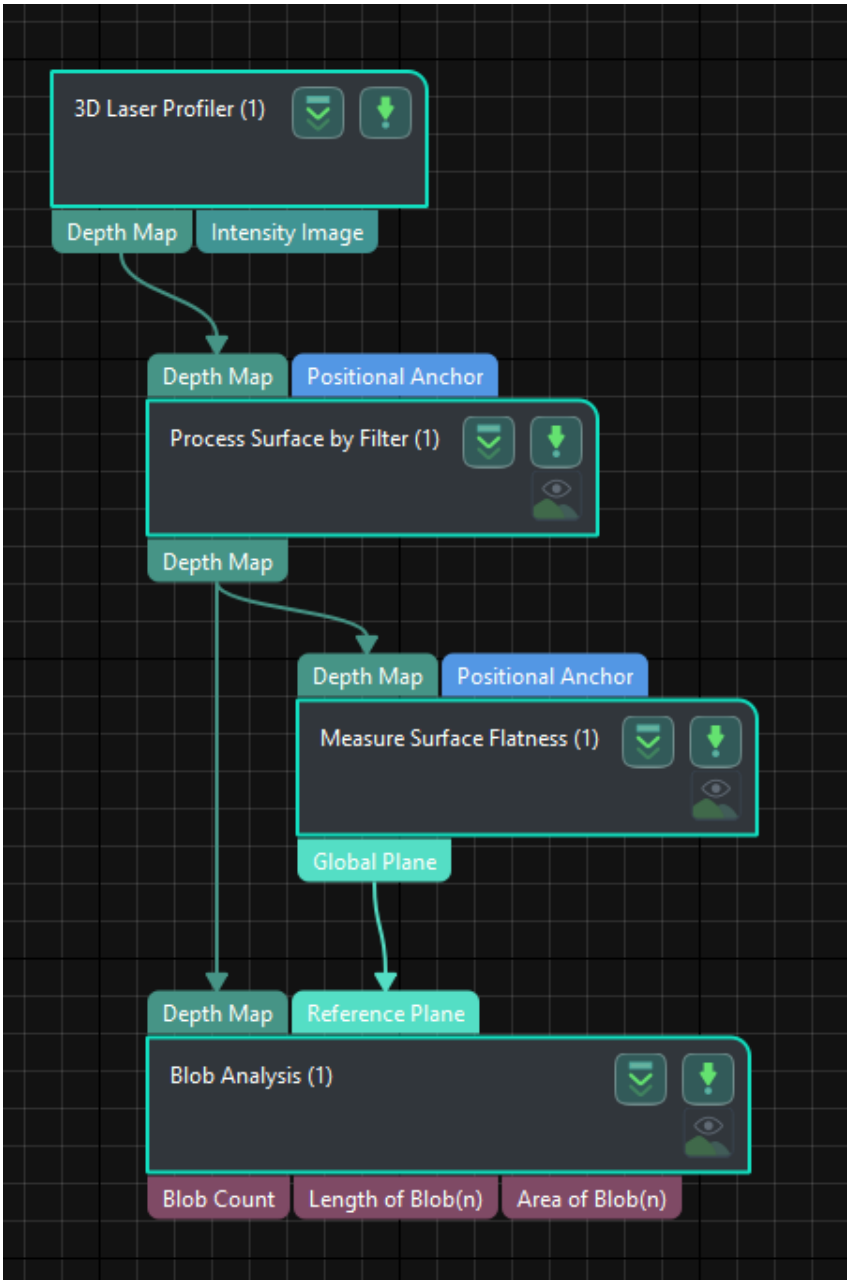
Solution Deployment

Measurement Project Configuration

Workflow Overview

In this solution, the laser profiler is used to acquire the depth map first. Then the acquired depth map will be input to the Process Surface by Filter Step to crop the measurement region. Next, the cropped depth map will be input to the Measure Surface Flatness Step to fit a reference plane. Afterwards, the reference plane and depth map will be input to the Blob Analysis Step for depression inspection. In the end, the corresponding measurement results will be output.

The following figure shows the overall workflow.



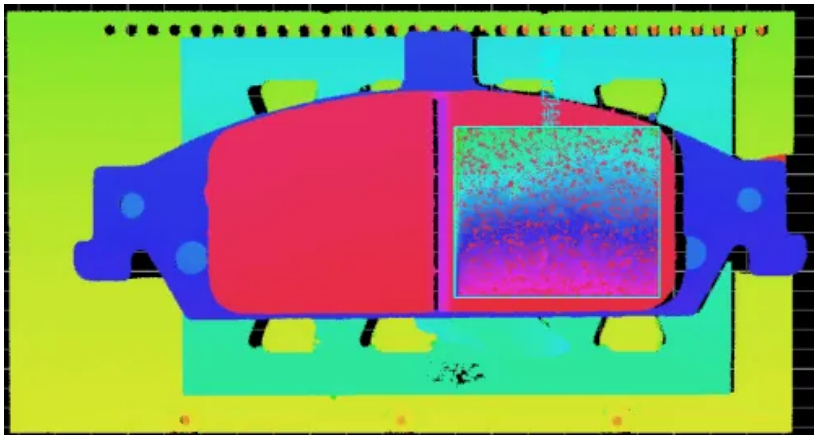
The key Steps in the workflow are described below.

Step Description

Process Surface by Filter

- Function:

  This Step can preprocess the surface to obtain a better surface quality for measurement. The selected region for defect detection is shown in the figure below.

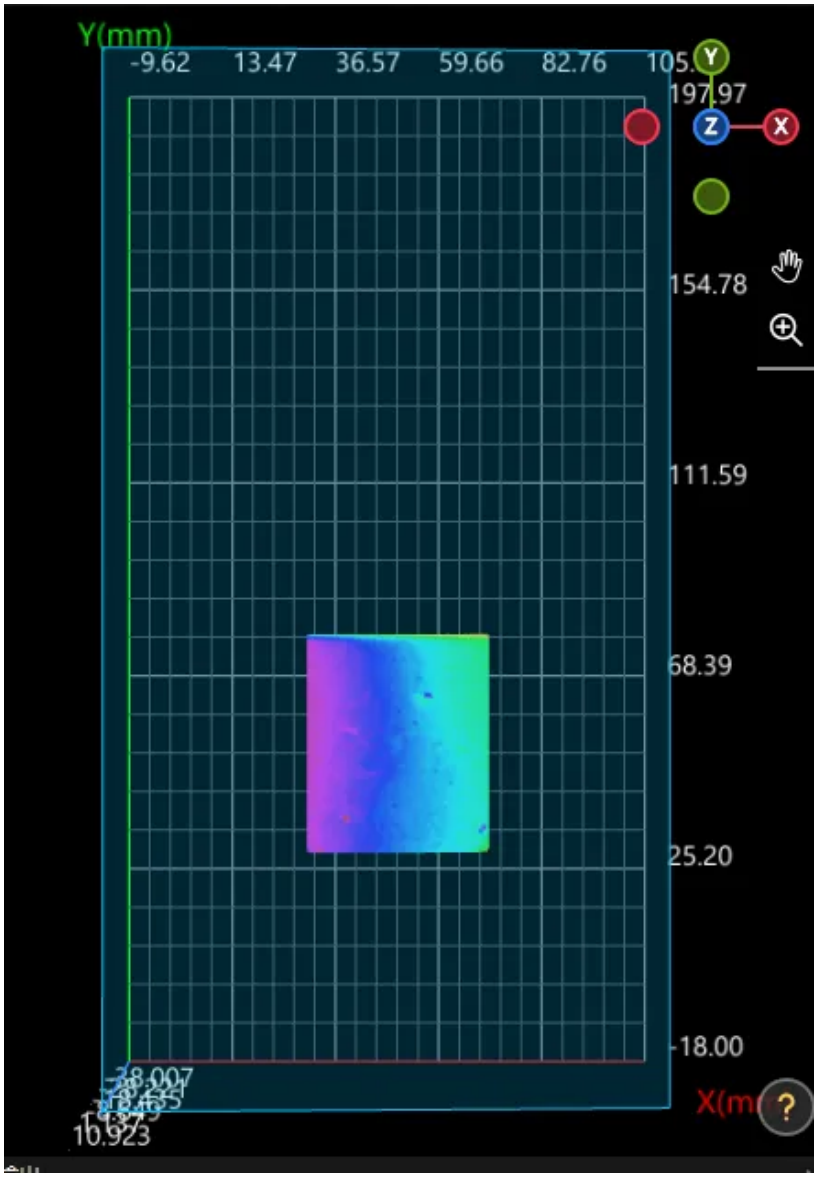


- Usage Procedure:
  1. Select **Show Advanced Filters** in the Parameters section, and set the **Filter Type** to **Crop**.
  2. Select **Use Feature Region**. Then add and move the feature region to the measurement region.

Measure Surface Flatness

- Function:

  This Step is used to measure the flatness of a specified surface region.

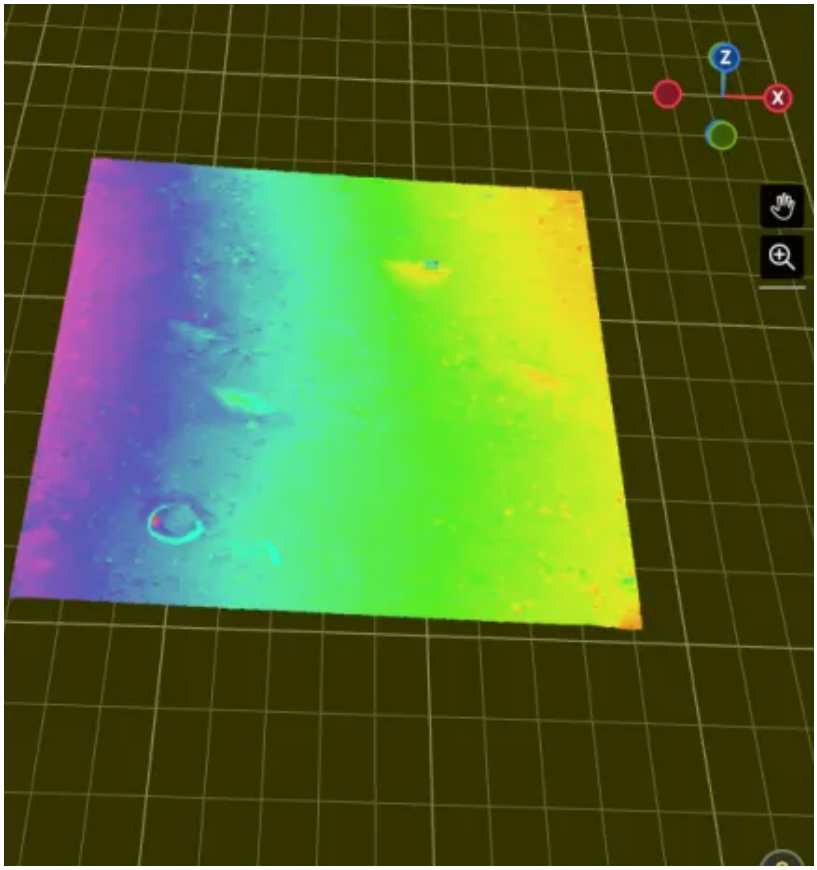


- Usage Procedure:
  1. Unselect **Use Feature Region** in the **Parameters** section.
  2. According to the actual situation, set **Data Filtering Mode** to **Global percentile** in the **Parameters** section. As there is noise in the measurement region, the surface flatness is calculated after removing the top 20% and bottom 20% points farthest from the fitted plane.
  3. Select **Global Plane** in the **Output** section.

Blob Analysis

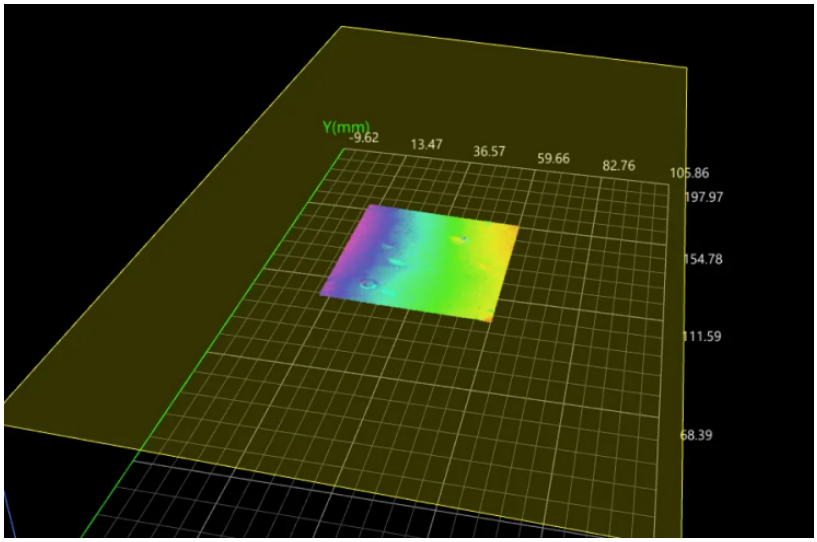
- Function:

  This Step can extract blobs or regions of specific shapes and sizes from the image.

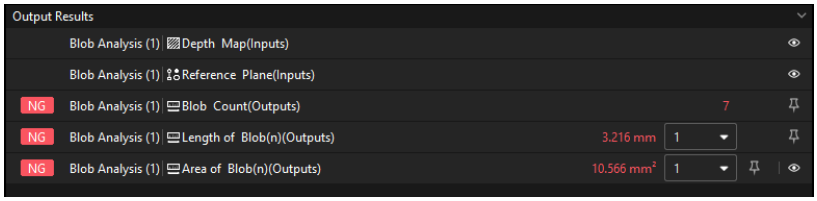


- Usage Procedure:
  1. Set the **Reference Type** to **Reference plane** in the **Parameters** section.
  2. Set **Threshold Filter** to **Below**.
  3. Set the **Height Threshold** according to the actual situation.
  4. Set the **Max Area** and **Min Area** of the **Area Filter** according to the actual situation.
  5. Select **Length of Blob(n)** and **Area of Blob(n)** in the **Output** section.
- Check Output Result:

  The output result of this Step is shown in the figure below. The semi-transparent yellow plane is the reference plane, and the bright blue marks the depression.



The measured defect length is **3.216 mm**, and the measured defect area is **10.566 mm²**.

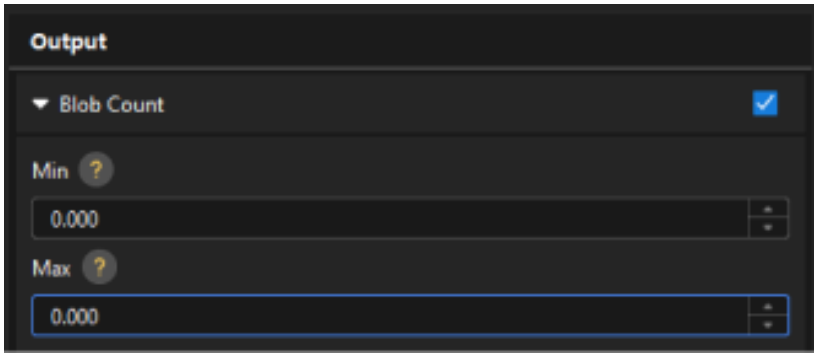


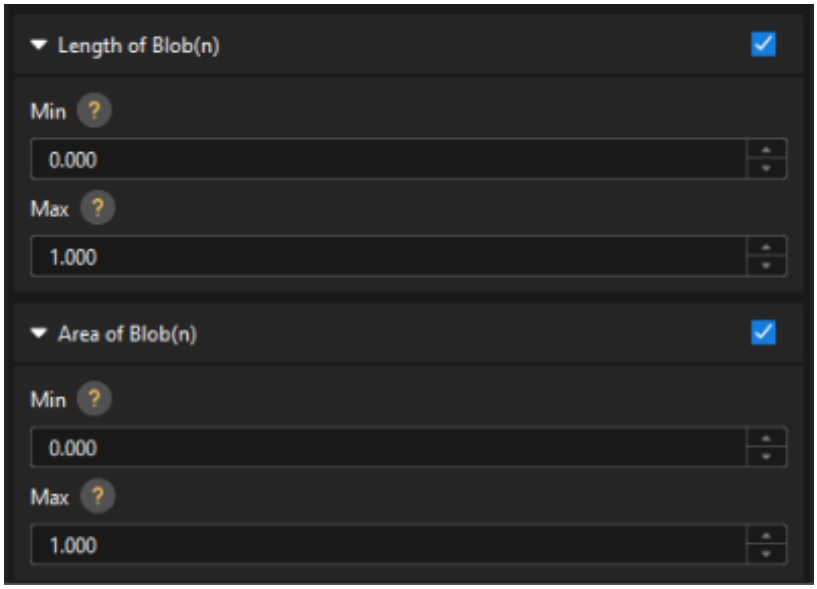
Configure Quality Judgment Rules

After adjusting the Step parameters, you need to configure the quality judgment rules for outputting the measurement and inspection results.

1. In the **Output** section of the "Blob Analysis" Step, set the acceptable range for the **Blob Count**, **Length of Blob(n)**, and **Area of Blob(n)**.

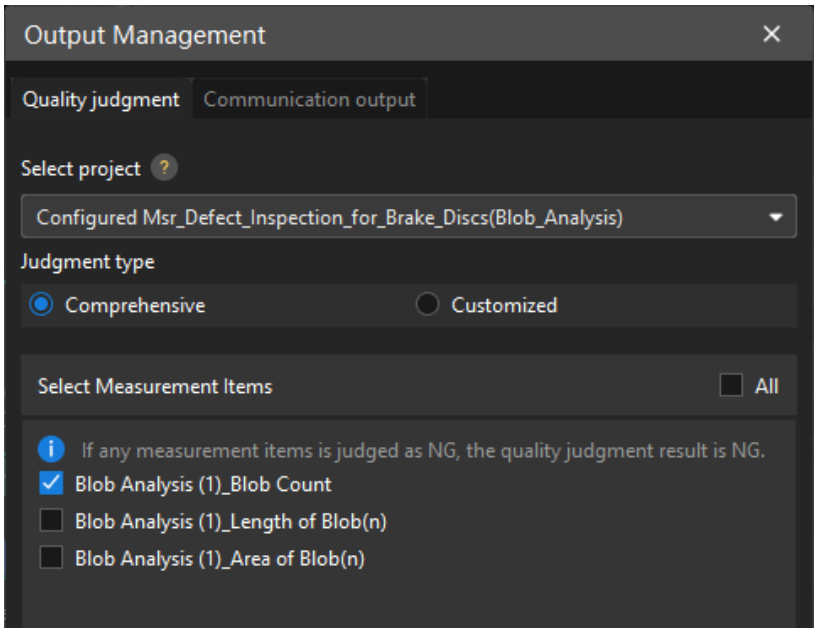
   In the collapsible tabs of **Blob Count**, **Length of Blob(n)**, and **Area of Blob(n)**, set the maximum and minimum values allowed for the measurement results. When the measured value is within the acceptable range, the inspection result is OK. Maximum and minimum values need to be set according to the drawing and process requirements of the target object.





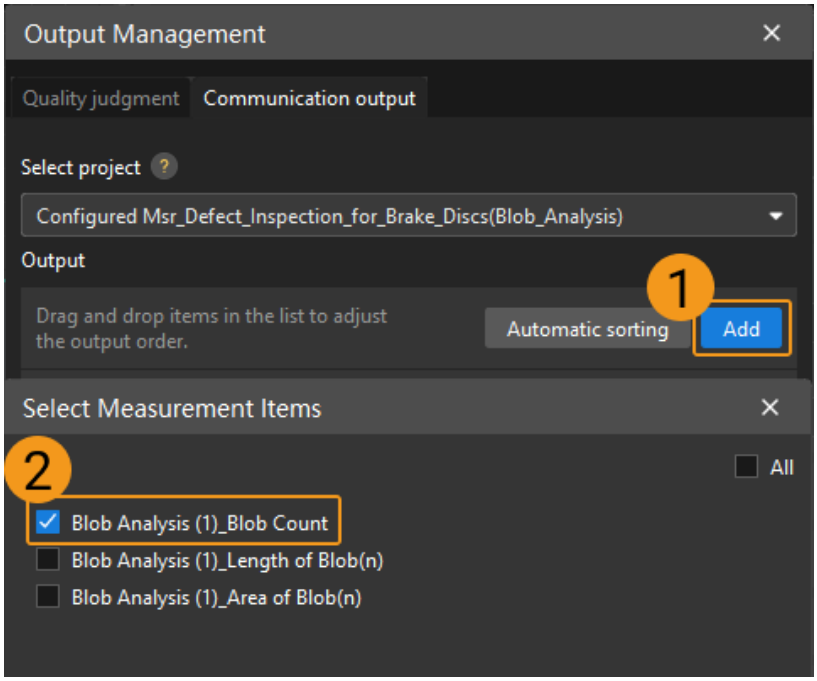
2. Go to **Output Management** and set the **Judgment type** to **Comprehensive**.

   Since only the blob count is inspected in this solution, "0" (OK) will be sent to the external device when all inspection results are OK.



3. Output measurement results (optional).

   If external devices require access to measurement results, the measurement items need to be added as output. To do so, go to Output Management › Communication output to add the measurement item as shown below.



Communication Configuration

To ensure smooth communication between Mech-MSR and external devices (PLC or other production line equipment), allowing them to trigger Mech-MSR project executions and retrieve measurement results, communication configuration is also required. For detailed instructions, please refer to Communication Configuration.

Now you have completed configurations related to the measurement project.

3.3. Hole Measurement for Metal Parts

This section introduces the basic information, design, and deployment of the Hole Measurement for Metal Parts solution.

Basics

Application Scenario Description

In the processes of mechanical manufacturing and electronic product fabrication, measuring circular hole dimensions is crucial to ensuring the accuracy and quality of components. For instance, in the manufacturing of vehicles like cars and aircraft, precise measurement of the diameter, depth, and position of circular holes is necessary to ensure assembly accuracy and overall performance among components.

Target Object Example

The metal part used in this solution is shown in the figure below.

Key Technical Specifications

The technical specifications of the Hole Measurement for Metal Parts solution are as follows.

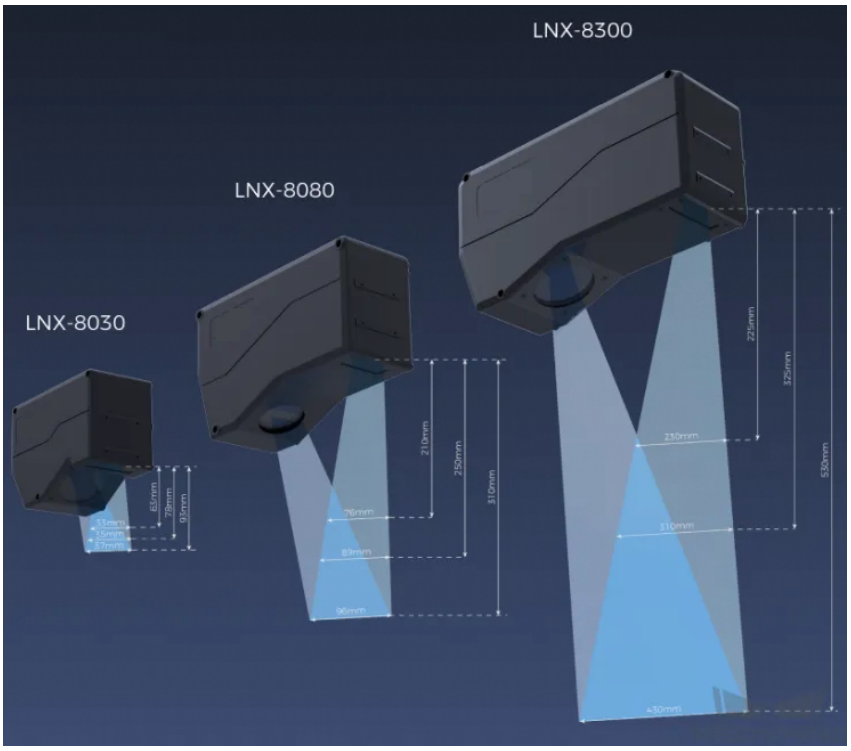
- Repeatability: ＜ 20 μm
- Vision cycle time: ＜2 s

Solution Design

Select the Laser Profiler Model

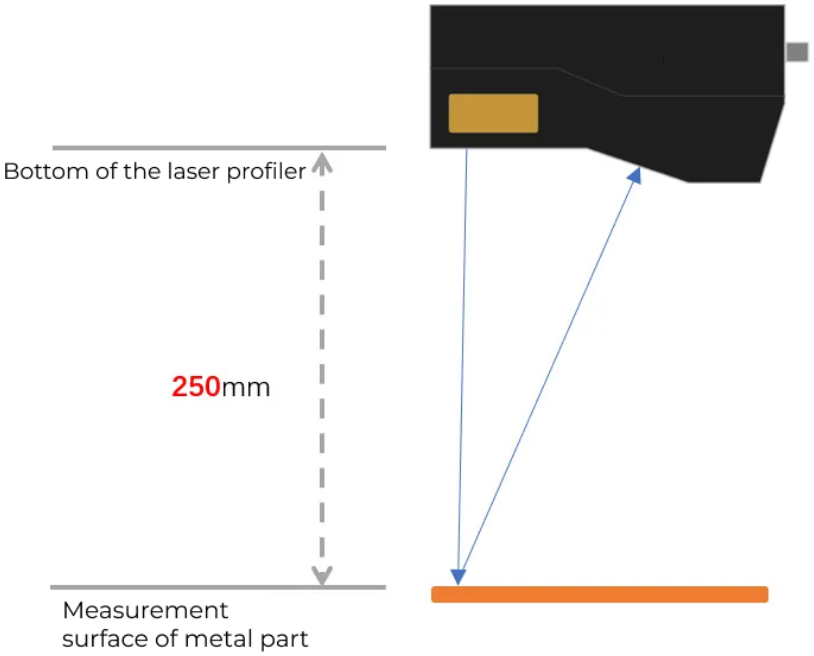
When selecting a laser profiler, the laser profiler's X-axis measurement range should be greater than the length or width of the object to be measured, and the long side of the laser profiler typically aligns with the long side of the object to be measured.

The following figure illustrates the field of view for various models of sensor heads in the LNX-8000 series. Since the dimensions of the target object to be measured are 150 mm × 60 mm, to ensure that the laser profiler's field of view can completely cover the target object, model LNX-8080 is recommended.



Mounting Method of Laser Profiler

You can mount the laser profiler at a fixed location or mount it on a moving rail. Please select the mounting method according to the actual situation. For this solution, the laser profiler is mounted at a fixed location.



Laser Profiler Triggering

The laser profiler supports multiple triggering methods, allowing it to be integrated into a system and work with other devices flexibly to obtain the intensity image, depth map, and point cloud. In this solution, the external + encoder method is used to trigger data acquisition. The detailed instructions are as follows.

1. Set parameters in Mech-Eye Viewer.
   a. Set the **Data Acquisition Trigger Source** parameter to **External**.
   b. Set the **Line Scan Trigger Source** parameter to **Encoder**.
   c. Based on actual needs, adjust other parameters in the **scan mode**.
2. Set the parameters of the 3D Laser Profiler Step.
   a. In the **Parameters** section, click **[Open the editor]** to select and connect the laser profiler you want.
   b. Activate **Data Acquisition Status** to enable the laser profiler to receive external signals, triggering data acquisition once the signal is received.
3. Run the measurement project, and the external signal triggers the laser profiler to acquire data.
4. Once data acquisition is complete, the data will be transferred to Mech-MSR.

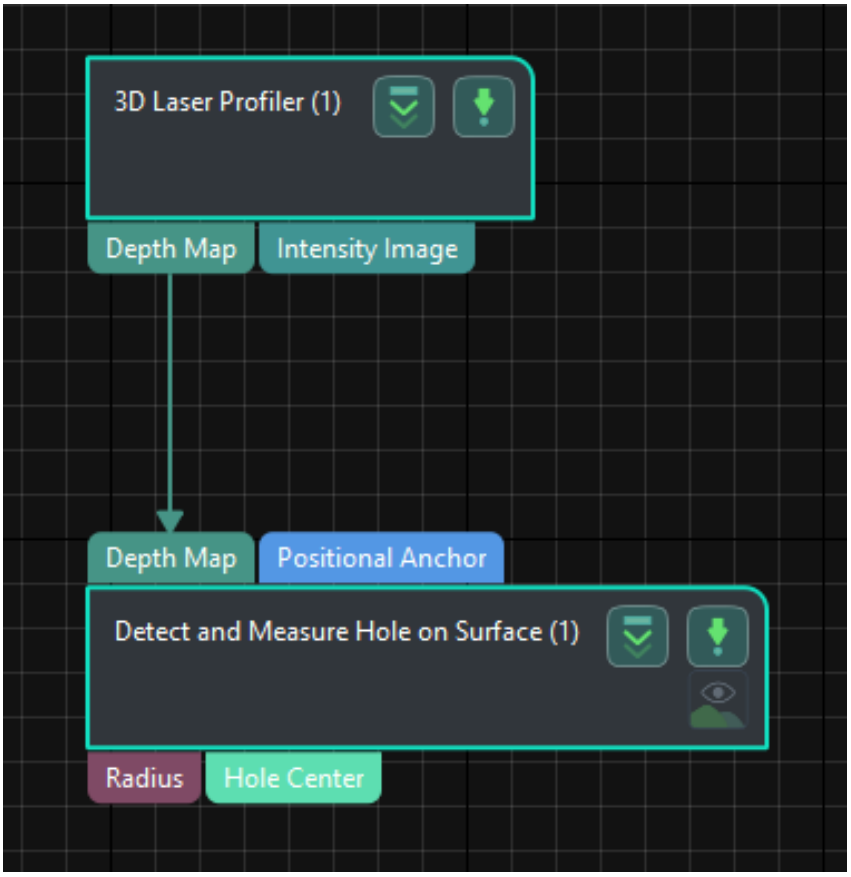
Solution Deployment

Measurement Project Configuration

Workflow Overview

In this solution, the laser profiler is used to acquire the depth map first. Then the acquired depth map will be input to the Detect and Measure Hole on Surface Step to measure the holes. In the end, the corresponding measurement results will be output.

The following figure shows the overall workflow.



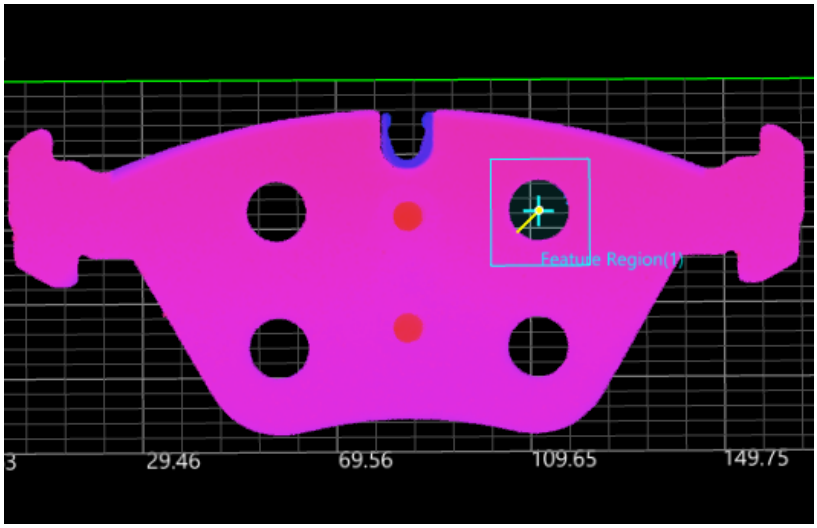
The key Steps in the workflow are described below.

Step Description

Detect and Measure Hole on Surface

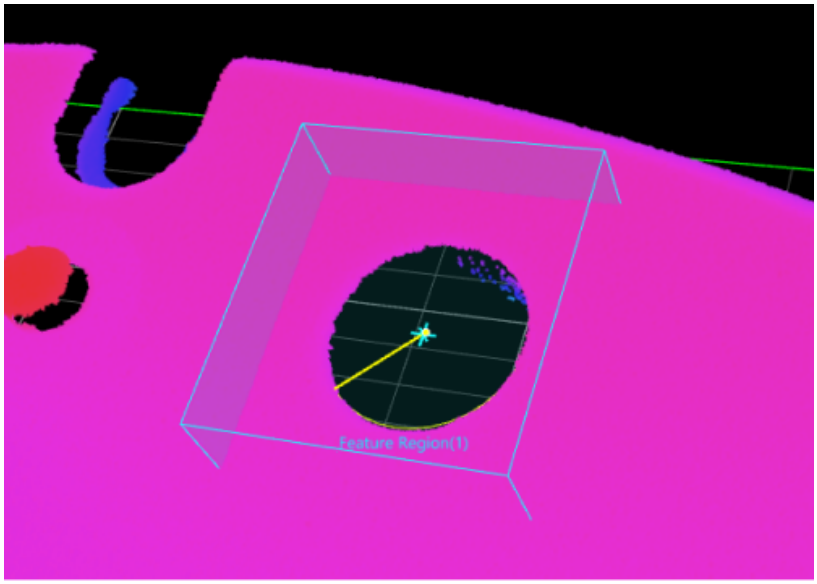
- Function:

  This Step is used to detect the hole on a surface and output the location and radius of the detected hole.

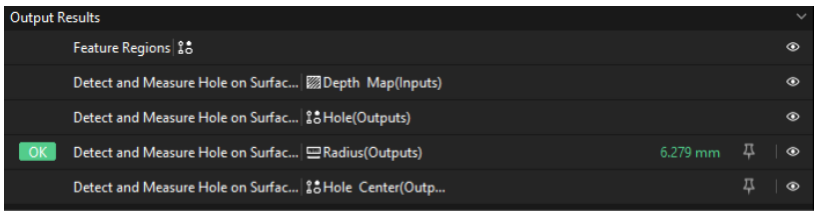


- Usage Procedure:
  1. According to the actual situation, set **Nominal Radius** and **Radius Tolerance** in the **Parameters** section.
  2. Move the feature region to the location of the hole to be measured.
  3. Select **Radius** and **Hole Center** in the **Output** section.
- Check Output Result:

  The output result of this Step is shown in the figure below. The yellow circle is the fitted circle for measurement.



The measured circle radius is **6.279 mm**.

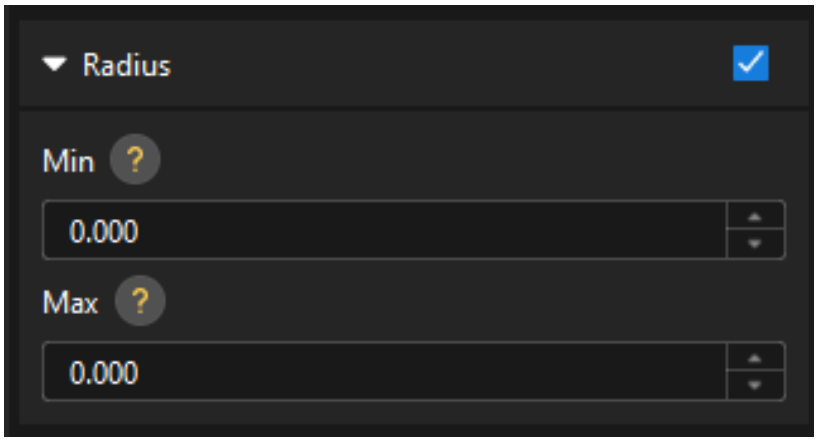


Configure Quality Judgment Rules

After adjusting the Step parameters, you need to configure the quality judgment rules for outputting the measurement and inspection results.

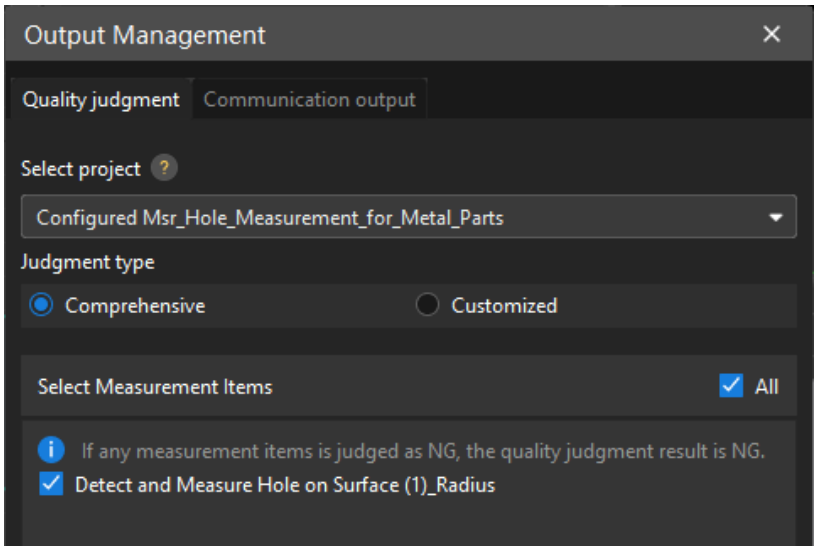
1. In the **Output** section of the "Detect and Measure Hole on Surface" Step, set the acceptable range for **Radius**.

   In the collapsible tab of **Radius**, set the maximum and minimum values allowed for the measurement results. When the measured value is within the acceptable range, the inspection result is OK. Maximum and minimum values need to be set according to the drawing and process requirements of the target object.



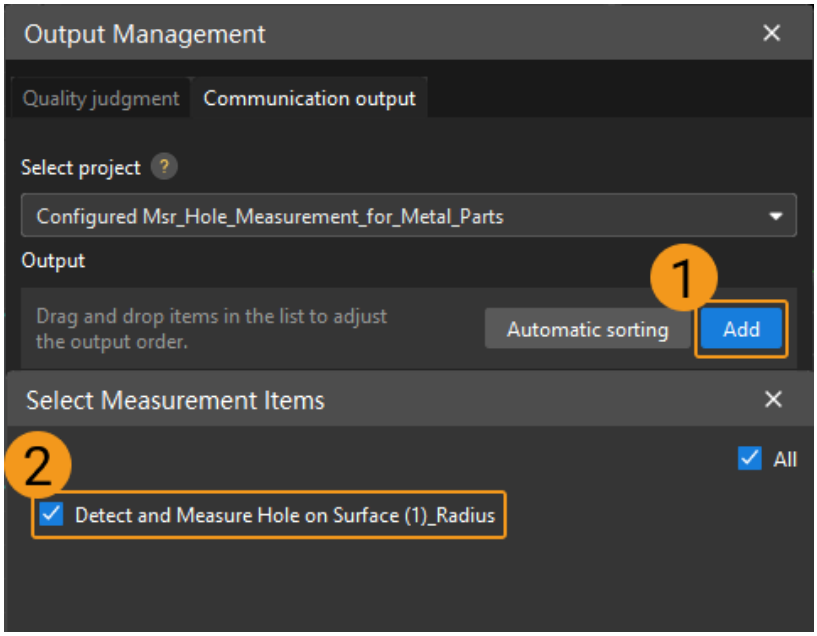
2. Go to **Output Management** and set the Judgment type to Comprehensive.

   Since only the radius is inspected in this solution, "0" (OK) will be sent to the external device when all inspection results are OK.



3. Output measurement results (optional).

   If external devices require access to measurement results, the measurement items need to be added as output. To do so, go to Output Management › Communication output to add the measurement item as shown below.



Communication Configuration

To ensure smooth communication between Mech-MSR and external devices (PLC or other production line equipment), allowing them to trigger Mech-MSR project executions and retrieve measurement results, communication configuration is also required. For detailed instructions, please refer to Communication Configuration.

Now you have completed configurations related to the measurement project.

3.4. Pin Counting

This section introduces the basic information, design, and deployment of the Pin Counting solution.

Basics

Application Scenario Description

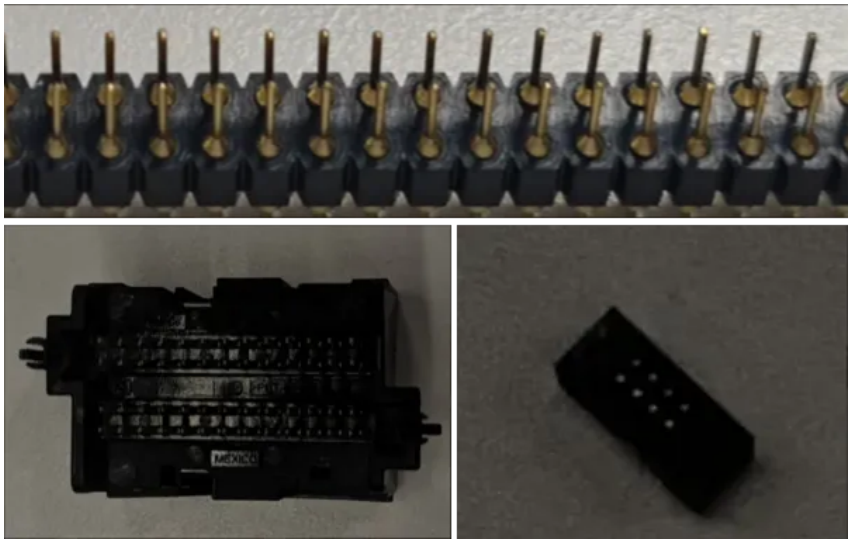
In industrial measurement scenarios, the quality inspection of pins is crucial for the processing and assembly of precision components. The application scenarios of pin counting are as follows.

- Semiconductor manufacturing: In the semiconductor manufacturing process, pins are often used to connect wafers and carrier plates. It is necessary to precisely measure the height and position of pins to ensure good electrical connections and prevent wafer damage.
- Electronic equipment assembly: During the assembly of electronic devices, pins may be used to secure or connect small electronic components. Measuring the height and position of pins helps ensure the correct placement and fixation of components.
- Aerospace: In the aerospace field, component accuracy is crucial to flight safety, and measuring the height of pins helps ensure high-precision fitting and connection of components.
- Precision instruments: In precision instruments, pins may be used for positioning or connecting key components. Measuring the height and position of pins contributes to ensuring the performance and accuracy of the instruments.

In summary, pin quality inspection has wide-ranging applications, and pin counting is a vital part of pin quality inspection.

Target Object Example

The connector pins used in this solution are shown in the figure below.



Key Technical Specifications

The technical specifications of the Pin Counting solution are as follows.

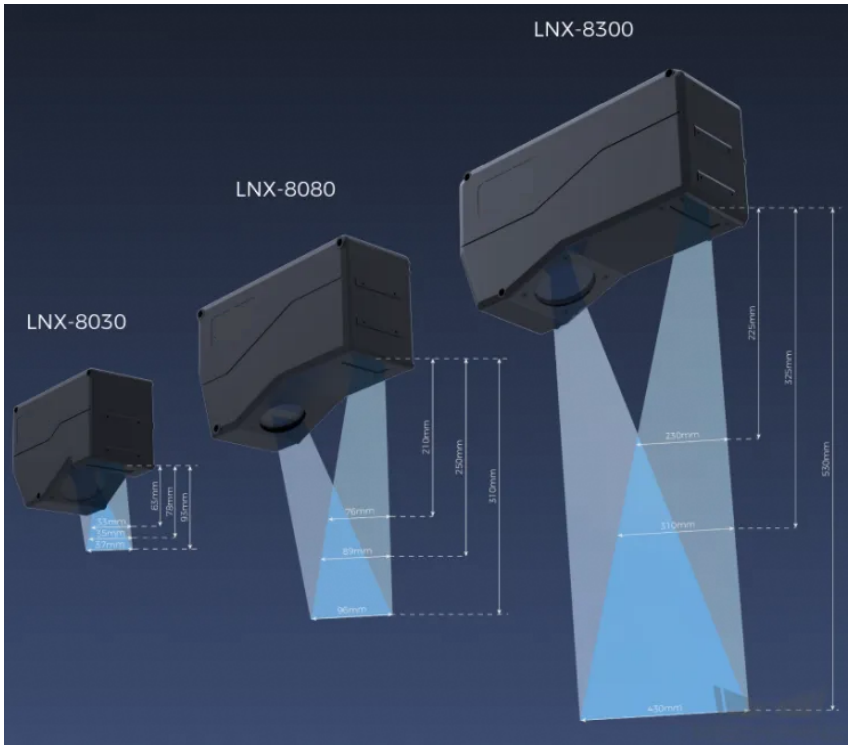
- Vision cycle time: ＜2 s

Solution Design

Select the Laser Profiler Model

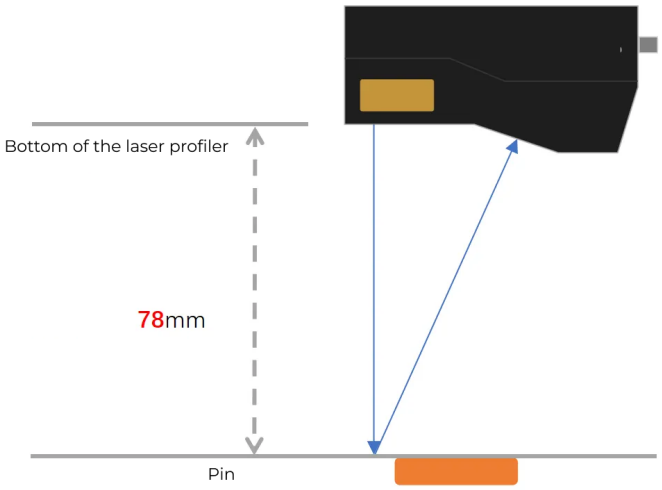
When selecting a laser profiler, the laser profiler's X-axis measurement range should be greater than the length or width of the object to be measured, and the long side of the laser profiler typically aligns with the long side of the object to be measured.

The following figure illustrates the field of view for various models of sensor heads in the LNX-8000 series. Since the dimensions of the target object to be measured are 24 mm × 7 mm, to ensure that the laser profiler's field of view can completely cover the target object, model LNX-8030 is recommended.



Mounting Method of Laser Profiler

You can mount the laser profiler at a fixed location or mount it on a moving rail. Please select the mounting method according to the actual situation. For this solution, the laser profiler is mounted at a fixed location.



Laser Profiler Triggering

The laser profiler supports multiple triggering methods, allowing it to be integrated into a system and work with other devices flexibly to obtain the intensity image, depth map, and point cloud. In this solution, the external + encoder method is used to trigger data acquisition. The detailed instructions are as follows.

1. Set parameters in Mech-Eye Viewer.
   a. Set the **Data Acquisition Trigger Source** parameter to **External**.
   b. Set the **Line Scan Trigger Source** parameter to **Encoder**.
   c. Based on actual needs, adjust other parameters in the **scan mode**.
2. Set the parameters of the 3D Laser Profiler Step.
   a. In the **Parameters** section, click **[Open the editor]** to select and connect the laser profiler you want.
   b. Activate **Data Acquisition Status** to enable the laser profiler to receive external signals, triggering data acquisition once the signal is received.
3. Run the measurement project, and the external signal triggers the laser profiler to acquire data.
4. Once data acquisition is complete, the data will be transferred to Mech-MSR.

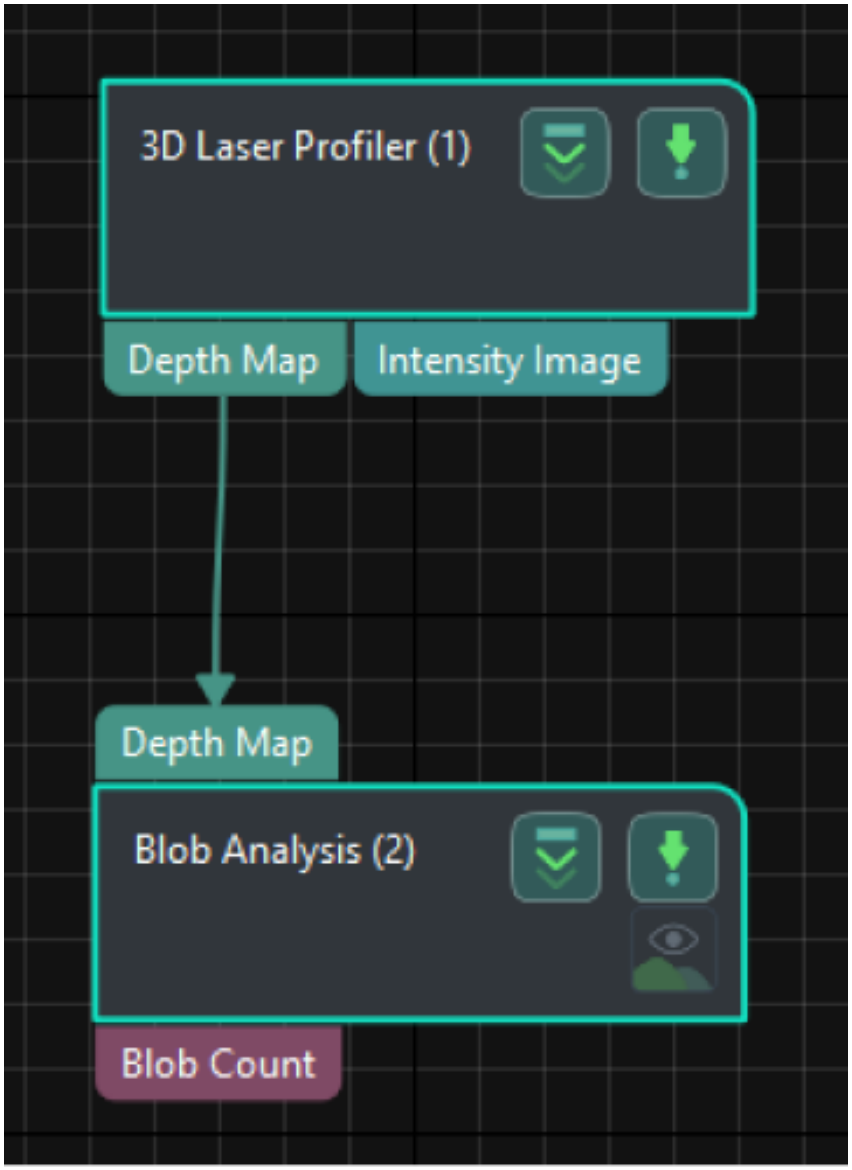
Solution Deployment

Measurement Project Configuration

Workflow Overview

In this solution, the laser profiler is used to acquire the depth map first. Then the acquired depth map will be input to the Blob Analysis Step to calculate the number of pins. Then the corresponding measurement results will be output.

The following figure shows the overall workflow.



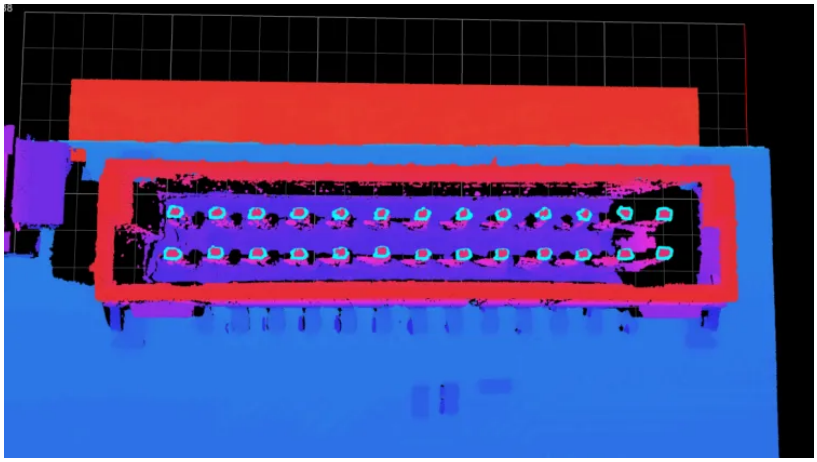
The key Steps in the workflow are described below.

Step Description

Blob Analysis

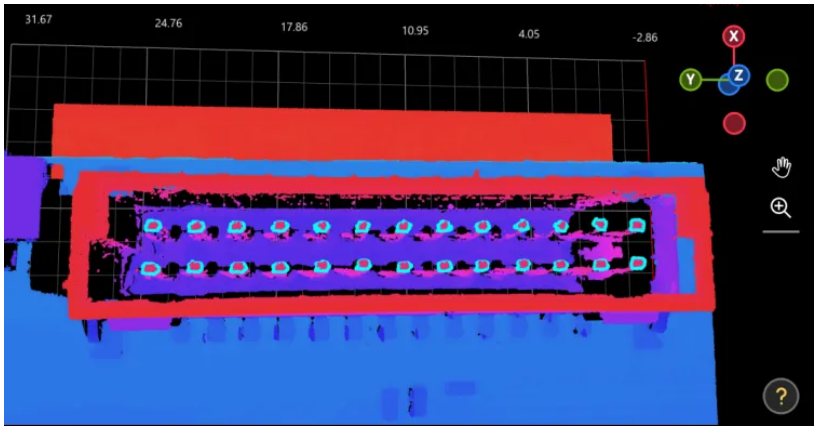
- Function:

  This Step can extract blobs or regions of specific shapes and sizes from the image.

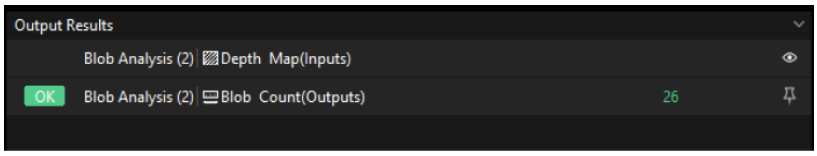


- Usage Procedure:
  1. According to the actual situation of the target objects, set **Height Threshold**, **Max Area**, **Min Area**, and other parameters in the **Parameters** section.
  2. Select **Blob Count** in the **Output** section.
- Check Output Result:

  The output result of this Step is shown in the figure below.



The measured number of pins is **26**.

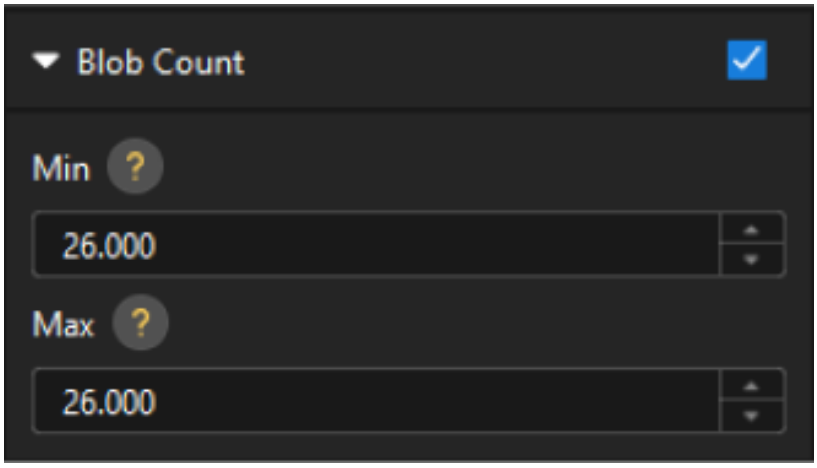


Configure Quality Judgment Rules

After adjusting the Step parameters, you need to configure the quality judgment rules for outputting the measurement and inspection results.

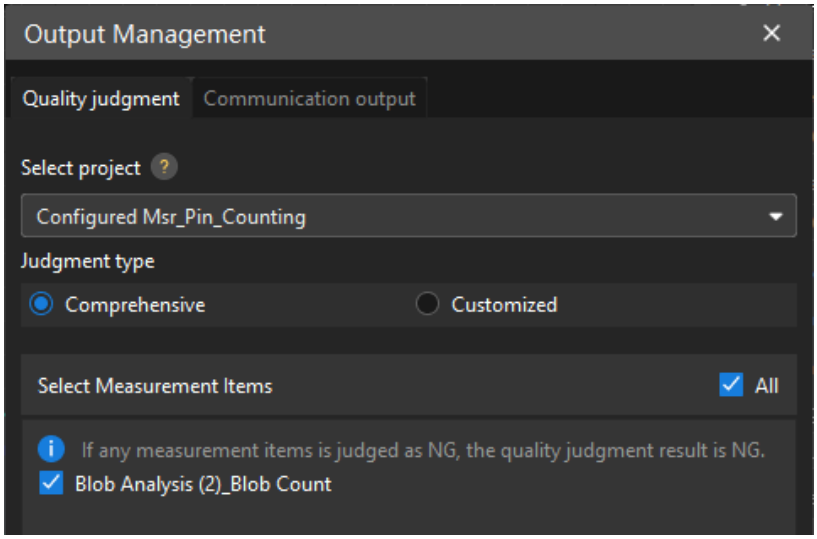
1. In the **Output** section, set the acceptable range for **Blob Count**.

   In the collapsible tab of **Blob Count**, set the maximum and minimum values allowed for the measurement results. When the measured value is within the acceptable range, the inspection result is OK. Maximum and minimum values need to be set according to the drawing and process requirements of the target object.



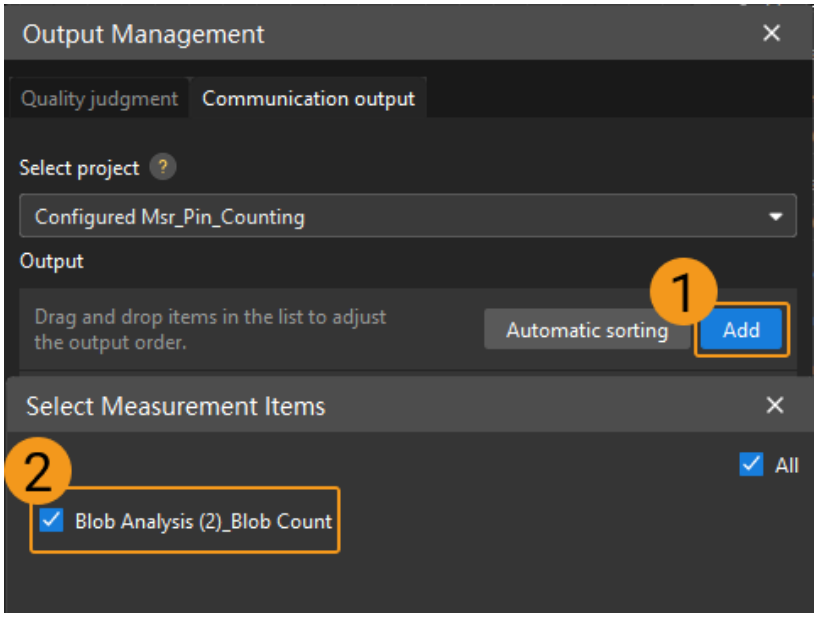
2. Go to **Output Management** and set the Judgment type to Comprehensive.

   Since only blob count is inspected in this solution, "0" (OK) will be sent to the external device when all inspection results are OK.



3. Output measurement results (optional).

   If external devices require access to measurement results, the measurement items need to be added as output. To do so, go to Output Management › Communication output to add the measurement item as shown below.



Communication Configuration

To ensure smooth communication between Mech-MSR and external devices (PLC or other production line equipment), allowing them to trigger Mech-MSR project executions and retrieve measurement results, communication configuration is also required. For detailed instructions, please refer to Communication Configuration.

Now you have completed configurations related to the measurement project.

3.5. Pin Height Measurement

This section introduces the basic information, design, and deployment of the Pin Height Measurement solution.

Basics

Application Scenario Description

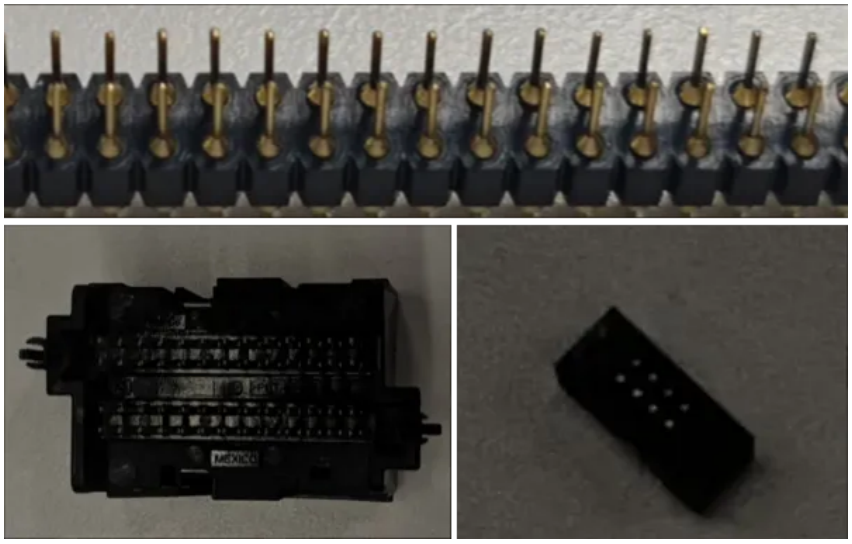
In industrial measurement scenarios, the quality inspection of pins is crucial for the processing and assembly of precision components. The application scenarios of pin height measurement are as follows.

- Semiconductor manufacturing: In the semiconductor manufacturing process, pins are often used to connect wafers and carrier plates. It is necessary to precisely measure the height and position of pins to ensure good electrical connections and prevent wafer damage.
- Electronic equipment assembly: During the assembly of electronic devices, pins may be used to secure or connect small electronic components. Measuring the height and position of pins helps ensure the correct placement and fixation of components.
- Aerospace: In the aerospace field, component accuracy is crucial to flight safety, and measuring the height of pins helps ensure high-precision fitting and connection of components.
- Precision instruments: In precision instruments, pins may be used for positioning or connecting key components. Measuring the height and position of pins contributes to ensuring the performance and accuracy of the instruments.

In summary, pin quality inspection has wide-ranging applications, and pin height measurement is a vital part of pin quality inspection.

Target Object Example

The connector pins used in this solution are shown in the figure below.



Key Technical Specifications

The technical specifications of the Pin Height Measurement solution are as follows.

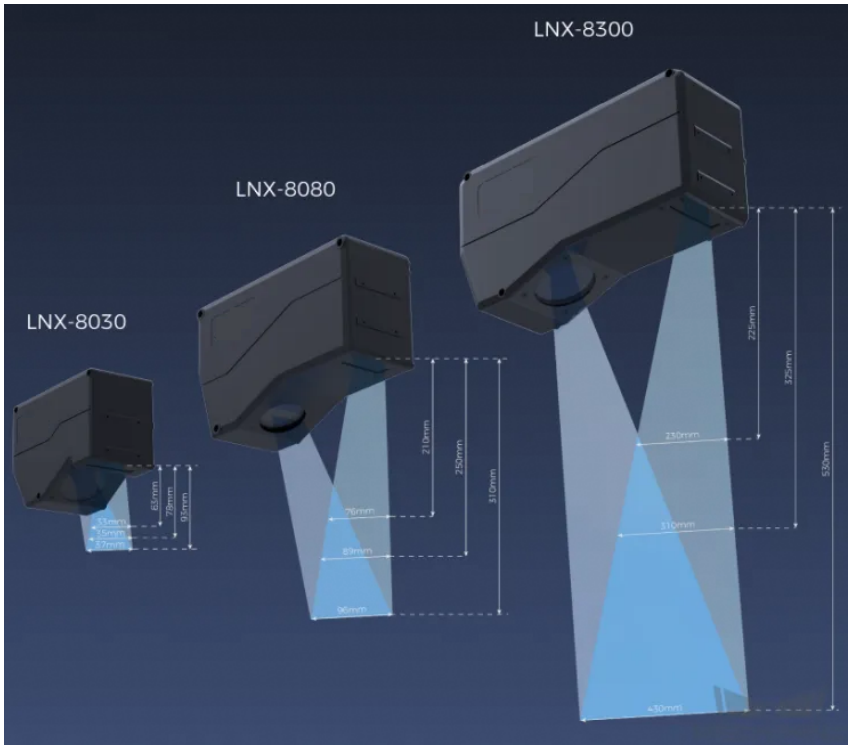
- Repeatability: ＜ 0.1 mm
- Vision cycle time: ＜2 s

Solution Design

Select the Laser Profiler Model

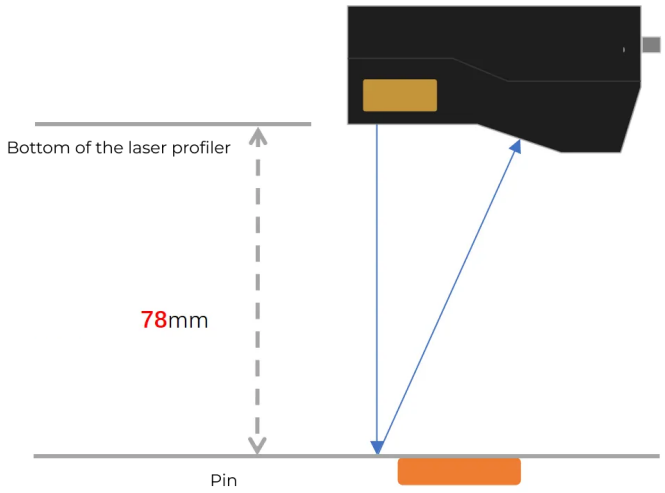
When selecting a laser profiler, the laser profiler's X-axis measurement range should be greater than the length or width of the object to be measured, and the long side of the laser profiler typically aligns with the long side of the object to be measured.

The following figure illustrates the field of view for various models of sensor heads in the LNX-8000 series. Since the dimensions of the target object to be measured are 18 mm × 5 mm, to ensure that the laser profiler's field of view can completely cover the target object, model LNX-8030 is recommended.



Mounting Method of Laser Profiler

You can mount the laser profiler at a fixed location or mount it on a moving rail. Please select the mounting method according to the actual situation. For this solution, the laser profiler is mounted at a fixed location.



Laser Profiler Triggering

The laser profiler supports multiple triggering methods, allowing it to be integrated into a system and work with other devices flexibly to obtain the intensity image, depth map, and point cloud. In this solution, the external + encoder method is used to trigger data acquisition. The detailed instructions are as follows.

1. Set parameters in Mech-Eye Viewer.
   a. Set the **Data Acquisition Trigger Source** parameter to **External**.
   b. Set the **Line Scan Trigger Source** parameter to **Encoder**.
   c. Based on actual needs, adjust other parameters in the **scan mode**.
2. Set the parameters of the 3D Laser Profiler Step.
   a. In the **Parameters** section, click **[Open the editor]** to select and connect the laser profiler you want.
   b. Activate **Data Acquisition Status** to enable the laser profiler to receive external signals, triggering data acquisition once the signal is received.
3. Run the measurement project, and the external signal triggers the laser profiler to acquire data.
4. Once data acquisition is complete, the data will be transferred to Mech-MSR.

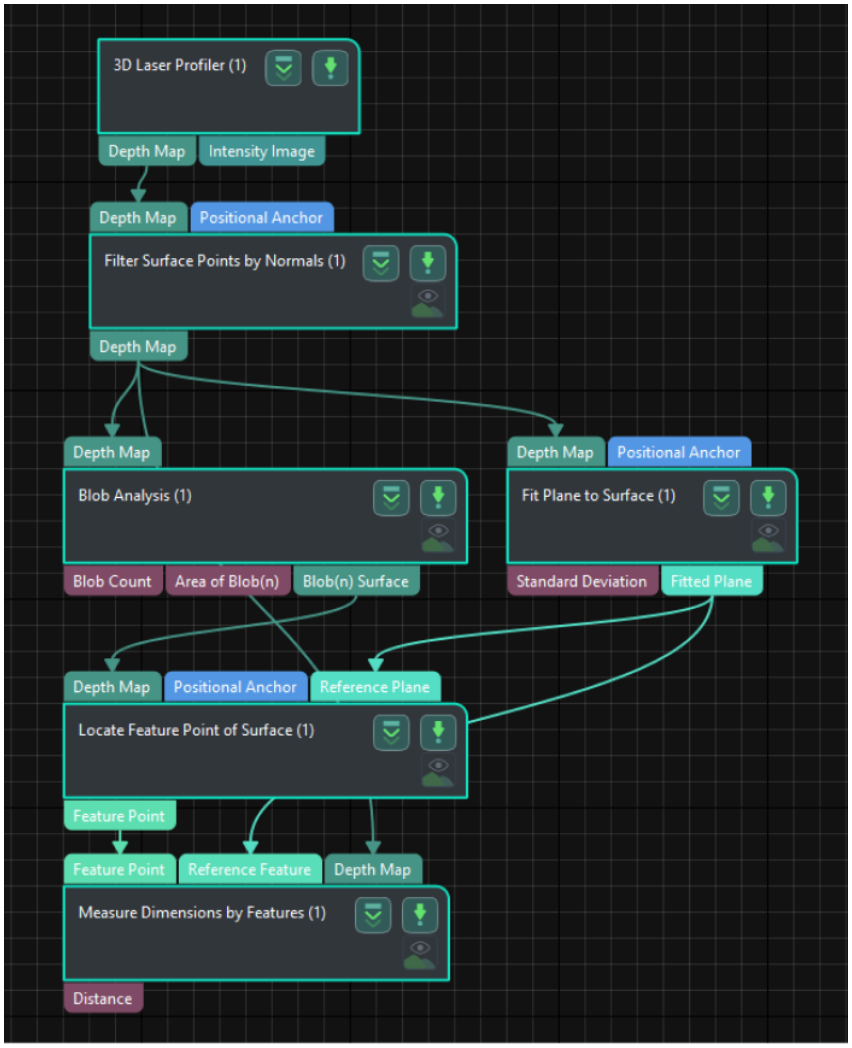
Solution Deployment

Measurement Project Configuration

Workflow Overview

In this solution, the laser profiler is used to acquire the depth map first. Then the acquired depth map will be input to the Blob Analysis Step to locate the pins and obtain their feature points. At the same time, a specific region will be selected to fit the reference plane, and thus the height of the pin to the reference plane can be measured.

The following figure shows the overall workflow.



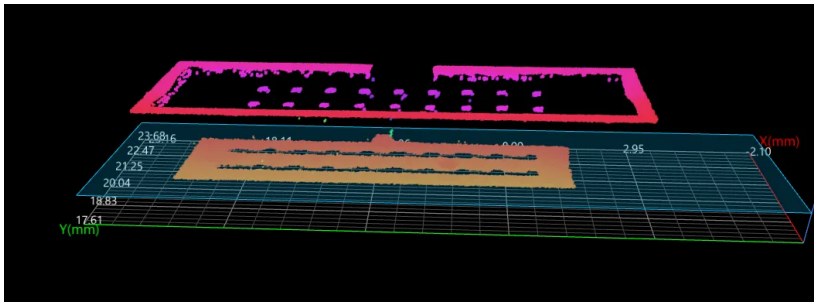
The key Steps in the workflow are described below.

Step Description

Fit Plane to Surface

- Function:

  This Step uses the surface information of the custom region to fit a reference plane. As shown in the figure below, the semi-transparent plane is the fitted plane.



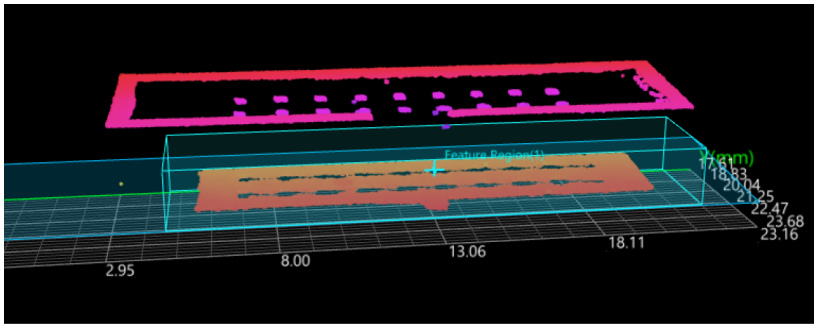
- Usage Procedure:

  1. Add a feature region.

2. Move the feature region to the desired measurement region.
3. Select **Fitted Plane** in the **Output** section.

- Check Output Result:

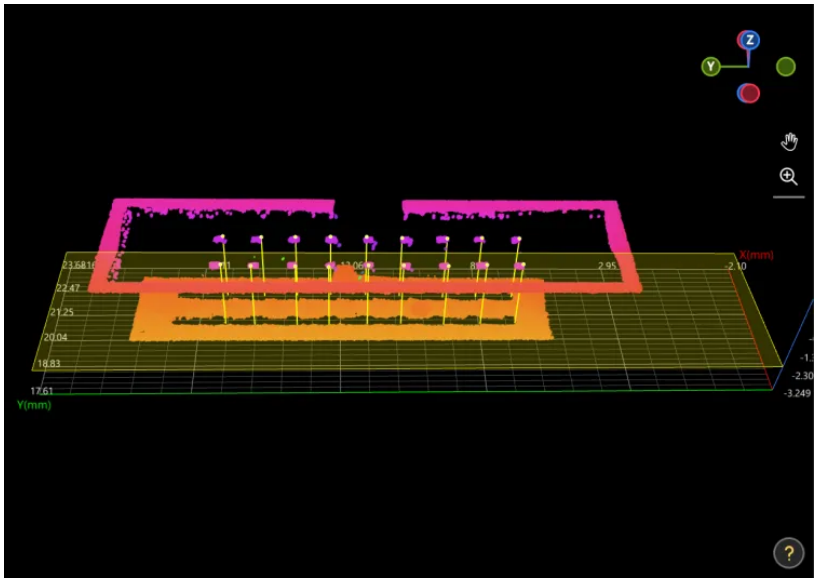
  The output result of this Step is shown in the figure below. The semi-transparent plane is the fitted plane.



Measure Dimensions by Features

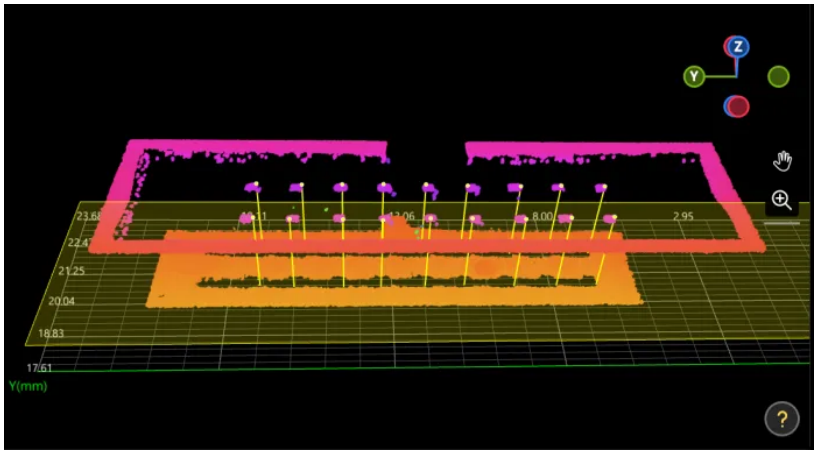
- Function:

  This Step is used to perform dimensional measurements from a feature point (pin) to a reference feature (fitted plane).

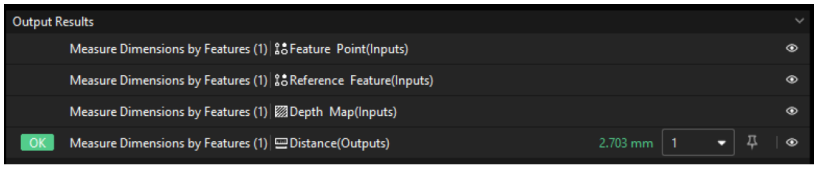


- Usage Procedure:
  1. Select the **Feature Point** and **Reference Feature** in the Input section.
  2. Select **Distance** in the **Output** section.
- Check Output Result:

  The output result of this Step is shown in the figure below. The semi-transparent yellow plane is the fitted plane, and the yellow line indicates the distance from the pin to the plane.



The measured height of pin is **2.703 mm**.

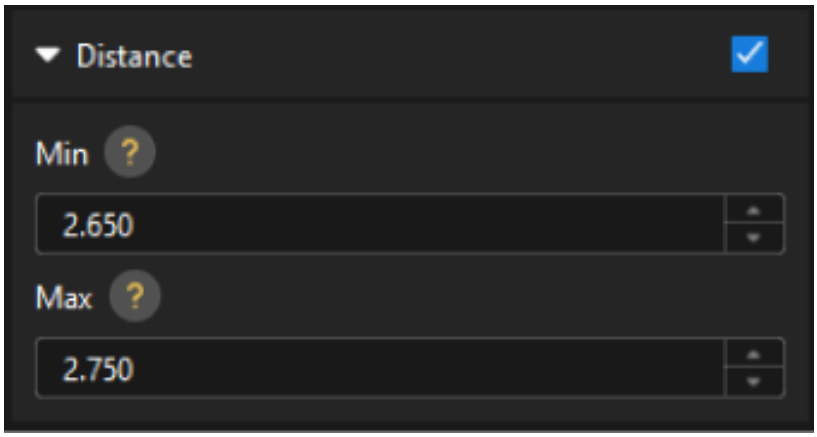


Configure Quality Judgment Rules

After adjusting the Step parameters, you need to configure the quality judgment rules for outputting the measurement and inspection results.

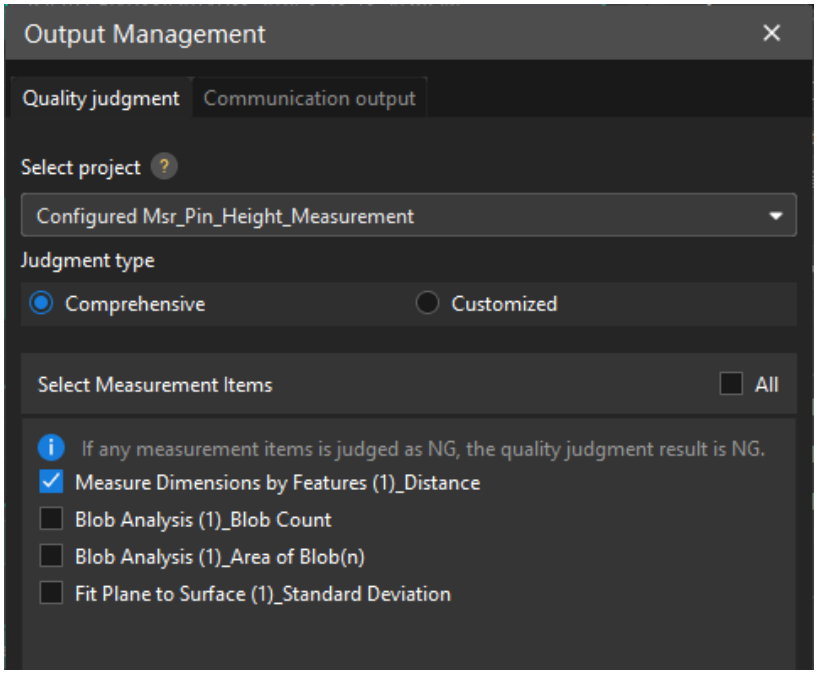
1. In the **Output** section of the “Measure Dimensions by Features” Step, set the acceptable range for **Distance**.

   In the collapsible tab of **Distance**, set the maximum and minimum values allowed for the measurement results. When the measured value is within the acceptable range, the inspection result is OK. Maximum and minimum values need to be set according to the drawing and process requirements of the target object.



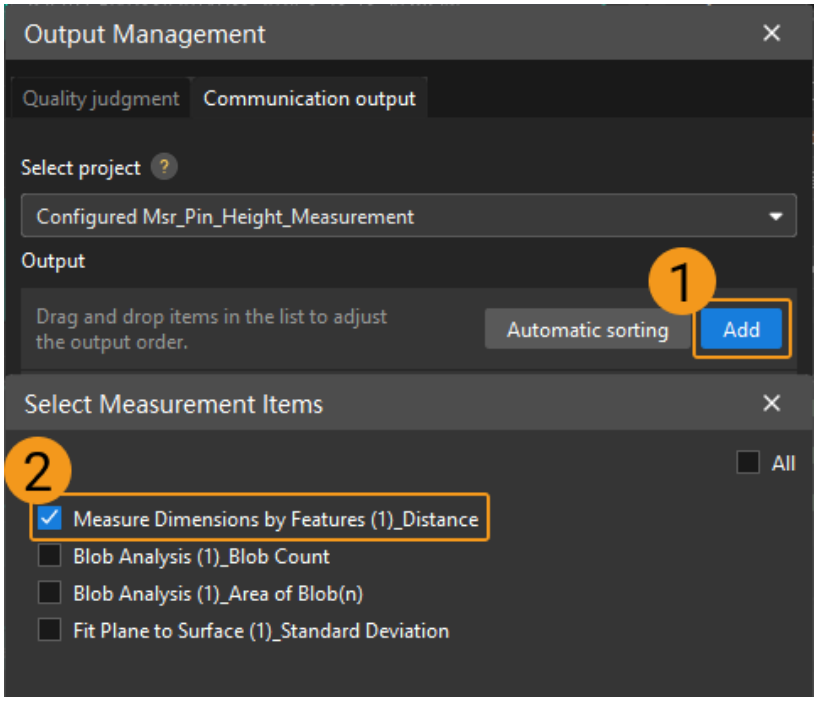
2. Go to **Output Management** and set the Judgment type to Comprehensive.

   Since only the distance is inspected in this solution, “0” (OK) will be sent to the external device when all inspection results are OK.



3. Output measurement results (optional).

   If external devices require access to measurement results, the measurement items need to be added as output. To do so, go to Output Management › Communication output to add the measurement item as shown below.



Communication Configuration

To ensure smooth communication between Mech-MSR and external devices (PLC or other production line equipment), allowing them to trigger Mech-MSR project executions and retrieve measurement results, communication configuration is also required. For detailed instructions, please refer to Communication Configuration.

Now you have completed configurations related to the measurement project.

3.6. Smartphone Midplate Flatness Measurement

This section introduces the basic information, design, and deployment of the Smartphone Midplate Flatness Measurement solution.

Basics

Application Scenario Description

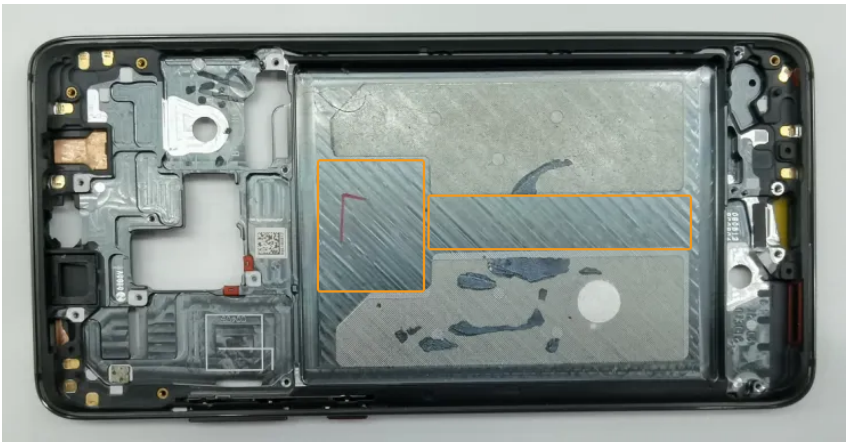
The smartphone midplate is a core structural component of the phone, requiring precise assembly with numerous other key components. Therefore, there are high requirements for the flatness of the smartphone midplate during the production process. In the assembly process of the smartphone, the flatness of the following regions on the midplate directly affects the assembly quality of the corresponding components.

- Front surface—for assembling the display module
- Back surface—for assembling the rear shell
- Antenna attachment surface—for assembling the antenna module
- Camera assembly surface—for assembling the camera module
- Battery compartment surface—for assembling the battery module
- Other connector assembly surfaces

Any flatness deviation in these regions may result in corresponding components being unable to be precisely assembled, leading to issues such as light leakage, part displacement, poor contact, and other problems, seriously affecting the overall quality and appearance of the smartphone.

Target Object Example

The flatness of the battery compartment surface will be measured in this solution. As shown in the figure below, the selected regions are the regions to be measured on the smartphone midplate.



Key Technical Specifications

The technical specifications of the Smartphone Midplate Flatness Measurement solution are as follows.

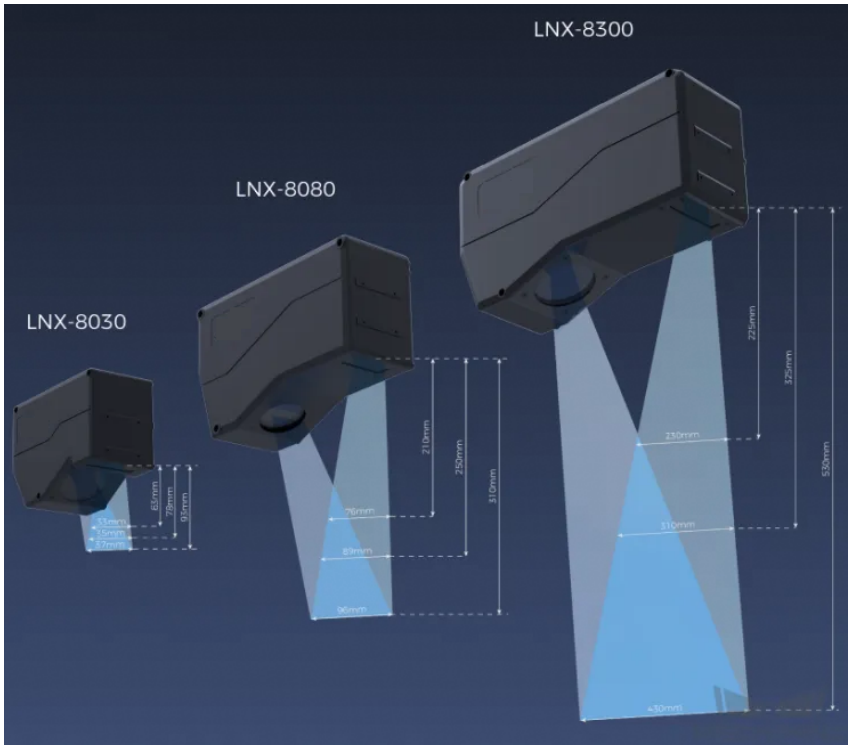
- Repeatability: 8–12 μm
- Vision cycle time: ＜2 s

Solution Design

Select the Laser Profiler Model

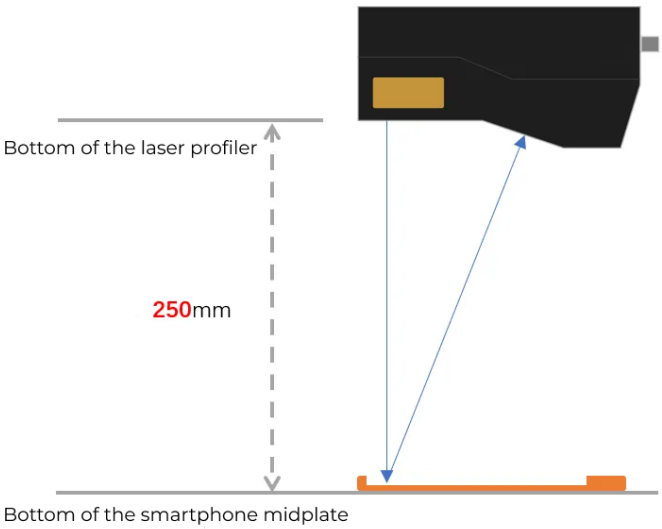
When selecting a laser profiler, the laser profiler's X-axis measurement range should be greater than the length or width of the object to be measured, and the long side of the laser profiler typically aligns with the long side of the object to be measured.

The following figure illustrates the field of view for various models of sensor heads in the LNX-8000 series. Since the dimensions of the target object to be measured are 155 mm × 76 mm, to ensure that the laser profiler's field of view can completely cover the target object, model LNX-8080 is recommended.



Mounting Method of Laser Profiler

You can mount the laser profiler at a fixed location or mount it on a moving rail. Please select the mounting method according to the actual situation. For this solution, the laser profiler is mounted at a fixed location.



Laser Profiler Triggering

The laser profiler supports multiple triggering methods, allowing it to be integrated into a system and work with other devices flexibly to obtain the intensity image, depth map, and point cloud. In this solution, the external + encoder method is used to trigger data acquisition. The detailed instructions are as follows.

1. Set parameters in Mech-Eye Viewer.
   a. Set the **Data Acquisition Trigger Source** parameter to **External**.
   b. Set the **Line Scan Trigger Source** parameter to **Encoder**.
   c. Based on actual needs, adjust other parameters in the **scan mode**.
2. Set the parameters of the 3D Laser Profiler Step.
   a. In the **Parameters** section, click **[Open the editor]** to select and connect the laser profiler you want.
   b. Activate **Data Acquisition Status** to enable the laser profiler to receive external signals, triggering data acquisition once the signal is received.
3. Run the measurement project, and the external signal triggers the laser profiler to acquire data.
4. Once data acquisition is complete, the data will be transferred to Mech-MSR.

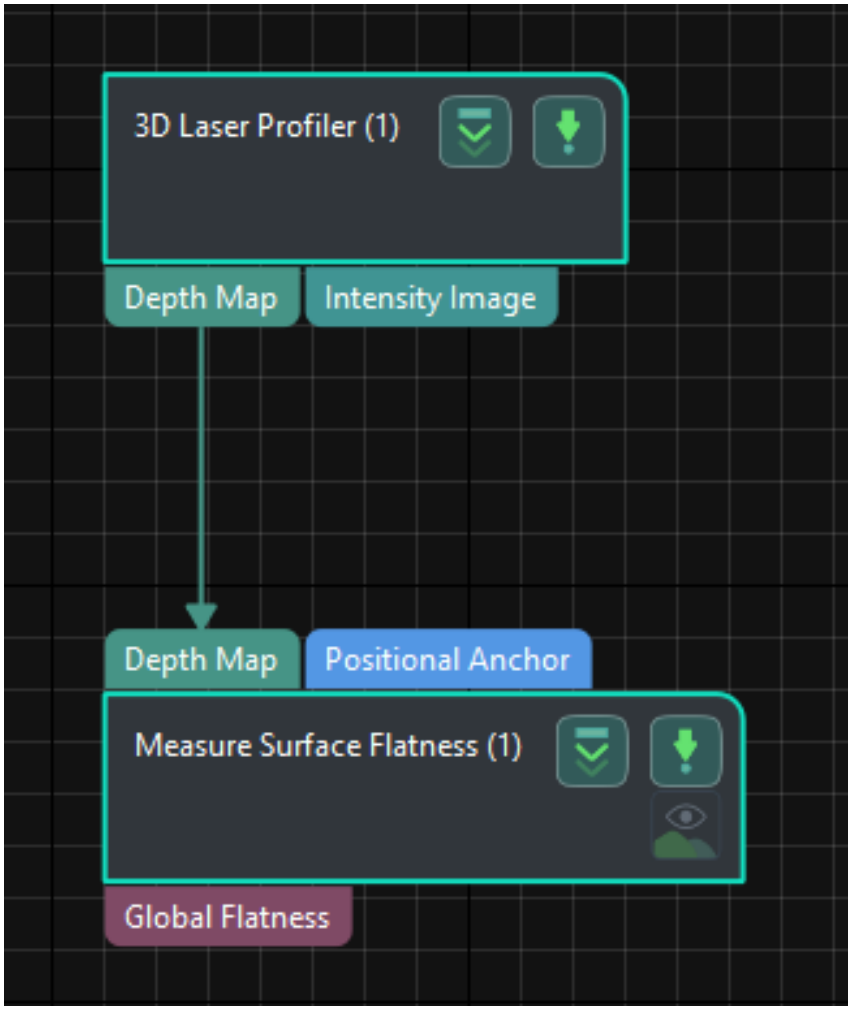
Solution Deployment

Measurement Project Configuration

Workflow Overview

In this solution, the laser profiler is used to acquire the depth map first. Then the acquired depth map will be input to the Measure Surface Flatness Step for accurate flatness measurement. Once the measurement is complete, the corresponding inspection result will be output.

The following figure shows the overall workflow.



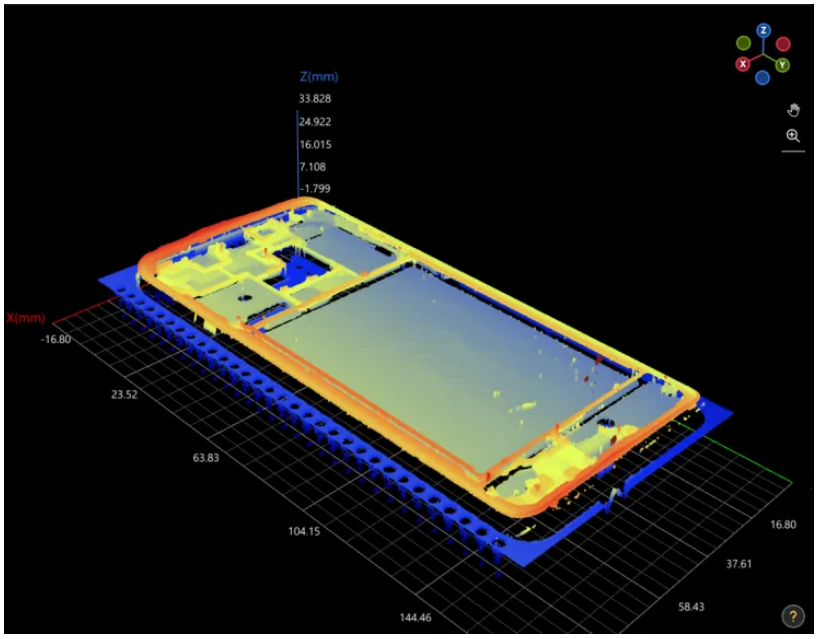
The key Steps in the workflow are described below.

Step Description

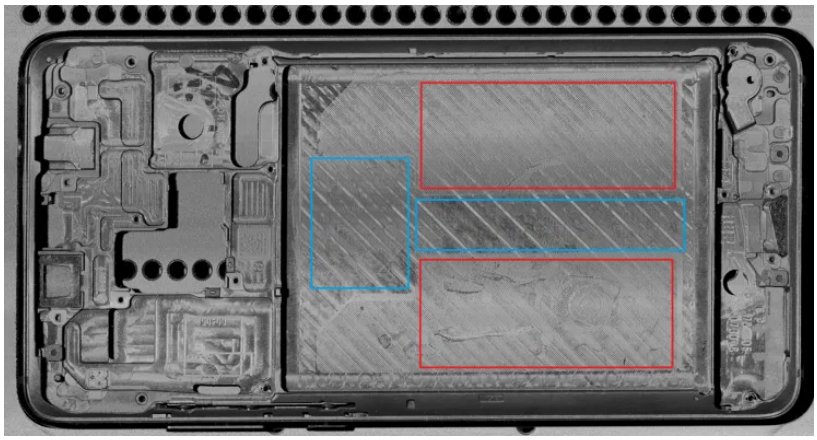
Measure Surface Flatness

- Function:

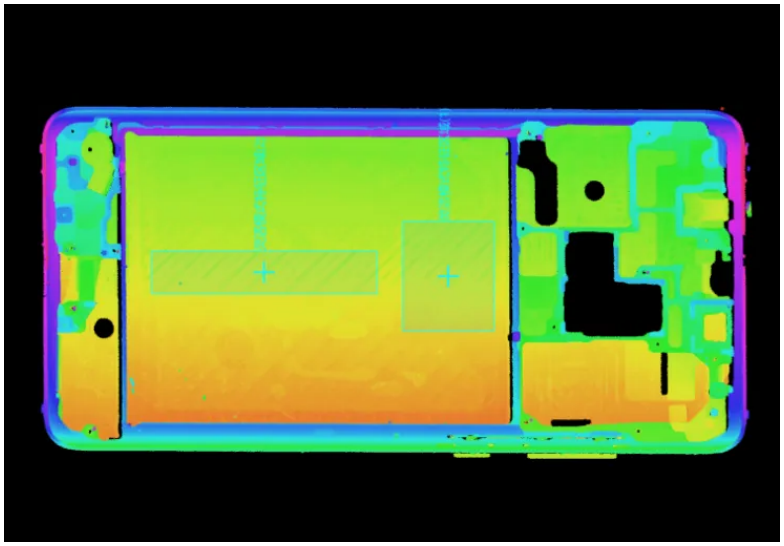
  This Step is used to measure the flatness of a feature region.



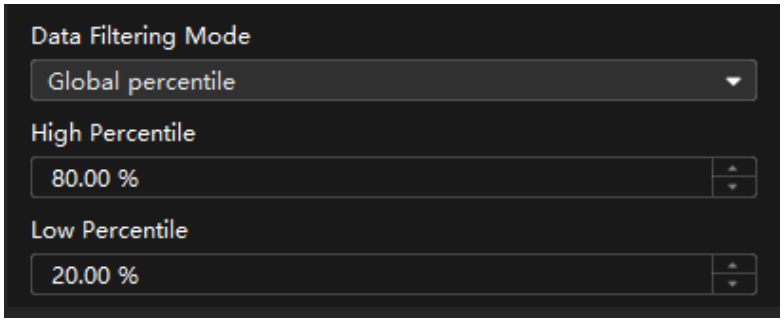
The measurement region is shown in the figure below. The red region is the region for gluing, and the blue region is where flatness measurement is required.



- Usage Procedure:
  1. Add a feature region.
  2. Move the feature region to the desired measurement region.



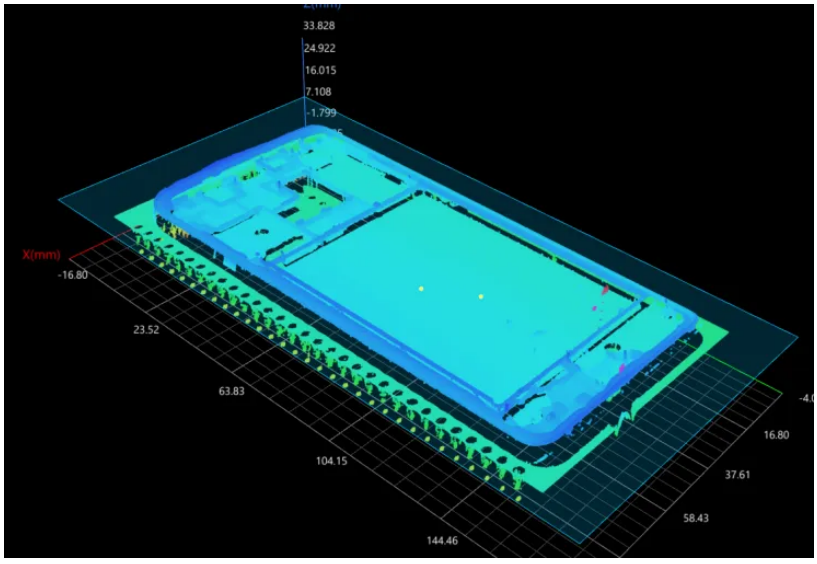
3. Select **Data Filtering Mode** in the **Parameters** section according to the actual situation. As there is noise in the measurement region, the surface flatness is calculated after removing the top 20% and bottom 20% points within the feature region.



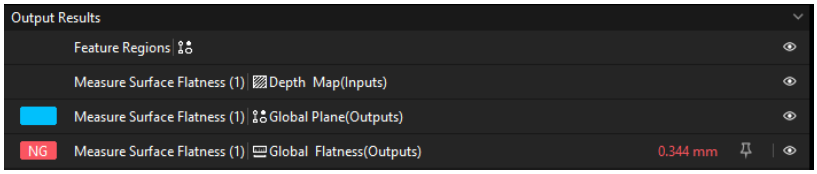
4. Select **Global Flatness** in the **Output** section.

- **Check Output Result:**

  The output result of this Step is shown in the figure below. The semi-transparent blue plane is the fitted plane, and the yellow points are the global maximum and minimum feature points.



The flatness measured by this Step is **0.344 mm**.



Configure Quality Judgment Rules

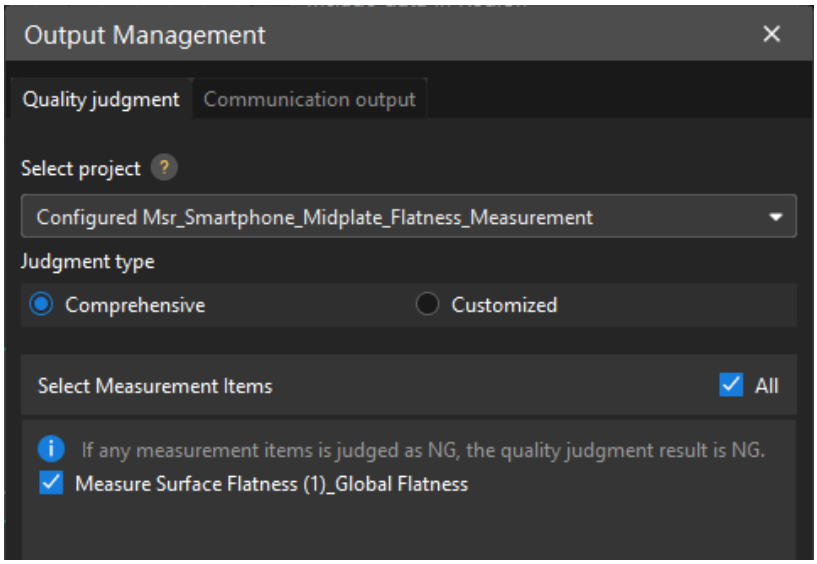
After adjusting the Step parameters, you need to configure the quality judgment rules for outputting the measurement and inspection results.

1. Set the acceptable range for **Global Flatness** in the **Output** section.

   In the collapsible tab of **Global Flatness**, set the maximum and minimum values allowed for the measurement results. When the measured value is within the acceptable range, the inspection result is OK. Maximum and minimum values need to be set according to the drawing and process requirements of the target object.

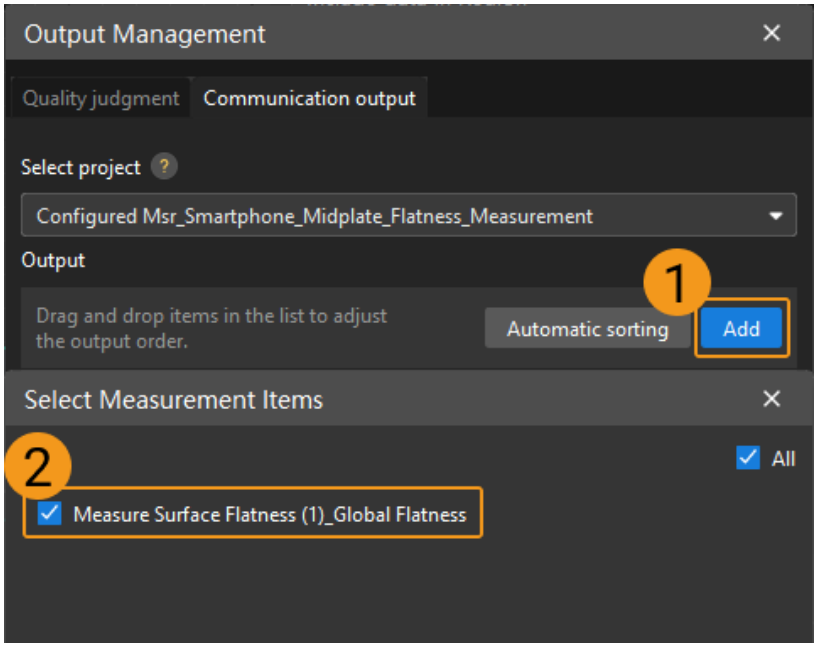
2. Go to **Output Management** and set the Judgment type to Comprehensive.

   Since only the global flatness is inspected in this solution, “0” (OK) will be sent to the external device when all inspection results are OK.



3. Output measurement results (optional).

   If external devices require access to measurement results, the measurement items need to be added as output. To do so, go to Output Management › Communication output to add the measurement item as shown below.



Communication Configuration

To ensure smooth communication between Mech-MSR and external devices (PLC or other production line equipment), allowing them to trigger Mech-MSR project executions and retrieve measurement results, communication configuration is also required. For detailed instructions, please refer to Communication Configuration.

Now you have completed configurations related to the measurement project.

4. References

4.1. TCP ASCII Commands

This section introduces the communication commands supported for TCP ASCII communication.

Trigger

Command Description

The trigger command is used to trigger Mech-MSR projects to run. Multiple projects can be triggered at the same time.

Sent Data Format

Trigger a Mech-MSR project to run:

```
trigger, project_ID
```

Trigger multiple Mech-MSR projects to run:

```
trigger, project_ID, project_ID ...
```

trigger

Name of the command, which is case-sensitive.

project_ID

This parameter specifies the ID of the Mech-MSR project to be triggered. You can view the Mech-MSR project ID in the **Project List** section of Mech-MSR. The number before the project name is the project ID.

If you need to trigger multiple Mech-MSR projects at the same time, you can specify multiple project IDs separated by the string delimiter set in the **Communication Configuration** window.

Returned Data Format

```
status_code
```

If the command is executed successfully, Mech-MSR returns a normal status code of 0. If the command execution fails, Mech-MSR returns an error code (not 0).

status_code

- **0**: a normal status code. If the command is executed successfully, Mech-MSR returns this

status code.

- **-1**: an error code. If the project ID does not exist, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The specified Mech-MSR project ID did not exist in the project list.
  - The Autoload Solution option has not been selected for the solution to which the Mech-MSR project belongs.

  Solution:

  - Ensure that the Autoload Solution option has been selected for the current solution.
  - Ensure that the entered Mech-MSR project ID exists in the project list.

- **-4**: an error code. If an invalid command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The command name was entered incorrectly, for example, in inconsistent case or spelt mistakenly.
  - The delimiter between the command name and parameter or between parameters was not the string delimiter set in the **Communication Configuration** window.

  Solution:

  - Ensure that the entered command name is correct.
  - Ensure that delimiter between the command name and parameter or between parameters is the **string delimiter** set in the **Communication Configuration** window.

Return

Command Description

The return command is used to get the result of the specified Mech-MSR project. You can get the results of only one Mech-MSR project at a time.

Sent Data Format

```
return, project_ID
```

return

Name of the command, which is case-sensitive. This command must be called after **trigger**.

project_ID

This parameter specifies the ID of the Mech-MSR project for which the result is got. You can view the Mech-MSR project ID in the **Project List** section of Mech-MSR. The number before the project name is the project ID.

Note that the project specified by this parameter must have been triggered to run by **trigger**. Otherwise, you may fail to get the result.

Returned Data Format

The data format returned by this command is set by the "Data format of return commands" parameter in the **Communication Configuration** window.

Example 1: Get the overall quality judgment result of the project successfully.

The data format of the return command is `%judge`.

```
status_code
```

Example 2: Obtain the overall quality judgment result of the project, as well as the measured values and judgment results of the measurement items.

The data format of the return command is `%judge,%value[%id],%judge[%id]`.

```
status code, measured_value_of_measurement_item1,
judgment_result_of_measurement_item1, measured_value_of_measurement_item2,
judgment_result_of_measurement_item2, ...
```

Example 3: Command execution failed.

```
status_code (error code)
```

status_code

- 0: a normal status code. If the command is executed successfully and the overall quality judgement result of the project is OK, Mech-MSR returns this status code.
- 1: a normal status code. If the command is executed successfully, and the overall quality judgment result of the project is NG, Mech-MSR returns this status code.
- -1: an error code. If the project ID does not exist, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The specified Mech-MSR project ID did not exist in the project list.
  - The Autoload Solution option has not been selected for the solution to which the Mech-MSR project belongs.

  Solution:

  - Ensure that the Autoload Solution option has been selected for the current solution.
  - Ensure that the entered Mech-MSR project ID exists in the project list.
- -2: an error code. If there is no result, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The project was not triggered.

- The Mech-MSR software was running abnormally.

Solution:

- Ensure that the Mech-MSR software is running normally and the project can output results normally.
- Ensure that the project has been triggered by the **trigger** command.

- **-3**: an error code. If the project has not finished running within 10 seconds after this command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The project execution time is too long, exceeding the timeout period (10 seconds).

  Solution: Check if the execution time of the project is longer than 10 seconds, and check if the execution time is abnormal. If it is an abnormal behavior, locate and fix the reasons for the excessive project execution time. If it is a normal behavior, you can avoid the error by any of the following methods:

  - Add an appropriate delay before the client calls this command.
  - Increase the timeout period (self.vision_timeout) in the msr_dispatcher.py program. The default timeout period is 10 seconds. Please save and restart the software after modification.

- **-4**: an error code. If an invalid command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The command name was entered incorrectly, for example, in inconsistent case or spelt mistakenly.
  - The delimiter between the command name and parameter or between parameters was not the string delimiter set in the **Communication Configuration** window.

  Solution:

  - Ensure that the entered command name is correct.
  - Ensure that delimiter between the command name and parameter or between parameters is the **string delimiter** set in the **Communication Configuration** window.

measured_value_of_measurement_item#

Measured value of a measurement item. The measured value of a measurement item is output only if the following conditions are met:

- In the **Communication output** tab of **Output Management**, this measurement item has been added to the **Output** area. The ID before the measurement item name is the order of the measurement item in the output.
- In the **Communication Configuration** window, the value of the **Data format of return commands** parameter contains either “%value[%id]” or “%value[ID of the measurement item].”

judgment_result_of_measurement_item#

Judgement result of a measurement item. 0 stands for OK and 1 for NG. The judgement result of a measurement item is output only if the following conditions are met:

- In the **Communication output** tab of **Output Management**, this measurement item has been added to the **Output** area. The ID before the measurement item name is the order of the measurement item in the output.
- In the **Communication Configuration** window, the value of the **Data format of return commands** parameter contains either "%judge[%id]" or "%judge[ID of the measurement item]."

Judge

Command Description

The judge command is used to get the overall judgement result of the specified Mech-MSR project and the judgment result of each measurement item.

Sent Data Format

```
judge, project_ID
```

judge

Name of the command, which is case-sensitive. This command must be called after **trigger**.

project_ID

This parameter specifies the ID of the Mech-MSR project for which the judgement results are got. You can view the Mech-MSR project ID in the **Project List** section of Mech-MSR. The number before the project name is the project ID.

Note that the project specified by this parameter must have been triggered to run by **trigger**. Otherwise, you may fail to get the judgement results.

Returned Data Format

Example 1: Obtain the overall quality judgment result of the project successfully.

```
status_code
```

Example 2: Obtain the overall quality judgment result of the project and the measured value of each measurement item successfully.

```
status code, judgment_result_of_measurement_item1,
judgment_result_of_measurement_item2, ...
```

Example 3: Command execution failed.

```
status_code (error code)
```

status_code

- 0: a normal status code. If the command is executed successfully and the overall quality judgement result of the project is OK, Mech-MSR returns this status code.
- 1: a normal status code. If the command is executed successfully, and the overall quality judgment result of the project is NG, Mech-MSR returns this status code.
- -1: an error code. If the project ID does not exist, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The specified Mech-MSR project ID did not exist in the project list.
  - The Autoload Solution option has not been selected for the solution to which the Mech-MSR project belongs.

  Solution:

  - Ensure that the Autoload Solution option has been selected for the current solution.
  - Ensure that the entered Mech-MSR project ID exists in the project list.
- -2: an error code. If there is no result, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The project was not triggered.
  - The Mech-MSR software was running abnormally.

  Solution:

  - Ensure that the Mech-MSR software is running normally and the project can output results normally.
  - Ensure that the project has been triggered by the **trigger** command.
- -3: an error code. If the project has not finished running within 10 seconds after this command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The project execution time is too long, exceeding the timeout period (10 seconds).

  Solution: Check if the execution time of the project is longer than 10 seconds, and check if the execution time is abnormal. If it is an abnormal behavior, locate and fix the reasons for the excessive project execution time. If it is a normal behavior, you can avoid the error by any of the following methods:

  - Add an appropriate delay before the client calls this command.
  - Increase the timeout period (self.vision_timeout) in the msr_dispatcher.py program. The default timeout period is 10 seconds. Please save and restart the software after modification.
- -4: an error code. If an invalid command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The command name was entered incorrectly, for example, in inconsistent case or spelt mistakenly.
  - The delimiter between the command name and parameter or between parameters was not the **string delimiter** set in the **Communication Configuration** window.

Solution:

- Ensure that the entered command name is correct.
- Ensure that delimiter between the command name and parameter or between parameters is the **string delimiter** set in the **Communication Configuration** window.

judgment_result_of_measurement_item#

Judgement result of a measurement item. 0 stands for OK and 1 for NG. The judgement result of a measurement item is output only if the following conditions are met:

- In the **Communication output** tab of **Output Management**, this measurement item has been added to the **Output** area. The ID before the measurement item name is the order of the measurement item in the output.
- In the **Communication Configuration** window, the value of the **Data format of return commands** parameter contains either "%judge[%id]" or "%judge[ID of the measurement item]."

Value

Command Description

The value command is used to get the measured value of the specified project.

Sent Data Format

```
value, project_ID
```

value

Name of the command, which is case-sensitive. This command must be called after **trigger**.

project_ID

This parameter specifies the ID of the Mech-MSR project for which the measured values are got. You can view the Mech-MSR project ID in the **Project List** section of Mech-MSR. The number before the project name is the project ID.

Note that the project specified by this parameter must have been triggered to run by **trigger**. Otherwise, you may fail to get the measured values.

Returned Data Format

Example 1: Obtain the overall quality judgment result of the project successfully.

```
status_code
```

Example 2: Obtain the overall quality judgment result of the project and the measured value of each measurement item successfully.

```
status code, measured_value_of_measurement_item1,
measured_value_of_measurement_item2, ...
```

Example 3: Command execution failed.

```
status_code (error code)
```

status_code

- 0: a normal status code. If the command is executed successfully and the overall quality judgement result of the project is OK, Mech-MSR returns this status code.
- 1: a normal status code. If the command is executed successfully, and the overall quality judgment result of the project is NG, Mech-MSR returns this status code.
- -1: an error code. If the project ID does not exist, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The specified Mech-MSR project ID did not exist in the project list.
  - The Autoload Solution option has not been selected for the solution to which the Mech-MSR project belongs.

  Solution:

  - Ensure that the Autoload Solution option has been selected for the current solution.
  - Ensure that the entered Mech-MSR project ID exists in the project list.
- -2: an error code. If there is no result, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The project was not triggered.
  - The Mech-MSR software was running abnormally.

  Solution:

  - Ensure that the Mech-MSR software is running normally and the project can output results normally.
  - Ensure that the project has been triggered by the **trigger** command.
- -3: an error code. If the project has not finished running within 10 seconds after this command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The project execution time is too long, exceeding the timeout period (10 seconds).

  Solution: Check if the execution time of the project is longer than 10 seconds, and check if the execution time is abnormal. If it is an abnormal behavior, locate and fix the reasons for the excessive project execution time. If it is a normal behavior, you can avoid the error by any of the following methods:

  - Add an appropriate delay before the client calls this command.

- Increase the timeout period (self.vision_timeout) in the msr_dispatcher.py program. The default timeout period is 10 seconds. Please save and restart the software after modification.

- **-4**: an error code. If an invalid command is sent, Mech-MSR returns this status code.

  The possible causes of this error are:

  - The command name was entered incorrectly, for example, in inconsistent case or spelt mistakenly.
  - The delimiter between the command name and parameter or between parameters was not the **string delimiter** set in the **Communication Configuration** window.

  Solution:

  - Ensure that the entered command name is correct.
  - Ensure that delimiter between the command name and parameter or between parameters is the **string delimiter** set in the **Communication Configuration** window.

measured_value_of_measurement_item#

Measured value of a measurement item. The measured value of a measurement item is output only if the following conditions are met:

- In the **Communication output** tab of **Output Management**, this measurement item has been added to the **Output** area. The ID before the measurement item name is the order of the measurement item in the output.
- In the **Communication Configuration** window, the value of the **Data format of return commands** parameter contains either “%value[%id]” or “%value[ID of the measurement item].”

4.2. Terms and Concepts

Solution Description

Mech-Mind 3D Measurement and Inspection Solution

Based on the Mech-Eye 3D Laser Profiler and Mech-MSR 3D measurement and inspection software developed by Mech-Mind, the 3D measurement and inspection solution provides various typical 3D measurement and inspection applications such as 3D geometric measurement, height measurement, 3D defect inspection, and object counting. This solution is applicable to consumer electronics, EV battery, automobile, photovoltaic, and other industries.

The solution mainly consists of the Mech-Eye 3D Laser Profiler, industrial personal computer (IPC), and Mech-Mind software products (Mech-Eye Viewer and Mech-MSR).

Mech-Mind 3D Measurement System

Provides the 3D measurement and inspection solution. The Mech-Eye 3D Laser Profiler, IPC, and Mech-Mind software products (Mech-Eye Viewer and Mech-MSR) provided by Mech-Mind constitute the Mech-Mind 3D Measurement System.

Mech-Eye 3D Laser Profiler

The 3D laser profiler developed by Mech-Mind, which can output high-quality intensity images, depth maps, and point clouds. Together with Mech-MSR, it can be deployed for various 3D measurement and inspection applications.

IPC

The computer that provides the operating environment for the Mech-Mind's software products. You can use the standard IPC provided by Mech-Mind (recommended) or use your own device as the IPC.

Mech-Eye Viewer

Mech-Eye Viewer, installed on the IPC, is the configuration and data visualization software for the Mech-Eye 3D Laser Profiler. It allows users to adjust the parameters of the Mech-Eye 3D Laser Profiler according to the characteristics of the target object, thus obtaining high-quality intensity images, depth maps, and point clouds simply and quickly.

Mech-MSR

Mech-MSR, installed on the IPC, is a software designed for 3D measurement and inspection. It can work with the Mech-Eye 3D Laser Profiler to deploy various 3D measurement and inspection applications, such as 3D geometric measurement, height measurement, 3D defect inspection, and object counting. The software has various built-in measurement algorithms and features, and it boasts a user-friendly interface. Users can apply the software to rapidly achieve one-stop, end-to-end deployment of applications.

Laser Profiler and Mech-Eye Viewer

Profile

Each time the laser is emitted, the Mech-Eye 3D Laser Profiler extracts a profile from the raw image. The profile reflects the change in the distance to the sensor head along a section of the target object, that is, the change in height.

Line Scan

The process during which the Mech-Eye 3D Laser Profiler emits the laser light once and generates one profile.

One Round of Data Acquisition

The process during which the Mech-Eye 3D Laser Profiler completes multiple line scans, generates multiple profiles, and stitches the profiles to generate the intensity image, depth map, and point cloud.

Trigger

The action that makes the Mech-Eye 3D Laser Profiler start a round of data acquisition or a line scan.

Profile Mode

A parameter adjustment mode provided by Mech-Eye Viewer, used to adjust the quality of the profile.

Scan Mode

A parameter adjustment mode provided by Mech-Eye Viewer, used to adjust the quality of the intensity image, depth map, and point cloud.

Data Points

Data points represent the number of data points on each profile.

Scan Rate

The scan rate is expressed in the number of profiles that the Mech-Eye 3D Laser Profiler can scan per second (in Hz).

Max Scan Rate

The fastest scan rate currently achievable by the Mech-Eye 3D Laser Profiler, which is determined by the exposure time and Region of Interest (ROI). For a fixed exposure time, the smaller the exposure time, the greater the corresponding max scan rate; for a fixed ROI, the smaller the exposure time, the greater the corresponding max scan rate.

Actual Scan Rate

The rate at which the Mech-Eye 3D Laser Profiler actually performs line scans. It is determined by the “Trigger Rate” parameter (fixed-rate triggering) or the encoder resolution and parameters related to the encoder (encoder triggering).

Z-Axis Measurement Range

Z-axis measurement range represents the maximum depth that can be measured by the Mech-Eye 3D Laser Profiler. At the same accuracy level, the larger the Z-axis measurement range, the larger the object height that the Mech-Eye 3D Laser Profiler can measure.

X-Axis Measurement Range

X-axis measurement range represents the maximum width that can be measured by the Mech-Eye 3D Laser Profiler on the X-axis direction. The X-axis measurement range provided by the Mech-Eye 3D Laser Profiler varies at different depths (near, reference distance, far). At the same accuracy level, the larger the X-axis measurement range, the larger the object width that the Mech-Eye 3D Laser Profiler can measure.

Reference Distance

Reference distance is the distance with the highest accuracy of the Mech-Eye 3D Laser Profiler. The reference distance can be used to determine the mounting position for the Mech-Eye 3D Laser Profiler. When the distance between the laser emitter and the target object is the reference distance, the laser line reflected from the target object’s surface will appear in the central part of the receiver unit.

X-Axis Resolution

X-axis resolution refers to the distance between two adjacent data points on the X-axis direction.

X-Axis Resolution = X-Axis Measurement Range (Far) / Data Points

Y-Axis Resolution

The Y-axis resolution of the scan data is the distance between two neighboring data points along the travel direction of the target object. This is equal to the distance between two neighboring profiles. The Y-axis resolution determines the accuracy of the scan data, as well as the aspect ratio of the target object in the intensity image and depth map.

Z-Axis Repeatability

Z-axis repeatability refers to the consistency of height data acquired by the Mech-Eye 3D Laser Profiler during repeated measurements for the target object. The target object used for testing was a ceramic plate. This parameter is laboratory data and is for reference only. It cannot be directly used to evaluate actual projects.

Z-Axis Linearity

Z-axis linearity is the ratio of the maximum error to the full Z-axis measurement range of the Mech-Eye 3D Laser Profiler. It is expressed in “%F.S.”. Notably, the maximum error represents the difference between the actual measured value and the fit line within the Z-axis measurement range. This parameter is laboratory data and is for reference only. It cannot be directly used to evaluate actual projects.

Mech-MSR

Measurement

The process of using measurement instruments or methods to measure the number, properties, or features of objects.

Measurement Item

The specific object, attribute, or feature to be measured, such as height and flatness.

Measured Value

The specific value of the measurement item obtained during measurement.

Quality Judgment

In measurement scenarios, quality judgment refers to the evaluation of the measurement data to determine whether the target object meets predetermined quality standards or specifications. In the Mech-MSR software, you can set an acceptable range as a criterion or specification for quality judgment.

Judgment result

The result or conclusion that has been reached through quality judgment. The Mech-MSR software can output the overall judgment result of the project or the judgment result/measured data of each measurement item.

Solution Library

A resource library that provides typical solutions or projects (with example data) coming from different application scenarios.

Solution

A solution is a collection of functional configurations and data required for a 3D measurement and inspection application.

Mech-MSR Project

A Mech-MSR project refers to a 3D measurement project created using Mech-MSR. One or more projects make up a solution. Projects cannot be used independently and must belong to a solution.

Step

Steps are the basics of a project. A Step is a minimum algorithm unit for data processing. By connecting different Steps in a project, you can achieve different data processing tasks.

Communication

TCP ASCII Communication

TCP ASCII communication refers to the way in which the ASCII format is used to exchange data through TCP (Transmission Control Protocol) in network communication.

Mech-Mind supports TCP ASCII communication between the Mech-Mind 3D Measurement System and external devices such as PLCs. When TCP ASCII communication is used, the Mech-Mind 3D Measurement System (Mech-MSR) acts as the TCP server while the external device as the TCP client.

For the commands supported for TCP ASCII communication, refer to TCP ASCII Commands.

4.3. FAQs

Does the Mech-Mind 3D measurement and inspection solution support LNX 8080A?

No. The Mech-Mind 3D measurement and inspection solution currently supports only laser profiler models that are split devices.

What communication methods does the Mech-Mind 3D Measurement System support?

Only the Transmission Control Protocol (TCP) communication in ASCII format is supported. More communication methods will be supported in later releases.