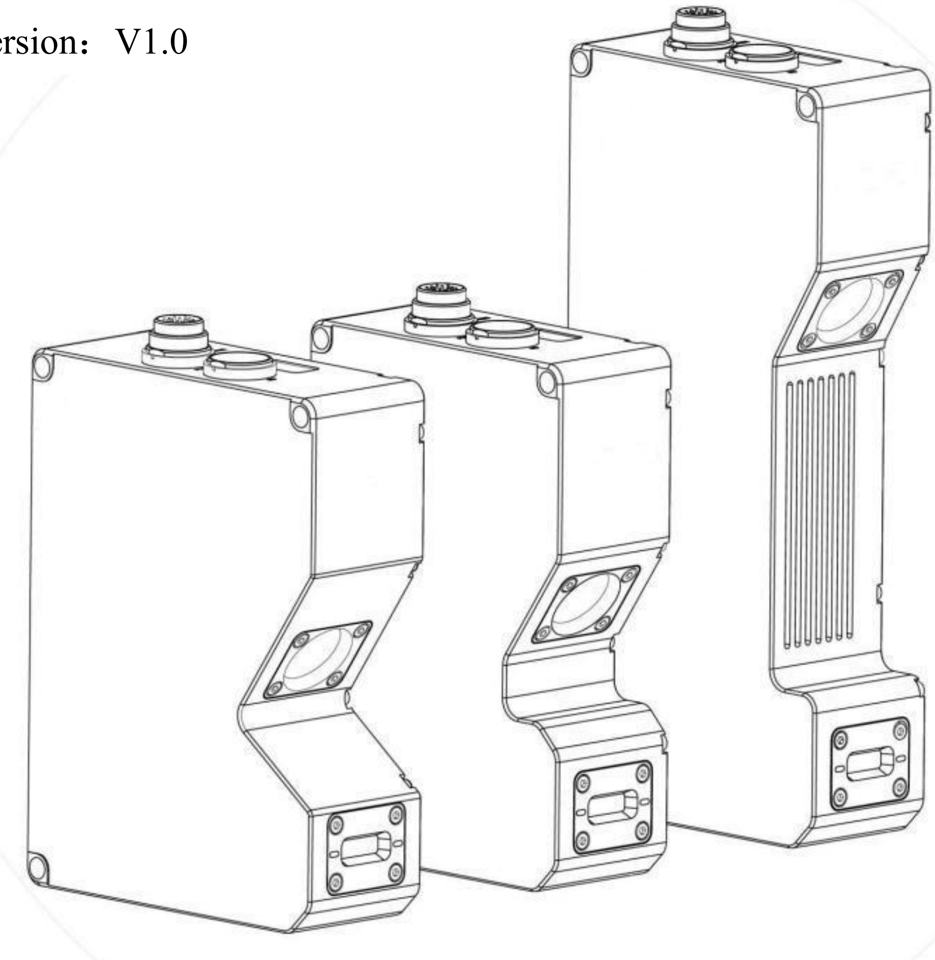
Laser Profile Sensor User Manual

Version：V1.0



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If printing or binding errors are found in this manual, please contact our company for replacement.

Contact information

Address: No.12 Saida Fourth Branch Road, Xiqing Economic Development Zone, Tianjin

Phone:400-652-5009

Email:sales@elco.cn

Please read this manual carefully before use and keep it properly for future reference.

If there is any unclear or difficult to understand content during reading, please contact us.

catalogue

1 Brief introduction

The intelligent laser contour sensor (hereinafter referred to as the sensor) is designed for 3D measurement and control applications in industrial automation scenarios. It can connect different input and output devices, providing users with fast and real-time measurement results. At the same time, it can convert the measurement results into digital output and be directly used for defect screening, marking, and other purposes on production lines.

This document introduces how to install, connect, configure, and use sensors, including the working principle, measurement range, resolution, and other parameters of the sensors, providing reference for user selection.

Applicable scope

This document applies to the following sensors:

- LVM2100 series
- LVM2200 series

Symbolic conventions

This document uses the following symbols to highlight key points. Please be sure to read and understand the meanings of these symbols.

⚠	Please follow these safety guidelines to avoid potential injury or property damage.
🗋	This information helps to better use the product.

2 Special instructions

2.1 Product warranty period and scope

We are committed to providing customers with the most perfect products and services possible. If you find any product malfunctions during use, please promptly confirm the symptoms and contact us.

Warranty period

The warranty period of this product is within one year from the date of purchase.

Product replacement

We can provide free replacement services for product malfunctions related to the manufacturer.

Note: The following situations are not covered by the warranty.

* Product malfunctions caused by non-standard use or handling.

* Unauthorized disassembly, modification, or repair of products.

* Product malfunction caused by other items.

* Product malfunctions caused by natural disasters.

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Article 8 Applicable Law

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3 Safety instructions

3.1 Laser safety

This product contains laser components. Depending on the product model, the laser level can be level 2, 2M, 3R, or 3B. Necessary protection should be taken according to the laser level during the use of this product.

* Laser level standard basis EN/IEC 60825-1:2014，Simultaneously referencing FDA（CDRH）， 21 CFR 1040.10.

General protection requirements for various levels of lasers:

- Please do not stare at the laser and mirror reflected light.
- Please do not intentionally point the laser towards people.
- Please pay full attention to the optical path of the laser. Laser can be specular or diffuse reflected. If there is a risk of being illuminated by reflected light, please use a baffle or other cover to cover the reflected light.
- Please do not set the laser path to human eye height.
- Turn off the laser promptly when the product is not in use.

2 Level laser description:

If the following operating conditions are met, the Level 2 laser component is considered safe.

- The user's blink reflex can terminate exposure (within 0.25 seconds).
- Users do not repeatedly observe the beam or reflected light.
- Exposure is only an accidental phenomenon.

2M Level laser description:

If the following operating conditions are met, the 2M level laser component should not cause permanent damage to the eyes.

- Do not allow the beam to enter areas where telescopic optical instruments such as telescopes and binoculars may be used.
- The user's blink reflex can terminate exposure (within 0.25 seconds).
- Users do not repeatedly observe the beam or reflected light.
- Exposure is only an accidental phenomenon.

3R Level laser description:

If a 3R level laser is directly observed in the beam, it may be injured, but compared to a 3B level laser, the risk of using a 3R level laser is lower. Compared to 3B level laser users, 3R level laser users require fewer manufacturing requirements and control measures.

- There is no need to wear eye protection equipment and protective clothing.
- Do not allow the beam to enter areas where telescopic optical instruments such as telescopes and binoculars may be used.
- The laser beam must be terminated at the end of the corresponding path.
- Avoid accidental reflections.
- Relevant personnel must undergo training before using laser equipment.

3B Level laser description:

Class 3B laser components can harm the human eye.

- Usually, only eye protection equipment is needed, and protective gloves may also need to be worn.
- Do not allow the beam to enter areas where telescopic optical instruments such as telescopes and binoculars may be used.
- If the observation distance is not less than 13 cm and the observation time does not exceed 10 seconds, diffuse reflection is safe.
- If the laser beam is irradiated on flammable materials, a fire may occur.
- The laser area must be clearly identified.
- Use button switches or other mechanisms to prevent unauthorized use.
- When using a laser, it should be indicated by a clear and visible indicator.
- The laser beam should be limited to the working area.
- Ensure that there are no reflective surfaces in the work area.

⚠ If the control or adjustment device is not used according to this regulation, or if various operations are carried out, it may cause harmful radiation exposure.

This product contains optical components, which may increase eye risk when used.

⚠ Laser radiation emitted through the laser aperture: wavelength 405nm, maximum output 0.844 MW. Exceeding Class I limit.

3.2 Electricity safety

⚠	Please follow the safety guidelines described in this section, otherwise it may cause electric shock or equipment damage.

Sensors and synchronization controllers should be grounded

All sensors and synchronous controllers (used in multi-sensor systems) should be grounded through their housings. All sensors and synchronization controllers should be installed on grounding brackets through conductive hardware or directly grounded through conductive hardware to ensure that the casing of the sensors and synchronization controllers is grounded. Please use a multimeter to check the continuity between the sensor connector or synchronization controller ground point and ground to ensure proper connection.

Minimize the voltage between system ground and sensor ground as much as possible

Please carefully reduce the voltage between the system ground (ground reference for I/O signals) and the sensor ground to the minimum. This voltage can be measured by measuring Analog_ out Determine the voltage between the out pin and system ground. The maximum allowable voltage is 12V, but it should be kept below 10V to avoid damaging the serial connection and encoder connection.

Using a suitable power supply

The +24 to +48 VDC power supply used for the sensor should be an isolated power supply with surge current protection or capable of handling high capacitance loads.

Please handle the powered equipment with caution

When the sensor is powered on, do not touch the wiring of the sensor, otherwise it may cause electric shock to the user or equipment damage.

3.3 High temperature warning

Do not touch the product while the equipment is in operation and not completely dissipating heat to avoid burns. To avoid burns and ensure the normal operation of the sensor, the sensor should be fixed to a thermal conductive material.

3.4 Environmental safety

static electricity

The sensor meets the EN61000-6-2:2006 standard in terms of anti-static performance. Please avoid installing the sensor in a location that is prone to generating static electricity.

electromagnetic interference

The sensor complies with EN55011:2016+A1-2017 Class A and EN61000-6-2:2006 standards in terms of electromagnetic compatibility. However, this does not guarantee that the entire system using this sensor can meet relevant standards. Whether the entire system can meet the standards should be confirmed by the user themselves. In addition, when using non-standard cables, please confirm whether the sensor meets relevant standards.

Vibration and shock

- Please avoid subjecting this product directly to strong vibrations or impacts, as this may result in electric shock or malfunction.
- If the measurement target experiences vibration, there may be deviations in the measurement values. Users can improve the accuracy of measurement results by increasing the average number of contours or increasing the average number of measurements.
- This product has passed industry vibration and impact testing, please refer to GB/T2423 for specific standards. This is a non repetitive test. Long term operation of products under the same harsh conditions may result in failure.

Temperature and humidity

The suitable working environment temperature for laser sensors is 0-50 ° C and a relative humidity of 25-85% (non condensing), and the storage temperature is -30-70 ° C.

The rated working environment temperature of the synchronous controller is also 0-50 ° C.

⚠	This product is a high-precision measurement equipment, and the internal temperature has an impact on the measurement accuracy. In order to achieve stable measurement, it is recommended to preheat the sensor for 1 hour after power on, and then perform the measurement operation after the internal temperature stabilizes.

Ambient light

The imaging device used in this product is sensitive to ambient light, so stray light may have adverse effects on measurement. Do not operate this product near windows or lighting fixtures that may affect measurement. If the product must be installed in an environment with strong ambient light, it may be necessary to install a light shield or similar equipment to prevent light from affecting the measurement.

3.5 Cleaning and Maintenance

Keep the sensor clean

- Dirty or damaged sensor windows (laser cables or cameras) can affect measurement accuracy. Please handle the sensor window carefully.
- Use dry and clean air to blow away dust or foreign objects. If there is still dirt, please use a lint-free cloth to

clean the window.

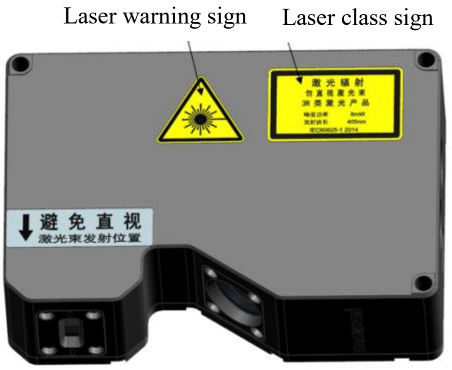
- When replacing window lenses, users should be careful not to allow dust to enter the interior of the product to avoid affecting measurement.
- Avoid direct contact with water, organic solvents, and other chemical reagents to avoid equipment damage and leakage.

Please turn off the laser when not in use

Semiconductor lasers are used in sensors. To maximize the lifespan of the sensor, please turn off the laser when not in use.

3.6 Warning label

ICE Warning label



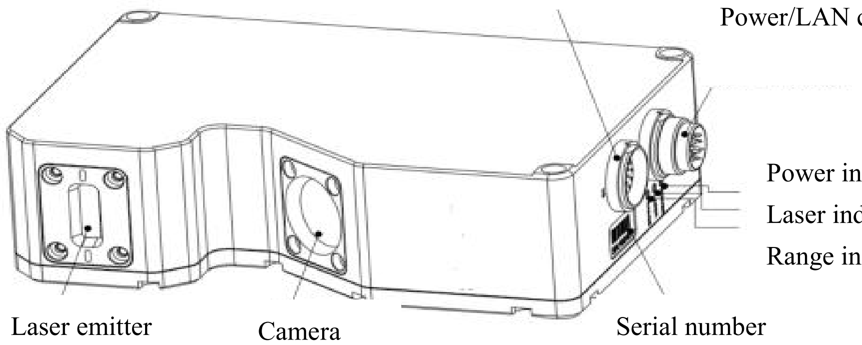
4 Getting Started

This section contains an overview of the system and hardware.

4.1 Hardware Overview

The following section introduces the hardware related to sensors.

4.1.1 Sensor



project	describe
Camera	Observing the laser reflected from the target surface
Laser emitter	Emission line laser
I/O connector	Receive input signals and output signals outward
Power/LAN connector	Receive power, synchronization control, and laser safety signals, and connect to an Ethernet network
Power indicator light	Illuminates when powered on (red)
Range indicator light	Illuminates when the target is within the measurement range of the sensor (green)
Laser indicator light	Illuminates when laser safety input is activated (blue)

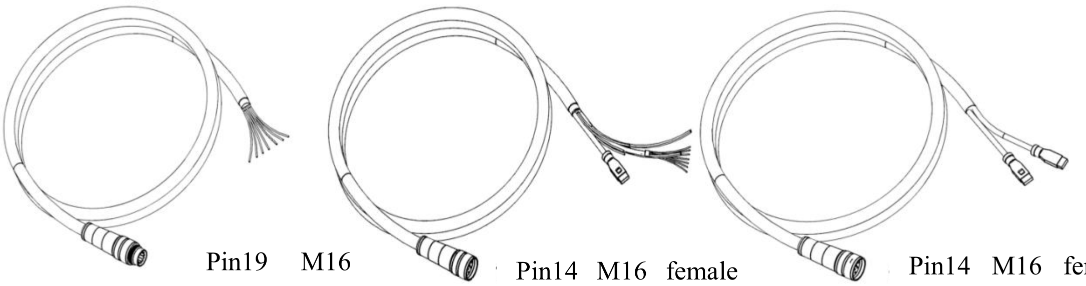
Serial number	Unique serial number of the sensor

4.1.2 Cable

Sensors use two types of cables: Power/Ethernet cables and I/O cables.

The Power/Ethernet cable is used to power sensors and achieve laser safety interlocking. It can also be connected to a 1000Mb/s Ethernet interface through a standard RJ45 connector for sensor communication. The Power/Ethernet cable (to the synchronization controller) can connect the sensor to the synchronization controller.

I/O cables are used to connect digital I/O, encoder interfaces, RS-485 serial port connections, and analog output.



■ **Power/Ethernet cables**

colour	Input/Output	explain
Black RJ45	/	GigE Vision
White, white to black	input	Power +
Brown, brown to black	input	Power -
Yellow	input	Laser safety +
Yellow to Black	input	Laser safety -

■ **Power/Ethernet cable (to synchronous controller)**

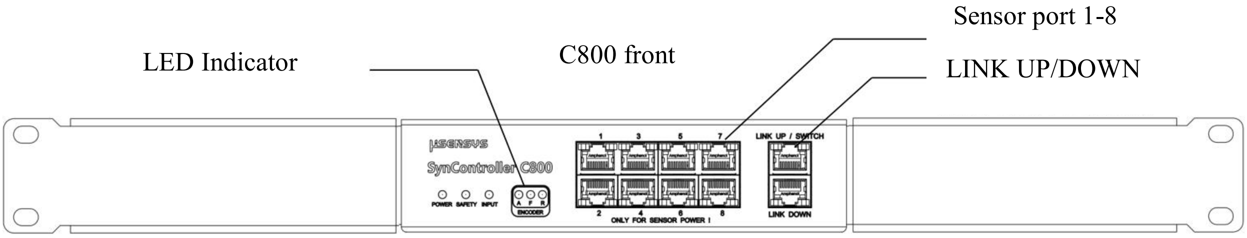
colour	Input/Output	explain
Black RJ45	/	GigE Vision
Red RJ45	/	Power supply, synchronization signal, laser safety signal

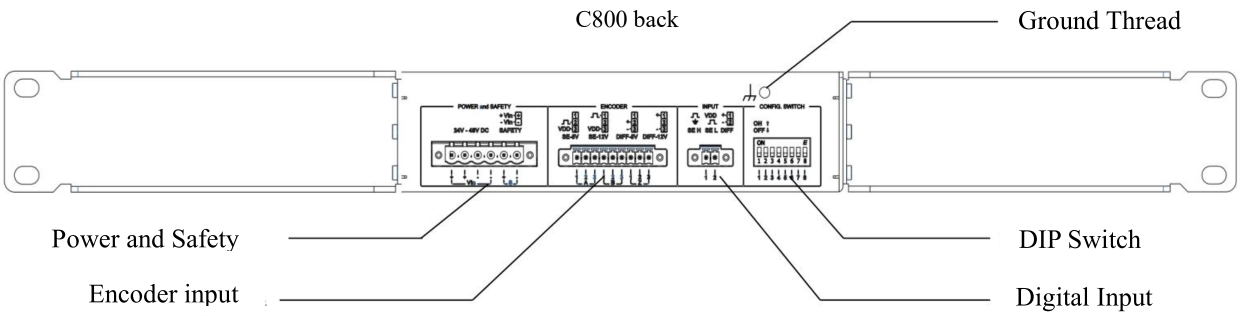
■ **I/O cable**

colour	Input/Output	explain
Red	output	Digital output 1-
Red to White	output	Digital output 1+
Blue	output	Digital output 2-
Blue to Black	output	Digital output 2+
Black	output	4-20mA Analog output
Black to White	/	GND
Green to Black	input	Encoder EZ+
Green	input	Encoder EZ-
Yellow	input	Encoder EB+
Yellow to Black	input	Encoder EB-
Purple	input	Encoder EA+
Purple to black	input	Encoder EA-
Brown	input	Serial port 1 input +
Brown to black	input	Serial port 1 input -
Gray	output	Serial port 1 output +
Gray to black	output	Serial port 1 output -
White	input	External trigger signal -
White to Black	input	External trigger signal +

4.1.3 Synchronous controller

When deploying a multi-sensor system, multiple sensors and synchronization controllers are required to form a multi-sensor network. The synchronization controller is used to power the sensors and broadcast synchronization information to all sensors in the network. The C800 model synchronous controller supports the connection of up to eight sensors. Multiple synchronous controllers can also be connected through their LINK UP and LINK DOWN ports to form a daisy chain structure, thereby supporting the integration of more sensors into the network.





project	**describe**
Sensor port	Connecting Sensors
LINK UP/DOWN	Synchronous controller access switch, connected with the switch
Ground Thread	Ground connection point
Power and Safety	Power and safety connections
Encoder input	Connect encoder signal
LED Indicator	Power supply, safety, input, encoder status
DIP Switch	Supports faster encoders

- **Interface definition**

project	**Pin**	**function**	**Remarks**
Power and Safety	1	Power In+	
	2	Power In+	
	3	Power In-	
	4	Power In-	
	5	SAFETY+	Require connection of 24-48VDC differential voltage
	6	SAFETY-	
Digital input	1	Input_Pin1	Please refer to the introduction of "Digital Input Signal" later for the wiring method
	2	Input_Pin2	
Encoder input	1	Encoder_A_Pin1	Please refer to the introduction of "Encoder Signal" later for the wiring method
	2	Encoder_A_Pin2	
	3	Encoder_A_Pin3	
	4	Encoder_B_Pin1	
	5	Encoder_B_Pin2	
	6	Encoder_B_Pin3	
	7	Encoder_Z_Pin1	
	8	Encoder_Z_Pin2	
	9	Encoder_Z_Pin3	
DIP Switch	1	Set the frequency divider for encoder orthogonal frequency. Output orthogonal frequency=Input orthogonal frequency/Divider	A frequency divider must be set to output orthogonal frequencies; Not exceeding 300kHz
	2		
	3		

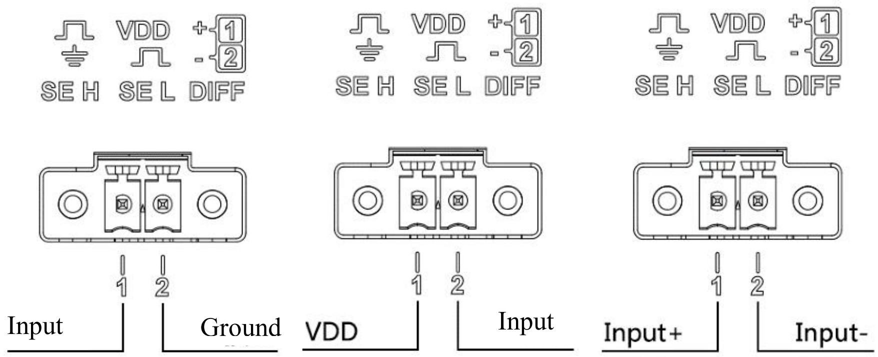
	4	Reserved	
	5		
	6		
	7		
	8		
Sensor Port	Connecting to sensors		No specific order required
LED Indicator	Indicates the status of power supply, safety, input, and encoder		
LINK UP	① Used to connect with a synchronous controller, forming a daisy chain. ② Used for accessing Ethernet.		Use a universal network cable，100Mbps
LINK DOWN	Used to connect to the next synchronization controller, forming a daisy chain.		Use a universal network cable

- **Electrical characteristics**

specifications	value
Supply voltage	+24VDC to +48VDC
Power supply current (maximum)	8.5A (Each sensor port is fully loaded with 1A)
Power consumption (minimum)	2.7W (excluding power consumption of sensors)
Safe input voltage range	+24VDC to +48VDC
Encoder signal voltage	Single ended （5VDC、12VDC） Differential （5VDC、12VDC）
Digital input voltage range	Single ended effective low level: 0 to +0.8 VDC Single ended effective high level:+3.3 to +24 VDC Voltage differential low level: 0.8 to -24 VDC

	Voltage differential high level:+3.3 to +24 VDC (When the input voltage is above 24V, an external series resistor needs to be used)

■ **Digital input signal**



Single effective high-voltage Single effective low-voltage Differential

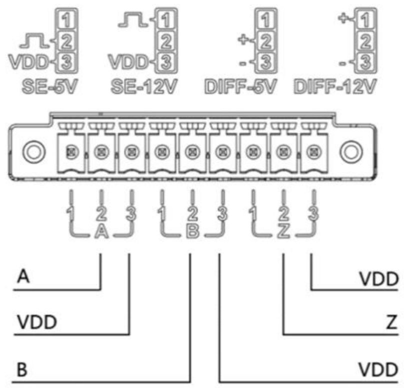
Voltage range of digital input

	Input Status	**minimum value（VDC）**	**Maximum value（VDC）**
Single effective high-voltage	Disconnect	0	+0.8
	Connect	+3.3	+24
Single effective low-voltage	Disconnect	（VDD - 0.8）	VDD
	Connect	0	VDD-0.3
Differential	Disconnect	-24	+0.8
	Connect	+3.3	+24

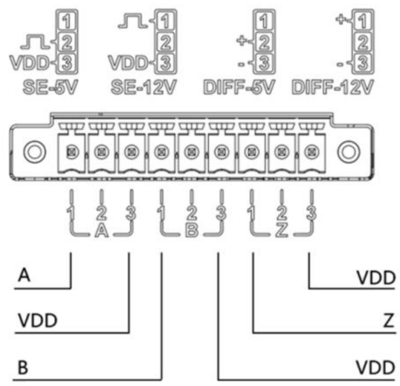
	If the input voltage is higher than 24 V, please use an external resistance, and the resistance calculation formula is R = [（Vin - 1.2V） / 10mA] – 680ohm。

■ **Encoder signal**

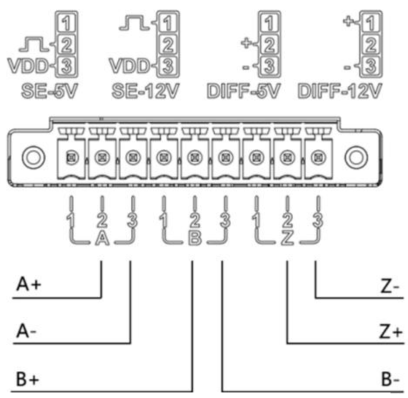
The synchronous controller supports access to single ended (5 VDC, 12 VDC) and differential (5 VDC, 12 VDC) encoder signals. For a 5 VDC encoder signal, it needs to be connected through pins 2 and 3 of each channel; For a 12 VDC encoder signal, it needs to be connected through pins 1 and 3 of each channel. The specific connection method is shown in the following figure.



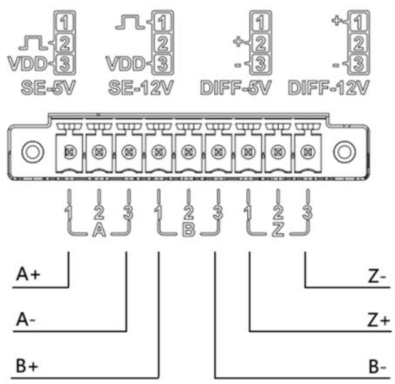
Single 5 VDC



Single 12 VDC



Differential 5 VDC



Differential 12 VDC

Set the frequency division coefficient through the DIP switch to ensure that the encoder frequency used inside the synchronization controller does not exceed 300KHz.

Frequency divider	**DIP switch 1**	**DIP switch 2**	**DIP switch 3**
1	Disconnect	Disconnect	Disconnect

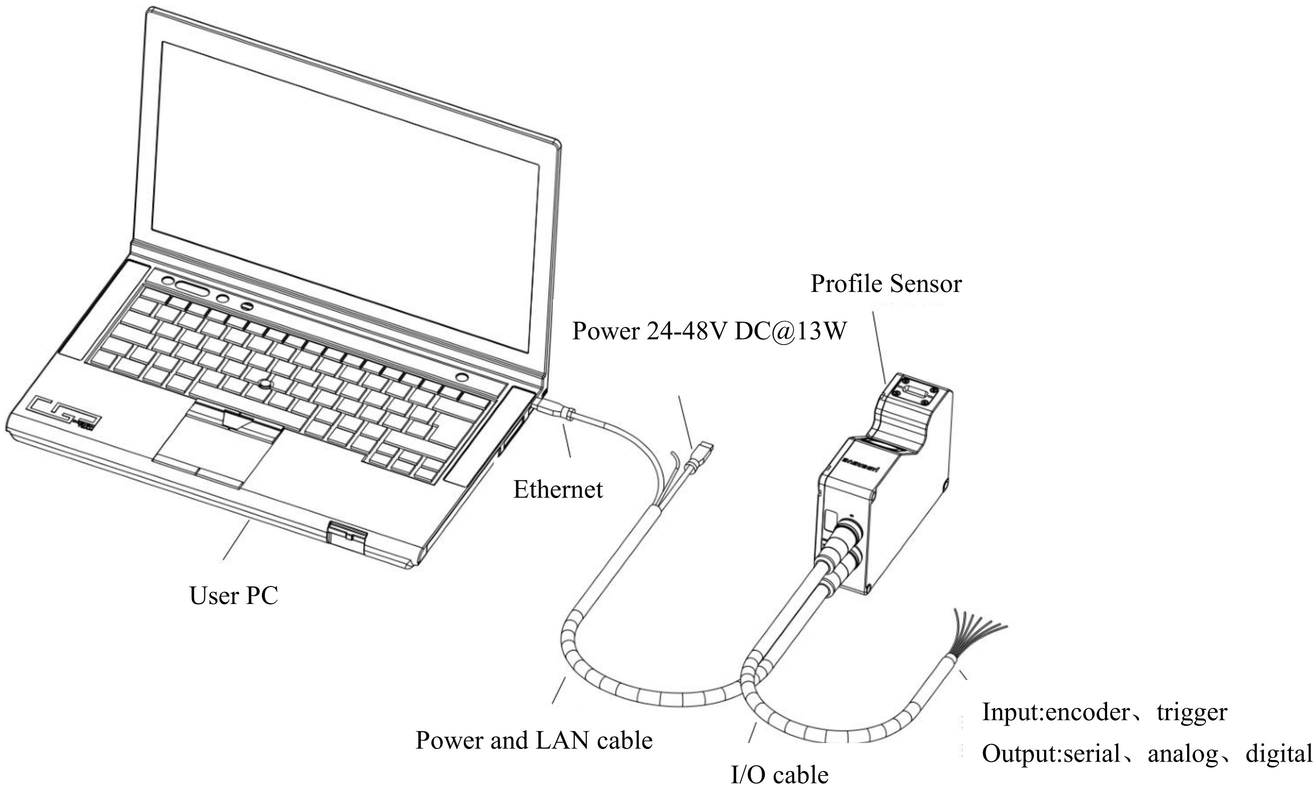
2	Connect	Disconnect	Disconnect
4	Disconnect	Connect	Disconnect
8	Connect	Connect	Disconnect
16	Disconnect	Disconnect	Connect
32	Connect	Disconnect	Connect
64	Disconnect	Connect	Connect
128	Connect	Connect	Connect

4.2 System Overview

Sensors can be connected as independent devices or as multi-sensor systems.

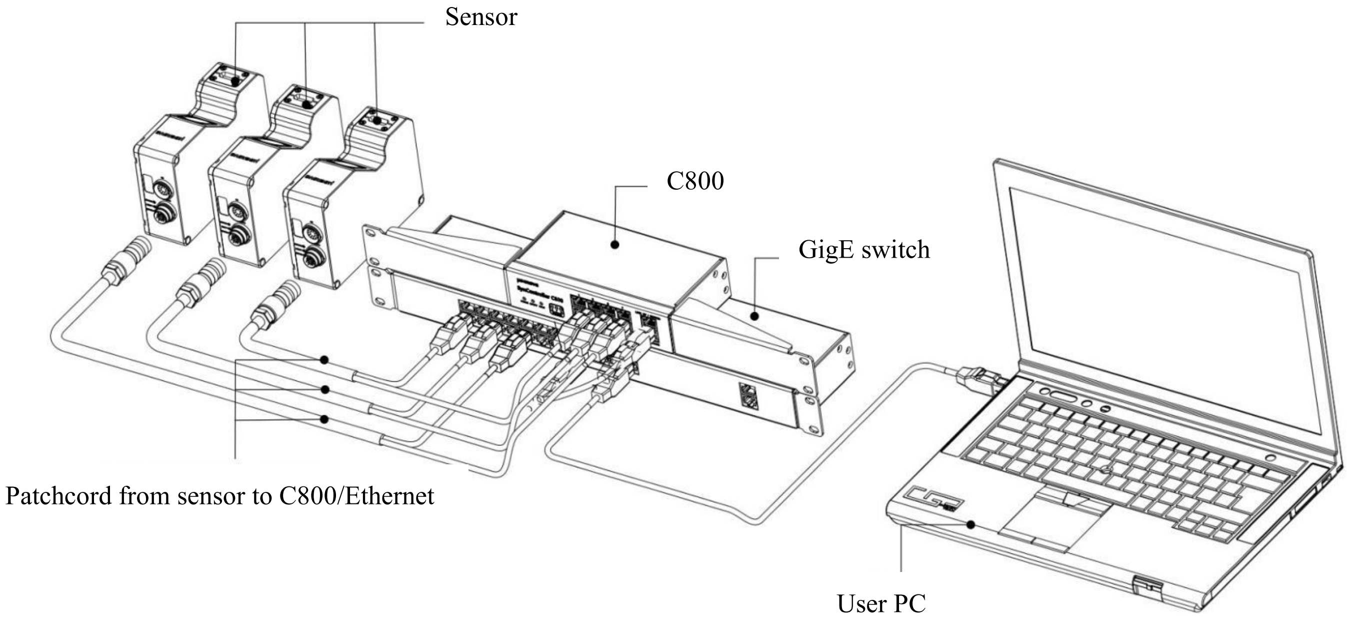
4.2.1 Single sensor system

When a single sensor can meet the measurement requirements, a single sensor system is usually chosen. The device can be connected to the Ethernet port of the computer for setting, as well as to devices such as encoders, photocells, or PLCs.



4.2.2 Multi sensor system

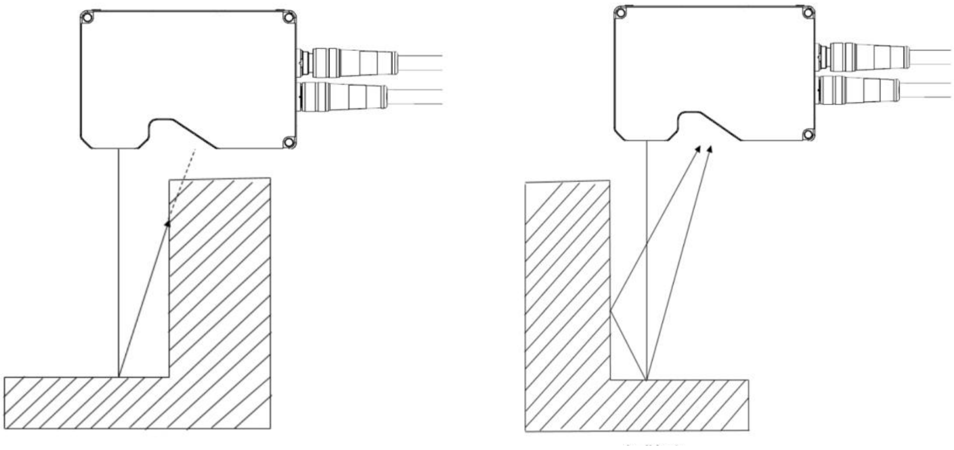
For some complex application requirements, multiple sensors usually need to work together to complete measurement tasks. One sensor serves as the main sensor for implementing global control and outputting the final results, while the other sensors serve as auxiliary sensors to collect local data. Each sensor is connected to the synchronization controller through a dedicated cable for the synchronization controller, which achieves precise synchronization of scanning timing between each sensor. Sensors, synchronization controllers, and client computers communicate through Ethernet switches (recommended Gigabit Ethernet switches).



4.3 Installing sensors

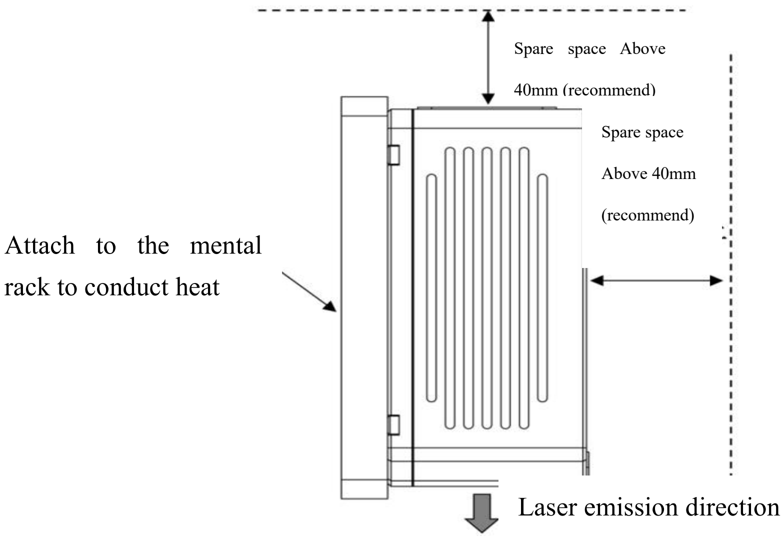
Before installation, users need to first confirm the product size, net installation distance, and operational space of the installation tools to ensure proper installation and that the tested object is within the measurement range indicated by this product.

During installation, it should be avoided that the laser reflected by the tested object is obstructed by the object itself or other objects, which may cause the sensor to be unable to receive the reflected light. Avoid installing in areas that may generate stray light.



Blocked　　　　Stray light

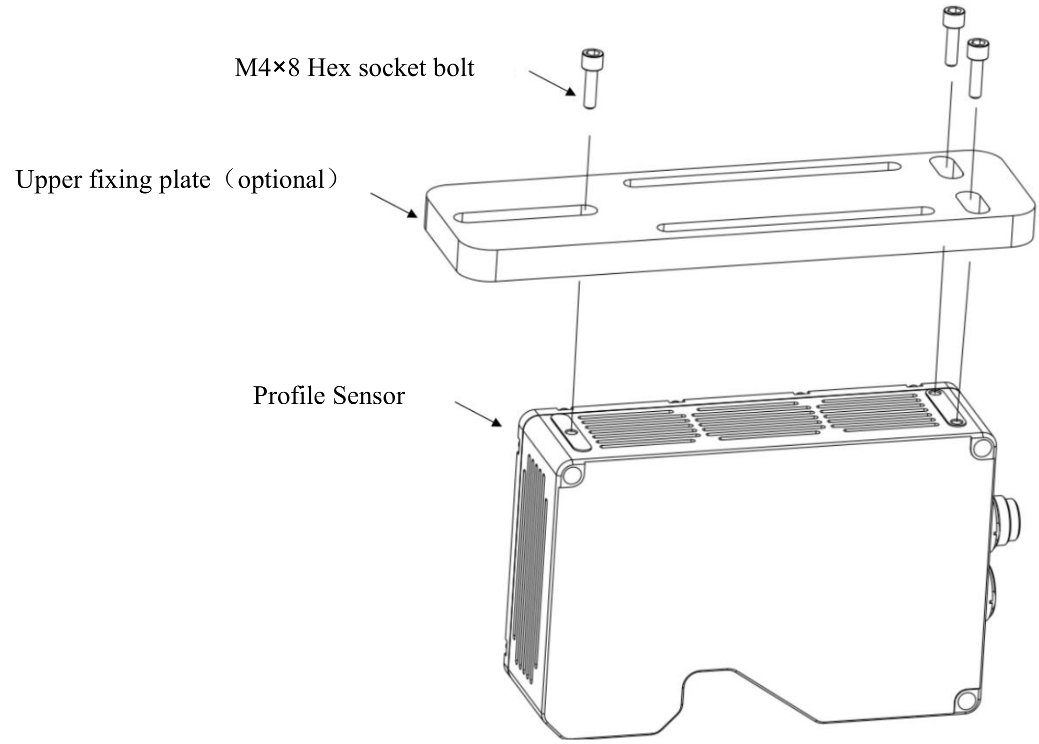
When installing sensors, ensure that sufficient space is reserved around the sensor to achieve good heat dissipation.



4.3.1 Top Mount

After adjusting the distance between the sensor and the object to be tested, fix it with three M4 screws.

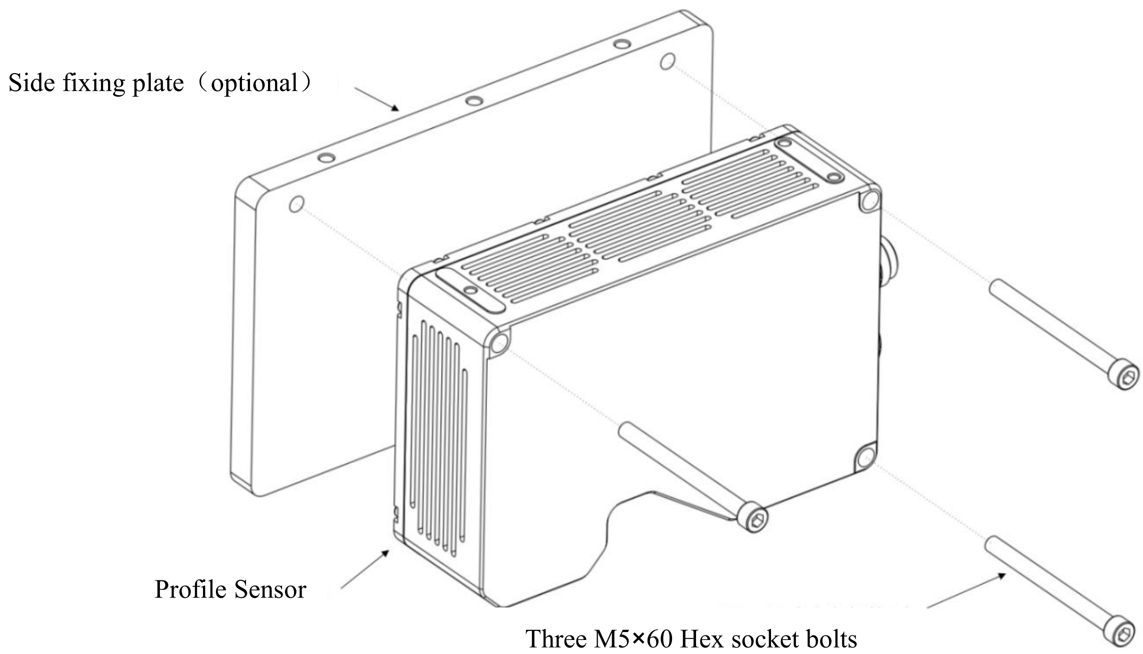
Choose whether to order a fixed plate (metal plate) based on the hole position of the installation position and the hole position of the sensor.



4.3.2 Side Mount

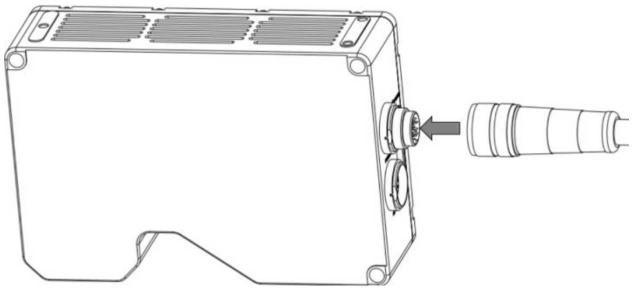
After adjusting the distance between the sensor and the measurement object, fix it with three M5 screws.

Choose whether to order a side fixing plate (metal plate) based on the hole position of the installation position and the hole position of the selected sensor.

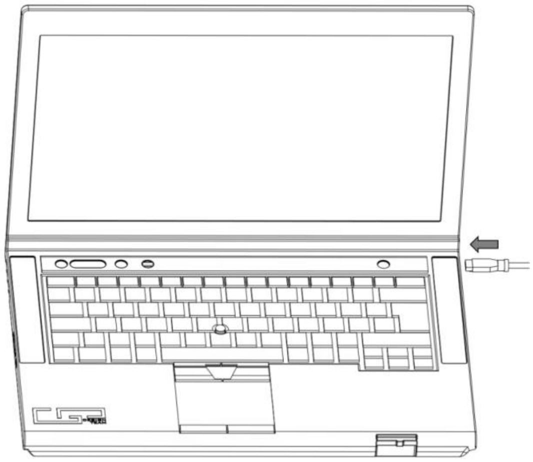


4.3.3 Connects Cables

（1） Connect the female end of the power/Ethernet cable to the power/LAN connector on the sensor.

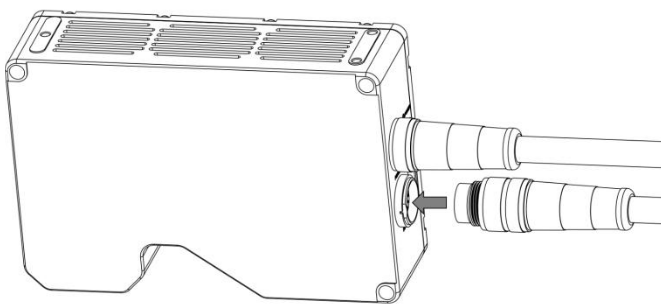


（2） Connect the RJ45 plug of the above cable to the PC or switch.

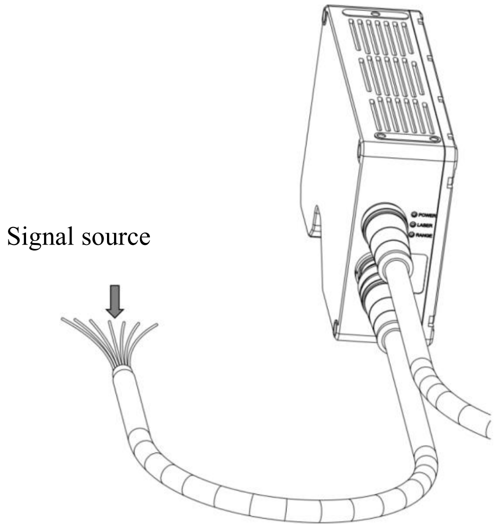


（3） Connect the power lead of the above patch cord to a suitable power source.

（4） Connect the male end of the I/O cable to the I/O connector on the sensor.



（5） Connect the leads of the required signals to the signal source.



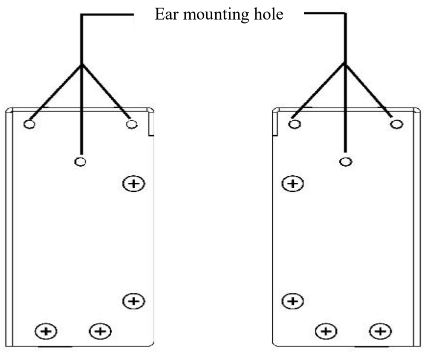
> The sensor should be grounded to the ground/rack through the shell and the shielding layer of the "power/Ethernet cable" or "power/Ethernet cable (to synchronous control)" and I/O cable. The sensor is designed to be fully grounded by installing screws. Be sure to use a multimeter to check the grounding and ensure the electrical connection between the mounting bracket and the sensor connector.

4.4 Installing the synchronization controller

The synchronous controller supports rack or DIN rail installation (optional).

4.4.1 Rack installation

Install the synchronization controller using the ear bracket provided with the synchronization controller, locate the mounting hole on the side of the synchronization controller (supports M3 × 6 screws), as shown in the following figure.

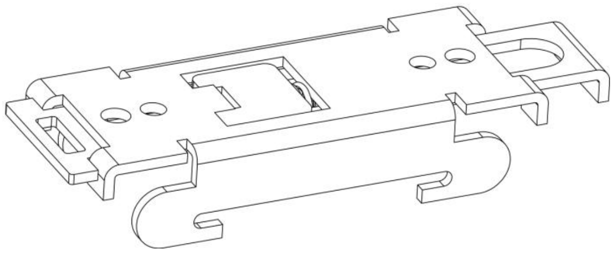


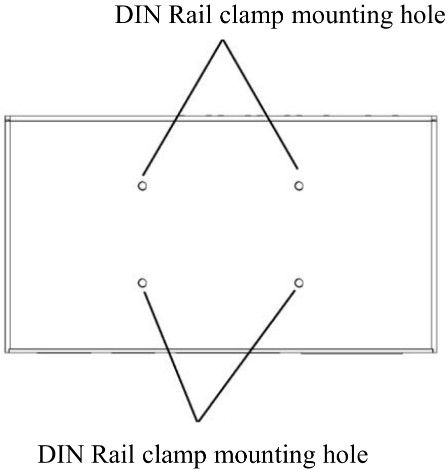
C800 side

The grounding wire can be connected to any installation hole in the upper figure to ensure the correct grounding of the synchronous controller. Be sure to use a multimeter to check the grounding and ensure that the electrical connection between the ear stand and the RJ45 connector of the synchronization controller is intact.

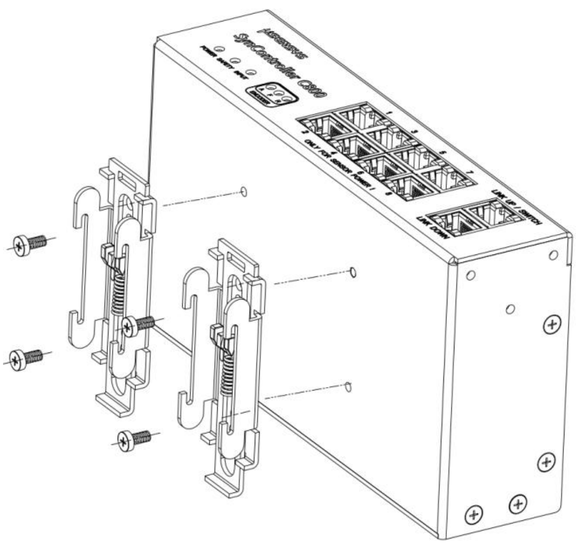
4.4.2 DIN DIN-Rail Mounting

You can use DIN rail clamps to fix and install the synchronization controller, and find the installation hole on the back rail clamp of the synchronization controller (supporting M3 × 6 screws), as shown in the following figure.

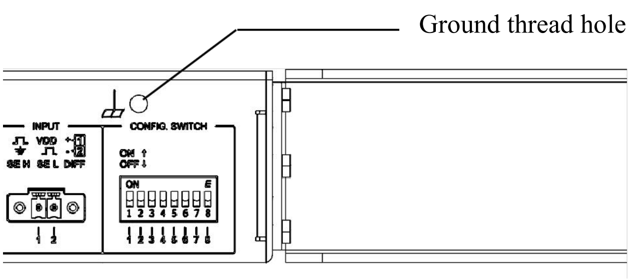




Clamp the two DIN rails with M3 × Install the 6 screws on the back of the synchronization controller, as shown in the following figure.

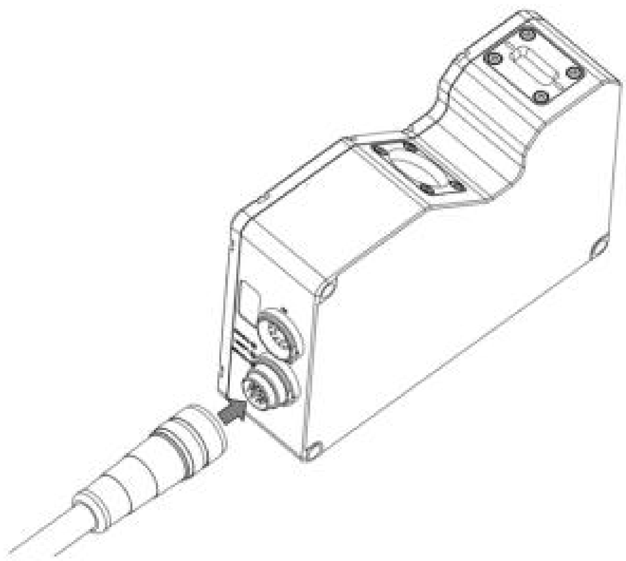


The grounding wire can be connected to any installation hole in the upper figure to ensure the correct grounding of the synchronous controller. You can also connect the grounding wire to the threaded hole marked with the grounding symbol on the back of the synchronous controller housing, which supports M3 × 6 screws.

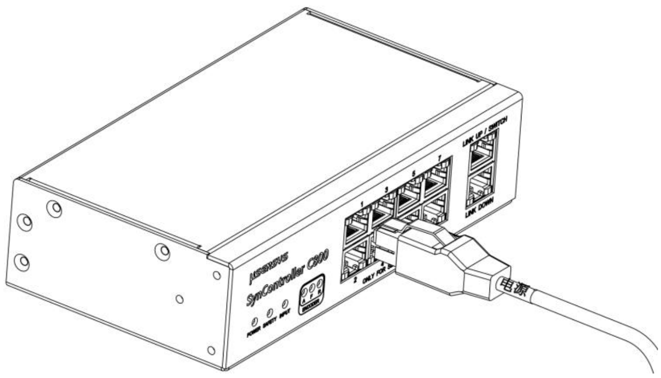


4.4.3 Connects Cables

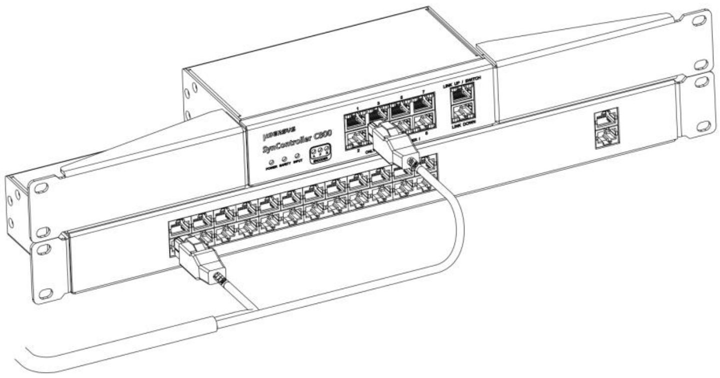
（1） Connect the female end of the power/Ethernet (to synchronous controller) cable to the power/LAN interface of the sensor.



（2） Connect the RJ45 plug labeled as' power 'on the above cable to any port labeled 1-8 on the synchronization controller.

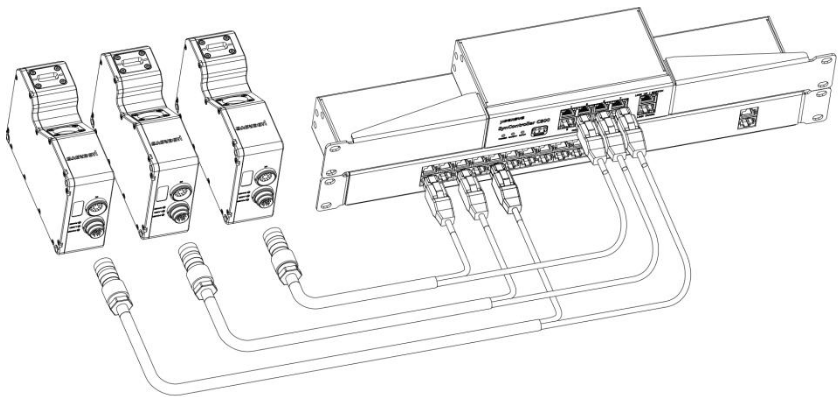


（3） Connect the RJ45 plug labeled as Ethernet on the above cable to the switch.

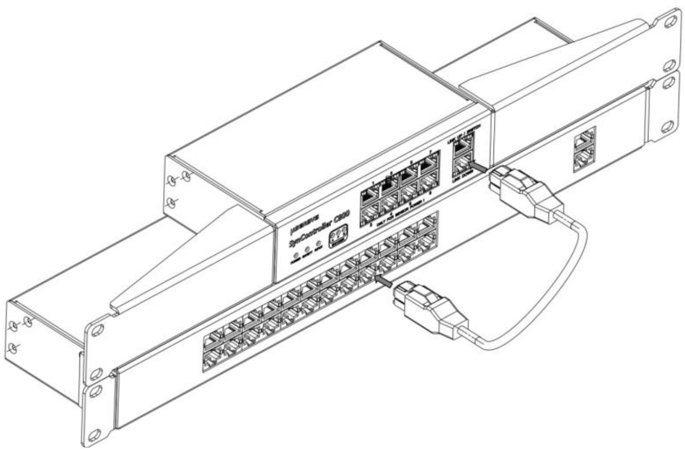


⚠ Please carefully check the RJ45 plug markings, as reverse connections may cause equipment damage.

（4） Repeat the above steps for each sensor to be connected.



（5） To connect the synchronization controller to Ethernet, connect one end of the network cable to the LINK UP port of the synchronization controller and the other end to the switch.



Both sensors and synchronous controllers should be connected to the ground/rack through the grounding shield of the enclosure and power/Ethernet patch cords. Be sure to use a multimeter to check the grounding.

（6） Connect the power cord to the connector labeled 'POWER and SAFETY' on the rear panel of the synchronization controller, and connect the necessary I/O signals to the connectors labeled 'ENCODER' and 'INPUT' on the rear panel of the synchronization controller.

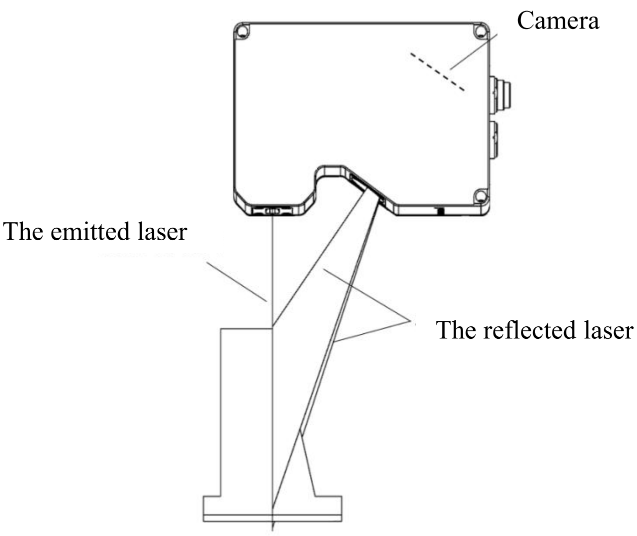
5 Operational principle

This section introduces how sensors acquire and generate data, measure parts, and output results.

5.1 data acquisition

5.1.1 Basic measurement principles

The sensor is based on the principle of triangulation to achieve high-precision three-dimensional measurement. The laser emission line inside the sensor irradiates the surface of the target to be tested, and the camera inside the sensor obtains the laser reflected back from the target surface from an angle. Due to the different distances from the target to the sensor, the reflected laser will fall at different positions in the camera's imaging area. The laser emitter of the sensor, the camera, and the target to be tested form a triangle. By using pre calibrated sensor parameters from the factory, the height of each point on the laser contour formed by laser irradiation on the target surface can be calculated, which is 3D contour data, and then contour measurement can be carried out.



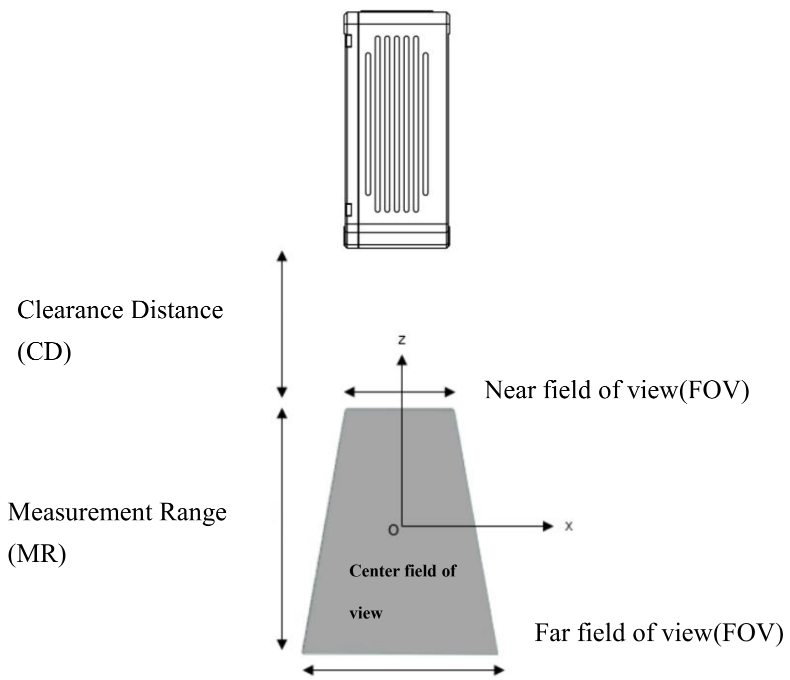
The laser profile

By installing sensors above the conveyor belt, continuous scanning of moving targets on the conveyor belt can be achieved, obtaining a series of 3D contour data. Additionally, sensors can be installed on the robotic arm to achieve continuous scanning of stationary targets and obtain a series of 3D contour data. Through data stitching, point cloud data of the entire scanned surface can be obtained for surface measurement.

5.1.2 Net distance, measurement range, and field of view

Understanding the concepts of clear distance (CD), measurement range (MR), and field of view (FOV) is helpful for sensor selection and installation.

concept	describe
Net distance	The shortest distance between the target to be tested and the sensor. If the distance between the target and the sensor is less than this value, valid data cannot be obtained.
measuring range	A vertical distance from the end of the net distance, within which the target can be scanned and measured. If the target exceeds the measurement range, effective data will not be obtained.
field	The width along the X-axis, which is the direction of the laser line, within the measurement range. At the far end of the measurement range, the field of view is wider, but the resolution in the X and Z directions is lower. At the near end of the measurement range, the field of view is narrower, but the resolution in the X and Z directions is higher. If resolution is crucial, it is recommended to bring the target closer to the near end.

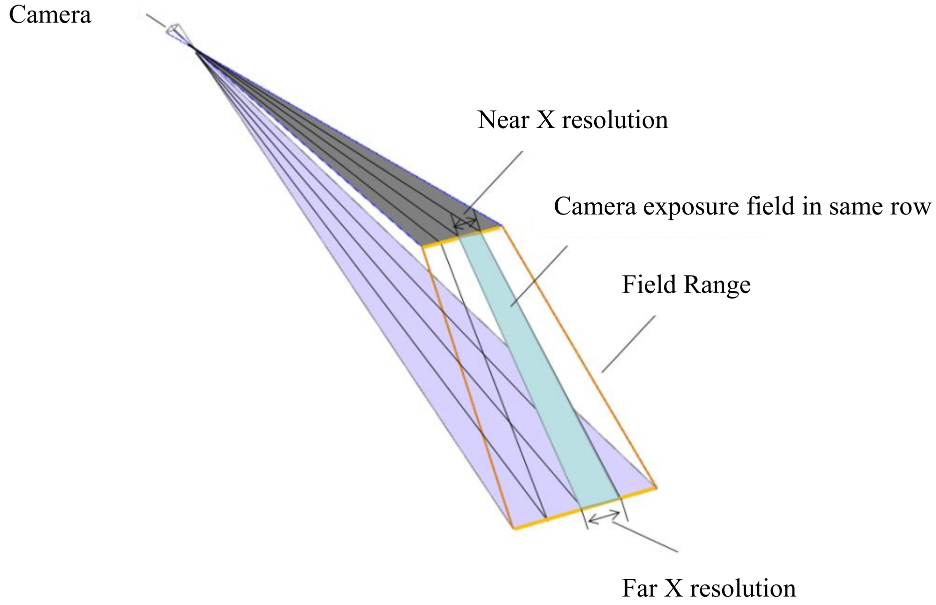


5.1.3 Resolution and accuracy

Resolution and accuracy are key indicators for sensor selection, representing the measurement capability of the sensor.

■ **X Directional resolution**

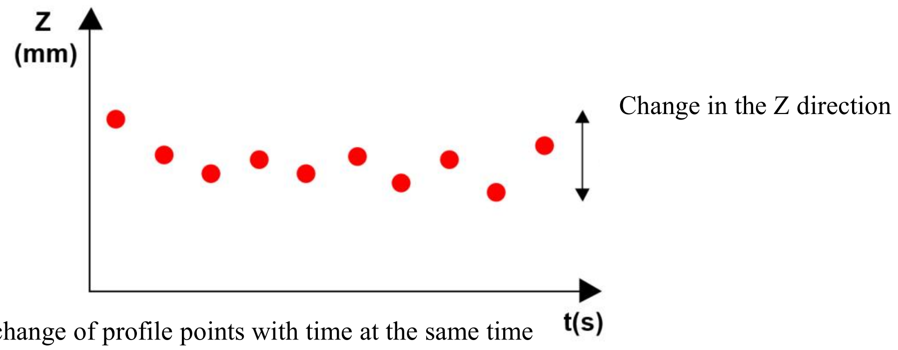
X Directional resolution refers to the horizontal distance between measurement points along the laser line, which depends on the resolution of the built-in camera of the sensor and the field of view of the sensor. Due to the fact that the field of view is a trapezoidal area (as shown in the orange wireframe in the figure below), the closer it is to the near end, the smaller the distance between points, i.e. the higher the resolution in the X direction, the closer it is to the far end, and the greater the distance between points, i.e. the lower the resolution in the X direction.



The X-direction resolution is an important parameter for selecting a sensor model. Users need to first clarify the accuracy requirements of the measurement task, then determine the X-direction resolution based on the accuracy requirements, and then select the appropriate sensor.

■ **Z Directional resolution**

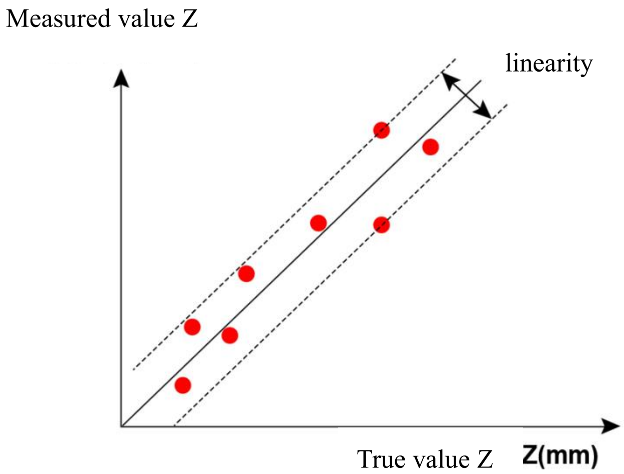
The Z-direction resolution represents the minimum detectable height difference at each point, reflecting the highest measurement accuracy of the sensor in the Z-direction. When the relative position of the tested target and the sensor is stationary, due to internal electronic components of the sensor, there may be slight jitter in the data collected at different times at the same position. This jitter determines the resolution in the Z direction, and the smaller the jitter, the higher the resolution in the Z direction. Similar to the resolution in the X direction, the closer the sensor is, the higher the resolution in the Z direction.



The change of profile points with time at the same time

■ **Z Directional Linearity**

Z-direction linearity refers to the difference between the true value and the actual measured value within the measurement range, representing the absolute distance measurement capability of the sensor. In the most ideal state, the measured value is equal to the true value. If the true value is used as the X-axis and the measured value is used as the Y-axis, a straight line with a slope of 1 and an intercept of 0 will be obtained. However, in reality, there is a certain deviation between the measured value and the true value. Multiple measurements are taken from the near end to the far end, and the true value and measured value are recorded. As shown in the following figure, the farthest distance d1 from the point above the line to the ideal line and d2 from the point below the line to the ideal line are calculated. The calculation method for Z-direction linearity is La=(d1+d2)/MR, and the results are expressed in percentage form, Where MR is the measurement range.



■ **Z Direction repetition accuracy**

The Z-direction repetition accuracy refers to the average height of a flat target tested at the mid range within the measurement range, and the variation in the average height of 4096 frames tested repeatedly.

5.2 Outline output

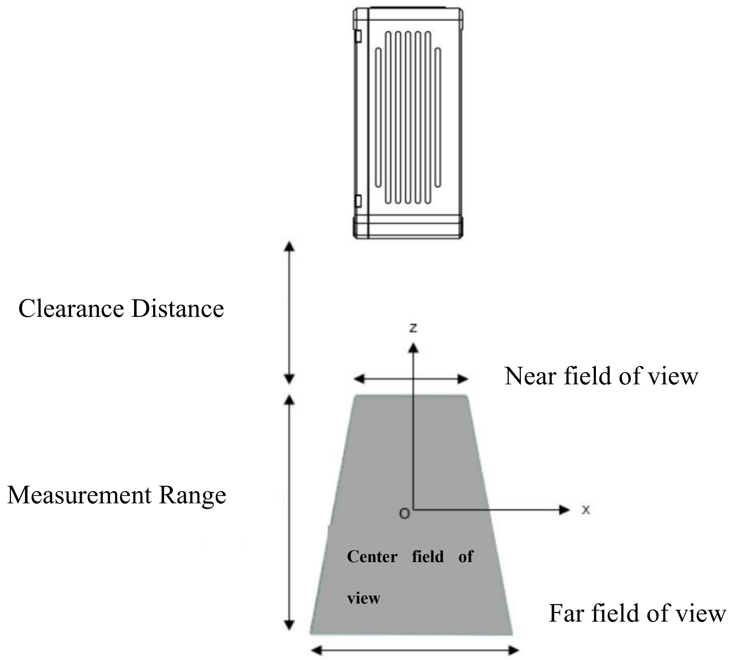
Sensors can output contour information composed of a series of data points. The data point is described by coordinates (X, Z), representing its position in the sensor field of view.

5.2.1 Coordinate system

The coordinates of data points can be reported using the following two coordinate systems, depending on whether the sensor has been calibrated.

- **Sensor coordinate system**

Uncalibrated sensors use sensor coordinates. The X-axis represents the field of view (FOV) direction of the sensor, the Z-axis represents the measurement range (MR) direction, and the Y-axis represents the movement direction of the measurement target. The system coordinate system adopts a left-hand coordinate system, with the origin of the coordinate system located at the center of the measurement range and field of view. The coordinate system seen from the perspective of the front end of the sensor, which is near the laser end, is shown in the following figure.



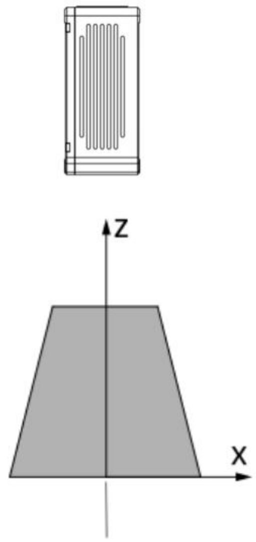
- **System coordinate system**

After the sensor is calibrated, the data point coordinates are transformed from the sensor coordinates to the system coordinates. The transformation from the sensor coordinate system to the system coordinate system mainly includes X-axis offset, Z-axis offset, Y-axis offset, as well as X-axis rotation angle, Z-axis rotation angle, and Y-axis rotation angle.

（1）X-axis offset calibration: By calibrating, the X-axis of the system coordinate system is parallel to the calibration target point cloud.

（2）Z-axis offset calibration: By calibration, the Z-axis origin of the system coordinate system is located at the bottom of the calibration target.

For calibration of a single sensor, installation errors can be compensated and a reference plane can be set, such as a conveyor belt plane.

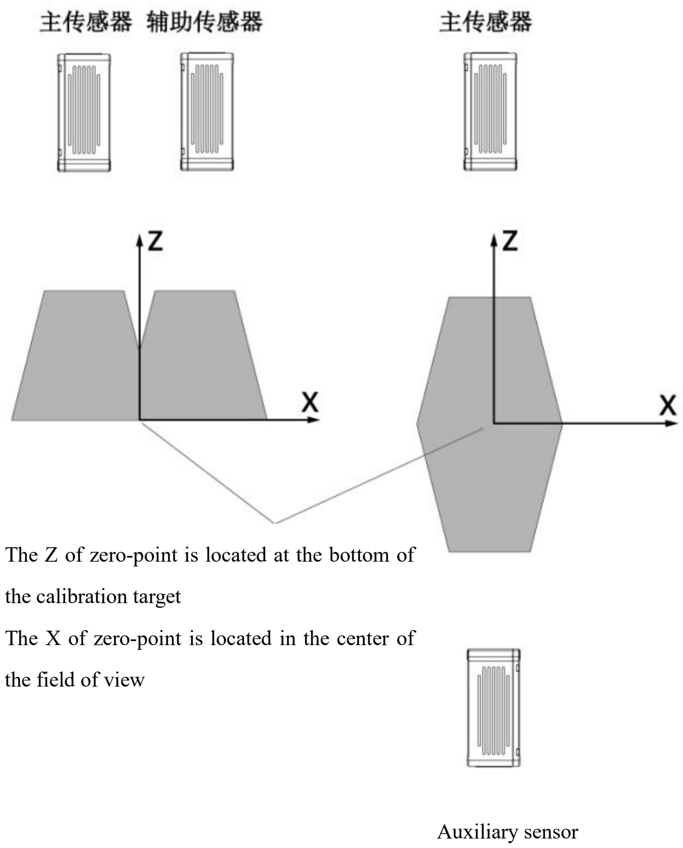


The Z of zero-point is located at the bottom of the calibration target

The X of zero-point is located in the center of the field of view

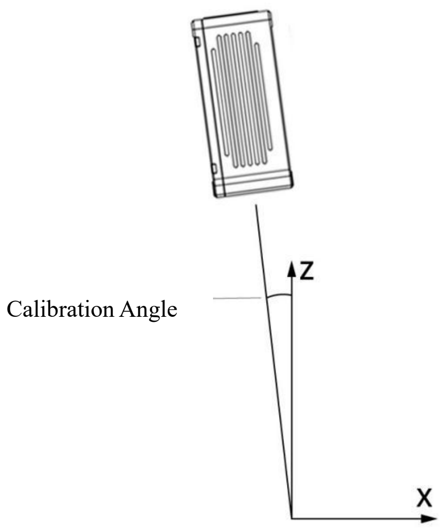
For multi-sensor systems, it is necessary to calibrate all sensor coordinate systems to a common coordinate system, so that the data collected by all sensors is represented in a unified coordinate system.

Primary sensor Auxiliary sensor Sensor

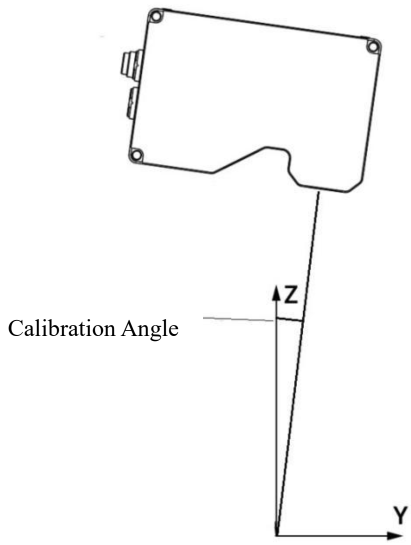


（3）Y-axis offset calibration: Determine the offset between multiple sensors along the Y-axis direction, i.e. the conveyor belt direction, through calibration, suitable for parallel and staggered layout of multiple sensors in point cloud mode.

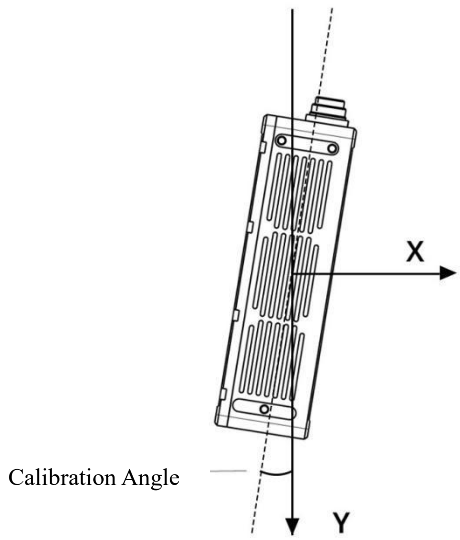
（4）Y-axis rotation calibration: Determine the rotation angle of the X-Z plane around the Y-axis, also known as rolling calibration.



（5）X-axis rotation calibration: Determine the rotation angle of the Y-Z plane around the X-axis, also known as pitch calibration. When measuring surfaces with severe mirror reflection, inclined installation is usually used, in which case X-axis rotation calibration is required.



（6）Z-axis rotation calibration: Determine the rotation angle of the X-Y plane around the Z-axis, also known as deflection calibration.



> Y-axis offset, X-axis rotation, and Z-axis rotation calibration are used in point cloud mode, where X-axis rotation and Z-axis rotation calibration will cause an increase in CPU load during scanning, thereby reducing the maximum scanning speed. It is recommended to adjust the sensor installation structure as much as possible to achieve the measurement accuracy required by the task without calibrating the X and Z axis rotation.

- **Sample coordinate system**

In point cloud mode and with sample detection enabled, the sample coordinate system can be used. Use the center of the sample as the origin of the X and Y axes. If the sensor system is not calibrated, use the center of the measurement range as the origin of the Z axis. If the sensor system is calibrated, use the bottom surface of the calibration target as the origin of the Z axis.

- **Cross section coordinate system**

In point cloud mode, any cross-section can be selected to measure the profile in the cross-section. The center of the cross-section profile is used as the X-axis origin. If the sensor system is not calibrated, the center of the measurement range is used as the Z-axis origin. If the sensor system is calibrated, the bottom surface of the calibration target is used as the Z-axis origin.

5.2.2 Contour point cloud data

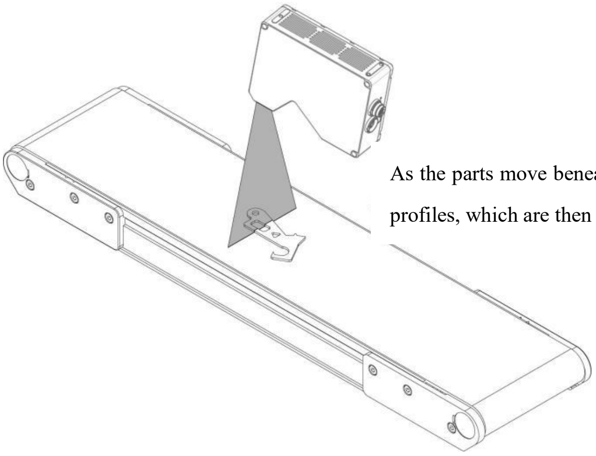
The contour point cloud data obtained in contour mode includes two types: resampled point cloud data and original point cloud data. Resampling point cloud data with uniform spacing in the laser line or X-axis direction is beneficial for simplifying subsequent contour measurement algorithms, but resampling will increase CPU load and reduce maximum scanning speed (without external hardware acceleration). The original point cloud data is not resampled and does not increase CPU load. It is suitable for scenarios that require high-speed scanning and data transmission to external PCs for processing.

When the sensor scans the side of the target, if the tilt angle increases, there will be a loss of side point data after resampling. In this case, the uniform spacing option can be disabled, and all side point data will be retained in the original point cloud data.

5.3 Surface point cloud generation and sample detection

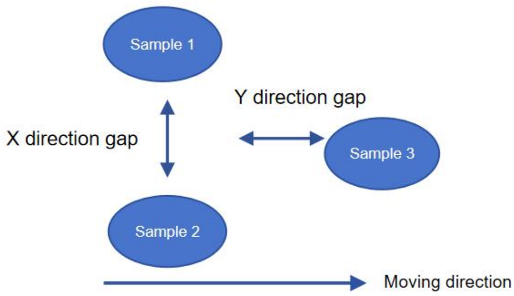
5.3.1 Surface point cloud generation

When the target moves on the conveyor belt where the sensor is installed or the robotic arm drives the sensor to scan the target, the sensor generates a series of contour point clouds, which, after splicing, will generate the entire scanned surface point cloud. For detailed information, please refer to the introduction of point cloud generation in section 6.6.6.



5.3.2 Sample detection

When there are multiple independent samples in the scanned area, automatic detection can be used to segment the point clouds of each sample and measure each sample point cloud. For detailed information, please refer to the introduction of 6.6.7 Sample Detection section.



5.4 Measure

After scanning to generate a contour or surface point cloud, the sensor will measure the scanned data. The sensor is equipped with various contour and surface point cloud measurement tools, each of which can be independently executed and produce measurement results.

5.4.1 Measurement tool chain

Sensors support connecting multiple measurement tools together to form a measurement tool chain, where the output of one measurement tool serves as the input of another measurement tool. For example, the Z-highest point in the contour obtained by "Position Tool 1" and the Z-lowest point in the contour obtained by "Position Tool 2". By referencing the measurement results of these two position tools in "Size Tool", the distance between the Z-highest point and the Z-lowest point in the contour can be obtained.

In complex measurement tasks, the measurement tool chain is very useful for achieving flexible and customized measurements.

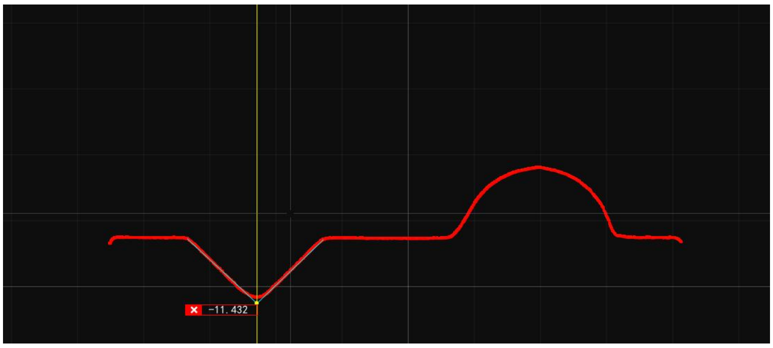
5.4.2 Tool Data

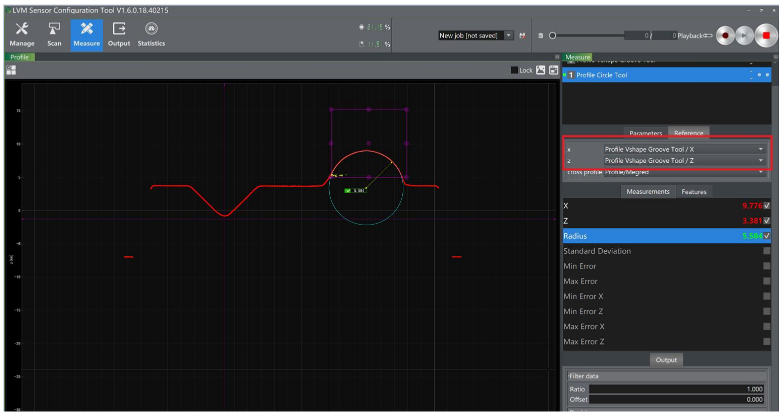
In addition to generating measurement results, measurement tools can also generate new contour and surface point cloud data, such as differential contours generated after matching with contour templates or corrected surfaces generated by surface tools. The point cloud data generated by measurement tools is called tool data, and like the data generated by scanning, it can be used as input for other measurement tools for measurement.

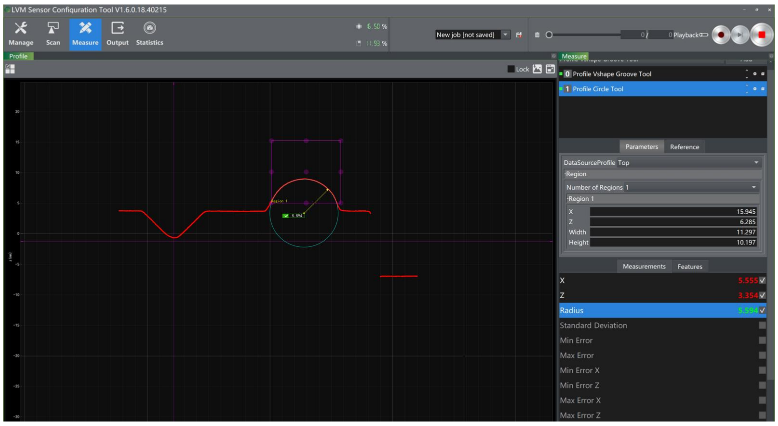
5.4.3 Anchoring measurement

When there is a slight change in the position of the tested sample, the actual measurement area may deviate from the measurement area set by the user, which may lead to unstable or even incorrect measurement results. The anchoring function provided by the sensor can effectively compensate for the position deviation of the sample. The specific process is: the anchoring tool "locks" the anchoring point to the position of a certain measuring tool and the Z angle measurement result. It is required that the measuring tool as the anchoring object can stably measure the feature point position and Z angle of the sample even if there is a position deviation, such as the highest position of the contour or the Z angle of a certain edge line. The anchoring tool applies the calculated position offset and Z rotation angle to the current generated point cloud to compensate for the measurement area and achieve stable measurement.

In the following example, it is expected to measure the size of the arc part of the workpiece, but when performing circle fitting, it is necessary to accurately select the measurement area. The actual workpiece has horizontal and vertical movement, which has a significant impact on circle fitting. The workpiece has obvious features such as V-grooves. In this case, precise measurement of the circle can be achieved using the anchoring function. The specific method is to first add a "V-groove" measurement tool, select "positioning point" as the bottom corner in the parameter settings, check "point" in the feature panel, and then set "x" in the "Reference" panel to "Contour V-groove/X" and "z" to "Contour V-groove/Z" in the "Circle" measurement tool. During the measurement process, it can be seen that the measurement area of the circle is automatically tracked as the workpiece moves, thus achieving stable measurement, as shown in Figures 2 and 3.







The sensor supports multiple measurement tools to form an anchor chain, such as the output of measurement tool A as the anchor point of measurement tool B, the output of measurement tool B as the anchor point of measurement tool C, and so on. However, cyclic anchoring is not allowed. If the output of C is no longer allowed to be set as the anchor point of A, the sensor will automatically detect to avoid the setting of cyclic anchoring.

Anchor measurement is supported in both contour and surface point cloud modes. In surface point cloud mode, combining sample matching and anchoring measurement can better eliminate measurement errors caused by sample position deviation and achieve more stable measurement.

5.4.4 Feature Tools

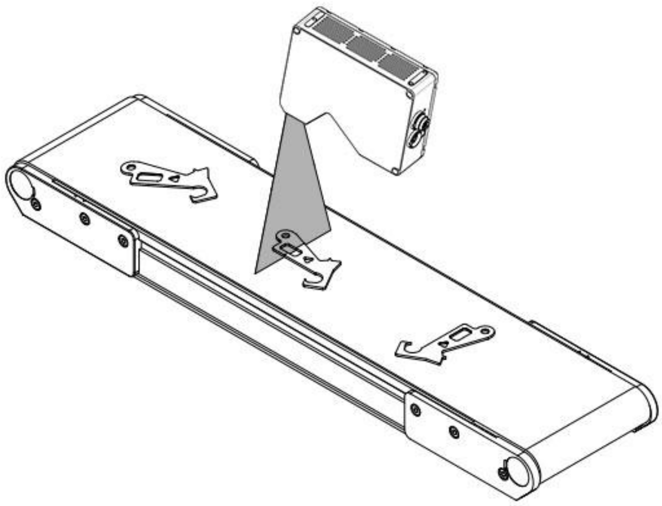
Geometric features refer to points, lines, surfaces, and circles. Most measurement tools can use geometric features as output results. The specialized feature tools built into sensors reference geometric features output by other measurement tools, which can generate new geometric features, such as generating lines from two points or measuring geometric features, such as the distance between points and lines.

The new geometric features generated by feature tools can also serve as inputs for other measurement tools, enabling flexible and customized measurement in complex measurement tasks.

5.5 Part Detection

5.5.1 Part Detection

After enabling part decetion, the part detection function can be enabled. The sensor matches the current scanned part surface with the template surface set by the user based on information such as surface edge or bounding box. If it matches, the part surface will be rotated to align with the direction of the template surface. For the case where the tested part are randomly placed on the conveyor belt, stable measurement of the part can be achieved through part detection.



5.6 Output

The application of measurement tools can obtain measurement values and judgment results, which are the qualified or unqualified judgment results obtained by comparing the measurement values with the qualified range set by the user. The measured values and judgment results can be output to devices such as PC or PLC in the control system through Ethernet, digital quantity, analog quantity, and serial port.

6 Software usage

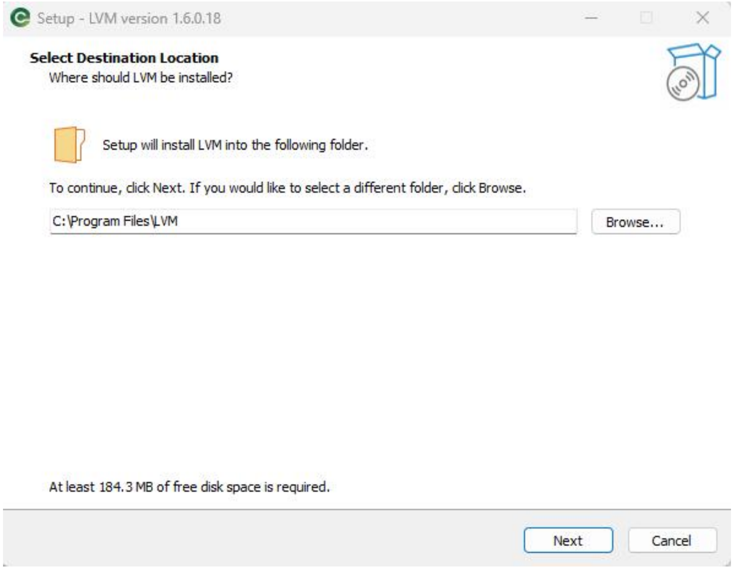
The following sections introduce the usage of LVM sensor configuration software.

6.1 PC Configuration requirements

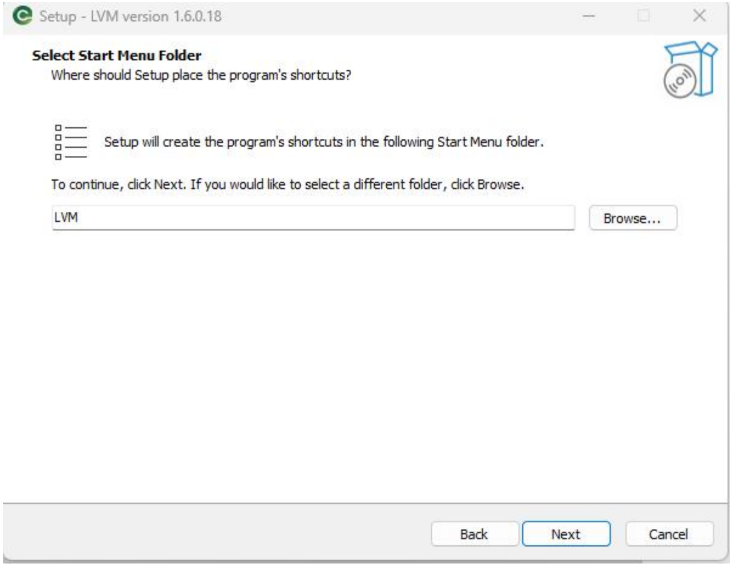
Operating system	Window7 64bit Or higher version
Processor	Intel Core i5 3.3 GHZ Or higher (64 bit)
Memory space	4GB Or higher
Graphics card	OpenGLVersion 4.1 or higher graphics memory 128 MB or higher
Hard disk space	128GBOr higher
Display	XGA 1024 × 768 pixels or higher, 256 colors or higher

6.2 Installation steps

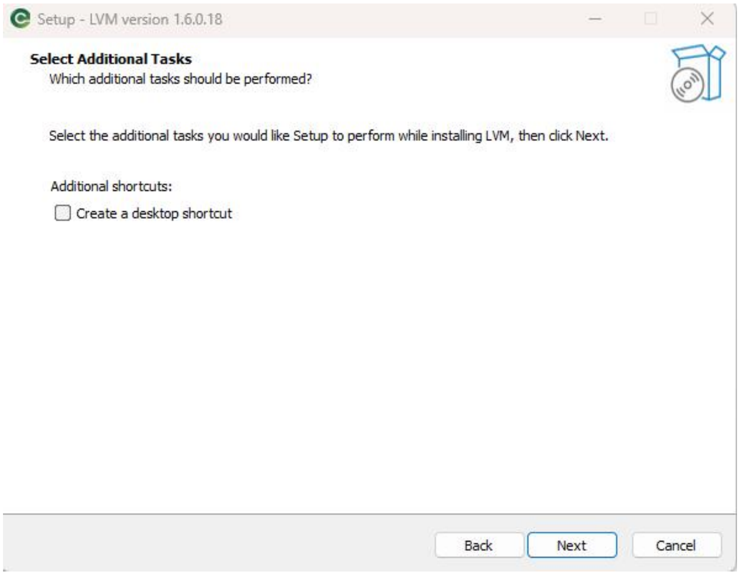
（1） Open to enter the installation process and select the installation path.



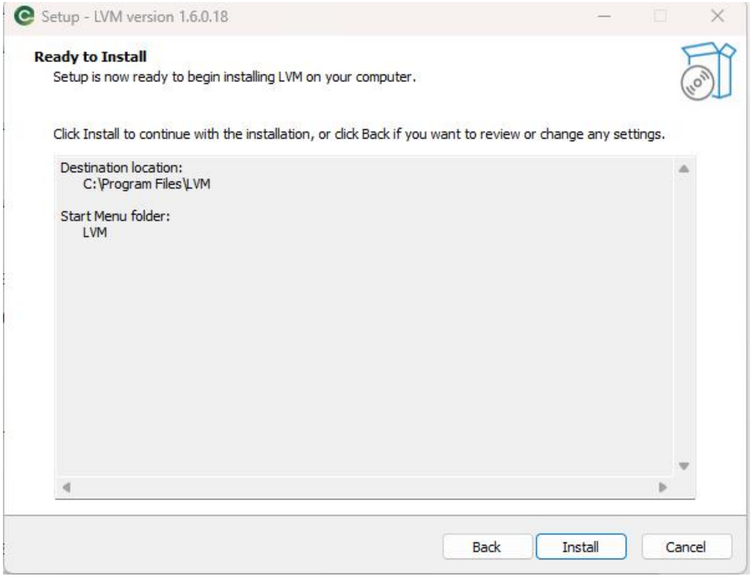
（2） Click Next and select the Start Menu Shortcuts folder.



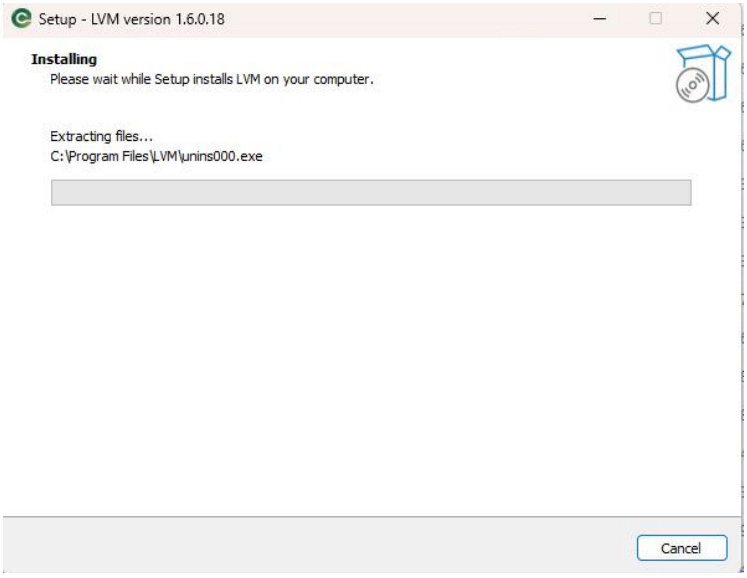
（3） Click Next and select the additional task.

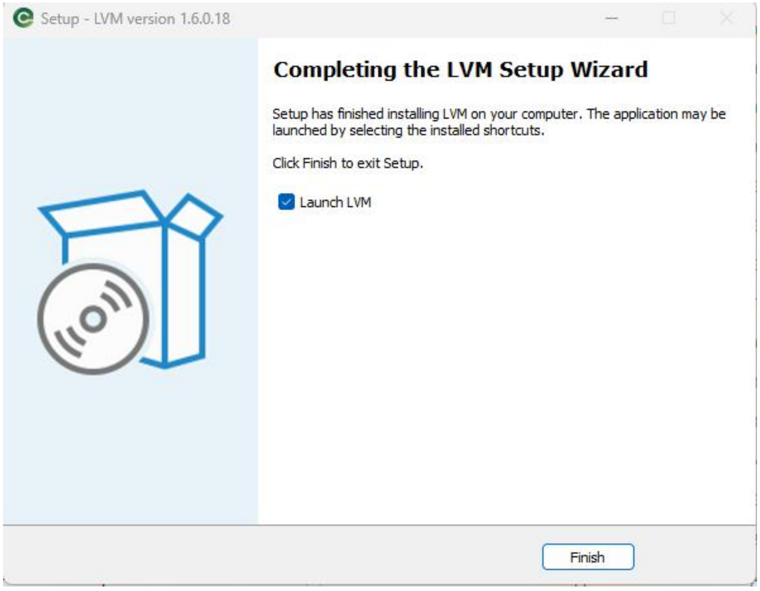


（4） Click Next to prepare for installation.



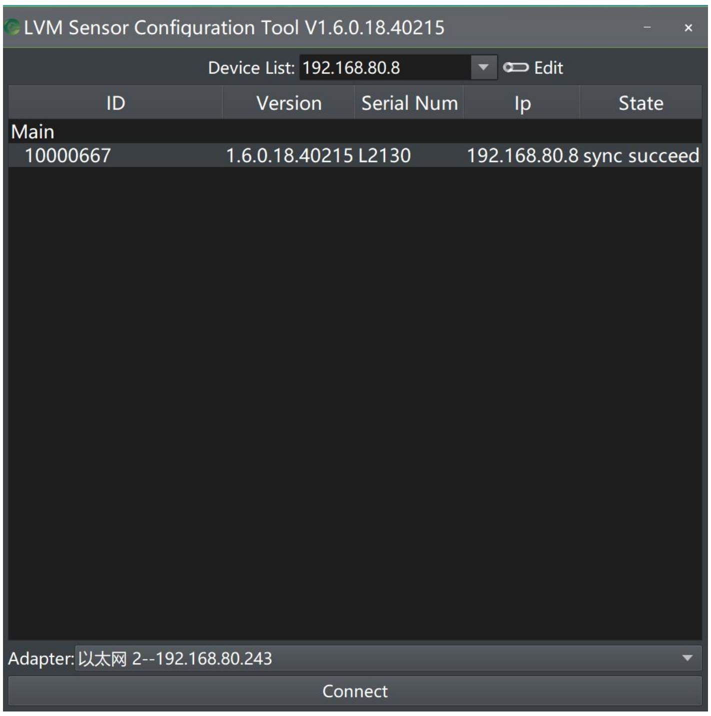
（5） Click Install.



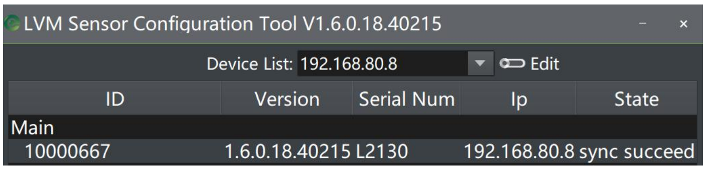


6.3 Login interface

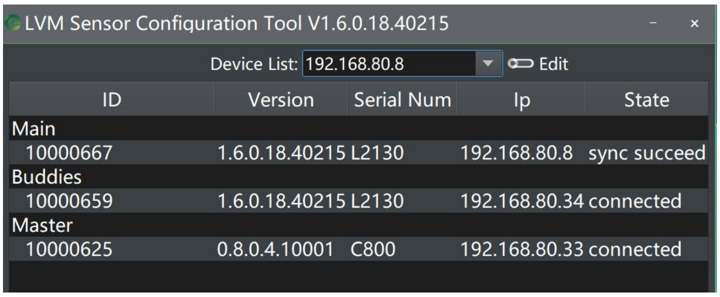
The software login interface is shown in the following figure. Users can see the IP addresses of all devices already in place in the current LAN in the "Device List". After selecting a sensor based on the IP address, they can see the device information. Click "Connect" to enter the main interface for configuring the sensor.



In a single sensor system, there is only one primary sensor. When the user selects the sensor, the window will display its sensor serial number, version number, type number, IP address, and status information, as shown in the following figure.

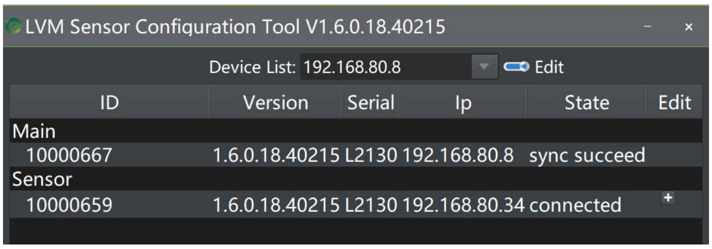


In a multi-sensor system, the window will display the serial number, version number, type number, IP address, and status information of the main sensor, buddies sensor, and master in the system, as shown in the following figure.

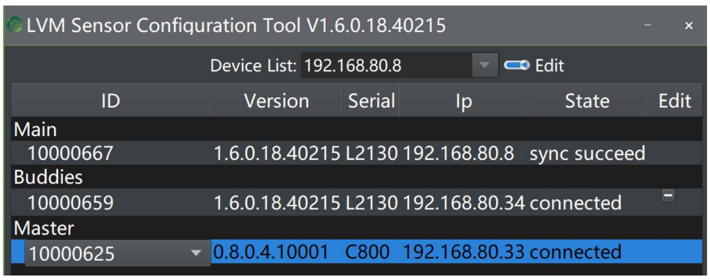


Users can expand a single sensor system into a multi-sensor system, or split a multi-sensor system into a single sensor system.

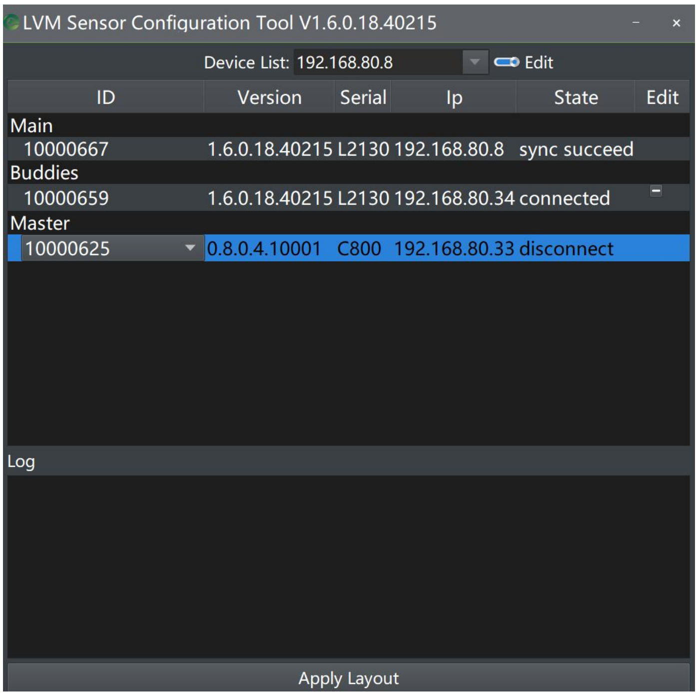
Taking single sensor expansion as an example. After selecting the sensor IP address in the device list, click the [Edit] checkbox to make changes. As shown in the following figure, all single sensor information within the local area network will be displayed in the list.



If you click the [Add] button next to sensor 192.168.80.34, it will become an buddies sensor for sensor 192.168.80.8, forming a multi-sensor system. At the same time, the interface will display all master connected to the local area network. By clicking the drop-down button in the list box, select the desired maser (a multi-sensor system has only one master). In editing mode, the buddies sensor can be removed from the multi-sensor system by clicking the [Delete] button on the right side of the buddies sensor.

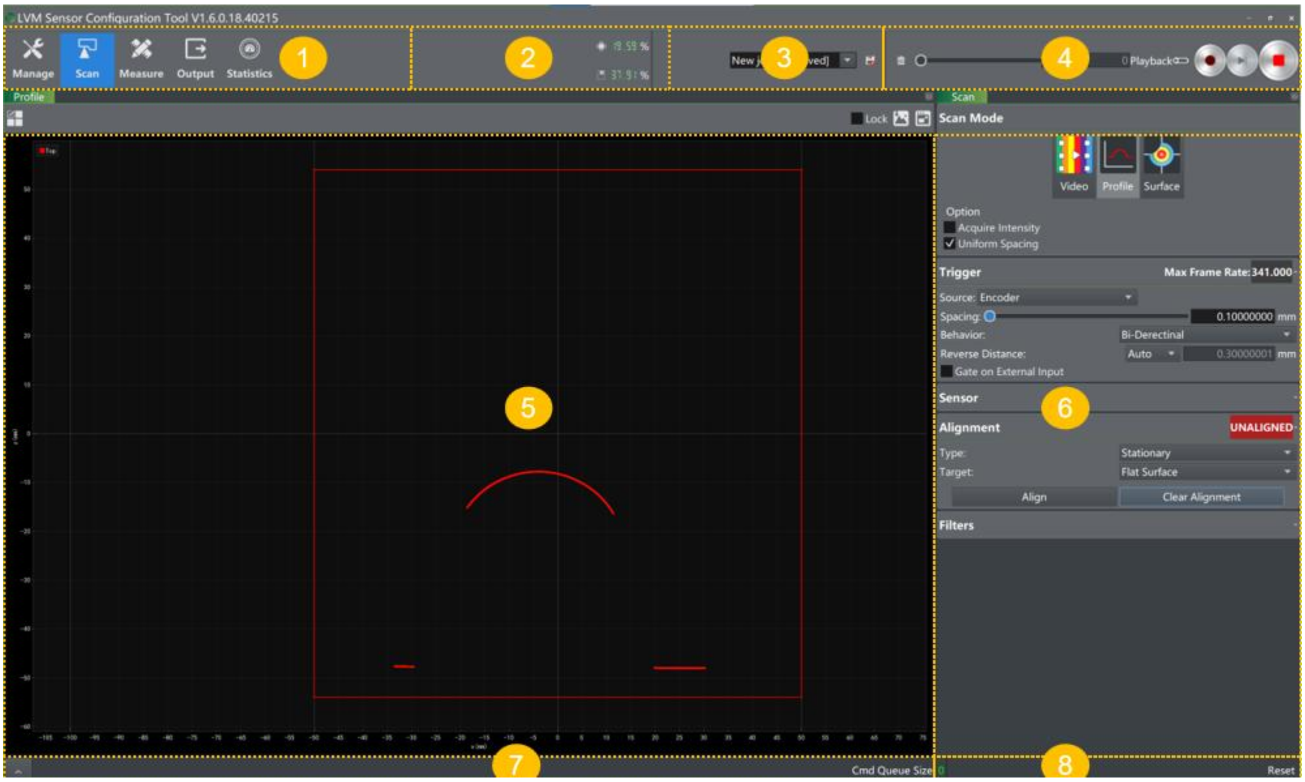


After selecting the buddies sensors and master, click on [Apply Layout] to complete the construction of the multi-sensor system.



6.4 Overview of Configuration Main Interface

The configuration main interface is shown in the following figure. The software interface is divided into 8 main areas according to functional classification. The functions of these areas are introduced below.



Region	Describe
1 Main control area	The main interaction areas for managing sensors are detailed in 6.4.1 Introduction to the main control area
2 Performance indicator area	Display the two main indicators of sensors, namely CPU load and memory load. If the CPU load is too high, it will cause frame loss
3 Work area	The area for quick operation of job management is detailed in 6.4.2 Introduction to Job Area
4 Operation area	Sensor start stop scanning, as well as recording and playback data operations, see 6.4.3 Operation Area Introduction for details
5 Data viewing area	Display images, contours, and surface point cloud data, as detailed in 6.4.4 Data Viewing Area Introduction
6 Parameter setting area	Scan parameter configuration and measurement tool parameter configuration are detailed in 6.6 Scan Settings and 6.8 Introduction to Profile Measurement
7 Log area	Display parameter setting information, warning and error messages, etc
8 Return to login	Return to the login interface, see Error for details! Reference source not found. introduce

6.4.1 Main control area

Area 1 of the main interface is the main control area, which mainly includes five modules: manage, scan, measure, output, and statistics.

（1） The manage module includes job, motion parameters, networking, matirx editor, SDK services, and about,laser. Please refer to the introduction of sensor management in section 6.5 for details.

（2） The scan module includes scan mode, trigger mode, sensor configuration, coordinate system calibration, surface generation mode, and filters settings. Please refer to Section 6.6 for more information on scan settings.

（3） The measurement module contains various measurement tool parameter settings. See error for details! Reference source not found. Partial introduction.

（4） The output module is configured with various interfaces and communication protocols for outputting measurement results and data. See error for details! Reference source not found. Partial introduction.

（5） The statistics module includes sensor operation status, measurement tool results, and performance statistics.

See error for details! Reference source not found. Partial introduction.

6.4.2 Job area

The second area of the main interface is the job area, which includes job switching, job creation, and job saving. Through the "Management -Job " module in the main control area, more comprehensive job management can be achieved. The homework area of the main interface provides a shortcut for job management, making it convenient for users to save and switch jobs when configuring job parameters.

- **Job switching**

Select a task from the drop-down list in the task area or enter a name to search for the task to switch to it.

- **Job creation**

Enter the job name. If the job list does not have that name, the mouse will lose focus or press the enter button to create a new job.

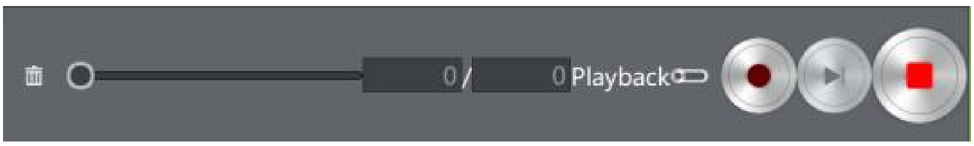
- **Job saving**

After creating and changing the settings of the job, it is a temporary configuration until manually saved. After the job name, "[not saved]" is displayed. Only after manually saving can it be stored in the sensor.

Users can create and save multiple jobs according to their needs, and switch freely during use. For example, you can create corresponding jobs for different types of workpieces in advance, and call the corresponding measurement job for this workpiece during a measurement task.

6.4.3 Operation area

Area 3 of the main interface is the sensor operation area, which can start and stop scanning, record and replay data, and manage the recorded data.



- **Enable scanning**

When the sensor is in standby mode, click the start button , Icon changes to , The sensor begins scanning and measuring operations.

- **Stop scanning**

When the sensor is performing scanning and measurement tasks, click the stop button , Icon changes to , The sensor stops scanning and measuring operations and enters standby mode.

- **Record**

If abnormal result analysis and troubleshooting are required, data can be recorded. First click on the record button , The icon becomes flashing , Indicates that the sensor is in recording mode, then click the start button , Icon changes to , The sensor starts recording data until the set maximum frame number is reached. If the user does not click the stop button after reaching the maximum frame number , Continue to save the current frame and delete the earliest recorded frame.

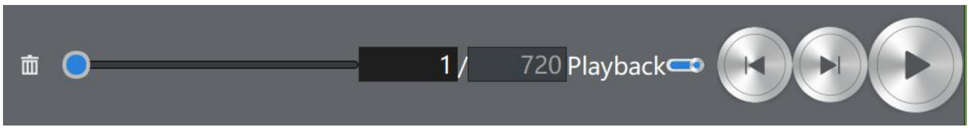
During the recording process, click the stop button , Stop recording.

When the sensor is in recording mode, click the flashing recording button , Icon changes to , Then the sensor switches to the scanning state.

- **Playback**

After recording, if you need to view data, press the playback button Playback Swipe right to turn the icon blue Playback , Indicates that the sensor is in playback mode. Click on the next frame button Or previous frame button , Single frame contour data will be displayed forward or backward in the data viewing area. Click the play button , Icon changes to , Continuously play contour data in the data viewing area. Click the stop button during continuous playback , Will stop at the current frame.

You can view specific frame contour data by dragging the playback slider on the left or directly entering the frame number.



- **Manage data**

Click the [Delete] button to delete the current recorded data from the sensor.

The recording and playback function currently only supports use in profile and video modes.

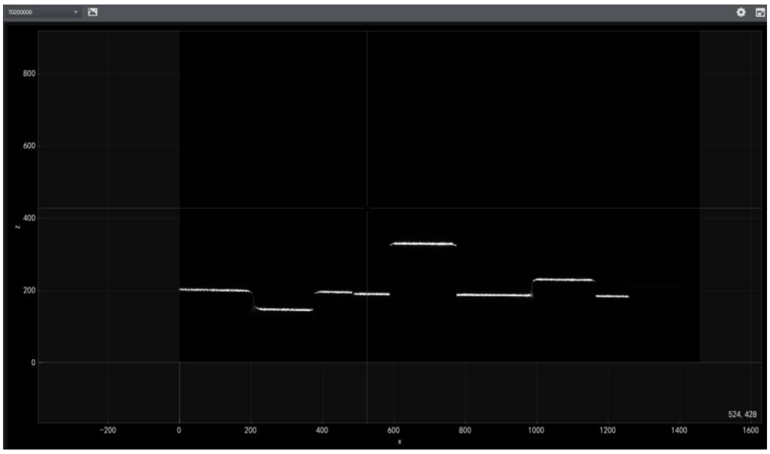
6.4.4 Data viewing area

Area 4 of the main interface is the data viewing area, which can display images, contours, and surface point cloud data.

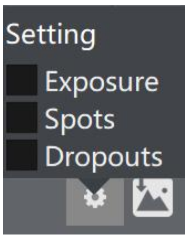
The basic functions of the data viewing area include dragging, zooming in, zooming out, local details, mouse coordinates, etc. Select a position in the display area and hold down the left mouse button to achieve the drag and drop window function; Slide the mouse scroll wheel to achieve the function of zooming in or out the window; Hold down the right mouse button, select a rectangular area, release the right button, and zoom in on the rectangular area to display local details; The current coordinate value of the mouse is displayed in the lower right corner of the 3D viewport.

- **video data**

When the scanning mode is in video mode, the image collected by the sensor is shown in the following figure, and the imaging of the laser in the field of view can be clearly seen.

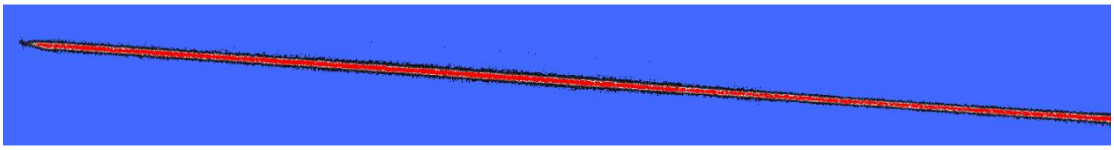


The drop-down list in the upper left corner of the figure allows you to switch between different sensor video in the system in the multisensor mode. The upper right corner of the image contains exposure assist settings and adaptive windows. The function of an adaptive window is to adjust the image to the center of the data viewing area for optimal display size. The function of exposure assist setting is to assist users in setting the optimal exposure value, and users can judge whether the current exposure selection is appropriate based on the instructions. The exposure assist setting includes three items: exposure , spots, and dropouts , as shown in the following figure.



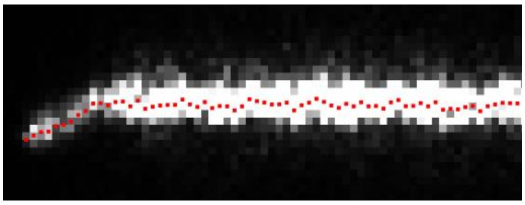
- **Exposure**

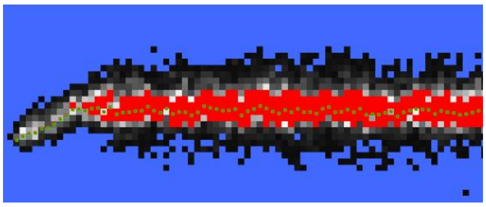
After checking, as shown in the following figure, the blue area is the background area, the red area is the saturation point, and the gray area is between the background and saturation. When there is one or two saturation points in each column, the set exposure value is optimal, the quality of the light strip is good, and the extraction accuracy is high.



- **Spots**

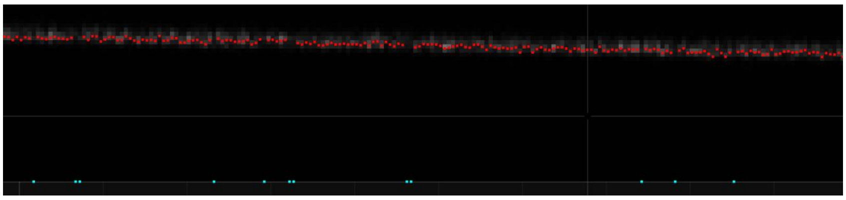
When the exposure indicator is not checked and the spots is checked, the extracted effective point will be displayed as a red dot in the data viewing area, as shown in the left image below. When both the exposure indicator and the spots are checked, they are represented by green dots, as shown in the right image below.





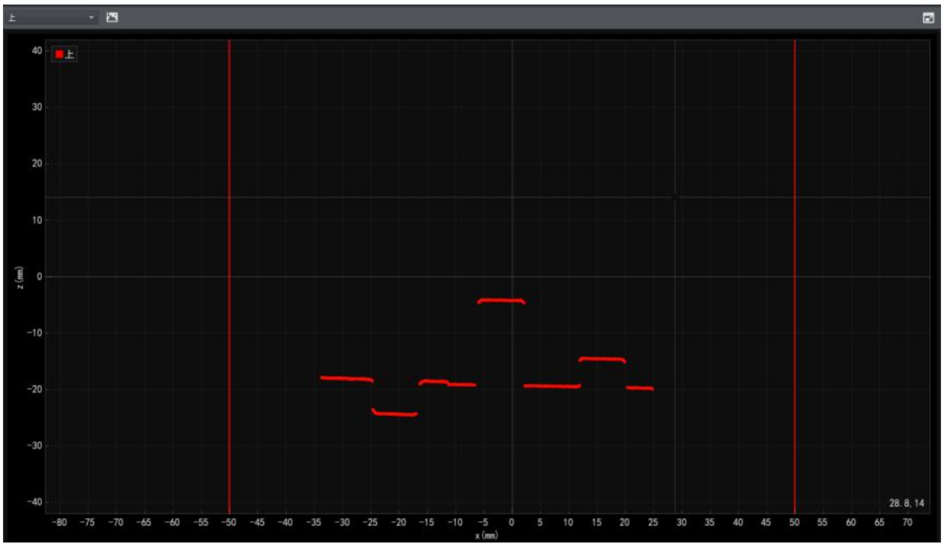
- **Dropouts**

After checking, the columns that have not been extracted with valid points will be displayed at the bottom of the area, represented by blue dots, as shown in the following figure.

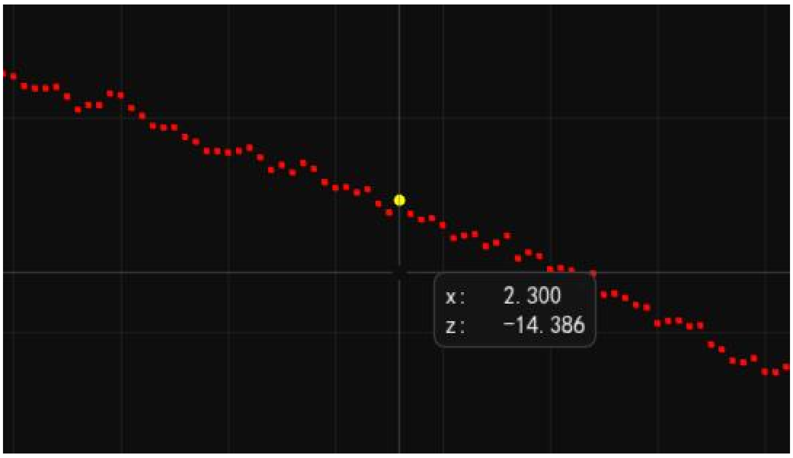


- **profile data**

When the scanning mode is in profile mode, the data viewing area is used to display profile data, and the display effect is shown in the following figure. The contour data points are displayed in red dots. In the multi sensor mode, the drop-down list at the upper left corner can switch the profile data of different sensors in the system, and the data name is consistent with the layout. The adaptive window in the upper right corner of the figure is used to adjust the profile data to the data viewing area and display it at the optimal size.

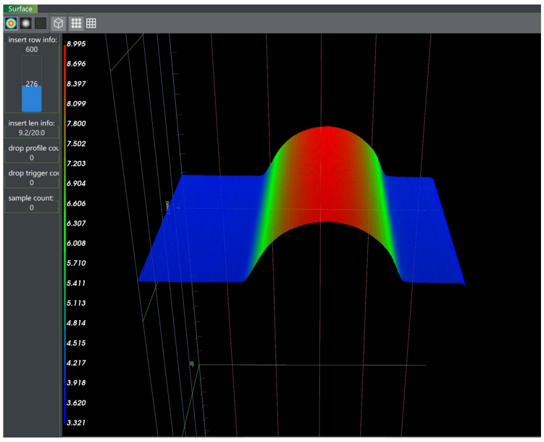


In profile mode, the mouse picking function for data points is shown in the following figure. The yellow dots represent the coordinate points currently picked by the mouse, and the coordinate values are displayed in the data box.

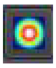
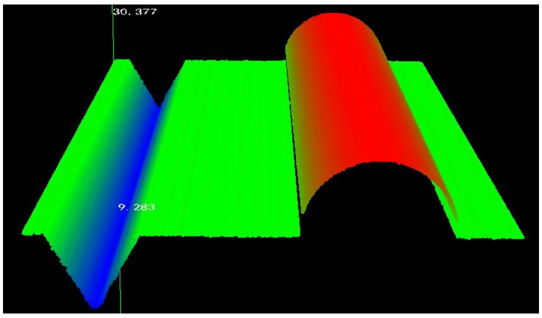
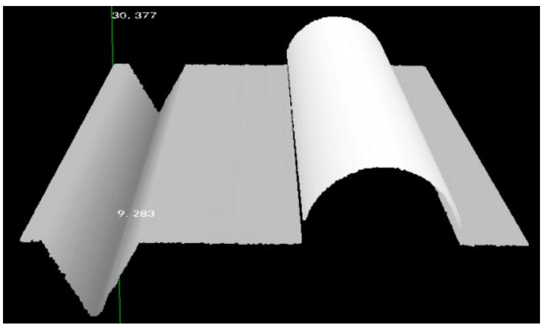


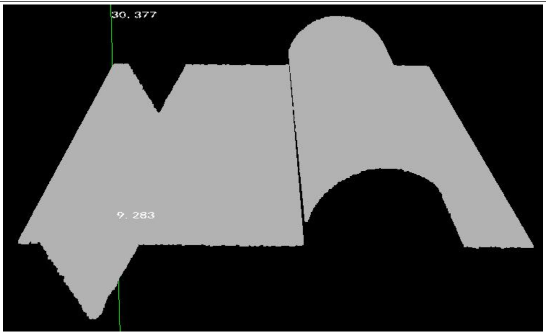
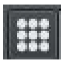
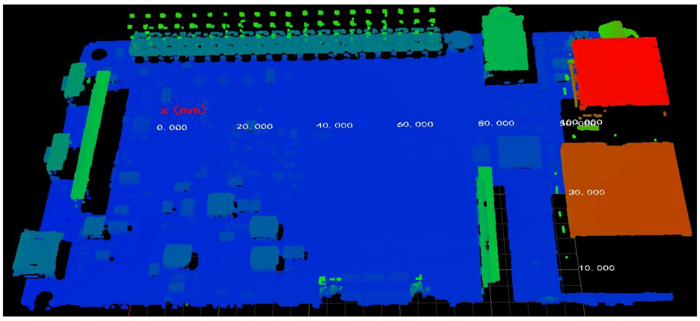
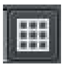
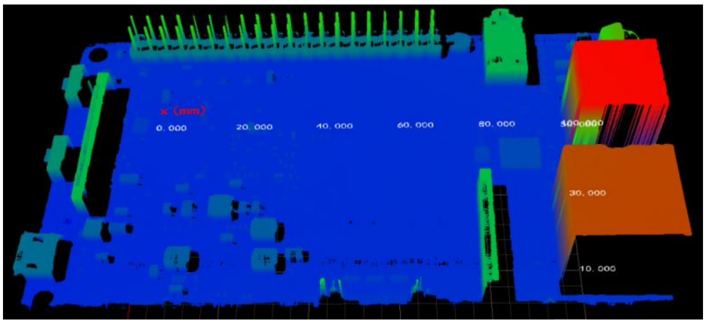
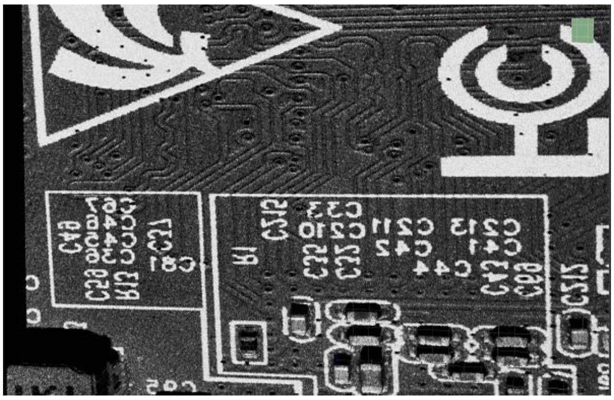
- **Surface data**

When the scanning mode is in surface mode, the data viewing area is used to display surface data, and the display effect is shown in the following figure. For easy viewing, users can press the left mouse button and drag the surface model to pan up, down, left, and right, or press the right mouse button to rotate the surface model centered around the current position of the mouse. The cube in the upper right corner of the viewing area is a rotation indicator icon that rotates with the model. Users can click on a certain area of the icon to quickly rotate the point cloud model to the corresponding angle.



The upper part of the data viewing area is the toolbar, and the left side of the toolbar is the display mode button. Please refer to the following table for specific instructions.

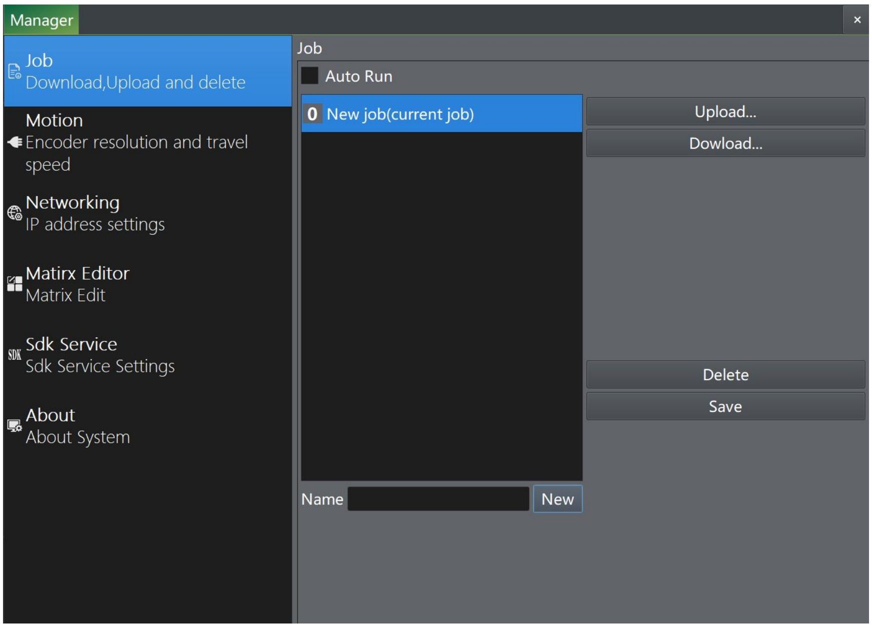
Button icon	describe
	height map 
	Grayscale 
	Uniformity

	
	Points: Presents raw point cloud data. 
	Mesh: A 3D model that presents a grid like form. 
	Intensity: When selecting "Collect Brightness Values" in scanning mode, the Brightness Map button will appear on the toolbar of the data viewing area. 

The toolbar in the data viewing area has a progress bar for insert row info in the middle, and a progress bar on the right Save Data and Fit to Window button. After clicking 'Keep Data', a save path dialog box will pop up, and the point cloud data will be saved in PLY format to the folder selected by the user. Click the 'Fit to Window' button, and the displayed model will be restored to the default angle and display size.

6.5 Sensor Management

Sensor management includes tasks, motion parameters, networks, array editing SDK services, and more.



6.5.1 Task

The job module is mainly used to manage stored jobs.

- **Auto run**

After the sensor is powered on, it can automatically run. The specific operation is as follows: Check [Auto Run], and the default job will automatically run after the sensor is powered on, that is, the corresponding scanning and measurement of the job, without the need for manual activation. If you want to use the sensor without connecting to a PC, you must enable auto run.

- **Job renaming**

Rename the assignment. The specific operation is as follows: double-click on a task to modify its name, and then click the Enter key.

- **Upload job**

Save the job from the sensor to the PC. The specific operation is as follows: click the [upload] button, a dialog box will pop up, set the job storage location and name, and click the [Save] command to complete the job upload.

■ **Job Download**

Download the saved job to the sensor. The specific operation is as follows: click the [download] button, a dialog box will pop up, select the job to download, and click the 'Open' command to complete the job download.

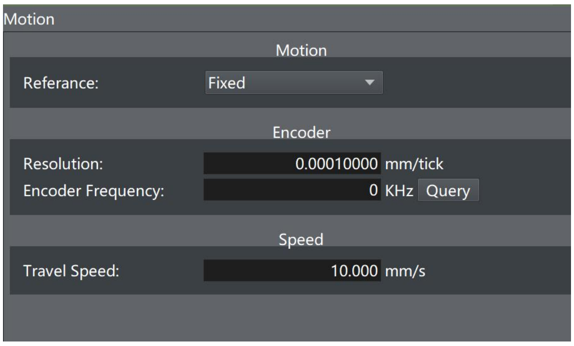
■ **Job delete**

Delete the stored job. The specific operation is as follows: select the task to be deleted, click the [Delete] button to complete the task deletion.

■ **Job save**

Save the assignment. If the content of the assignment has changed, click the [Save] button to save all the assignments.

6.5.2 Motion

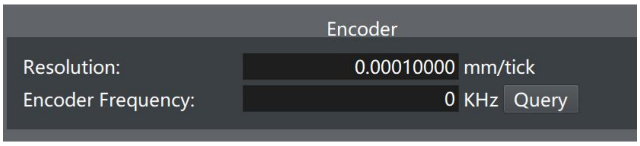


The referance the effective range of the parameter, which is divided into two types: Fixed and Dynamic, with the following differences.

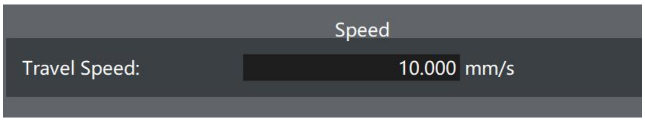
Scope	**describe**
fixed	All assignments use the same parameter settings. When the installation position of the sensor does not change over time, such as when the sensor is installed in a fixed position on the conveyor belt, this setting is usually used.
dynamic	Each assignment uses separate parameter settings. When the position of the sensor relative to the scanning object is constantly changing, such as when the sensor is installed on a robot arm moving to different scanning positions, this setting is usually used.

When the scanning mode is surface scanning, it is necessary to set the encoder or conveyor belt motion speed.

When the system installs an encoder and sets the scanning trigger source as the encoder, it is necessary to set the encoder resolution. The encoder frequency column is used to display the encoder signal frequency of the currently connected sensor.



When the system is not equipped with an encoder but the motion speed is relatively constant, it is necessary to set the travel speed.



> Due to the difficulty in ensuring uniform movement of the conveying system, it is strongly recommended to install an encoder in the system.
>
> Although the sensor can automatically calculate the encoder or motion speed through moving alibnment, it is recommended to manually input it when the encoder and motion are known to ensure accuracy.

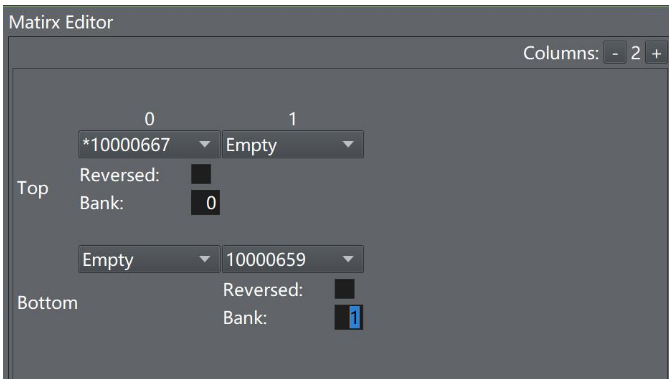
6.5.3 Network Settings

Each sensor has a unique IP address and needs to be set to the same subnet as the user's PC and master. The setting interface is shown in the following figure. After setting, click the [Save] button and the sensor will automatically restart to complete the setting.

6.5.4 Matirx editor

In a multi-sensor system, it is necessary to set the layout of each sensor through array editing.

As shown in the following figure, the user can edit the number of columns using "+" or "-" in the upper right corner (each column allows up to two sensors, one above the scanned object and the other below the scanned object), and select the sensor serial number from the drop-down menu in each cell. The main sensor is identified by the number before the device ID. The main sensor is assigned to the cell above the first column by default and can be changed according to the actual deployment situation.



- **Reversed**

When setting the layout position for each sensor, it is necessary to confirm whether it is installed in reverse (rotating 180 degrees around the Z-axis to avoid obstruction).

- **Bank**

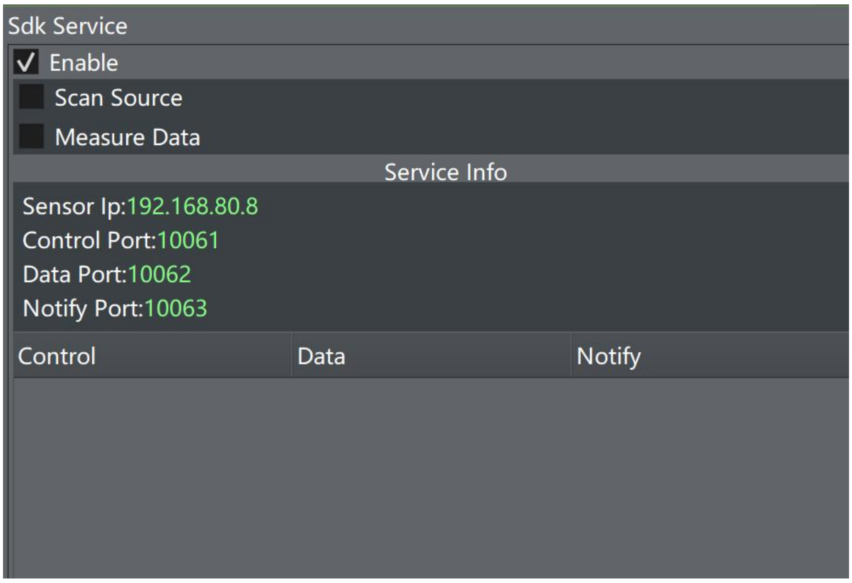
Sensors belonging to the same bank begin to be exposed at the same time, while sensors belonging to different groups are exposed asynchronously. The interference between laser lines emitted by different sensors is avoided through group management.

The starting bank number must be 0, with a value range of 0-7. The smaller the number, the higher the exposure order of the group.

After completing the layout settings, you need to click the [Apply] button to make the configuration effective.

6.5.5 SDK service

Introduction: The SDK Server has three link channels, each with specific services. The three link channels are control port, data port, and notify portl.



- **Control port**

Used to receive control instructions sent by the SDK client and perform control operations on sensors (such as starting scanning, stopping scanning, software triggering, etc.).

- **Data port**

Used for SDK Server real-time external transmission of data (video data, profile data, surface data).

- **Notify port**

Used to transmit the execution results of control instructions on the SDK server. Every time the SDK server executes a control instruction, it sends the result data of the command execution to the SDK client through this channel.

- **Scan source**

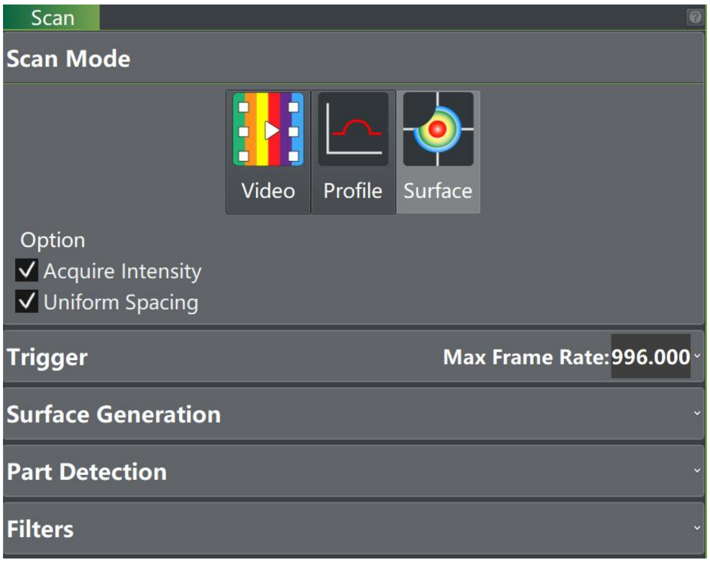
Refers to the original scanning data, and depending on the scanning mode settings, the scanning source can be video data, profile data, surface data.

When scanning source output is enabled, real-time scanning data will be pushed to the SDK in real time. After enabling measure data, the measure data under the "Data" tab in the measurement parameter panel will be pushed to the SDK in real-time.

> The SDK Server is turned off by default, and the sensor will not respond to SDK Client's link requests when turned off. After enabling the SDK Server, the SDK Server starts listening for connection requests from SDK clients and displays all SDK clients successfully connected to the SDK Server in the client information list. After the SDK Client is disconnected from the SDK Server, the relevant information will be automatically removed from the client information list.

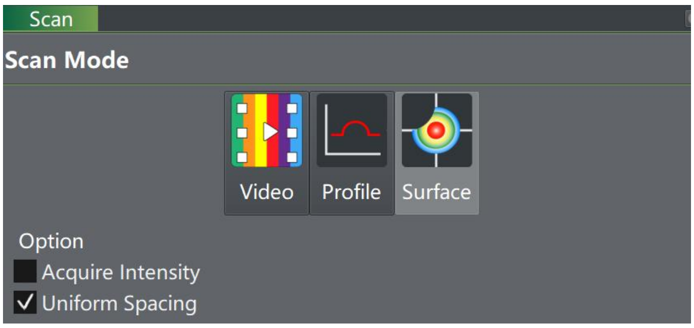
6.6 Scan Settings

The following sections mainly describe the parameter settings related to scanning.



6.6.1 Scan mode

The scanning mode is divided into video mode, profile mode, and surface mode, and its settings are shown in the interface below.



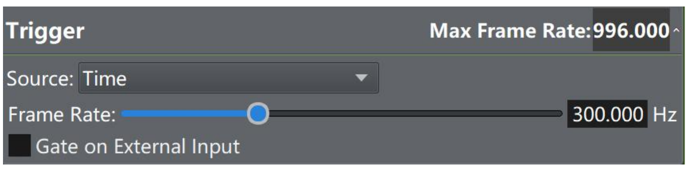
mode	describe
video mode	Output image data. This mode is used to configure exposure time and contour selection strategies to ensure the quality of collected contours
profile mode	Output contour data and execute contour measurement tools
surface mode	Output 3D point cloud data and execute point cloud measurement tools

option		describe
acquire internsity		Generate brightness values for each data point while generating profile data or surface data
Uniform spacing	profile mode	After enabling the option, resample the sampled original contour data to ensure that the sampled data has equal spacing between points in the X direction. In this mode, there are many types of built-in measurement tools available, except for roundness, roughness, and closed area, all other measurement tools can be used in the uniform spacing mode. After disabling the option, the contour data points are displayed directly, with different spacing between points in the X direction. In this mode, the scanning speed is fast, but there are few types of built-in measurement tools available. If complex measurements are needed, users can develop their own SDK based applications to perform measurements.
	surface mode	After activatng in the Y direction. After disabling the option, the oriing the option, resample the sampled original contour data to ensure equal point spacing in the X direction, and resample the concatenated point cloud data in the Y direction to ensure equal point spaciginal point cloud data points are displayed directly, with different spacing between points in the X and Y directions.

6.6.2 Trigger mode

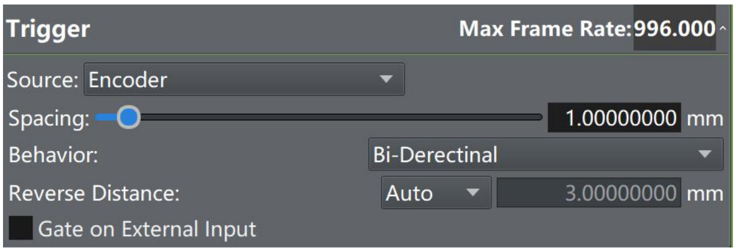
Sensors support four triggering modes: time, encoder, external input, and software. The following describes each mode and its parameters.

- **Time trigger**



The sensor triggers scanning according to the frequency set by the user, and the "gate on external input" can enable or disable time triggering.

■ **Encoder trigger**



The sensor triggers a scan based on the encoder data of the system, that is, every time the moving system accumulates a point distance, it triggers a scan. Supports three trigger modes:

（1） track backward: When the target object moves forward with the conveyor belt, the scanning is triggered. If the target object moves backward, the triggering stops, and the sensor will save the reverse position value. When the target object moves forward again and exceeds the reverse position, the scanning will continue.

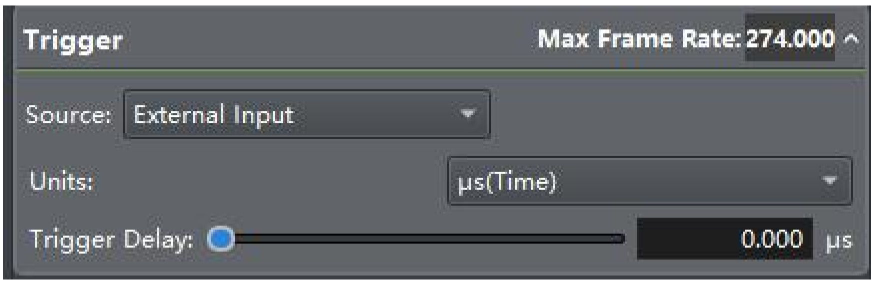
（2）Ingnore backward: The scanning is triggered when the target object moves forward with the conveyor belt. If the target object moves backward, the triggering stops. When the target object moves forward again, the scanning continues. Unlike "track backward", the scanning immediately continues as long as the target object moves forward again.

（3）Bi-derectinal: Scanning is triggered when the target object moves forward or backward with the conveyor belt.

When selecting bidirectional trigger mode, it is necessary to set the "reverse distance", which refers to the distance that the target object must pass before the trigger direction changes, and is used to ignore the jitter of the transmission system. If "auto" is selected, the reverse distance is 3 times the point distance. If "Custom" is selected, the value entered by the user should be greater than the maximum jitter of the transmission system.

Gate on External input control can enable or disable encoder triggering.

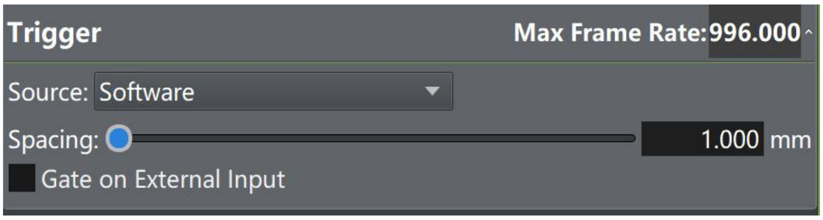
■ **External trigger**



The sensor triggers scanning through an external digital input signal, which is triggered at the rising edge of the signal. In general, there is a certain distance between the trigger source, such as a phototube, and the sensor. To supplement this distance, a "trigger delay" can be set. If the time corresponding to this distance is fixed, the "units" can be set to time, and the time value can be set by dragging the slider or manually entering it. If the system is equipped with an encoder, the distance can be measured in advance and set by dragging the slider or manually entering the distance value.

> Trigger delay is only supported when the sensor is in single exposure mode, not in multiple exposure mode.

■ **Software trigger**



External applications can send commands to trigger sensors through communication protocols, and 'Gate on external input' can enable or disable software triggering.

Here are some examples of triggers:

Example	**describe**
Encoder+conveyor belt	Perform evenly spaced profile measurements, ensuring constant contour spacing even when the conveyor belt speed changes and the encoder triggering mode
Time+conveyor belt	Perform contour measurement at a fixed frequency. If the conveyor belt speed changes, the contour spacing will be uneven. Therefore, it is recommended to use encoder trigger mode as much as possible
External trigger+conveyor belt	External sensors such as photocells can trigger a single scan of the sample; When using encoder or time triggered mode, external signals can be used as gating signals to continuously scan the sample during the period when the external signal is maintained at a high level
Software trigger+robotic arm	The robotic arm drives the sensor to measure the sample, and when it reaches the measurement position, external software can achieve a single scan of the sample

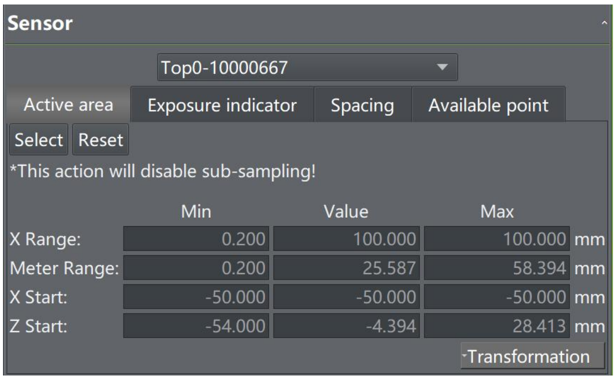
6.6.3 Sensor

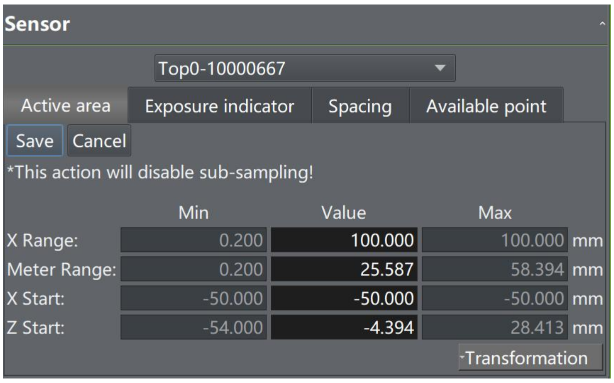
The active area of the sensor, built-in camera exposure parameters, contour point distance, and effective contour point selection strategy can be set, which is crucial for the quality of generated data.

■ **Active area**

The Active area refers to the area where data is collected. The default active area is the entire field of view of the sensor, and users can set the active area based on the contour characteristics of the tested sample. By reducing the active area, the upper limit of sensor scanning speed can be increased. The interface is shown in the following figure.

Region selection can only be used in contour mode and is disabled in video mode.





Click the [Reset] button to restore the active area to the default parameter, which is the entire field of view of the sensor.

The active area range cannot be changed without clicking the [Select] button. After clicking 'Select', you can set the active area by dragging and scaling the area edit box in the data viewing area, or directly modifying the area range value. After setting up, click the [Save] button to complete the settings. Click the 'Cancel' button to invalidate the current valid region settings.

- **Transformation**

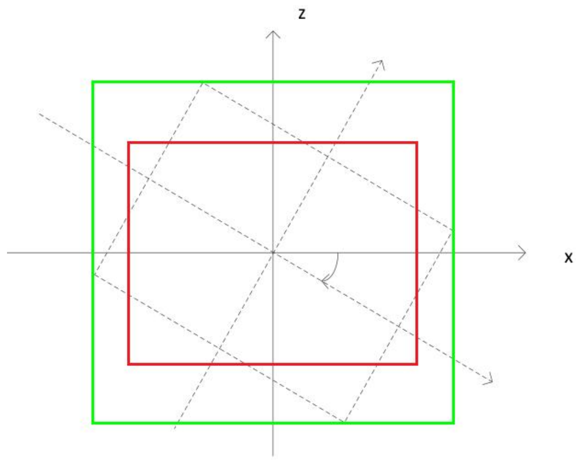
Transformation settings determine the conversion parameters for converting data from the sensor coordinate system to the system coordinate system. Conversion parameters are usually automatically obtained during sensor calibration, and can also be manually entered in the active area settings section. As shown in the following figure.

parameter	describe
X offset	Specify the offset along the X-axis. A positive value moves the contour data to the right; Negative values move the contour data to the left.

Y offset	Specify the offset along the Y-axis.
Z offset	Specify the offset along the Z-axis. A positive value moves the contour data upwards; Negative values move the contour data downward.
X angle	Specify the tilt angle around the X-axis.
Y angle	Specify the tilt angle around the Y-axis. A positive value rotates the contour clockwise, while a negative value rotates the contour counterclockwise.
Z angle	Specify the tilt angle around the Z-axis.

The tilt angle will affect the data bounding box. The following figure illustrates the impact of angle on the bounding box by taking rotation around the Y-axis as an example. When the angle is 0, the data bounding box is a red rectangular box in the middle; When the angle is not 0, the data bounding box changes to the outermost green rectangular box after rotation. After calibration, the calibration data will be updated to the coordinate system conversion.

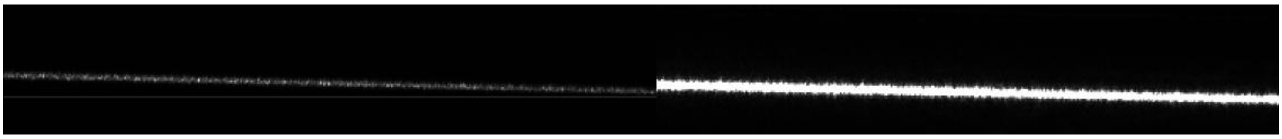
> If the X or Z angles are set to non-zero values, it will increase the sensor's computational load, thereby reducing the upper limit of scanning speed.



- **Exposure indicator**

The exposure time determines the duration of the camera and laser inside the sensor being continuously turned on. Different colors and materials require different exposure times for targets. Short exposure times are suitable for targets with white or weak light transmittance, while long exposure times are suitable for targets with dark or strong light transmittance. However, exposure time can affect the maximum frame rate, and long exposure time can reduce scanning speed. To achieve the best exposure effect, it is necessary to adjust the exposure time.

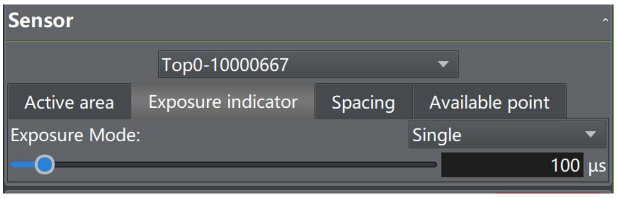
As shown in the following figure, based on the principle of optimal exposure value when there are one or two saturation points in each column, the exposure corresponding to the left image is too low, and the exposure corresponding to the right image is too high, which will affect the accuracy of the contour. Therefore, the optimal exposure value should be selected by combining the image and exposure assistance settings.



In order to adapt to various scene requirements, sensors provide two exposure methods: single exposure and multiple exposure.

（1） Single exposure

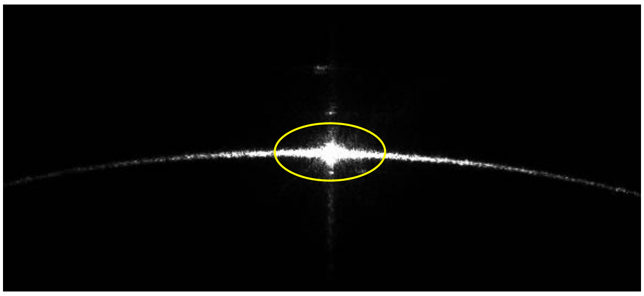
Single exposure refers to using the same exposure value for each exposure, generating one frame of contour data for each exposure. It is suitable for scenes where the color or material of the tested object is relatively single, and the light bar image is relatively uniform in image mode, without significant changes in brightness. The exposure time range is between 10us and 300000us, and can be changed by dragging the scroll bar or manually entering it.



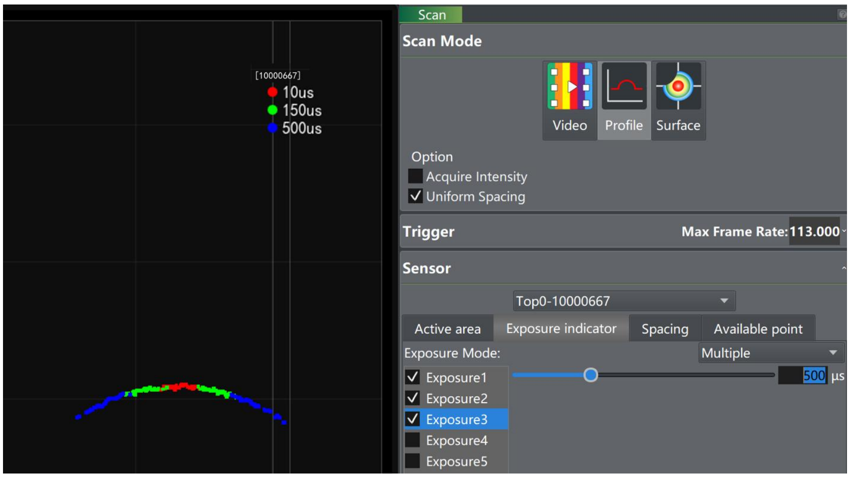
（2） Multiple exposure

Multiple exposure refers to the synthesis of a frame of contour data after multiple exposures. Multiple exposure can improve the dynamic range of sensor measurement, for example, when the tested sample has both bright and dark parts, using multiple exposure can obtain complete and clear contour data.

As shown in the scanned image of a metal cylinder in the figure below, due to different laser incidence angles, the reflected laser energy entering the sensor at each position of the cylinder is different. This is manifested in the image where the top of the arc is the brightest, and the farther it is from the top, the darker it becomes. If you choose single exposure, in order to extract the contours at both ends, you must increase the exposure value, but it will lead to overexposure at the top. To cope with this situation, LVM has designed multiple exposure technology, where users can set 2-5 exposure values. The sensor combines multiple exposure results into a complete contour according to the optimal algorithm.



The following figure takes triple exposure as an example, setting each exposure time separately, distinguishing the contours generated under different exposure times with different colors, and finally obtaining a complete contour. The legend in the upper right corner of the 3D viewport represents the contour data corresponding to each exposure time.

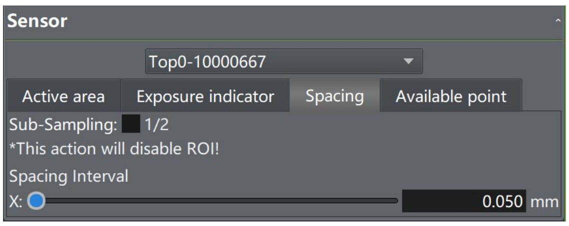


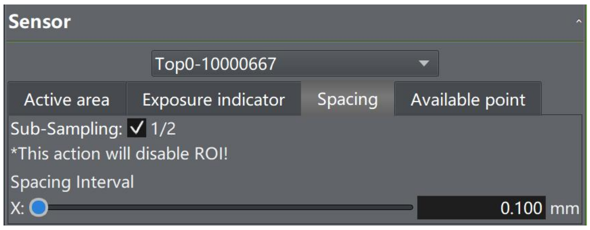
■ Spacing

Spacing is used to set the resolution of 1/2 sub-sampling and X-direction contours.

1/2 sub-sampling means collecting every other image row and column. 1/2 sub-sampling can improve the scanning frame rate and reduce CPU usage while ensuring the sensor's field of view, but it will result in a decrease in the resolution of the contour in the X and Z directions.

Spacing refers to the distance between adjacent data points in resampled data. A larger point spacing can improve the scanning frame rate and reduce CPU usage, but it will result in a decrease in the X-direction resolution of the contour.



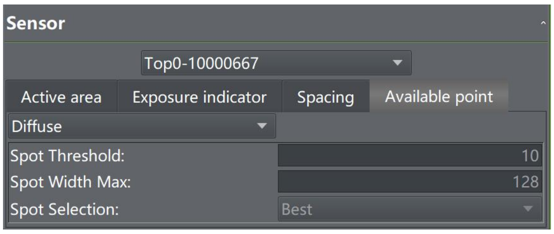


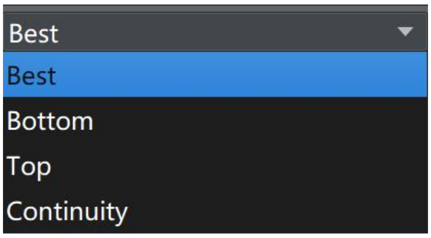
> The dot pitch setting only takes effect when "Uniform Spacing" is selected in the scanning mode panel.

■ Available point selection settings

When there is stray light in the measurement environment, there may be interference light stripes/spots in the images collected by the sensor, which affects the correct extraction of laser light stripes and subsequent contour generation. Users should set effective point selection parameters based on the actual environment to filter out stray light interference and improve contour quality.

The Available point selection strategy includes two methods: diffuse and custom. The default method is suitable for most measurement environments and targets. However, when there is stray light interference in the environment, such as multiple reflections of laser from high finish target surfaces, users need to maximize the contour quality through custom methods.





set up	describe
Available point threshold	Only when the grayscale difference between adjacent pixels is greater than the set value can valid points be generated. The larger the value set, the fewer valid points generated; The smaller the value set, the more valid points generated.
Available point threshold width threshold	The maximum pixel width allowed for laser light bars, which does not generate valid points for light bars greater than this threshold.
Availtive point selection	When there are multiple candidate valid points in a column, filtering can be carried out in the following ways: Best: Select the effective point with the largest grayscale; Bottom: Select the effective point farthest from the sensor; Top: Select the nearest valid point to the sensor; Continuity: Select effective points with forward and backward linkage relationships based on connected information to eliminate isolated noise; None: Keep all valid points.

As shown in the following figure, due to the presence of reflective interference on the target, there is interference (yellow area) in the original image of Figure a. If the Available point selection strategy is best, the effect is shown in Figure b, and there is interference in the obtained light strip data; If the Available point selection strategy is continuity, the best effect is achieved, as shown in Figure c.

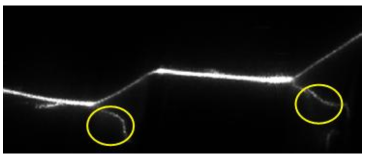


Figure a: Original Image

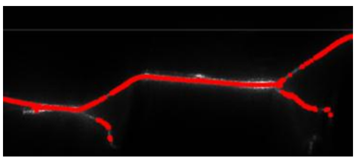


Figure b: availtive point of the best strategy

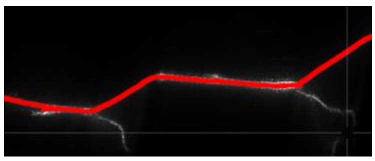


Figure c: availtive points of continuity strategy

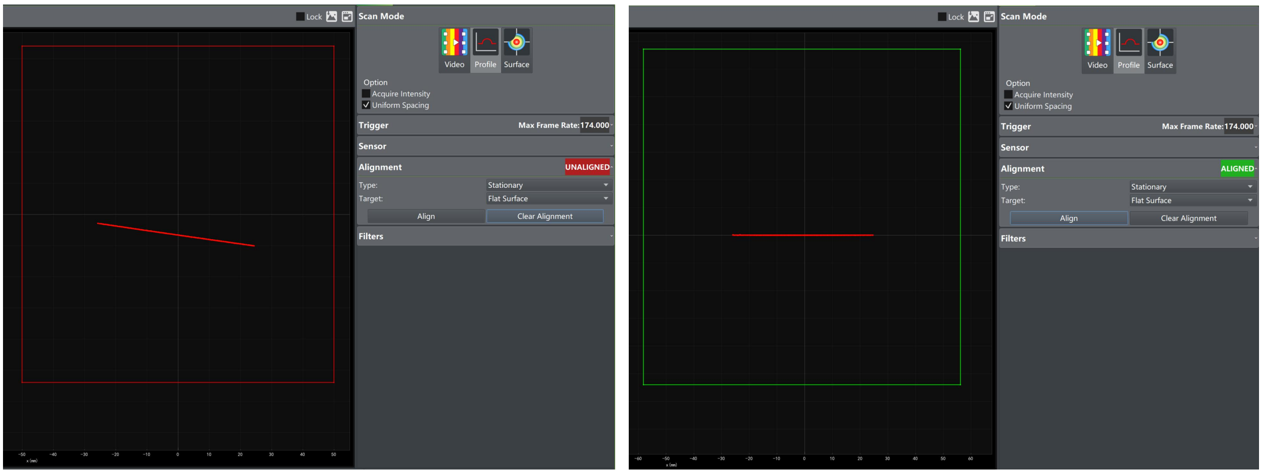
6.6.4 Alignment

After the sensor is installed, it is generally necessary to convert the coordinate system from the sensor coordinate system to the system coordinate system, and this process is called alignment . For example, when the conveyor belt plane is not horizontal, a sensor placed horizontally scans the target on the conveyor belt, and an inclined contour will be obtained in the sensor coordinate system. By alignment, the X-axis of the system coordinate system can be set parallel to the conveyor belt plane, and a horizontal contour will be obtained in the system coordinate system. In addition, when conducting joint measurement with multiple sensors, a common system coordinate system can be set up through alignment, in order to concatenate the contours generated by each sensor.

🗋	Alignment operations can only be performed in profile or surface scanning mode.

Stationary alignment is performed while the alignment target is not moving, mainly in profile mode. After stationary alignment, X offset, Z offset, and Y angle can be obtained. Clear alignment resets the X offset, Z offset, and Y angle to zero, and restores the coordinate system to the sensor coordinate system.

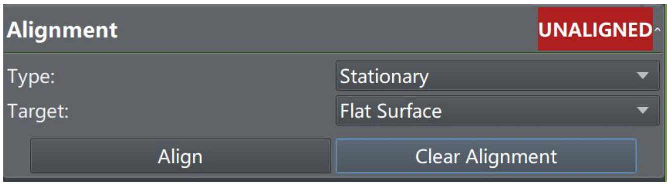
The following figure shows the changes in the interface before and after alignment. Before alignment, the measurement area box in the data viewing area is displayed in red, and the alignment panel on the scan settings page displays a red "UNALIGNED" icon. After alignment, the measurement area box in the data viewing area is displayed in green, and the alignment panel on the scan settings page displays a green "ALIGNED" icon.



According to the different alignment objectives, it can be divided into flat surface alignment, alignment rod calibration, and polygon calibration.

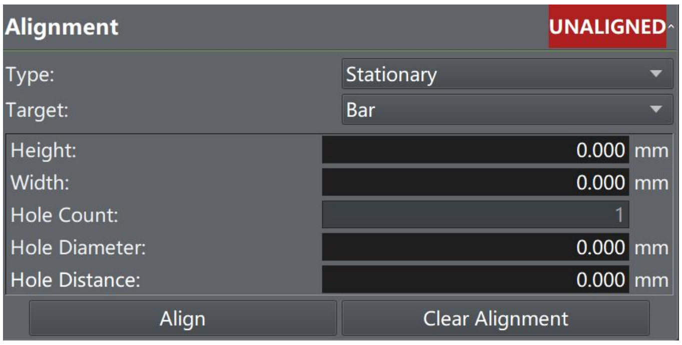
（1） Flat Surface alignment

Flat Surface alignment is mainly used for single sensor calibration, such as using the conveyor belt plane as the calibration plane.



（2） Bar alignment

The bar alignment is mainly used when multiple sensors are arranged in parallel or opposite directions. The parameter settings include the height, width, number of circular holes, diameter, and spacing of the calibration rod.

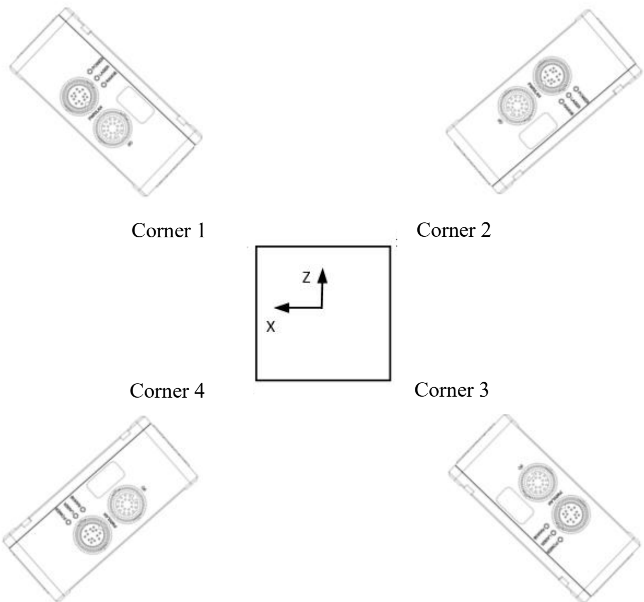


（3） moving alignment

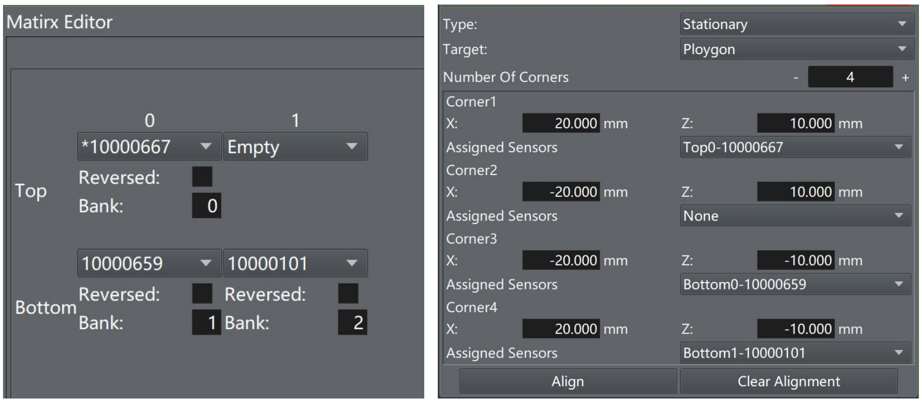
Moving alignment is mainly applied to circular layout schemes in multi-sensor systems. If the target requires 360 degree full surround scanning, polygon alignment is required, such as scanning cylindrical targets.

Several conditions for moving alignment:① Ensure that the light planes of each sensor are aligned;② Set the coordinates of each corner for the polygon calibration object, with the center of the polygon as the origin;③ Assign corresponding sensors to each corner.

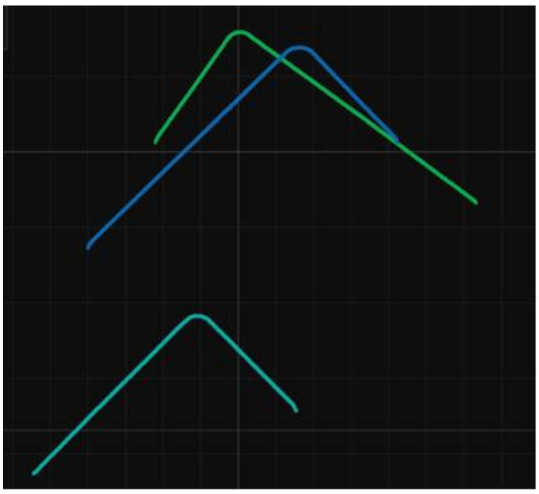
The schematic diagram of the circular layout is shown in the following figure.



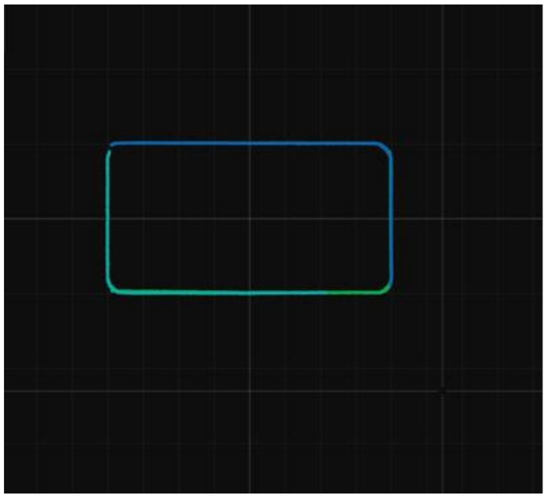
For example, a polygon is 40cm × A 20cm rectangular column with four corners, each represented by X and Z coordinates. Assign corresponding sensors to each corner according to the layout of the sensors, as shown in the following figure. The three sensors in the figure are alignment using a quadrilateral, and there are no corresponding sensors at corner 2, so they are assigned as empty. After assigning corner coordinates and sensors, click [align] to complete miving alignment.



The following figure shows the profile display before and after moving alignment.



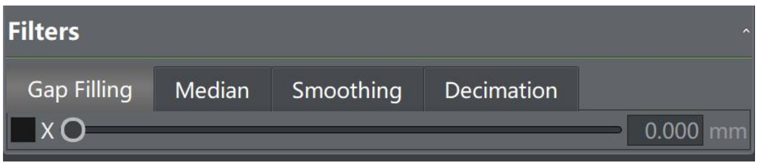
Outline before alignment



alignment profile

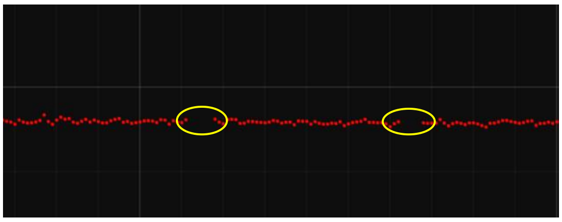
6.6.5 Filters

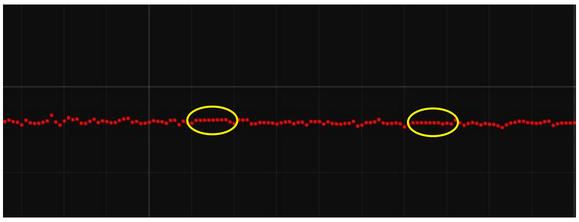
Filters is the post-processing of scanned data along the X or Y axis to eliminate interference and noise. The filtering function is only available in uniform spacing mode for contour and point cloud scanning. When using measurement tools, selecting appropriate filtering methods and window widths based on the application scenario can accelerate measurement time or improve measurement results.



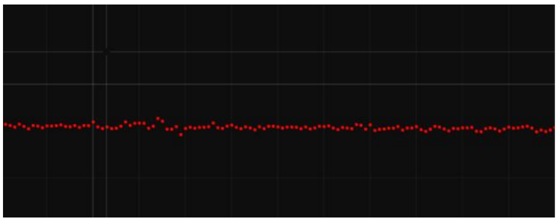
Filter type	describe
Gap Filling	Fill in missing data due to occlusion using information from the closest data point.
median	Replace the numerical values of the contour points with the median values of all points within the window.
smoothing	Replace the numerical value of the contour points with the mean of all points within the window.
Decimation	Reducing the number of contour points has the advantage of accelerating measurement and calculation speed, while the disadvantage is reducing accuracy.

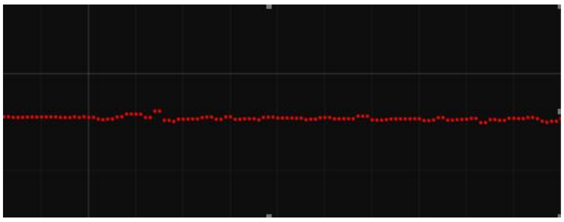
The effect of gap filling in the filter method is shown in the following figure.


Before filtering

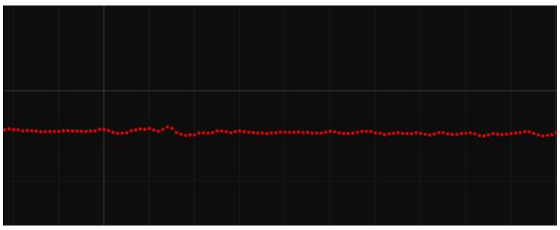

Before filtering

The effect when the filters method is median is shown in the following figure.


Before filtering


median filtering

The filters method is based on median and decimation, as shown in the following figure.

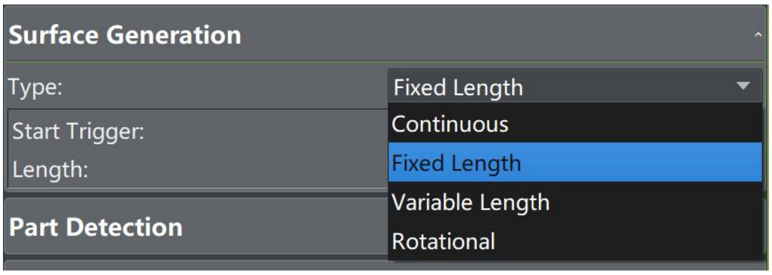

Mean filters


Decimation filtering

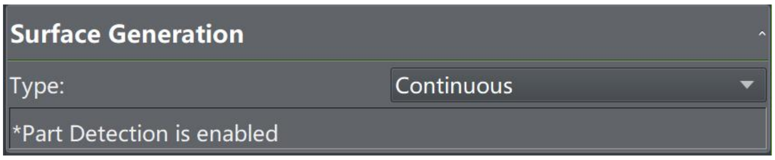
6.6.6 surface generation

When the scanning mode is selected as surface mode, the sensor can concatenate multiple frame contour data into a single frame point cloud in a certain direction.

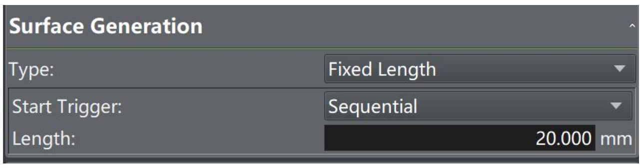
There are four types of surface generation, namely continuous, fixed length, Variable length, and rotational.The selection list is shown in the following figure:



（1）Continuous mode: part detection must be enabled by default. When multiple non overlapping samples are placed on the conveyor belt and run at a certain speed, the sensor can detect these samples in real-time.

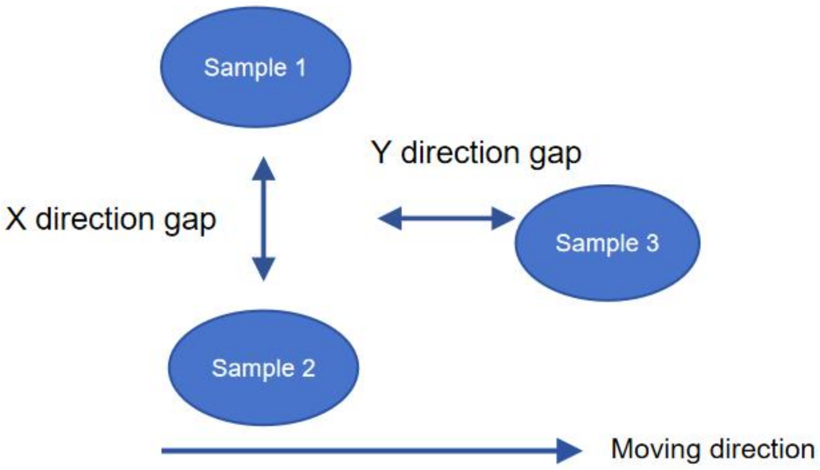


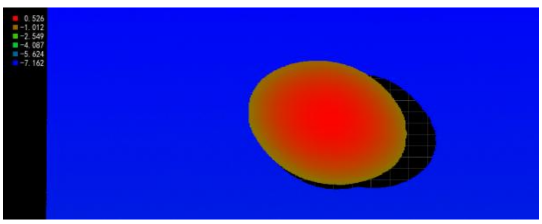
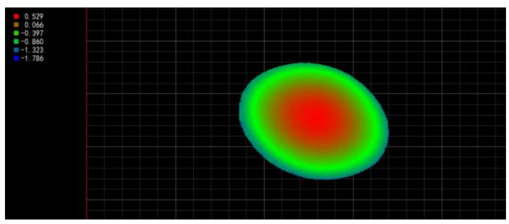
（2）Fixed length mode: Move a certain length in the Y direction to generate a frame of surface, and users can set the length according to their needs. After the length distance reaches 40mm as shown in the following figure, a frame of surface will be generated. Under fixed length, sample detection can also be selected, but when the generated surface length reaches the set fixed length value and the sample does not end, the sample will be divided into two frame surface. In fixed length mode, the triggering mode is divided into sequential triggering, Sequential triggering refers to the continuous insertion of contours to form a fixed length surface.

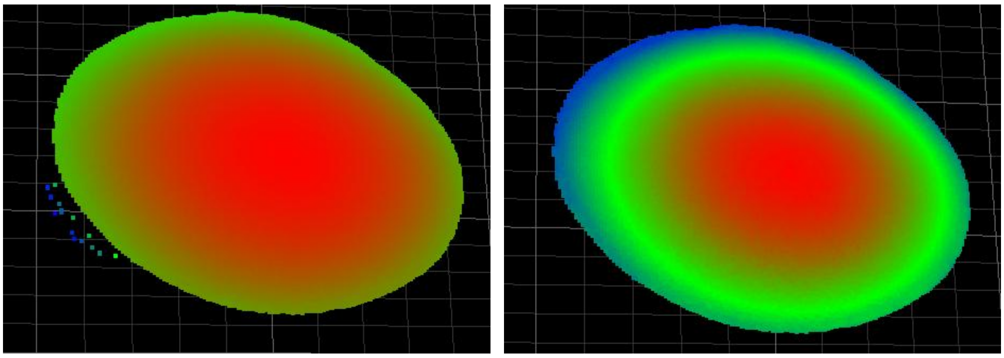


6.6.7 Part detection

In surface mode, sensors can automatically identify non overlapping samples by analyzing scanned data, and output each part surface separately. In continuous mode, the system automatically activates part detection, while in fixed length mode, the user manually activates part detection as needed. The following figure is a schematic diagram of the part separation surface.



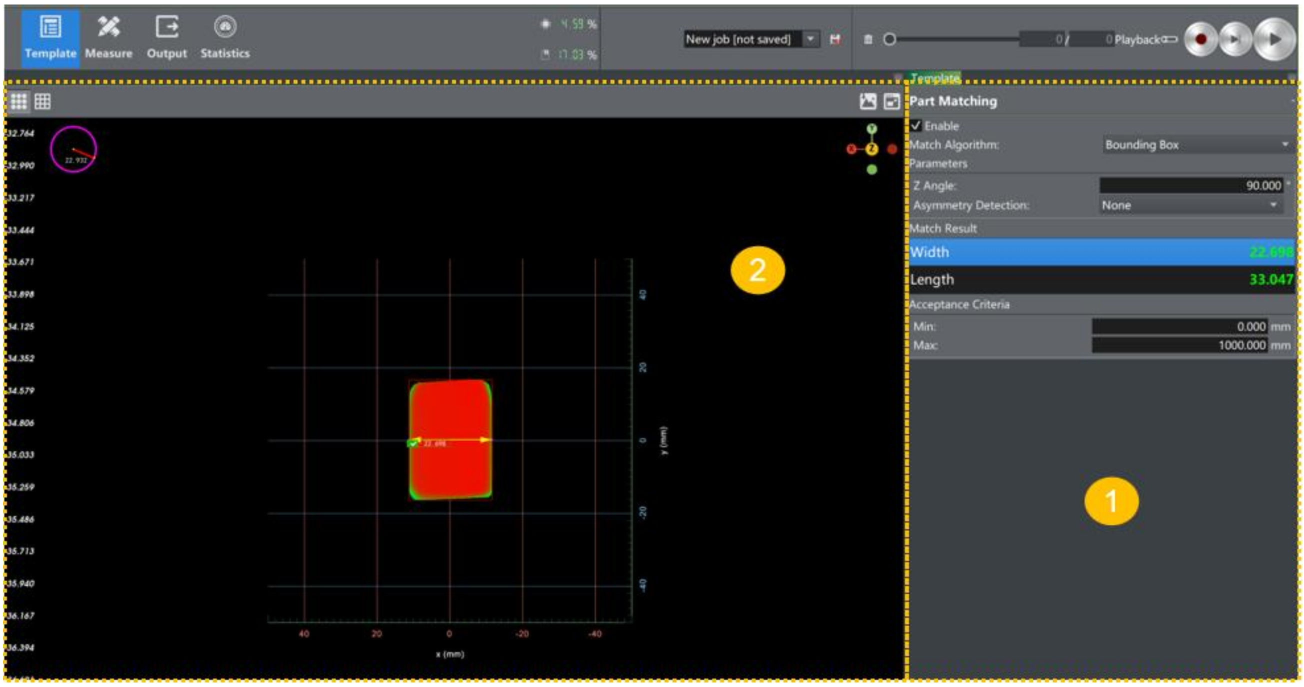
part detection parameters	**describe**
Height threshold	Used to limit the height threshold of the sample. As shown in the following figure, the height threshold is selected as -10mm, and the threshold direction is selected upwards to obtain the results in the left figure; Select a height threshold of -2mm and a threshold direction to obtain the results shown in the right image. The height threshold is mainly used to remove point clouds that are not in the sample area, such as conveyor belts.  

<table>
<tr><td>Threshold direction</td><td colspan="2">The threshold direction is used in conjunction with the height threshold. On the threshold direction selection, output the point cloud above the threshold; Under the threshold direction selection, output the point cloud below the threshold.</td></tr>
<tr><td>Gap width</td><td colspan="2">In the X-axis direction, the minimum interval between samples is used to separate samples with a width greater than the threshold.</td></tr>
<tr><td>Gap length</td><td colspan="2">In the Y-axis direction, the minimum interval between samples is used to separate samples with a length greater than the threshold.</td></tr>
<tr><td>Min area</td><td colspan="2">The min area of the sample, used to eliminate interference objects smaller than this area.</td></tr>
<tr><td>Max part length</td><td colspan="2">The maximum length of the sample. When the length exceeds this, the sample will be divided into two or even more sections.</td></tr>
<tr><td rowspan="4">Edge filtering</td><td colspan="2">Edge filtering is used to filter out noise interference in the boundary area of the sample. The following figure shows the comparison before and after filtering. The left side shows the point cloud image before edge filtering, and the right side shows the point cloud image after edge filtering.
</td></tr>
<tr><td>Preserve interior feature</td><td>Checking 'Keep Internal Data' will only filter out outer edge noise, and unchecking 'Keep Internal Data' will filter out both external and internal noise.</td></tr>
<tr><td>edge filtering width</td><td>The window size of point cloud edge filtering in the X direction.</td></tr>
<tr><td>edge filtering length</td><td>The window size of point cloud edge filtering in the Y direction.</td></tr>
</table>

6.7 Template Settings

6.7.1 Template Page Overview

The part matching mode and parameter settings can be set through the model page.

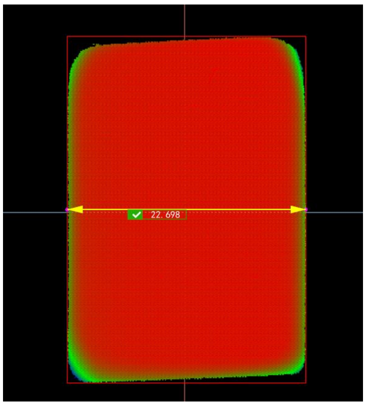


project	describe
1 Matching panel	Used for sample matching mode selection and sample matching parameter settings
2 Data viewing area	Display sample matching results and corresponding measurement data

6.7.2 Part matching

When using bounding box mode for part matching, regardless of the direction of the transmitted part, the system will perform the matching operation and determine whether the matching results of the test sample match the set parameters.

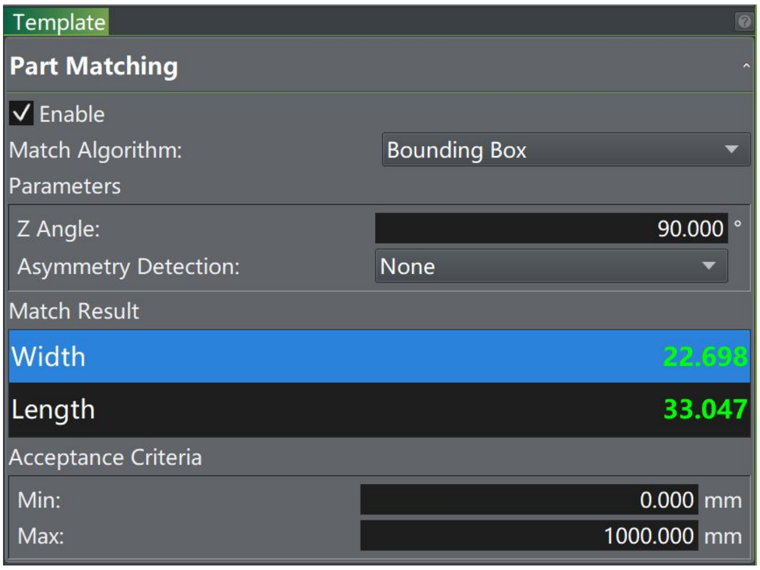
When using the bounding box mode, the data viewing area will display a part surface with a red rectangular box. If the part matching results meet the set parameters, the corresponding results can be applied to subsequent measurements.



When using bounding boxes for part matching, the main steps include:

1、 Scan the part (or use previously saved scan data).

2、 Set parameters related to bounding boxes.



Matching panels under bounding box conditions

Name	Describe
matching algorithm	Select the bounding box option and confirm that the sensor uses the bounding box algorithm for matching.
Z-angle	Change the direction of the bounding box to accurately match the sample in the typical direction and facilitate subsequent measurements.
Asymmetry detection	The system calculates the number of point clouds on both sides of the centroid of the point cloud sample in the current state, and performs corresponding rotational scans based on the asymmetry of the scanned sample point cloud. None - no flipping scan

	Along the long axis - ensure that the number of point clouds on the left is greater than the number of point clouds on the right, and flip and scan accordingly based on the obtained data. Along the short axis - ensure that the number of bottom point clouds is greater than the number of top point clouds, and perform corresponding flipping scans based on the obtained data.
Matching result	Set the maximum and minimum values for the width and length of the scanned sample in the matching threshold.

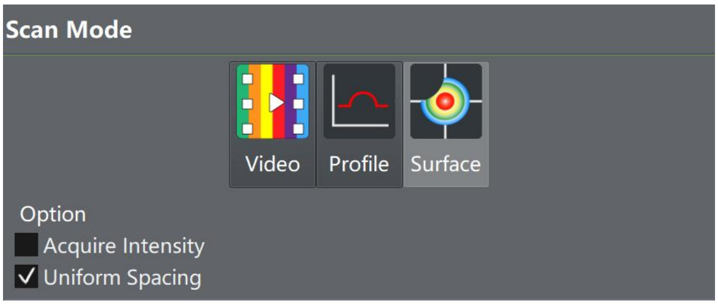
6.7.3 Configure bounding boxes

When using bounding boxes for part matching, acceptable variations between the reference part and the expected data must be taken into account.

Configure bounding boxes to achieve part matching:

1 Switch Scan Page

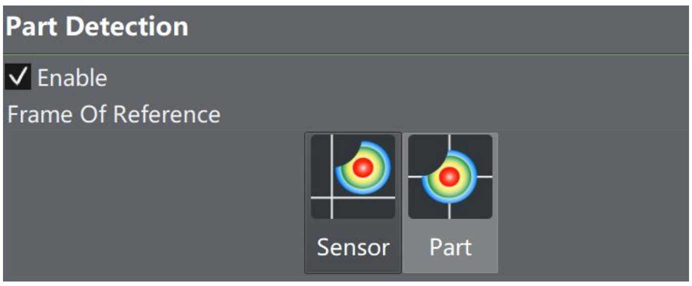
a. In scan mode, select surface mode.



Only by selecting surface mode can part scanning be performed, and the model page can only be displayed in surface mode.

When using bounding boxes for part matching, the Uniform Spacing option must be checked. Enabling Uniform Spacing is a prerequisite for enabling part detection, which is a prerequisite for enabling the template function. Acquire intensity can be enabled when measuring the required acquire intensity, otherwise it cannot be enabled.

b. In part detection, select the part as the coordinate system reference.



part matching is only available under part conditions.

2 Do one of the following:

（1）Scan reference part. For detailed information on scanning and alibnment, please refer to Scan Mode on page 58 and Calibration on page 66.

（2）Use the previously saved data and load it. For specific introduction, please refer to the relevant detailed operations in the operation area on page 48.

3 Go to the model page

a. Ensure that the part matches the enable button in the panel.

b. Select the rectangular box in the matching algorithm drop-down option.

4 Change the acceptable maximum and minimum values for width and length in the matching result panel, taking into account the acceptable changes in the maximum and minimum settings.

5 Click Save to save the job. For detailed operations, please refer to 6.4.2 Job Creation and Job Save Settings in the Job Area.

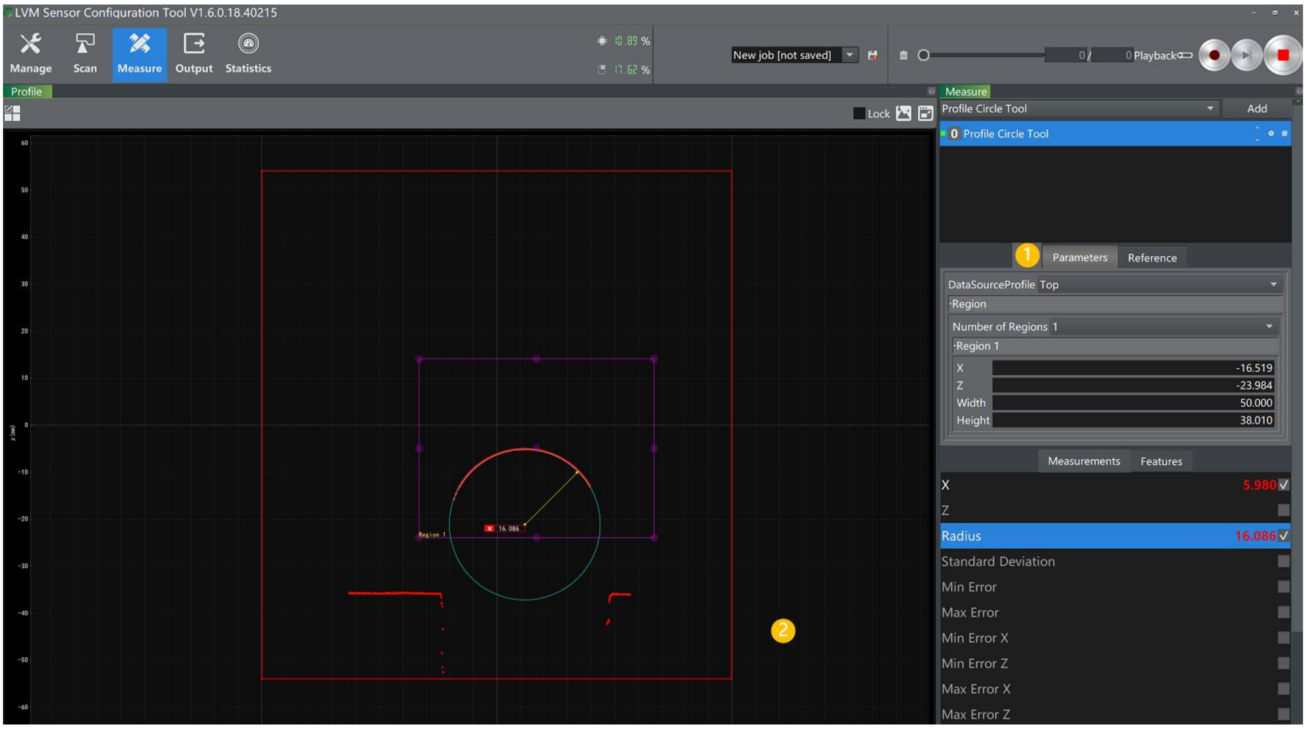
6.7.4 Run part matching

Ensure that the enable button on the part matching panel is selected when the system is running. If the matching result of the part is within the set condition range, all measurements added to the measurement page with river settings will be applied to the matched part, and the direction before the part matching has no effect on the matching result. At the same time, the bounding box returns the judgment result; If the matching result of the sample is not within the set condition range, the corresponding measurement will not be taken and an invalid value will be returned.

6.8 Measurement Overview

6.8.1 Measure Page Layout

Users add and configure measurement tools on the measurement page. The "Measure" button in the main control area is only visible when the scanning mode is "Profile" and "Surface".

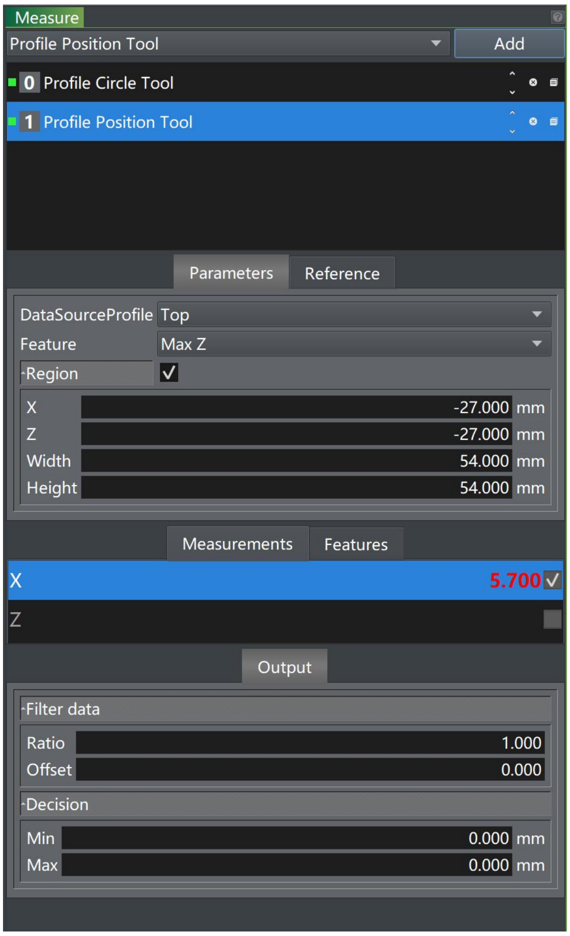


Project	Describe
1 Tool Panel	Perform tool addition, copying, deletion, sorting operations, and configure the parameters of each tool
2 Data viewing area	Display the contour generated by scanning, as well as the corresponding elements and measurement results of the measurement tool

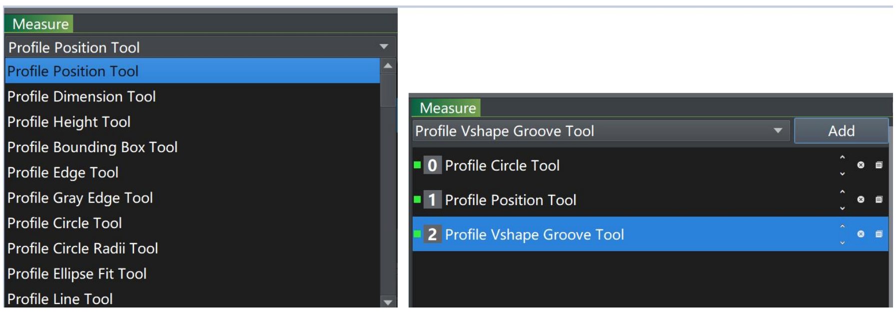
6.8.e2 Tool Panel

■ **Layout of tool panel**

The layout of the measurement tool panel is shown in the following figure. The upper part is the tool chain management area. When a tool is selected and highlighted, the lower part displays the setting area of the tool.



■ **Tool chain management**



Sensors support multiple measurement tools to execute simultaneously, forming a measurement tool chain. In the tool panel, you can manage the tool chain, such as adding, deleting, and copying tools, as shown in the table below.

Project	Describe
Add Tools	Click the drop-down button in the measurement tool list, select the measurement tool to be added from the displayed list, and then click the [Add] button.
Delete Tool	Click on the icon to the right of the added measurement tool name ⊠. You can delete the measurement tool.
Copy Tool	Click on the icon to the right of the added measurement tool name ▤. You can copy the measurement tool. The new tool and the copied tool have the same configuration parameters by default.
Position up	Click on the icon to the right of the added measurement tool name ▲. The position of the tool immediately moves upwards.
Position adjustment	Click on the icon to the right of the added measurement tool name ▼. The position of the tool immediately moves downwards.
rename	Double click on the added measurement tool to edit its name.

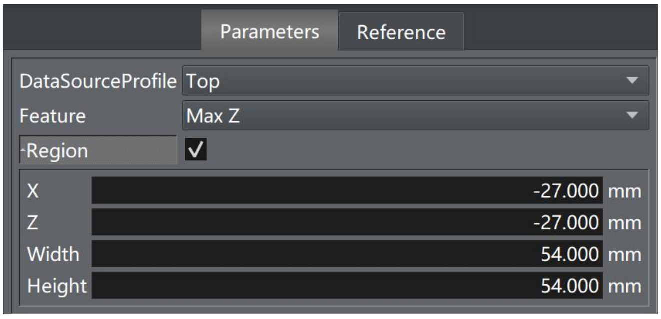
The numerical label in front of the measuring tool represents the execution order of the tool. When reference relationships occur with measurement tools, such as anchoring or referencing features, the execution order of the tools will automatically adjust. The color block before the number label indicates the status of the measuring tool, green indicates that the tool is executing normally, red indicates that the tool does not support non-uniform spacing modes such as chamfering tools, orange indicates that the tool does not support uniform spacing modes such as roughness tools, and yellow indicates that the tool anchoring is invalid. The tool's support for scanning mode is shown in the table below.

Tool Name	Supports uniform spacing mode	Support for non-uniform spacing mode	Tool Name	Supports uniform spacing mode	Support for non-uniform spacing mode
Bounding box	√	×	Protrusion	√	×
height	√	×	V-groove	√	×
area	√	×	overlapping	√	√
Roughness	×	√	straight line	√	√
circular	√	√	Gap surface difference	√	×

Roundness	√	√	position	√	√
Closed area	×	√	Chamfer	√	×
size	√	√	Depression	√	×
edge	√	×	template matching	√	×

■ **Tool parameter settings**

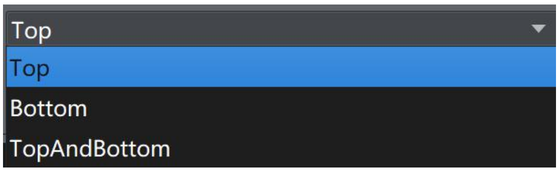
The parameter settings of each measurement tool are different, please refer to the introduction section of each tool for details. General settings include data source profile and measurement region.



（1）Data source profile

Select the data source profile for the measurement tool by selecting the desired data source from the drop-down list. In single sensor mode, the data source is only up; When there is opposite arrangement in the multi-sensor mode, the data source profile can be divided into two situations depending on the measurement tools: (up, down, up+down) or (up, down).

Unidirectional arrangement



Bidirectional arrangement

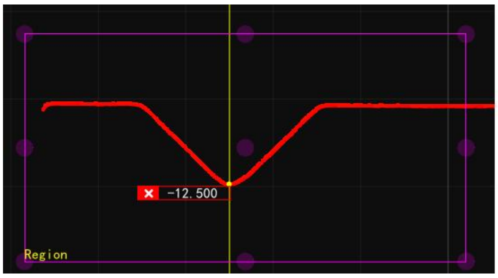
（2）Measurement region

Measurement tools can use user-defined areas to limit the region where measurements occur or generate features. For example, measuring the maximum Z value within the selected area, or fitting a line using contour data from two areas. By setting the measurement region, interference can be eliminated, thereby improving measurement accuracy and stability, and also reducing tool execution time.

The meaning of "measurement region" on the measurement tool page is different from that of "active area" on the sensor settings panel of the scanning page. The latter limits the area for generating contours, and reducing the active area can improve the scanning frame rate. The former acts on the

measurement tool, and reducing the measurement area frofile does not affect the scanning frame rate.

As shown in the following figure, after selecting the [Region] check box in the "Parameters" panel, a purple edit box will appear in the data viewing area. Users can adjust the measurement area by dragging and dropping the mouse, as shown in the left figure. They can also edit the values of X, Z, width, and height in the area to change the position and size of the measurement area profile, as shown in the right figure.

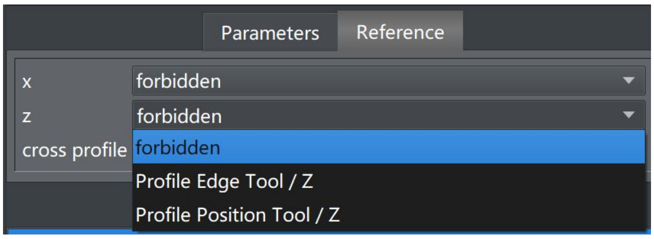


■ **Reference Settings**

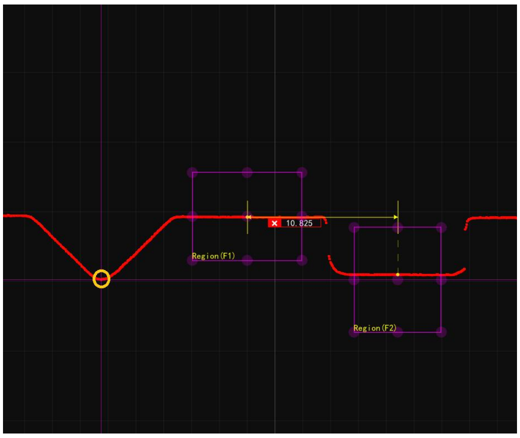
（3）Anchor reference

For an introduction to anchoring, please refer to Section 5.4.3, Anchoring Measurement. Make anchoring settings in the 'Reference' panel of the measurement tool. Only when the measurement tool used as the anchoring object selects an X or Z value in the output parameters can it be anchored by other measurement tools.

As shown in the following figure, all available sources for anchoring can be seen in the X and Z drop-down lists of the References panel.

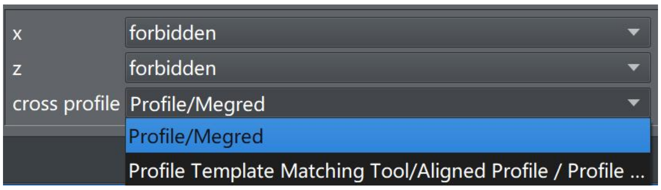


In the example below, it is necessary to measure the size between the mean position in area 1 and the mean position in area 2. Due to the fact that stable measurement can be achieved at the highest point of the contour, which is the maximum position of the Z value, it can be used as an anchoring source. Firstly, add the 'profile Position tool', select 'max Z' for the measurement feature, and select 'X' and 'Z' for the measurement result output. Then add the "Profile dimension tool", select measurement feature 1 and measurement feature 2, and in the "Reference" panel, select "profile Position tool/X" and "profile Position tool/Z" respectively. In the actual measurement process, when the sample shifts up, down, or left, the positions of measurement feature 1 and measurement feature 2 automatically shift accordingly, achieving tracking effect and ensuring the stability of the measurement results.



（2） Contour reference

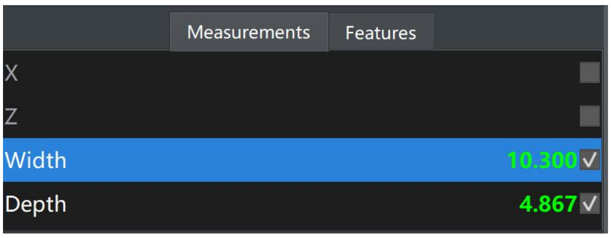
Some measurement tools will generate new contour data, such as template matching and advanced height difference tools, which can output the matched and differential contours. Other tools can measure based on these new contour data. In this case, it is necessary to select the contour to be measured in the "Reference" panel of the tool.



■ Selection of measurement results

After each measurement tool is executed, a series of measurement results will be generated, and users can select several measurement results from the "Measurement" list as needed for display and output. The following example shows the result list of the "V-shaped groove" measurement tool. Checked options will display the measurement results, while unchecked options will not be displayed.

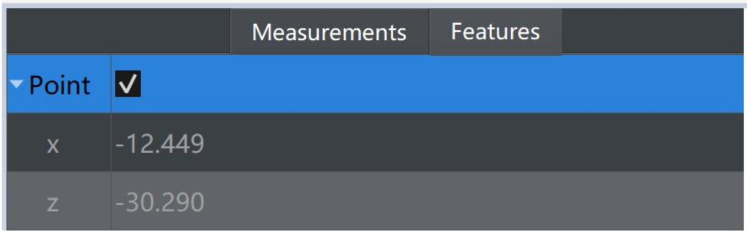
Users can also modify the name of the measurement result by double-clicking on the name to make it editable.

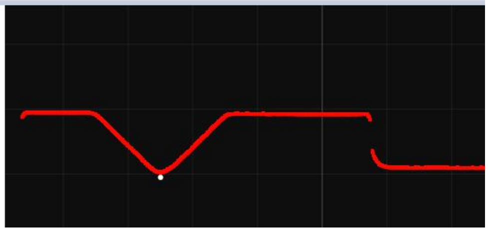


■ Tool generation feature data selection

After some measurement tools are executed, they can generate several feature data, such as points, lines, faces, circles, etc. Users can perform feature measurements based on these features. For an introduction to feature measurement, please refer to 6.9 Feature Measurement Content. Users can make selections in the "Features" panel.

The following example shows the feature list of the "V-shaped groove" measurement tool. The feature point is the inflection point at the bottom of the V-shaped groove. When checked, the feature value will be displayed, and the entity of the feature will be displayed in the data viewing area.

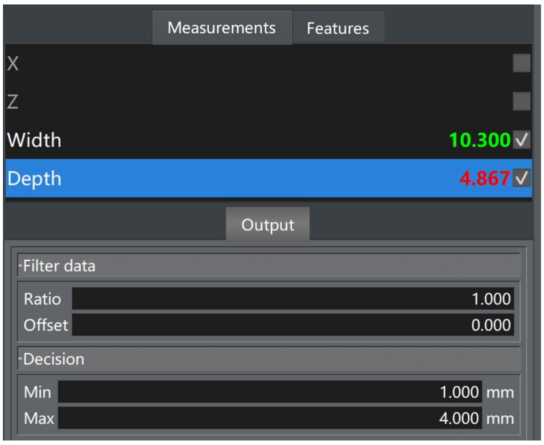




- **Measurement result processing and decision**

In some cases, it is necessary to process the measurement results and then output them externally. Users can set them in the "Filter data" section of the "Output" panel to perform simple multiplication and addition operations on the results. The default measurement result for the "Circle" tool is radius, and when users need a diameter, the scale can be set to 2.

In addition, the qualified range of the measurement results, namely "min" and "max", can be set to directly determine whether the results are qualified or not, and color identification can be made in the "measurements" list. Green represents qualified, and red represents unqualified. The judgment result will also be output externally, facilitating the external control system to eliminate unqualified workpieces.



Concept	Describe
Filter data	New output result=Old output result × Scale+Offset. For example, if the radius of a circle is obtained from the measurement results, the ratio is set to 2, and the offset is set to 0, then the diameter of the circle=the radius of the circle × 2+0.

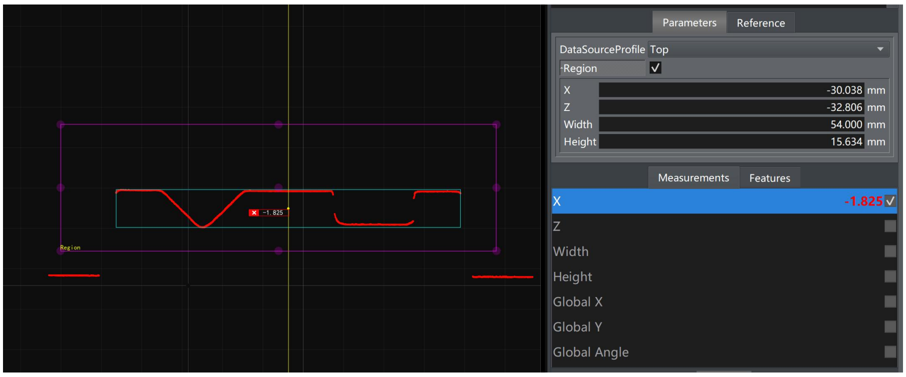
Decision	Limit the max and min values of the output results. If the output result is within the decision value range, it is considered qualified, and the qualified result is displayed in green. If it is not within the range, it is considered unqualified, and the unqualified result is displayed in red.

6.9 Contour measurement

The following sections introduce the purpose, input parameters, output parameters, and output features of each contour measurement tool. The data sources in the input parameters of each measurement tool refer to providing contour or cross-sectional data from single or multiple sensors to the measurement tool.

6.9.1 profile Bounding box tool

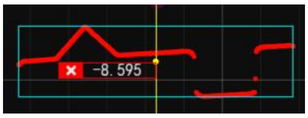
The function of the bounding box tool is to solve the minimum positive bounding box of the contour points in the region, which is suitable for solving the overall size of the workpiece. As shown in the following figure, the blue box represents the bounding box of the contour data within the region of interest.



Input parameters:

Parameter	Describe
Region	Configuration parameters for the region of interest.

Output parameters:

Parameter	Describe	Example
X	The X coordinate of the center point of the bounding box. Represented by a yellow line perpendicular to the X-axis passing through the center point, the result is displayed in the text box. With reference X label.	
Z	The Z coordinate of the center point of the bounding box. Represented by a yellow line passing through the center point parallel to the X-axis, the result is displayed in the text box. With reference Z	

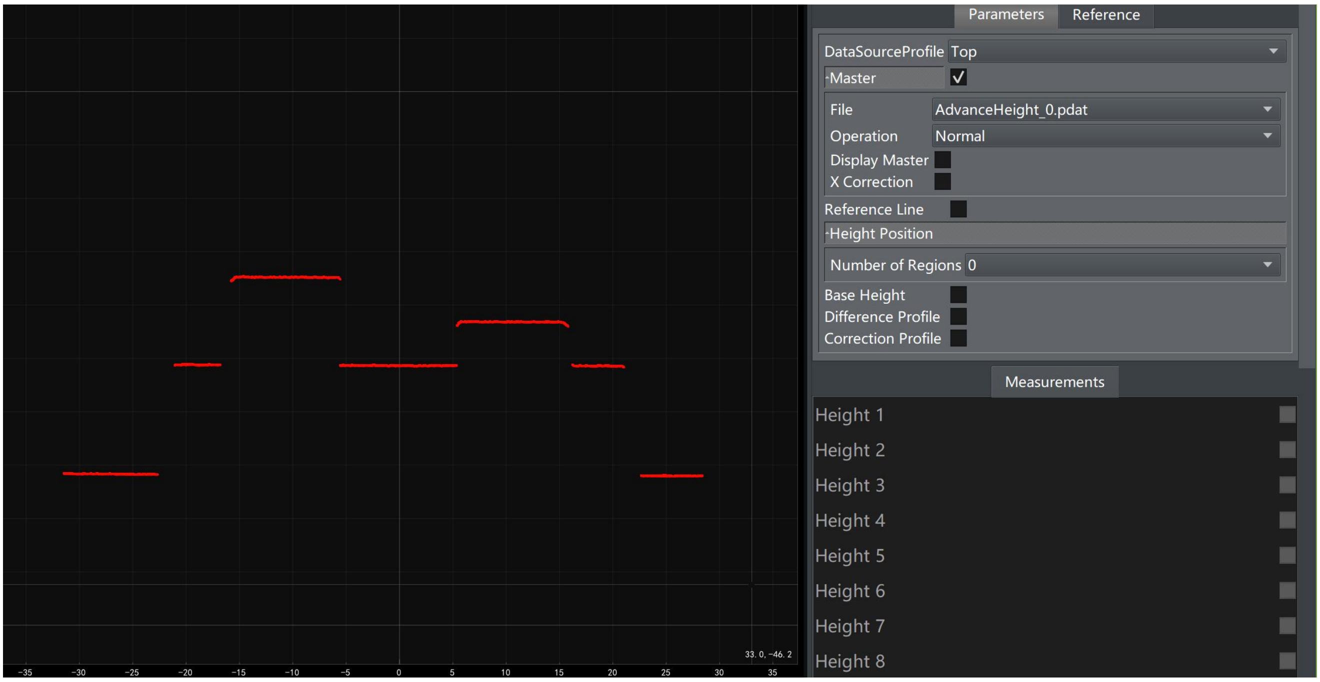
	label.	
Width	The width of the bounding box, represented by a yellow double arrow.	
Height	The height of the bounding box, represented by a yellow double arrow.	
Global X	Used in point cloud mode and 0 in contour mode.	
Global Z	Used in point cloud mode and 0 in contour mode.	
Global angle	Used in point cloud mode and 0 in contour mode.	

Feature output:

feature	**describe**
Center point	Output the center point of the bounding box as a point feature.
corner point	Output the bottom left corner of the bounding box as a point feature.

6.9.2 profile Height tool

The height tool can be used for height measurement, supporting up to 16 areas of height difference. As shown in the figure below, there are multiple height differences, and the positional relationship between multiple heights can be calculated through advanced height.

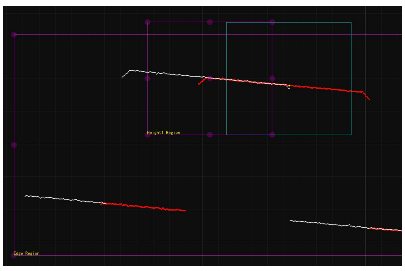


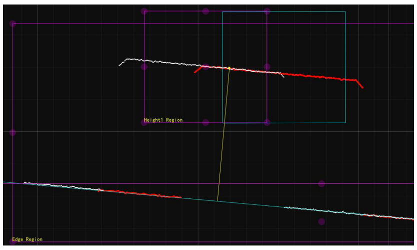
Input parameters:

<table>
<tr><th>Parameter</th><th colspan="3">Describe</th></tr>
<tr><td rowspan="5">Template</td><td>File name</td><td colspan="2">Select the desired template from the drop-down list.</td></tr>
<tr><td>Operation</td><td colspan="2">Normal: Jump to normal mode after executing save and delete commands.
Save: Saves the current frame as a template.
Delete: Delete the currently selected template.</td></tr>
<tr><td>Display master</td><td colspan="2">Display template contour data, represented by white dots.</td></tr>
<tr><td rowspan="2">X correction</td><td>Edge finding area</td><td>The area for X-axis correction.</td></tr>
<tr><td>Edge finding direction</td><td>Ascending: Find the rising edge.
Descending: Find the falling edge.</td></tr>
</table>

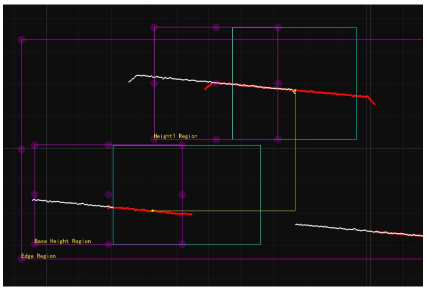
		Counting direction	From left to right: The edge count starts from the left. From right to left: Edge counting starts from the right side.
		Edge number	The selected edge number.
Reference line	line region	The number of regions used for reference line line fitting.	
	Region	Fit the area of the reference line.	
	The reference line is used for calibration and measurement. When selecting a template, it is used to calculate Y rotation and Z offset.		
Height positiion	Number of regions	The number of areas used for height measurement, supporting a maximum of 16.	
	Region	Settings for each measurement area.	
base height	Reference height region	Calculate the area of the reference point.	
	base height feature	Features include maximum, minimum, mean, and median values.	
Difference profile	Output and display differential contours.		
Correction profile	Output and display the matched contour, which can be referenced by other measurement tools.		

Output parameters:

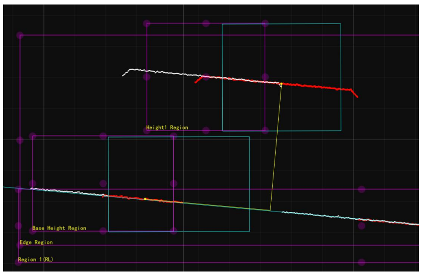
parameter	**describe**	**Example**
1~16 Height value	Height measurement result value. The image on the right shows the height measurement results when several parameters interact.	 Template ☑ Reference line ☐ altitude height ☐



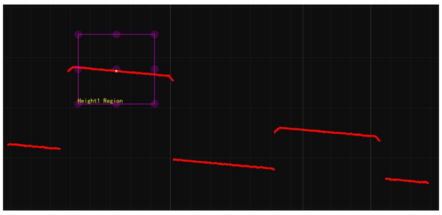
Template ☑ Reference line ☑ altitude height ☐



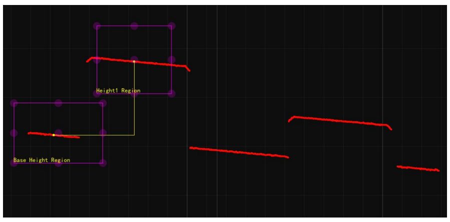
Template ☑ Reference line ☐ altitude height ☑



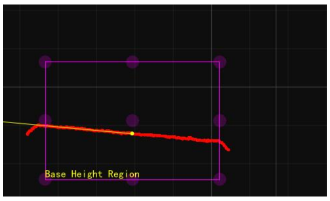
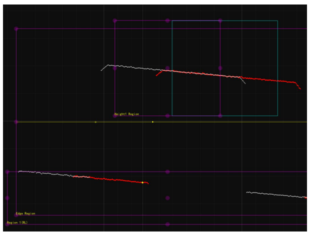
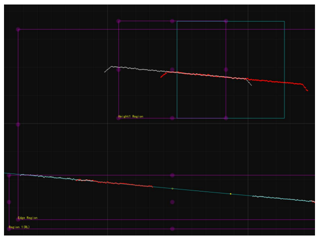
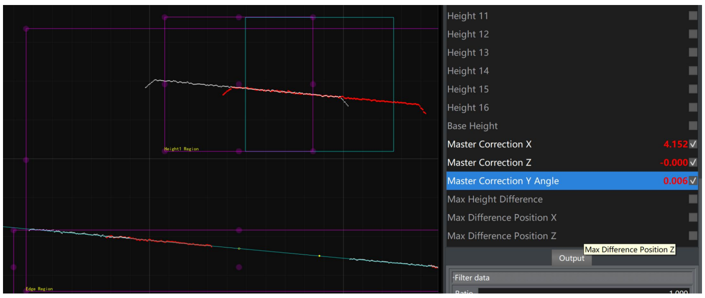
Template ☑ Reference line ☑ altitude height ☑



Template ☐ Reference line ☐ altitude height ☐



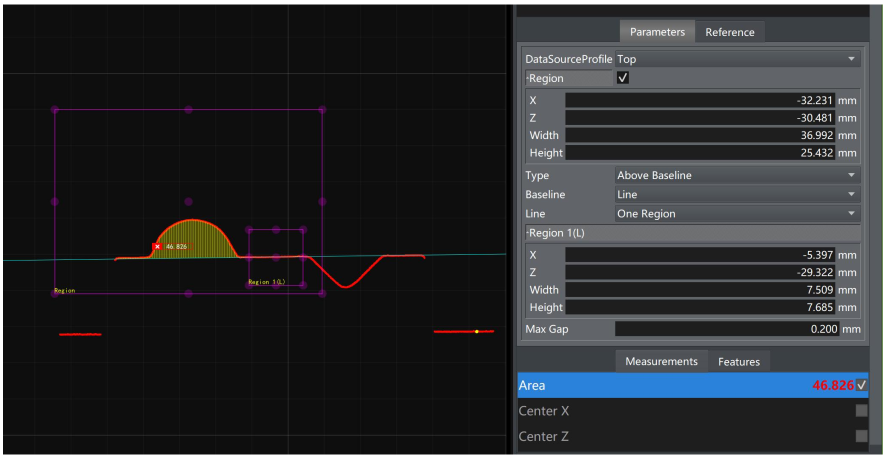
Template ☐ Reference line ☐ altitude height ☑

		 Template ☐ Reference line ☑ altitude height ☐  Template ☐ Reference line ☑ altitude height ☑
base height	Reference height area. Benchmark height features (maximum, minimum, mean, median).	
master correction X (Z)	Template matching X (Z) offset. In the right figure, the difference in the X (Z) direction between the solid yellow dot and the hollow yellow dot is the X (Z) offset.	 X  Z
\master correction Y angle	The template matches the Y angle. In Region 1 (RL), the difference in angle between the white template point fitted line and the red current point fitted line is the template Y angle.	
Max height	Coordinate the maximum height difference between the template and the matched contour.	

difference	
Maximum difference position X	The X value of the maximum height difference coordinate.
Maximum difference position Z	The Z value of the maximum height difference coordinate.

6.9.3 profile Area Tool

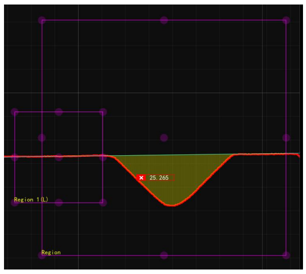
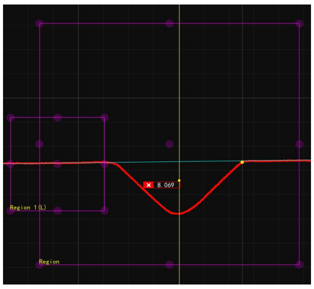
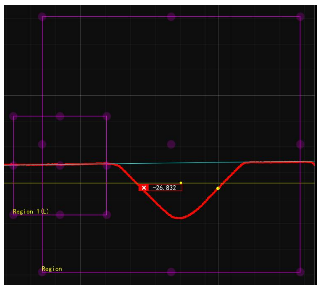
The area tool is used to measure the area of an area of interest. As shown in the following figure, calculate the area of the raised triangle area, where the yellow area represents the area area.



Input parameters:

Parameter	Describe
Region	Area of interest.
Type	Above baseline: Solve the area composed of data points above the baseline. Below baseline: Calculate the area composed of data points below the baseline.
Baseline	Line: The fitted line serves as the baseline. X-axis: The X-axis serves as the baseline.
Line area (number of areas participating in line fitting)	A region: Fit data within a region to a straight line. Two regions: fit the data within two regions to a straight line. All data: Fit all contour data to a straight line.
Region	Line fitting area.
Max gap	Maximum allowable breakpoint gap.

Output parameters:

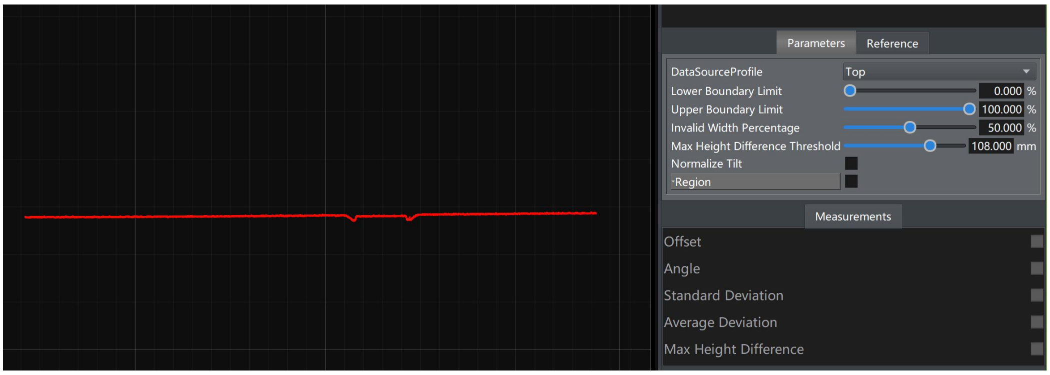
Parameter	Describe	Example
Area target area.	Area target area.	  Above baseline Below baseline
Center X，Z	The X, Z coordinates of the area centroid.	  X Z

Feature output:

Parameter	Describe
Center point	Output the centroid of the area area as a point feature.

6.9.4 Profile Roughness Tool

The roughness tool is used to measure the roughness of a straight line. When the normalized slope is not selected, the baseline is a straight line parallel to the X-axis passing through the mean of the data points; When selecting the normalized slope, the baseline is the straight line fitted to the data points.

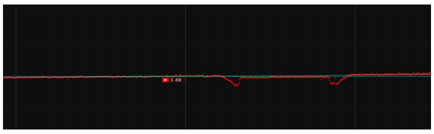
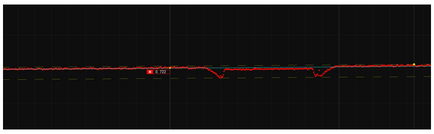


Input parameters:

Parameter	**Describe**
Lower boundary limit	The lower limit of the boundary refers to the percentage of extreme points below the baseline removed.
upper boundary limit	The upper limit of the boundary refers to the percentage of extreme points removed above the baseline.
Invalid width percentage	The percentage of invalid points within the region of interest to the entire width.
Max height difference threshold	The height difference between the effective maximum and minimum points from the data point to the baseline.
Normalize Tilt	The data points within the region of interest are projected to collaborate on a straight line as the baseline.
Region	Roughness region of interest.

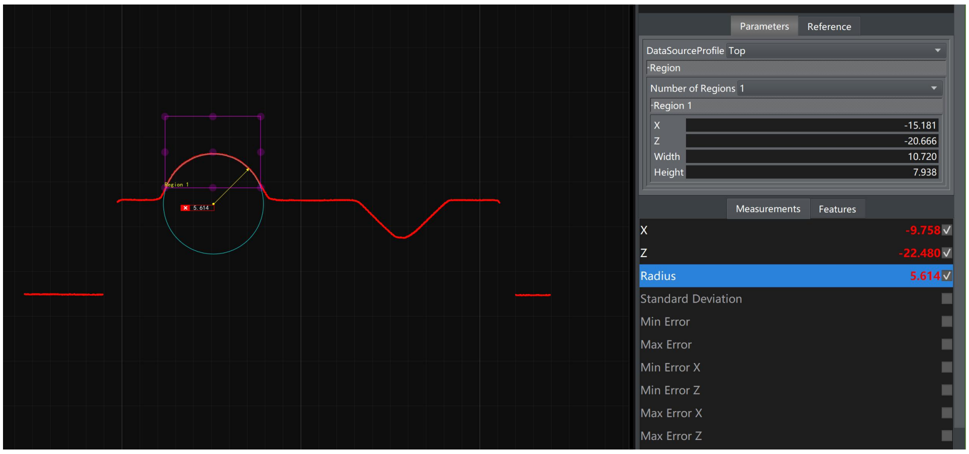
Output parameters:

Parameter	**Describe**	**Example**

offset	The intercept in a straight diagonal cut.	
Angle	The angle between the straight line and the X-axis is always 0 when the normalized slope is not selected.	
Standard deviation	The standard deviation of a straight line.	
Average Deviation	The average distance from a point to a straight line.	
Max height difference	Z spacing between maximum and minimum values.	

6.9.5 Profile Circular Tool

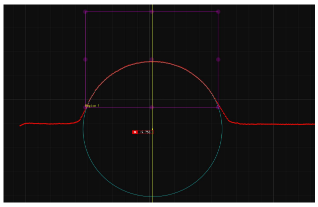
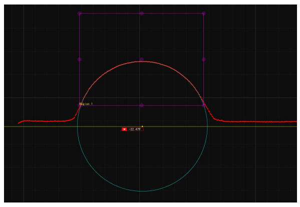
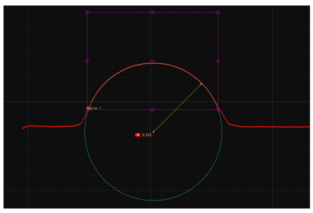
The function of a circle measurement tool is to obtain the relevant features of a circle through circle fitting.

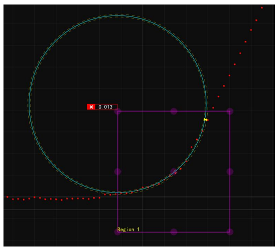
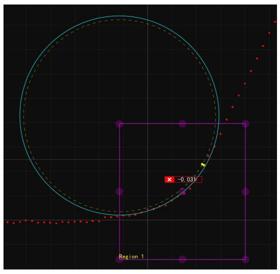
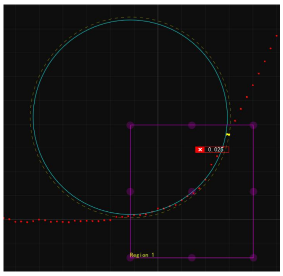
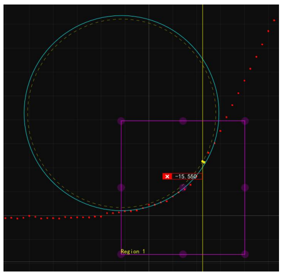
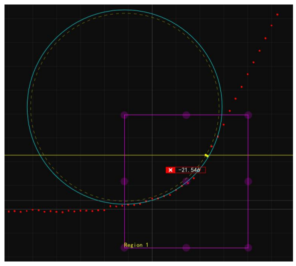
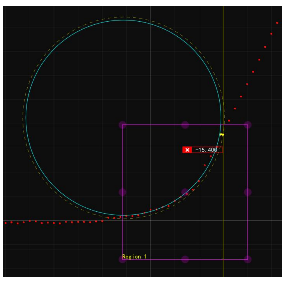
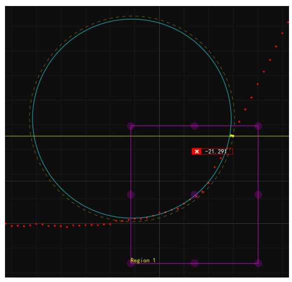


Input parameters:

Parameter	Describe
Number of regions	The number of regions of interest participating in circle fitting is 0 ≤ n ≤ 16, and the number of regions is selected according to actual needs.
Region	Configuration parameters for the region of interest.

Output parameters:

Parameter	Describe	Example
X，Z	Fit the X, Z coordinates of the center of the circle.	 X  Z
Radius	The radius of the fitted circle.	

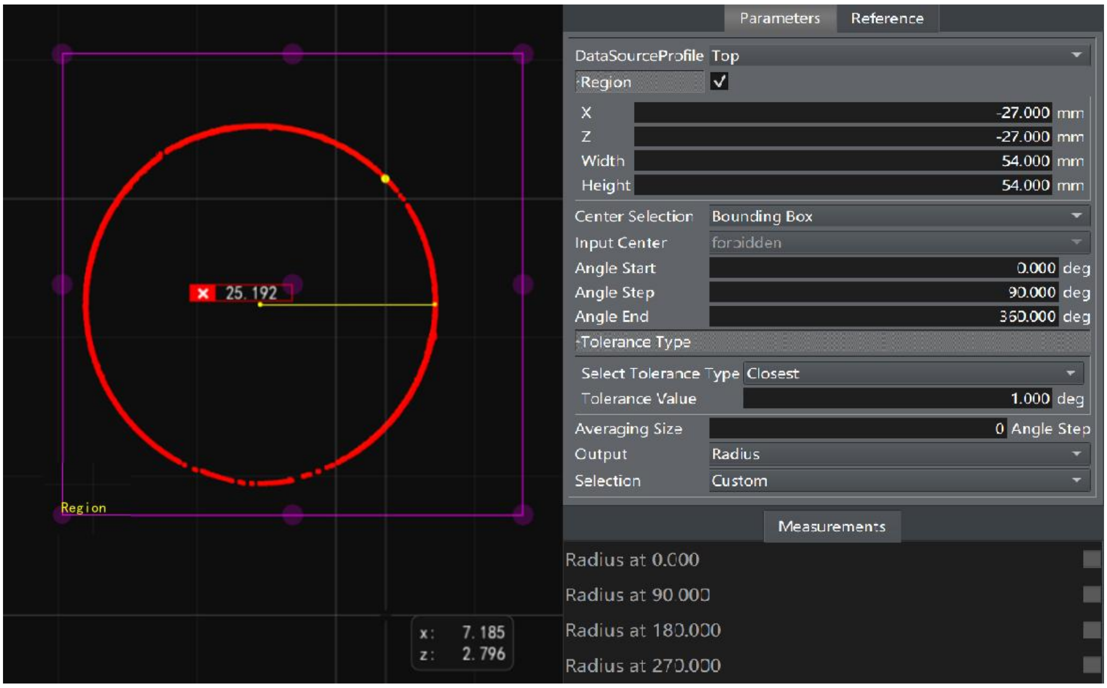
Standard deviation	The standard deviation of circle fitting.	
Min Error	The point inside the circle that is farthest from the circle.	
Max Error	The point outside the circle that is farthest from the circle.	
Min Error X (Z)	The X (Z) coordinate of the farthest point inside the circle.	 X  Z
Max Error X (Z)	The X (Z) coordinate of the farthest point from the outside of the circle.	 X  Z

Feature output:

Parameter	Describe
Circle	Output the fitting equation of a circle as a circle feature.
point	Output the center coordinates as point features.

6.9.6 Profile Circle Radii Tool

The function of the roundness tool is to calculate the intersection of a ray from the center of a circle at a certain angle with contour data, and calculate the radius or diameter here. It is mainly used for defect detection of cylindrical workpieces.

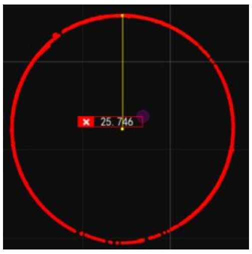
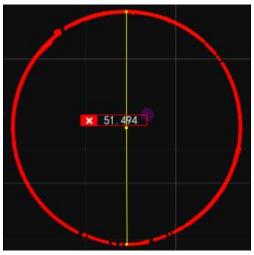


Input parameters:

Parameter	Describe
Region	The area used to calculate roundness.
Center selection	Bounding box: centered around the midpoint of the bounding box. Input feature: centered around the input feature point.
Input Center	When the center selection is a bounding box, this option is disabled. When selecting features for input, this selection selects features from other tools, such as selecting the center of the circle tool as the input center.
angle Start	The starting angle of the ray.
Angle step	Emit rays at a certain angle step size. For example, if the angle step is set to 10 degrees, one ray is emitted every 10 degrees from the

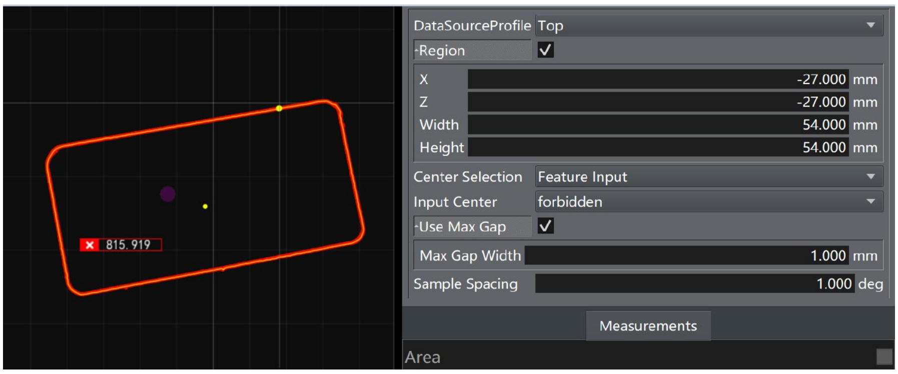
	starting angle until the ending angle.
angle end	Ray termination angle.
Error	If no contour point is found at this angle position, search for the closest contour point around the set angle. The larger the error set, the easier it is to find the contour points.
tolerance type	Average adjacent radius or diameter output results.
Output	Radius: Only output the radius. Diameter: Only output diameter, diameter requires opposite data. Radius and diameter: Output radius and diameter.
selection	Custom: Customize the measurement results that need to be output. Enable All: All results are output. Close All: All results are not output.

Output parameters:

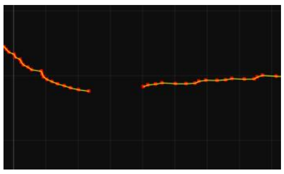
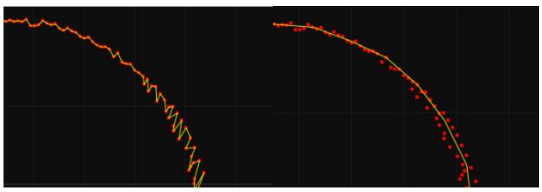
Parameter	Describe	Example
radius at * degrees	The radius at * angle. The right image shows the radius at 90 degrees.	
Diameter at * degrees	Diameter at * angle. The figure on the right shows the diameter at 90 degrees.	

6.9.7 profile closed area tool

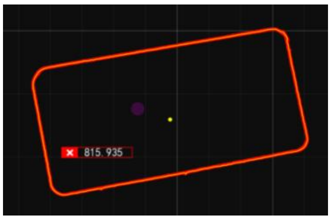
The enclosed area tool is used to measure the area of the enclosed area.



Input parameters:

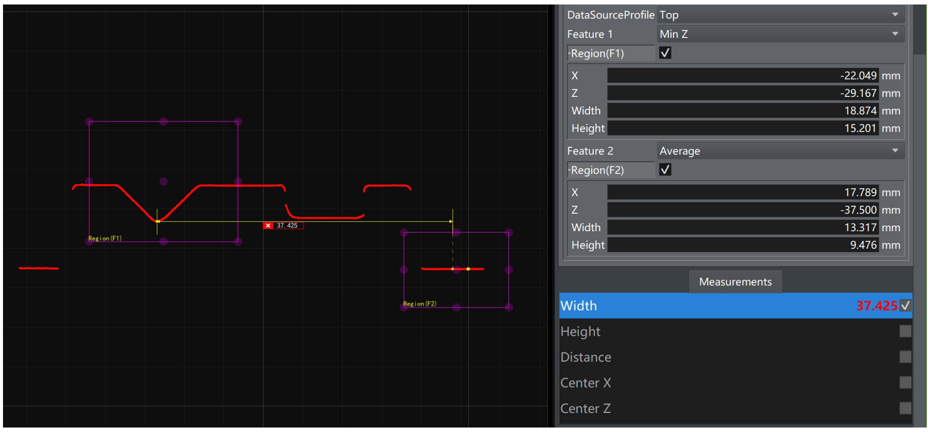
Parameter	Describe	
Region	Used to calculate the area of enclosed areas.	
Center selection	Bounding box: The midpoint of the bounding box serves as the center. Feature input: centered around the input feature points.	
Input Center	When the center selection is a bounding box, this option is disabled. When selecting feature input from the center, this selection selects features from other tools. For example, select the center of the circle tool as the input center.	
Use max gap	If the distance between the closest two points exceeds the threshold, it is considered not closed here.	
Sample spacing	Take an area support point for each interval at this angle threshold. The sampling interval for the left contour in the figure is 0 degrees, and the sampling interval for the right contour is 1 degree.	

Output parameters:

Parameter	Describe	Example
Area	Obtain the area of the enclosed area.	

6.9.8 Profile Dimension Tool

The size tool is used to find the positional relationship between feature points in two regions of interest, mainly used to measure whether the size between two obvious features on the same sample is within the tolerance range.



Input parameters:

Parameter	Describe
Feature 1	Max Z: Calculate the point with the highest Z in the contour points within the region. Max X: Calculate the point within the region where X is the largest among the contour points. Min Z: Calculate the point with the smallest Z in the contour points within the region. Min X: Calculate the point within the region where X is the smallest among the contour points. Average: Calculate the mean value of contour points within the region. Median: Calculate the median of the contour points within the region. Inflection point: the point in the calculation area where the slope changes the most among the contour points.
region(F1)	Region of interest for feature 1.
Feature 2	Max Z: Calculate the point with the highest Z in the contour points within the region. Max X: Calculate the point within the region where X is the largest among the contour points. Min Z: Calculate the point with the smallest Z in the contour points within the region. Min X: Calculate the point within the region where X is the smallest among the contour points. Average: Calculate the mean value of contour points within the region. Median: Calculate the median of the contour points within the region.

	Inflection point: the point in the calculation area where the slope changes the most among the contour points.
Region(F2)	Region of interest for feature 2.

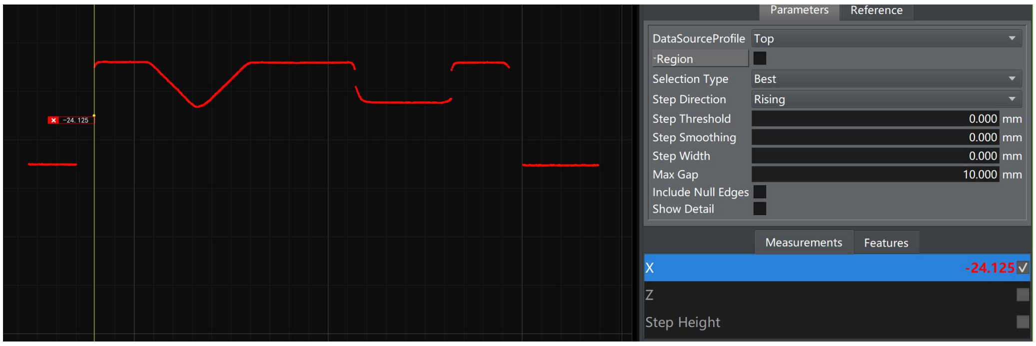
Output parameters:

Parameter	Describe	Example
Width	The difference in the X coordinate of the feature points within two regions. Width=X1 － X2. Select absolute value width=| X1 － X2 |.	
Height	The difference in Z coordinates of feature points within two regions. Height=Z1-Z2. Select absolute value height=| Z1 － Z2 |.	
Distance	The Euclidean distance of feature points within two regions.	
Center X	The midpoint X coordinate of the feature points within two regions. Center X=(X1+X2)/2. With an X reference label.	

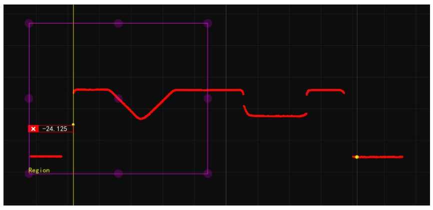
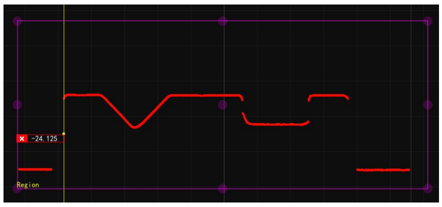
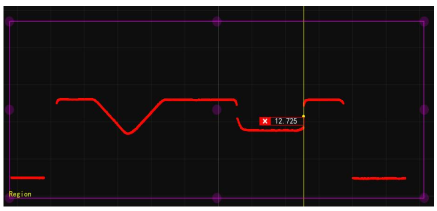
Center Z	The Z-coordinate of the midpoint of the feature points within two regions. Center Z=(Z1+Z2)/2. With Z reference label.	

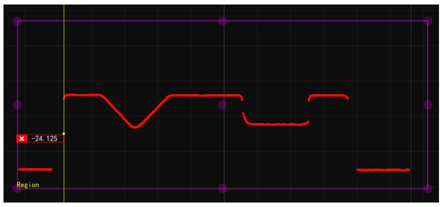
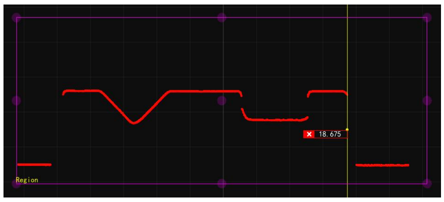
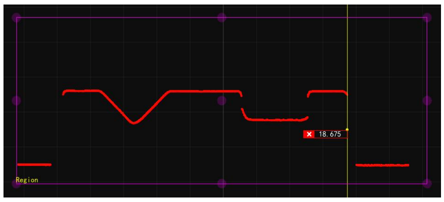
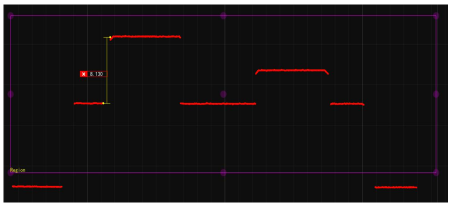
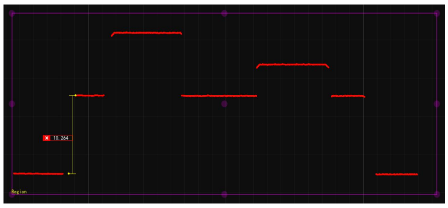
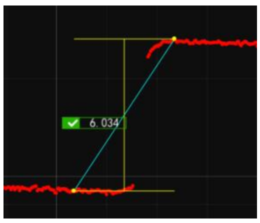
6.9.9 Profile Edge Tool

The function of the edge tool is to find the rising or falling edge in the contour.



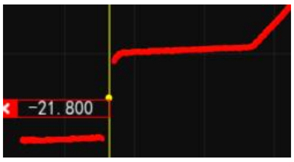
Input parameters:

Parameter	Describe	Example
Region	Edge tool area of interest.	
Selection Type	Optimal: Select the edge point with the highest drop on the contour. The right figure shows the optimal rising edge point.	
	First: Select the first edge point on the contour. The figure on the right shows the first rising edge point when the step threshold is set to 2.	
	Last: Select the last edge point on the contour. The figure on the right shows the last rising edge point when the step threshold is set to 2.	

Step direction	Rise: The edge point at which the contour rises (select type: optimal).	
	Descent: Edge point for contour descent (selection type: optimal).	
	Rise or fall: The edge point at which the contour rises or falls (select type: optimal).	
Step threshold	The edge point drop threshold is used to remove interference. The type in the right figure is the first, the step direction is ascending, the upper step threshold is 5, and the lower step threshold is 10.	 
Step smoothing	The window size for calculating the mean of contour data points is used to eliminate interference.	
Step width	The difference in X coordinate between drop points. The left step width in the right image is 2, and the right step width is 4.	  Step width 2 Step width 4
Max Gap	The maximum value allowed for filling in the X direction.	
include null	Due to occlusion or exceeding the range, contour points are missing, and invalid contour points can	

edges	be filled with a fixed value.	
Show Details	Used to display edge points, drop, step width, etc. in detail.	

Output parameters:

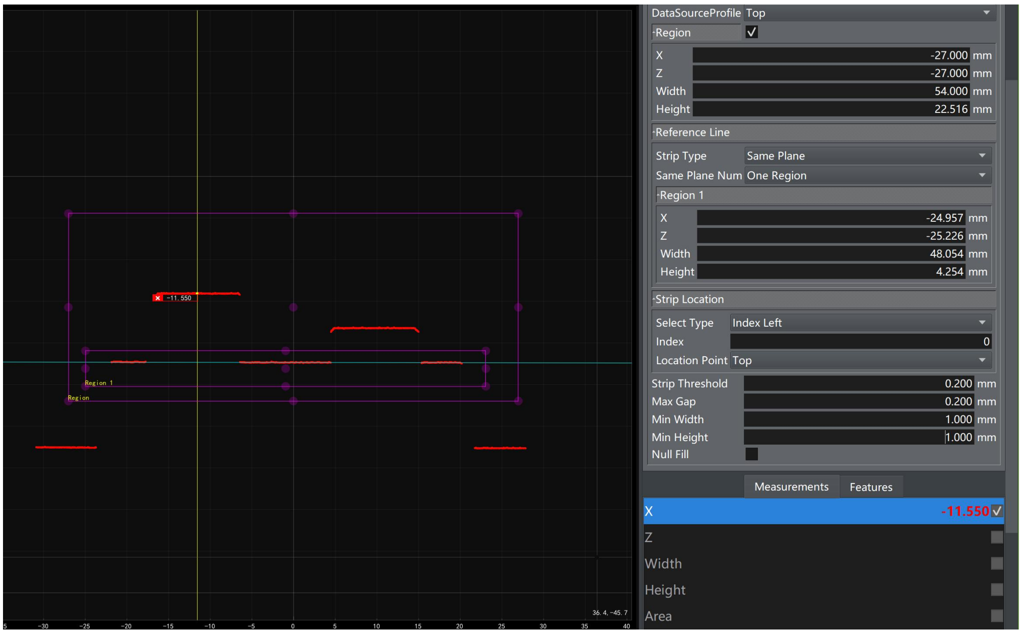
Parameter	Describe	Example
X，Z	The X, Z coordinates of the edge point.	 X  Z
step Height	Edge point drop.	

Feature output:

Parameter	Describe
Edge center point	Output edge points as point features.

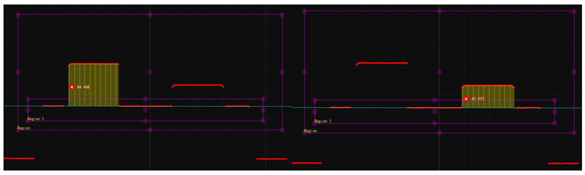
6.9.10 Profile strip tool

The protrusion tool is used to measure the information of protrusions on a flat surface. It can be used to detect raised defects on a plane or whether protrusions on a workpiece meet tolerance conditions.



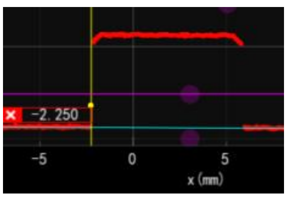
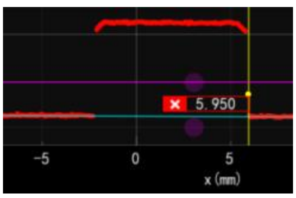
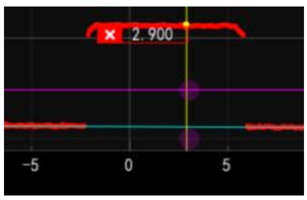
Input parameters:

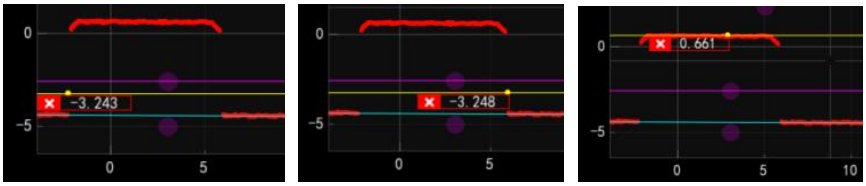
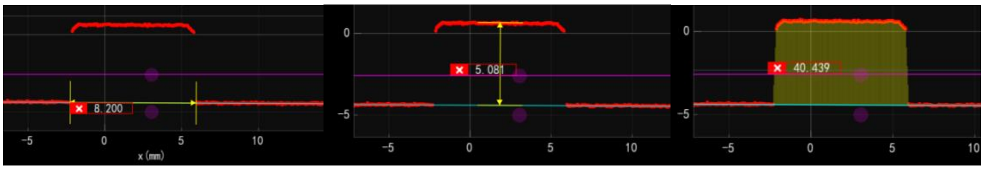
Parameter	Describe		
Region	Used to find the region of interest for bulge positions.		
strip type	Same plane	Number of regions	On both sides of the same plane, fit the number of flat (straight) areas.
		Region	Fit the region of interest of a plane (line).
	Difference planes (The two protrusions on the left and right are different planes)	Left plane	Number of regions: Fit the number of regions on the left plane (straight line). Region: Fit the region of interest of the left plane (line).
		Right plane	Number of regions: Fit the number of regions on the right plane (straight line). Region: Fit the region of interest of the right plane

			(line).
same plane num	Same plane	Select Type	Number from left: Calculate the position of the raised number from the left. Number from right: Calculate the position of the raised number from the right.
		Serial number	The serial number of the protrusion, as shown in the figure below, shows the selection of the 0th and 2nd protrusions. 
		Position	Optimal: The point with the maximum distance from the data point to the plane in the protrusion. Left side: The data point with the smallest X coordinate in the protrusion. On the right: The data point with the largest X coordinate in the protrusion.
	Difference plane	Position (Location of raised feature points)	Optimal: The point with the maximum distance from the data point to the plane in the protrusion. Left side: The data point with the smallest X coordinate in the protrusion. On the right: The data point with the largest X coordinate in the protrusion.
		Reference surface type	Left line:  Select the left line as the raised base

			Right line	 Select the right line as the raised base
			About	 Generate a new raised base using the left and right straight lines
strip threshold	Above a certain threshold on the plane, it is called a protrusion.			
Max gap	There are breakpoints in the X direction, and the maximum gap distance allowed for breakpoint filling.			
Max width	Used to filter protrusions, the width of the protrusion needs to be greater than a certain threshold.			
Max height	Used to filter protrusions, the height of the protrusion needs to be greater than a certain threshold.			
null fill	Due to occlusion or exceeding the range, contour points are missing, and invalid contour points can be filled with a fixed value.			

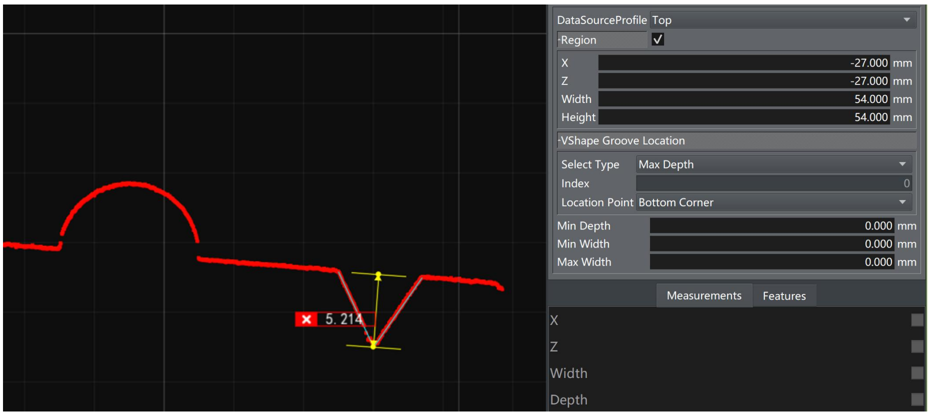
Output parameters:

Parameter	**Describe**	**Example**
X	The X coordinate of the raised feature point.	  

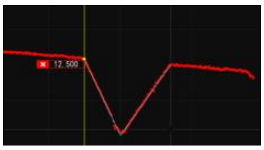
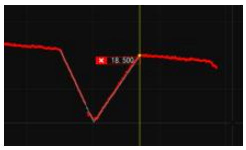
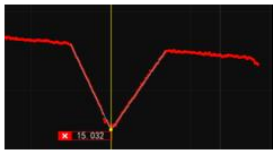
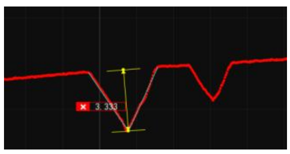
Z	The Z coordinate of the raised feature point.	
Width/Height/Area	The width, height, and area of a protrusion.	 Width Height Area

6.9.11 profile VShape groove tool

The V-groove tool is used to find V-grooves in the contour.

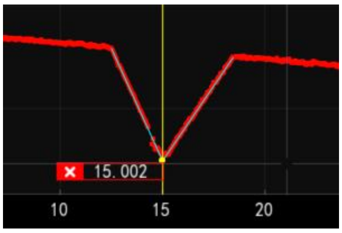
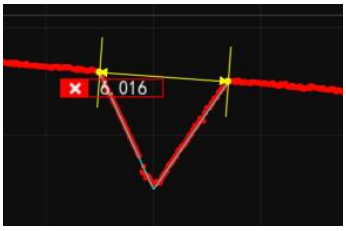
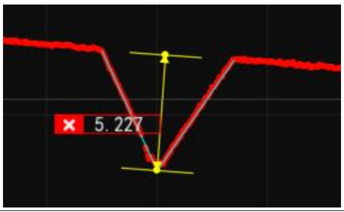


Input parameters:

<table>
<tr><th>Parameter</th><th colspan="3">Describe</th></tr>
<tr><td>Region</td><td colspan="3">The region of interest for the V-groove tool.</td></tr>
<tr><td rowspan="3">Vshape groove location</td><td>Position (V-groove feature point position)</td><td colspan="2">
Left corner

Right corner

Bottom corner</td></tr>
<tr><td>Select Type</td><td colspan="2">Max depth: Select the output with the highest depth among all V-grooves, and disable the serial number.
index left: Calculate the number position of the V-shaped groove from the left.
index right: Calculate the position of the V-groove number from the right side.</td></tr>
<tr><td>Serial number</td><td>Sort number of V-groove</td><td> </td></tr>
<tr><td>Min Depth/Min Width</td><td colspan="3">V-shaped grooves with too small filtering depth/V-shaped grooves with too small filtering width.</td></tr>
</table>

Maximum width	Filter V-shaped grooves with excessive width.

Output parameters:

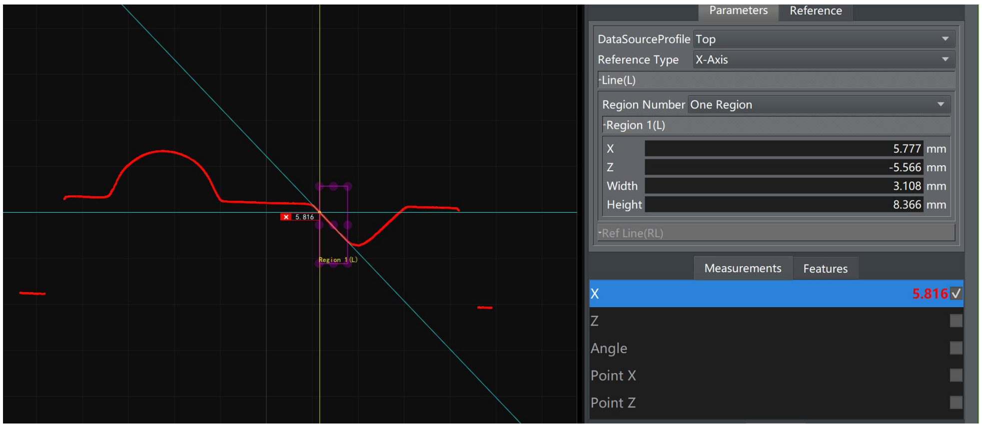
Parameter	Describe	Example
X，Z	The X, Z coordinates of the V-shaped groove feature points.	 X  Z
Width	The width of the V-shaped groove.	
Depth	The depth of the V-groove.	

Feature output:

Parameter	Describe
point	Output V-groove related feature points as point features.

6.9.12 profile position tool

The cross tool is used to measure the angle and intersection point between straight lines, and can be used to measure the angle of the workpiece.

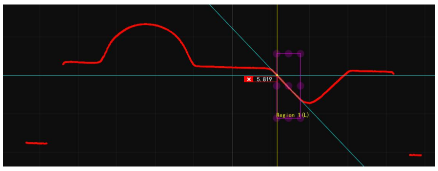


Input parameters:

Parameter	Describe
Reference type	X-axis: Calculate the angle and intersection coordinates between the fitted line and the X-axis. Z-axis: Calculate the angle and intersection coordinates between the fitted line and the Z-axis. Line: Calculate the angle and coordinates between the fitted line and the fitted reference line.
region number	The number of regions used for line fitting.
Line fitting area	Region of interest for line fitting.
Number of reference line areas	When the reference type is a straight line, the number of regions used for reference line fitting.
Reference line fitting area	When the reference type is a straight line, the region of interest used for reference line fitting.

Output parameters:

Parameter	Describe	Example

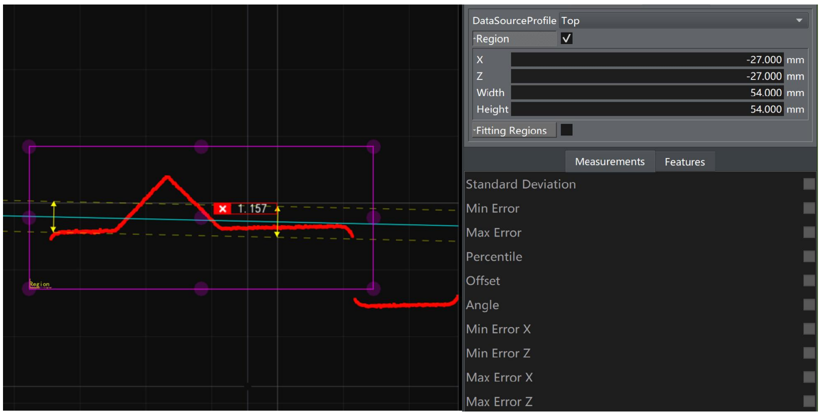
X，Z	X, Z of the intersection coordinates.	 X  Z
Angle	The angle between straight lines.	

Feature output:

Parameter	**Describe**
Intersection point	Output the coordinates of the intersection points of two straight lines as features.
line	Output the equation that fits a straight line as a line feature.
Baseline	Output the equation that fits the baseline as a line feature.

6.9.13 profile line tool

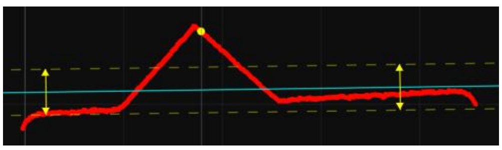
The line fitting tool is used to find lines in the contour and output line related parameters.

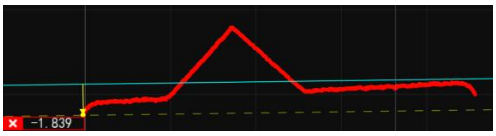
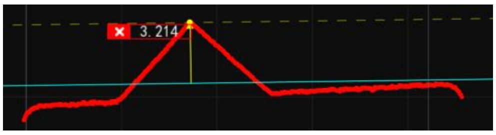
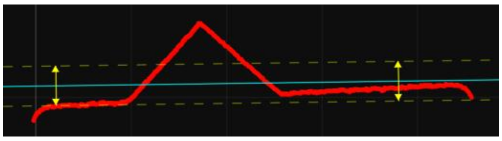
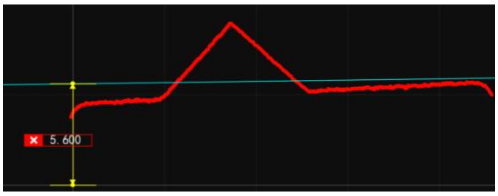
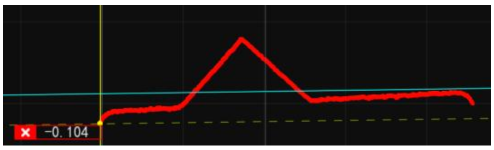
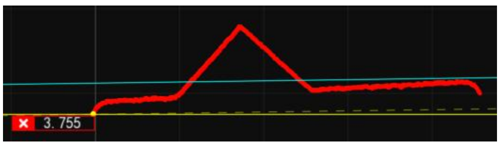
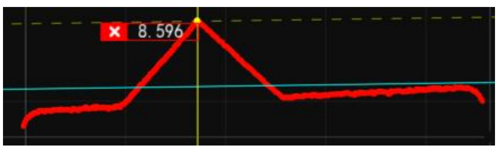


Input parameters:

Parameter	Describe	
Region	The data area used to calculate output parameters. When the fit area is not checked, this area is used to fit the straight line; When selecting the fitting area, it does not participate in line fitting.	
Fitting Regions	The area used for line fitting. After checking the checkbox, the data in this area is used for line fitting. Number of regions: one region, two regions, and all data.	

Output parameters:

Parameter	Describe	
Standard deviation	The standard deviation of the distance from a point to a straight line. The yellow double arrows indicate the standard deviation.	

Min error	The point below the line that is farthest from the line.	
Max error	The point above the line that is farthest from the line.	
Percentile	The percentage closest to the straight line point.	
offset	The intercept in the linear equation.	
Angle	The angle between the straight line and the X-axis.	
min error X	The X coordinate of the farthest point below the line.	
min error Z	The Z coordinate of the farthest point below the line.	
max Error X	The X coordinate of the farthest point above the line from the line.	

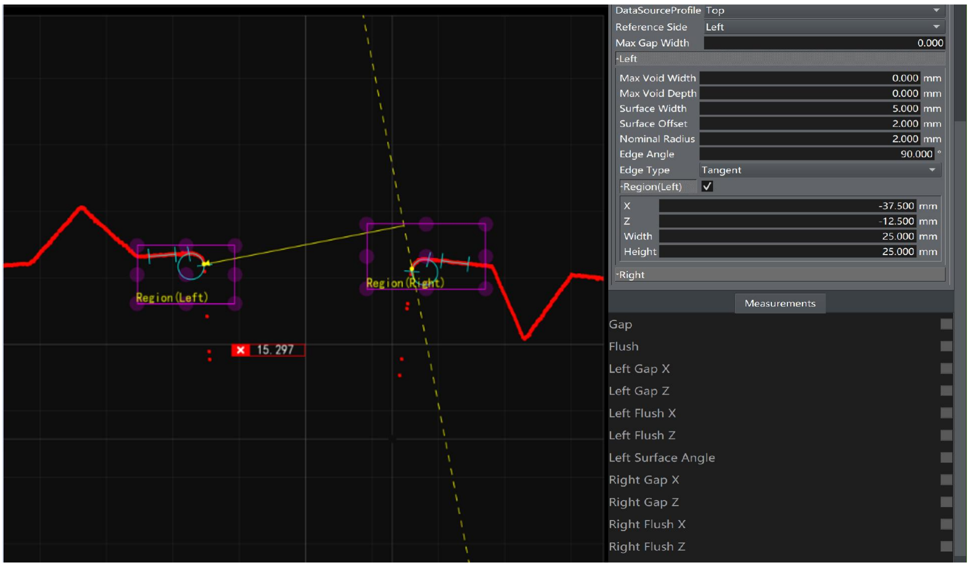
max error Z	The Z coordinate of the farthest point above the line from the line.	

Feature output:

Parameter	**Describe**
line	Output the fitted line equation as a line feature.
error Max point	Output the point above the line that is farthest from the line as a point feature.
error min point	Output the point below the line that is farthest from the line as a point feature.

6.9.14 profile panel tool

The gap surface difference tool is used to calculate the gap and surface difference between two chamfers.



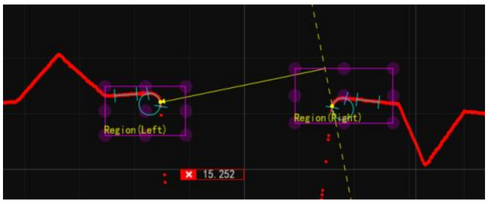
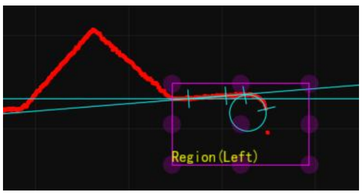
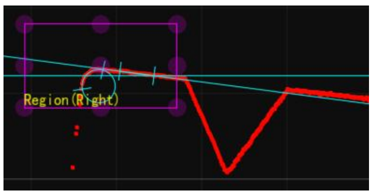
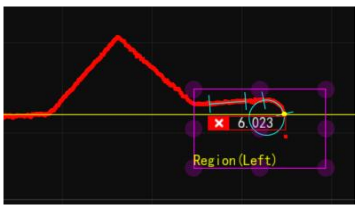
Input parameters:

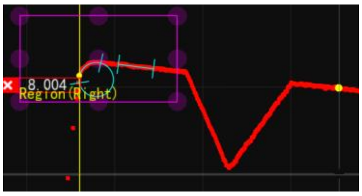
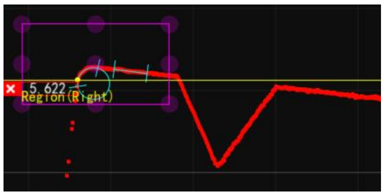
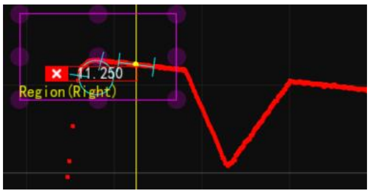
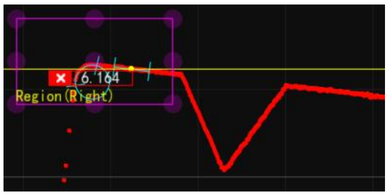
Parameter	Describe
Reference side	Left: Calculate the positional relationship from the left chamfer feature to the right chamfer feature. Right: Calculate the positional relationship from the right chamfer feature to the left chamfer feature.
Max Gap width	The maximum gap threshold is used to filter gaps with excessive width.
Left	Maxvoid width: The maximum allowable breakpoint width in the X direction.
	Max void depth: The maximum allowable breakpoint depth in the Z direction.
	Surface width: The width of a straight line.
	Surface offset: Excessive distance between lines and circles.
	Nominal radius: The ideal value of the radius of a circle.
	Edge angle: The machining angle of the chamfer.
	Region type: Left chamfer area of interest.

	Edge type	Tangent: The tangent point of a circular tangent.	
		Corner: The intersection of a circular tangent and a straight line.	

Note: The right chamfer parameter is the same as the left chamfer parameter

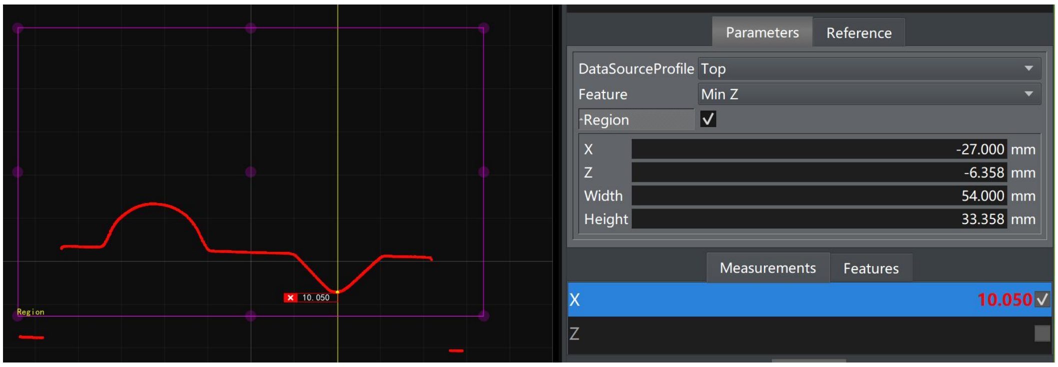
Output parameters:

Parameter	Describe	Example
gap	The gap between the left and right chamfers.	
flush	The surface difference between the two chamfered straight parts on the left and right.	
Left (right) side plane angle	The angle between the left (right) chamfer line and the X-axis.	 
Left gap X, Z	The coordinates of the left chamfer feature point are X and Z.	 X  Z

Left segment difference X, Z	The coordinates of the center point of the left chamfer line segment are X, Z.	 X  Z
Right clearance X, Z	The coordinates of the right chamfer feature point are X and Z.	 X  Z
Right segment difference X, Z	The coordinates of the center point of the right chamfer line segment are X and Z.	 X  Z

6.9.15 profile Position Tool

The function of the location tool is to find feature points in data points within the region of interest.



Input parameters:

Parameter	Describe
Feature	Maximum Z: Calculate the point with the highest Z in the contour points within the region. Maximum X: Calculate the point within the region where X is the largest among the contour points. Minimum Z: Calculate the point with the smallest Z in the contour points within the region. Minimum X: Calculate the point within the region where X is the smallest among the contour points. Mean value: Calculate the mean value of contour points within the region. Median: Calculate the median of the contour points within the region. Inflection point: the point within the calculation area where the slope of the contour point changes the most.
Region	The region of interest of the location tool.

Output parameters:

Parameter	Describe	Example

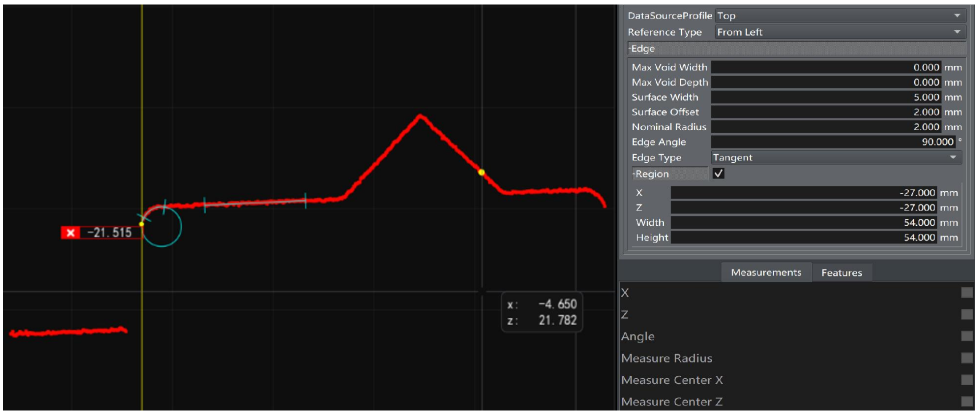
X，Z	X, Z of feature point coordinates.	 X  Z

Feature output:

Parameter	Describe
point	Output the feature points of the position tool as point features.

6.9.16 Profile Round Corner Tool

The chamfer tool is used to find chamfers in the contour. The specific effect is shown in the following figure.

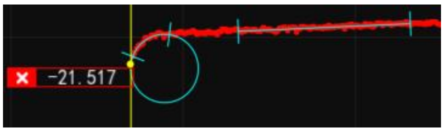
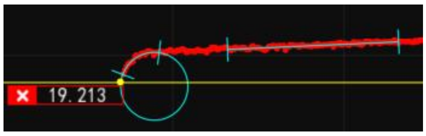
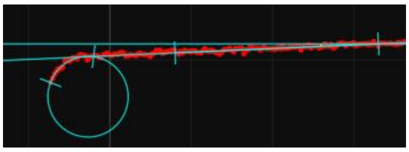


Input parameters:

Parameter	Describe	
Reference type	Choose the reference type based on whether the line is to the left or right of the circle.	
Max void width	The maximum allowable breakpoint width in the X direction.	
Max void depth	The maximum allowable breakpoint depth in the Z direction.	
Surface width	The width of the line.	
Surface offset	The transition distance between a straight line and a circle.	
Nominal radius	The ideal value of the radius of a circle.	
Edge angle	The machining angle of the chamfer.	
Edge type	Tangent: The tangent point of a circular tangent.	
	Corner: The intersection of a circular tangent and a straight line.	

Region	Chamfer the area of interest.

Output parameters:

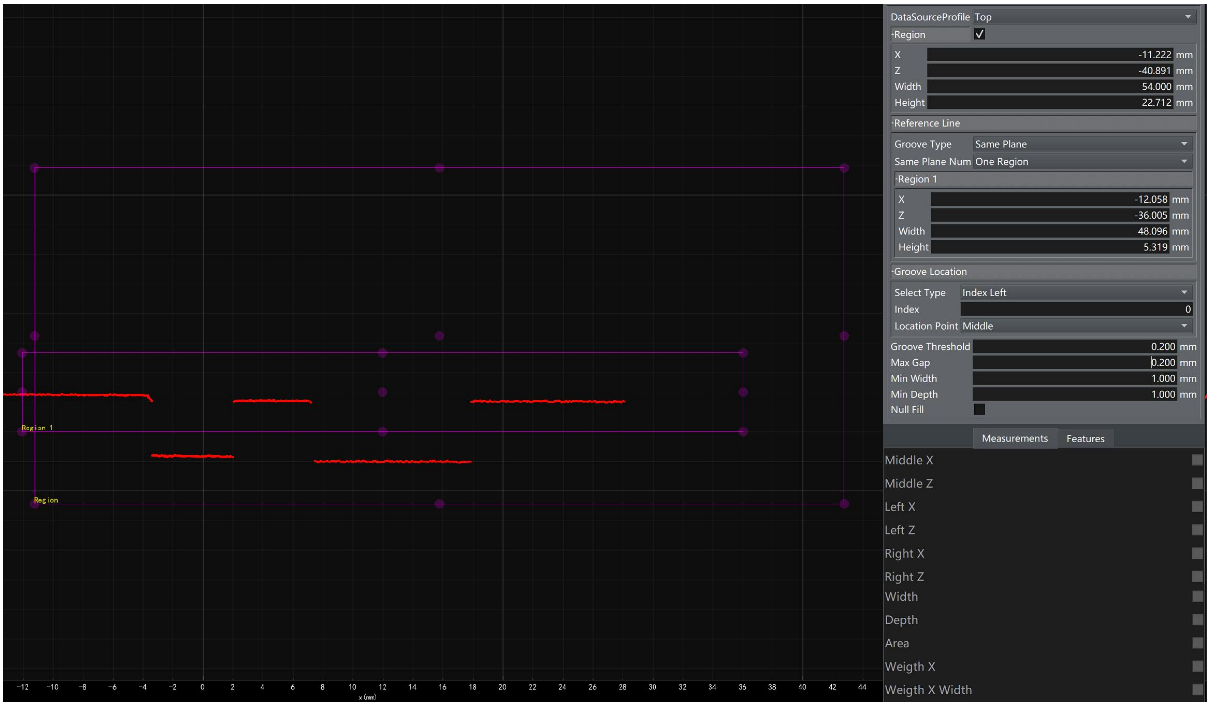
Parameter	Describe	Example
X , Z	The X, Z coordinates of the chamfered feature points.	 X  Z
Angle	The angle between the straight part and the X-axis.	
measure Radius	The radius of the fillet fitting.	

Feature output:

Parameter	Describe
Edge point	Output the edge points of the chamfer as point features.
Center point	Output the center of the chamfered circle as a point feature.

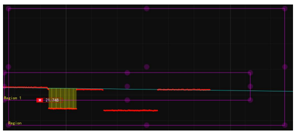
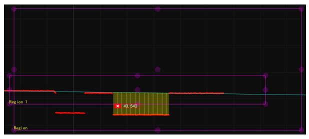
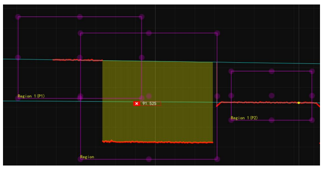
6.9.17 profile groove tool

The groove tool is used to measure information about depressions on a flat surface. It can be used to measure small concave defects on a plane or whether the concave on a workpiece meets tolerance conditions.



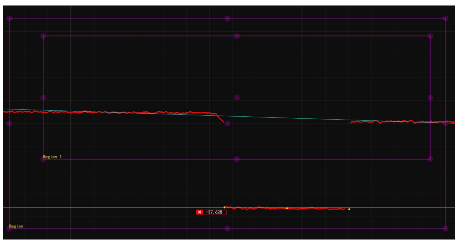
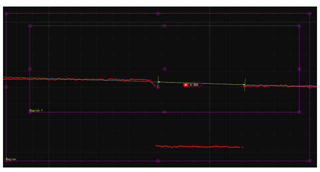
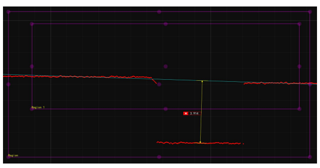
Input parameters:

<table>
<tr><th>Parameter</th><th colspan="3">Describe</th></tr>
<tr><td>Region</td><td colspan="3">The region of interest used to find the location of the depression.</td></tr>
<tr><td rowspan="2">Droove type</td><td>Same plane</td><td colspan="2">Number of regions: The number of regions on the same plane as the fitting plane (straight line) on both sides.
Region: Fit the region of interest of a plane (line).</td></tr>
<tr><td>Difference planes (the left and right sides of the depression are different planes)</td><td>Left (right) side plane</td><td>Number of regions: Fit the number of regions on the left (right) side plane (straight line).
Region: Fit the region of interest of the left (right) side plane (line).</td></tr>
<tr><td>Depression number</td><td>Same plane</td><td>Select Type</td><td>Starting from the left (right) side of the serial number: Calculate the position of the concave serial number from the left (right) side.</td></tr>
</table>

		Serial number	The serial number of the depression, as shown in the figure below, shows the selection of the 0th and 1st depressions.  	
		Position	Optimal: The point in the depression with the maximum distance from the data point to the plane. Left: The data point with the smallest X coordinate in the depression. On the right: The data point with the largest X coordinate in the depression.	
	Difference planes	Position (Location of feature points in the depression)	Optimal: The point in the depression with the maximum distance from the data point to the plane. Left: The data point with the smallest X coordinate in the depression. On the right: The data point with the largest X coordinate in the depression.	
		Reference surface type	Left line	 Select the left line as the concave base
			Right line	 Select the right line as the concave base
			About	 Generate a new concave base using the left and right straight lines

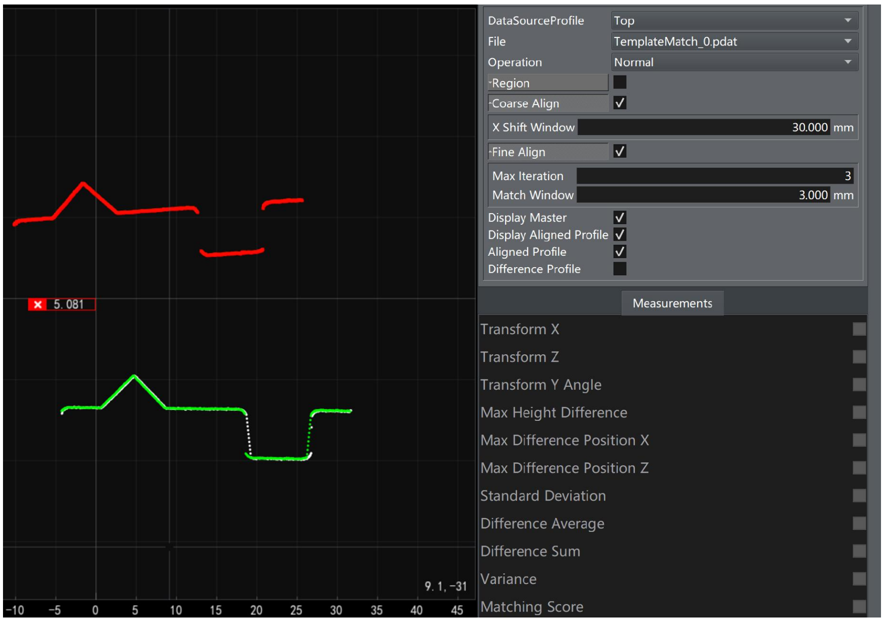
Groove threshold	After falling below a certain threshold on the plane, it is called a depression.
Max gap	There are breakpoints in the X direction, and the maximum gap distance allowed for breakpoint filling.
Min width	Used to filter depressions, the width of the depressions needs to be greater than a certain threshold.
Min depth	Used to filter depressions, the height of the depressions needs to be greater than a certain threshold.
null fill	Due to occlusion or exceeding the range, contour points are missing, and invalid contour points can be filled with a fixed value.

Output parameters:

Parameter	**Describe**	**Example**
X	The X-coordinate of the concave feature point	
Z	Z coordinate of concave feature points	
Width/Height/Area	The width, height, and area of the depression	  

6.9.18 profile Template matching Tool

The function of the template matching tool is to align the current contour with the template and output the matched contour data, which can be referenced by other measurement tool data sources. As shown in the following figure, the red contour line represents the current contour, the white contour line represents the template contour, and the green contour line represents the contour that matches the template.

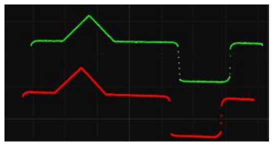
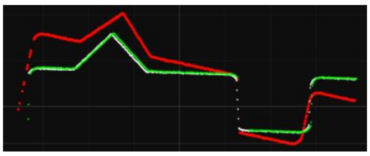
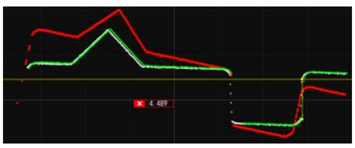
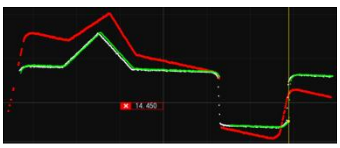
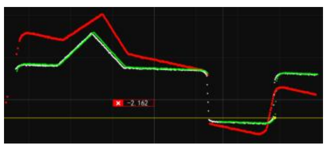


Input parameters:

Parameter	Describe
File name	The contour template is stored in the form of a file, and selecting a template file changes the template.
Operation	Normal: No processing is done. Save: Saves the current frame as a template. Delete: Delete the currently selected template file.
Region	Region of interest for template matching.
Coarse Align	Calculate the X and Z offsets of the translation matrix after matching the template with the current contour.
Fine align	After calculating the template and matching the current contour, the translation matrix X offset and Z offset, as well as the rotation angle of Y.

Display master	Used to display template contour data. In the above figure, white outline points represent template data.
display aligned profile	Used to display the matched contour data. In the above figure, green outline points represent template data.
alighned profile	The output matched contour can be used as a data source for input by other tools.
difference profile	After matching, the difference data between the template contour and the corresponding points of the matched contour forms the difference contour. After clicking on 'Difference Outline', the option to display the difference outline will pop up. The difference contour is represented by blue contour points.

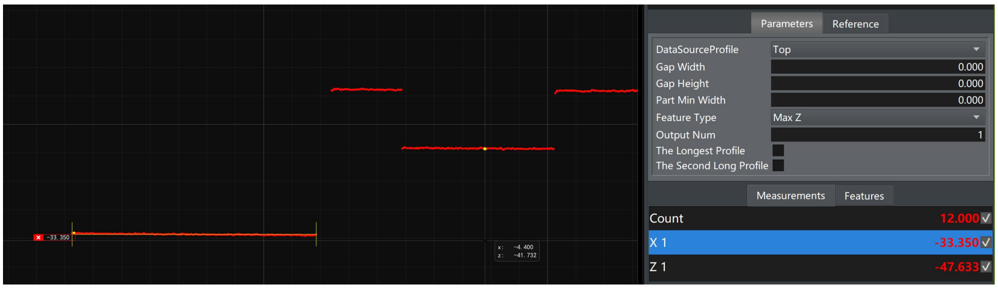
Output parameters:

Parameter	Describe	Example
transform X (Z)	The X (Z) offset after matching between the current contour and the template contour.	  X Z
transform Y angle	The Y rotation angle after matching between the current contour and the template contour.	
Max height difference	The maximum Z-direction difference between the template contour and the corresponding point of the matched contour.	
Max X (Z) difference	The X (Z) coordinate of the point corresponding to the maximum height difference.	  X Z
Maximum difference	The Z coordinate of the point corresponding to the maximum height difference.	

Standard deviation	The standard deviation of the height difference between the template contour and the corresponding point of the matched contour after matching.
difference average	Mean of difference contour data points.
Differences sum	The sum of Z coordinates of different contour data points.
Variance	Variance of differential contour data.
Matching score	The similarity between contour data and templates.

6.9.19 Advanced Location

The function of advanced position tools is to find eligible contour segments based on the threshold settings of width and height, and output the position of feature points in each contour segment according to the feature type.

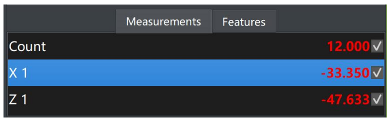
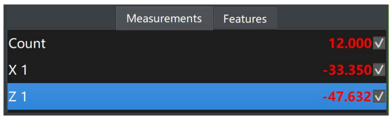


Input parameters:

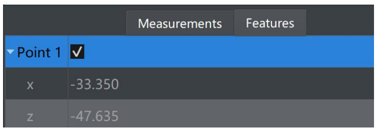
Parameter	Describe
Segment gap width	The maximum allowable gap width in the X direction, if it exceeds this width, it belongs to the next contour segment.
Segment gap height	The maximum allowable clearance height in the Z direction, if it exceeds this height, it belongs to the next contour segment.
Minimum width of segment	The minimum width of the detected contour segment, if less than this width, it will be filtered out.
Feature Type	Max Z: The point in the current contour segment where Z is the largest. Minimum Z: The point in the current contour segment where Z is the smallest. Mean: The average value of Z in the current contour segment.
Maximum number of segments	The maximum number of segments allowed for output in the measurement result, with a maximum value of 200.

Output parameters:

Parameter	Describe	Example
Count	The total number of segments detected.	

X，Y	X, Z values of feature point coordinates	   

Feature output:

Parameter	**Describe**	**Example**
Spot	Output the coordinates of feature points as features.	

6.10 Feature measurement

6.10.1 Overview of feature measurement

Some measurement tools can output data structures such as points, lines, faces, and circles, which are called geometric features. Feature measurement tools will measure dimensions based on these features.

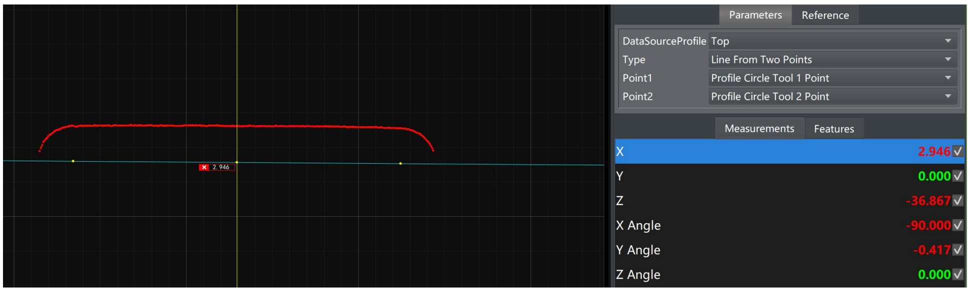
Feature	Describe
Spot	A meaningful point in contour data.
Line	A line or custom line that fits data points.
Surface	A certain plane.
Circular	A circle fitted to data points or a custom generated circle.

6.10.2 profile Feature Create

Feature creation tools can create new features from existing geometric features. Feature creation tools can create multiple features, such as creating a feature line from two feature points, creating a feature face from one feature point and one feature line, and so on.

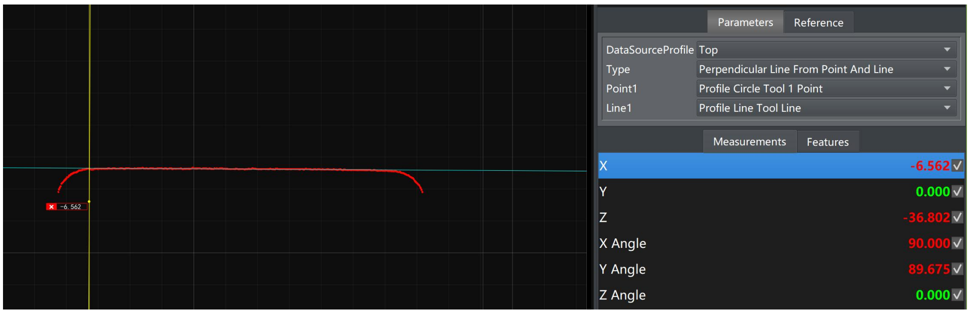
- **line from two points**

The feature points generated by two other tools generate a feature line and output the geometric features of the line.



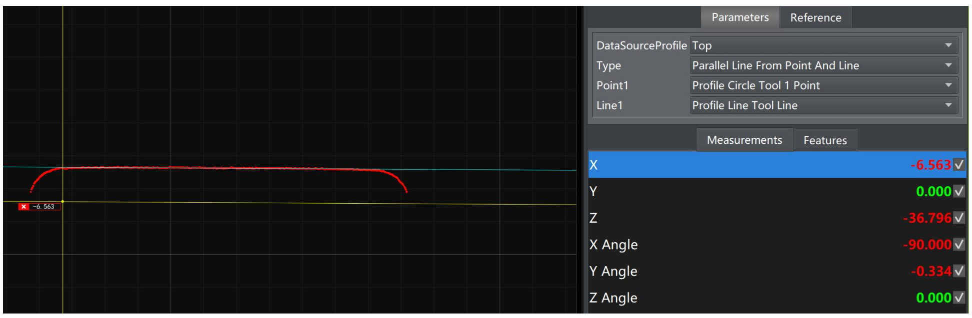
- **perpendicular line from point and line**

Generate a perpendicular line of a feature line through a certain feature point and output the geometric features of the line.



- **Parallel lines from point and line**

Generate a parallel line of a feature line through a certain feature point and output the geometric features of the line.

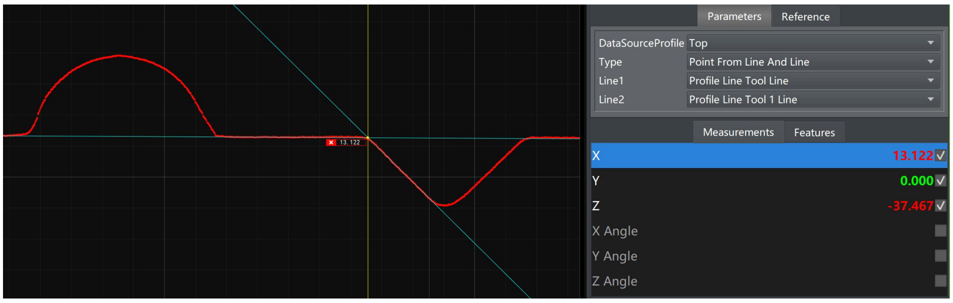


■ circles from points

Intersection point of feature circle and feature line, and output geometric features and intersection information of the line. There are two intersection points and two center points for the intersection of a line and a circle. These three points are divided into upper, middle, and lower points according to the size of the Z value. Users can choose the intersection point according to their needs.

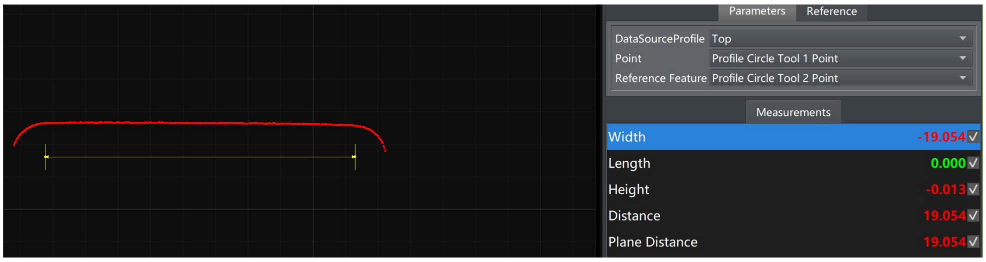
■ pointfrom line and circle

Two feature lines generate a feature point and output the coordinate values of that point.



6.10.3 Feature size measurement

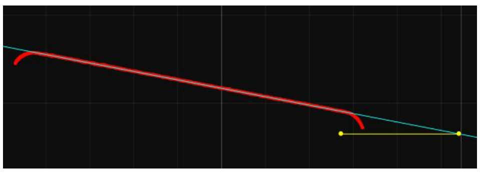
The feature size measurement tool can provide measurement from feature points to another feature point and feature line, but the current version does not support measurement from feature points to feature surfaces.

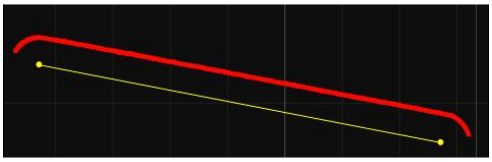


Input parameters:

Parameter	**Describe**
Characteristic points	Feature points generated by the tool.
Reference Features	Feature points: feature points generated by the tool. Line: A feature line generated by a tool, or a line created by a feature tool.

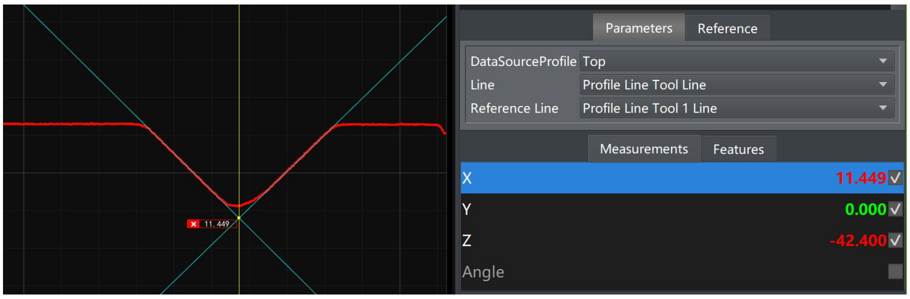
Output parameters:

Parameter	**Describe**	
Width	Point to point: The distance between two points in the X-axis direction.	
	Point to Line: The distance between a point and a point on the line in the X direction. For contour data, the Z coordinates of two points are the same, and the difference in X coordinates between these two points is the width.	
Length	Point to point: The distance between two points in the Y direction, which is 0 in contour mode. Point to Line: The distance between a point and the closest point on the line in the Y direction, which is 0 in contour mode.	

Height	Point to point: The distance between two points in the Z direction.	
	Point to Line: The distance between a point and a point on the line in the Z direction. For contour data, the X coordinates of two points are the same, and the difference in Z coordinates between these two points is the height.	
Distance	Point to point: The Euclidean distance between two points.	
	Point to Line: The perpendicular length of a point to a line.	

6.10.4 profile Feature　intersect

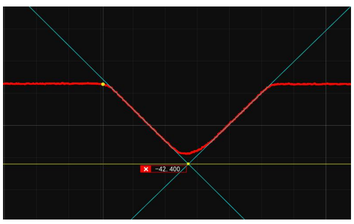
The function of the feature crossing tool is to return the intersection and angle of two feature lines.

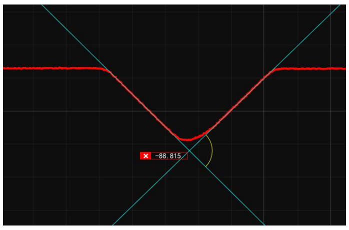


Input parameters:

Parameter	Describe
line	Line features generated by other tools.
Reference line	The straight line features generated by other tools measure the angle value based on the reference line, which rotates clockwise to the straight line and has a positive angle; The reference line rotates counterclockwise to a straight line, with a negative angle.

Output parameters:

Parameter	Describe	
X	The X coordinate of the intersection point of two feature lines.	
Y	The Y coordinate of the intersection point of two feature lines is 0 in contour mode.	
Z	The Z coordinate of the intersection point of two feature lines.	

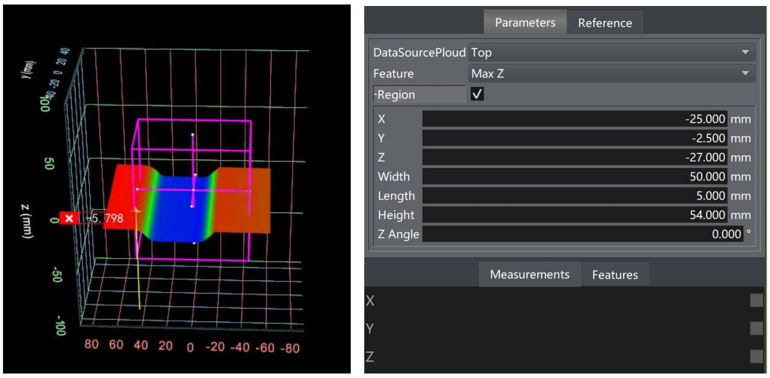
Angle	The angle between two feature lines.	

6.11 surface measurement

The following sections introduce the purpose, input parameters, output parameters, and output characteristics of each point cloud measurement tool. The data source in the input parameters of each measurement tool refers to providing single sensor and multi-sensor point cloud data to the measurement tool.

6.11.1 surface Position Tool

The function of the location tool is to find feature points in data points within the region of interest.

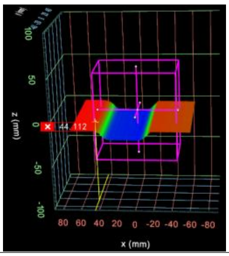
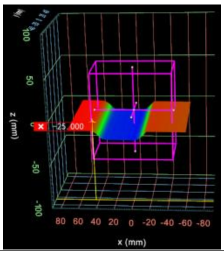
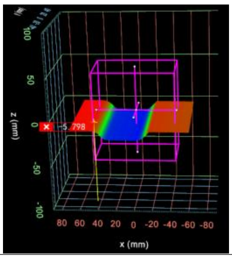


Input parameters:

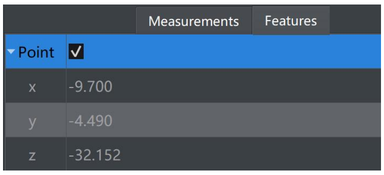
Parameter	Describe
Feature	Max X: The point in the calculation area where X is the largest in the point cloud. Min X: Calculate the point in the point cloud within the region where X is the smallest. Max Y: Calculate the point in the point cloud within the region where Y is the largest. MinY: Calculate the point in the point cloud within the region where Y is the smallest. Max Z: Calculate the point in the point cloud within the region where Z is the largest. Min Z: Calculate the point in the point cloud within the region where Z is the smallest. average: Calculate the mean of the point cloud within the region. Median: Calculate the median of the point cloud within the region. Centroid: Calculate the centroid of the volume of the point cloud in the region relative to the z=0 plane.
Region	The region of interest of the location tool.

Output parameters:

Parameter	Describe	Example

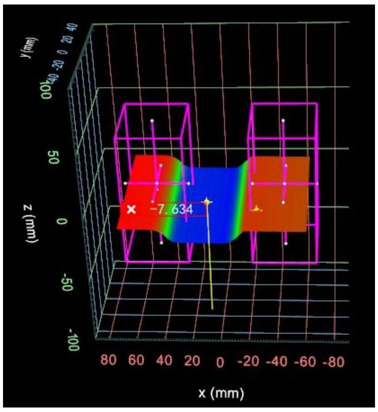
X，Y，Z	X, Y, Z of feature point coordinates. With X, Y, Z reference labels.	  

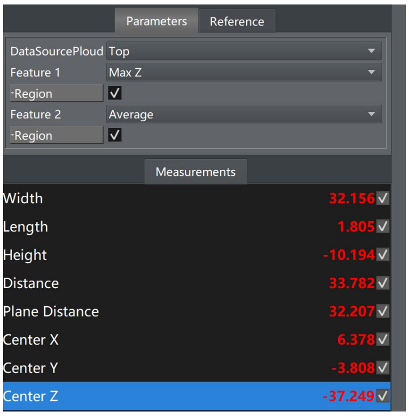
Feature output:

Parameter	**Describe**	**Example**
point	Output the feature points of the position tool as point features.	

6.11.2 surface dimension tool

The size tool is used to find the positional relationship between feature points in two regions of interest, mainly used to measure whether the size between two obvious features on the same sample is within the tolerance range. Two feature types must be specified.



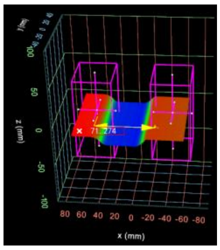
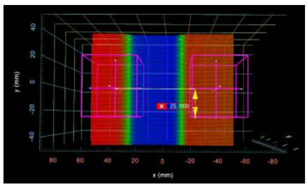
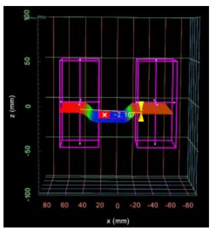


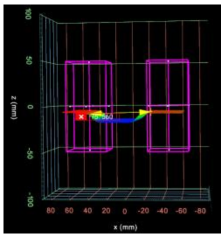
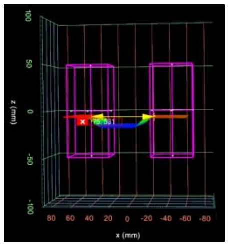
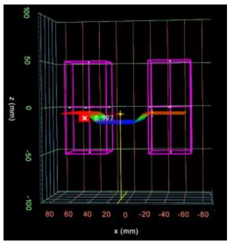
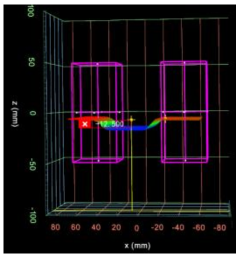
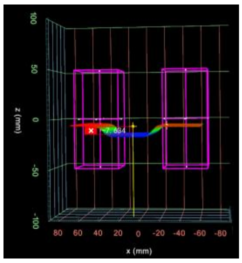
Input parameters:

Parameter	Describe
Feature 1	Max X: The point in the calculation area where X is the largest in the point cloud. Min X: Calculate the point in the point cloud within the region where X is the smallest. Max Y: Calculate the point in the point cloud within the region where Y is the largest. Min Y: Calculate the point in the point cloud within the region where Y is the smallest. Max Z: Calculate the point in the point cloud within the region where Z is the largest. Min Z: Calculate the point in the point cloud within the region where Z is the smallest. average: Calculate the mean of the point cloud within the region. Median: Calculate the median of the point cloud within the region. Centroid: Calculate the centroid of the volume of the point cloud in the region relative to the z=0 plane.
Area (F1)	Region of interest for feature 1.

Feature 2	Max X: The point in the calculation area where X is the largest in the point cloud. Min X: Calculate the point in the point cloud within the region where X is the smallest. Max Y: Calculate the point in the point cloud within the region where Y is the largest. Min Y: Calculate the point in the point cloud within the region where Y is the smallest. Max Z: Calculate the point in the point cloud within the region where Z is the largest. Min Z: Calculate the point in the point cloud within the region where Z is the smallest. Average: Calculate the mean of the point cloud within the region. Median: Calculate the median of the point cloud within the region. Centroid: Calculate the centroid of the volume of the point cloud in the region relative to the z=0 plane.
Area (F2)	Region of interest for feature 2.

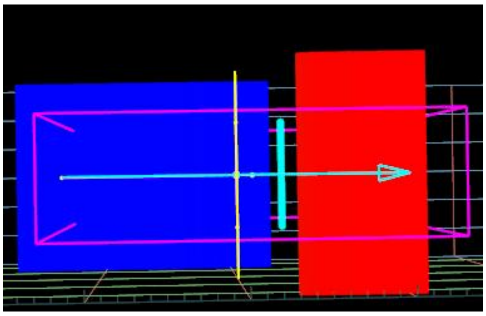
Output parameters:

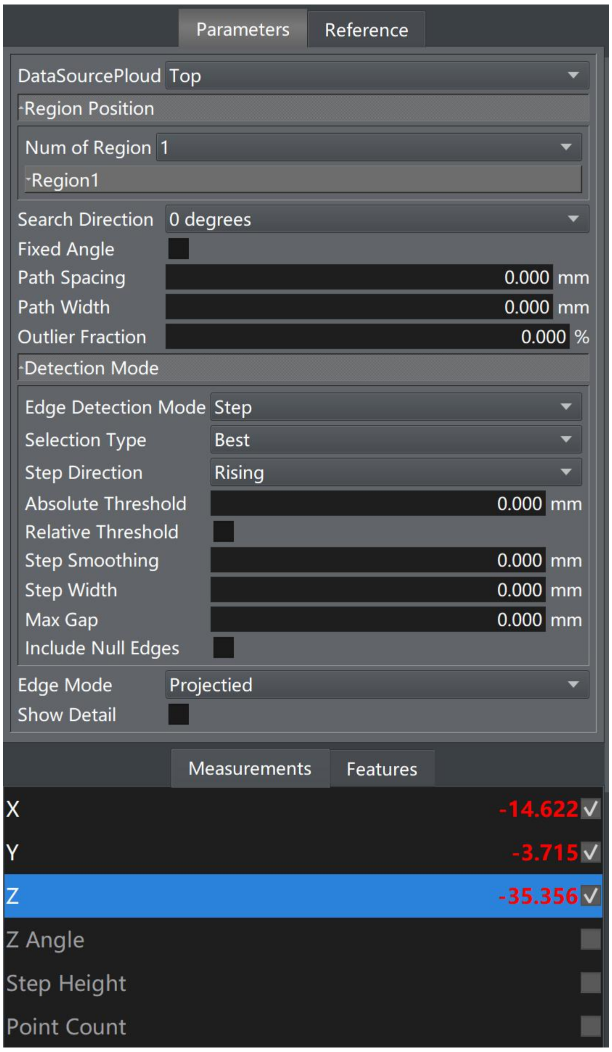
Parameter	**Describe**	**Example**
Width	The difference in the X coordinate of the feature points within two regions. Width=X1 – X2. Select absolute value width=| X1 – X2 |.	
Length	The difference in Y coordinates of feature points within two regions. Length=Y1 – Y2. Select absolute value length=| Y1 – Y2 |.	
Height	The difference in Z coordinates of feature points within two regions. Height=Z1-Z2. Select absolute value height=| Z1 – Z2 |.	

Distance	The Euclidean distance of feature points within two regions.	
Plane distance	The distance between the projection of the lowest feature point in two regions and the XY plane of the highest feature point.	
Center X	The midpoint X coordinate of the feature points within two regions. Center X=(X1+X2)/2. With an X reference label.	
Center Y	The midpoint Y coordinate of the feature points within two regions. Center Y=(Y1+Y2)/2. With a Y reference label.	
Center Z	The Z-coordinate of the midpoint of the feature points within two regions. Center Z=(Z1+Z2)/2. With Z reference label.	

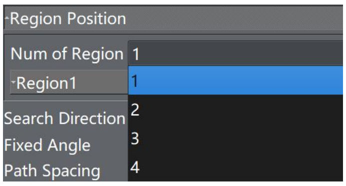
6.11.3 Surface Edge Tool

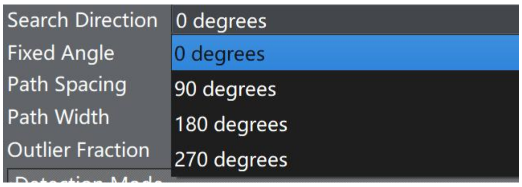
The function of the surface edge tool is to extract the edge information of the point cloud, mainly by using the height map to obtain the drop between points and related settings to obtain multiple edge points, and then fitting to form edge lines. This tool can fit the edge points of multiple regions into edge lines and return features such as the center point of the edge line and straight lines.





Input parameters:

<table>
<tr><th>Parameter</th><th colspan="2">Describe</th></tr>
<tr><td>Data source ploud</td><td colspan="2">Contourometer scans point cloud or other tool generated point cloud data.</td></tr>
<tr><td rowspan="2">Regional location</td><td>Number of region</td><td>The edge tool supports up to four area boxes.

</td></tr>
<tr><td>Regional location</td><td>Selecting the number of areas will display the specific locations of each area.

</td></tr>
<tr><td>search direction</td><td colspan="2">There are four references, mainly traversing along the X and Y directions.

</td></tr>
<tr><td>Fixed angle</td><td colspan="2">Given the angle of the edge line, fit the edge line according to this angle.</td></tr>
<tr><td>Path spcing</td><td colspan="2">Path spacing refers to how far apart there is an edge point. The smaller the path interval, the more edge points; The larger the path spacing, the fewer edge points. When the path spacing is less than the resolution, calculate and search for edge points based on the data resolution.</td></tr>
<tr><td>Path width</td><td colspan="2">Perpendicular to the path, this width is used as a window to calculate the average value of contour data points, used to eliminate noise interference.</td></tr>
<tr><td>outliers fraction</td><td colspan="2">During the calculation process, there may be incorrect edges in a large number of edge points, and the proportion of outliers is used to remove these interfering points, and the remaining edge</td></tr>
</table>

	points are used to fit the edge line.		
Edge detection mode	Step	Select Type (Please refer to the contour edge tool for details)	Optimal: Select the edge point with the highest drop on the path.
			First: Select the first edge point on the path.
			Last: Select the last edge point on the path.
		Step direction (Please refer to the contour edge tool for details)	Rise: Select the edge point on the path where the Z value rises.
			Descent: Select the edge point on the path where the Z value decreases.
			Rise or Fall: Select the edge point on the path where the Z value rises or falls.
		Absolute threshold	Only edge points with a step greater than this value can participate in the fitting.
		Relative threshold	Using the maximum step in the edge point multiplied by the percentage threshold as an absolute threshold to determine the qualified edge point, it is generally used in situations where the absolute value is not clear.
		Step smoothing	The window size for calculating the mean of path direction data is used to eliminate interference.
		Step width	Perform Z-value step calculation with a certain step width interval in the path direction, and use it when there is a certain slope in the path direction.
		Maximum clearance	The maximum value that allows path direction to remain intact.
		Invalid Edge	Due to occlusion or exceeding the range, contour points are missing, and invalid contour points can be filled with a fixed value.
	Corner	Optimal: Find the optimal corner on the path.	
		First: Find the first corner on the path.	

		Last: Find the last corner on the path.
		Top: Finds the top corner on the path.
		Bottom: Find the bottom corner on the path.
Edge mode	Projection: Fits a 2D edge line in the XY direction.	
	3D: Fit 3D edge lines.	

Output parameters:

Parameter	**Describe**	**Example**
X，Y，Z	The midpoint coordinates of the edge line.	
Z angle	Edge point drop.	
step Height	The average value of the Z-direction drop of all edge points participating in the fitting.	
point count	The number of edge points participating in the fitting.	
Max error	The point above the edge line that is farthest from the line.	
Min error	The point below the edge line that is farthest from the line.	

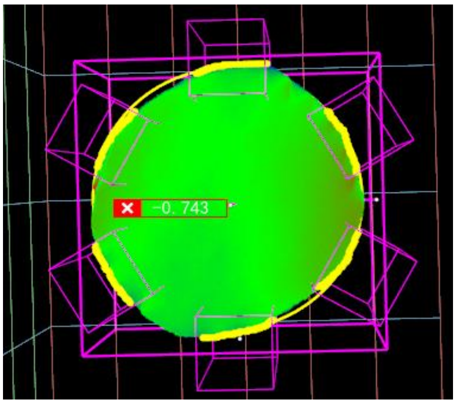
Feature output:

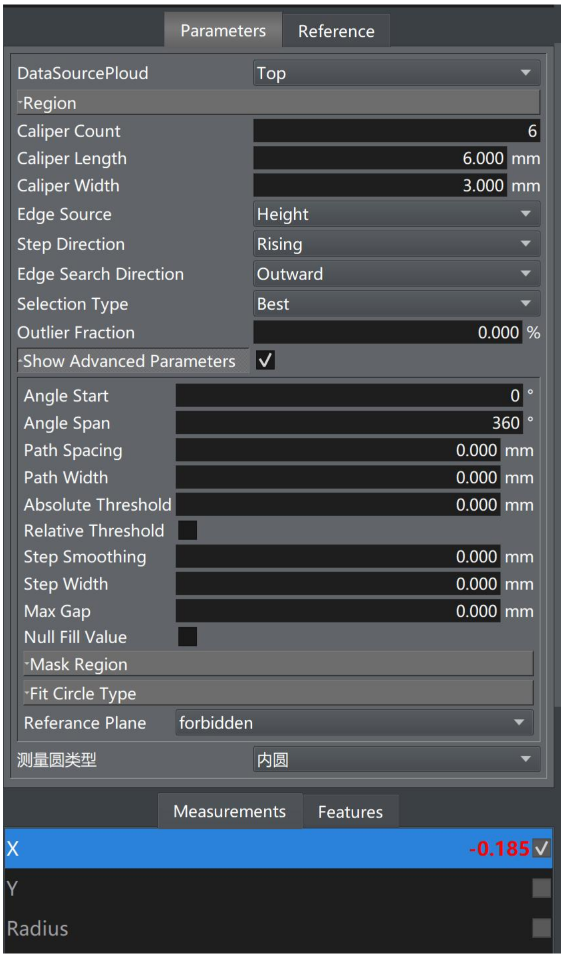
Parameter	**Describe**
point	The coordinates of the center point of the edge line.

line	Fitted edge lines.

6.11.4 surface circular edge tool

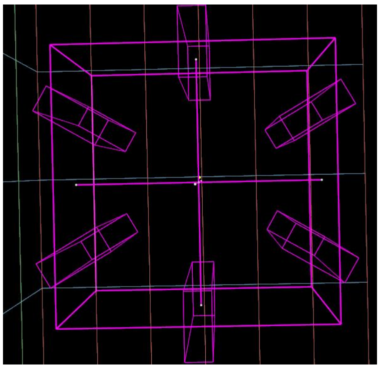
The arc edge tool is used to fit the outer edge of a circular sample and the inner edge of a circular hole sample. This tool can use partial edge data for circle fitting.

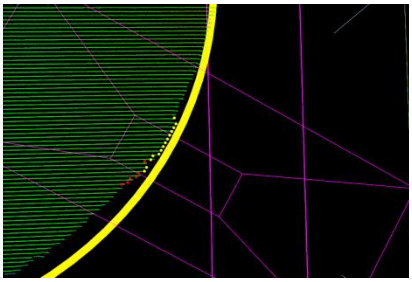


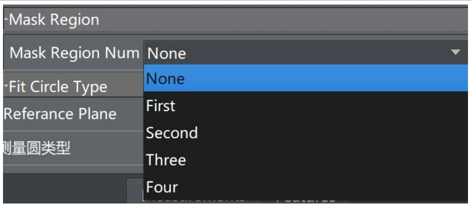


Input parameters:

Parameter	Describe

Data source	Contourometer scans point cloud or other tool generated point cloud data.
Region	Used to calculate the area of circular edges and also to constrain the specific position of calipers.
caliper counnt	Used to limit the number of regions for calculating edge points. When the width and length of the caliper remain unchanged, the more calipers there are, the more edge points will be obtained; But the more calipers there are, the slower the speed will be.
caliper length	The length of the area where the caliper is located. As shown in the figure, there are 6 small purple areas with a length of 5mm and a width of 2mm. 
Caliper width	The width of the area where the caliper is located.
Edge source	Height map: Use Z-direction steps to obtain edges.
	Brightness map: Use brightness steps to obtain edges.
Step direction	Rise: Select the edge point along the path where the height and brightness rise.
	Descent: Select the edge point on the path where the height and brightness decrease.
	Rise or Fall: Select the edge point on the path where the height and brightness rise or fall.
Selection Type	Optimal: Select the edge point with the highest drop on the path.
	First: Select the first edge point on the path.
	Last: Select the last edge point on the path.
outlier fraction	Used to remove points in circle fitting that are far from the edge of the fitted circle. As shown in the following figure, the red dots represent the edge points that have been removed.

	
angle start	Determine the position of the caliper center in a clockwise direction around the Z-axis, with 0 degrees representing the negative direction of the X-axis.
Angle span	Angle crossing refers to the circular path range where the caliper is placed from the starting angle. By combining the starting angle and angle crossing, certain areas can be avoided.
Path spacing	Path spacing refers to how far apart there is an edge point. The smaller the path interval, the more edge points; The larger the path spacing, the fewer edge points. When the path spacing is less than the resolution, calculate and search for edge points based on the data resolution.
Path width	Perpendicular to the path, this width is used as a window to calculate the average value of contour data points, used to eliminate noise interference.
Absolute threshold	Only edge points with a step greater than this value can participate in the fitting.
Relative threshold	Use the maximum step in the edge points multiplied by the percentage threshold as the absolute threshold to determine the qualified edge points. Generally used in situations where the absolute value is not clear.
Step smoothing	The window size for calculating the mean of path direction data is used to eliminate interference.
Step width	Perform Z-value step calculation with a certain step width interval in the path direction, and use it when there is a certain slope in the path direction.
Max gap	The maximum value that allows path direction to remain intact.
Null fill value	Due to occlusion or exceeding the range, contour points are missing, and invalid contour points can be filled with a fixed value.
Mask area	The mask area is used to remove some edge points that interfere with circular fitting. There are a maximum of four regions in the mask area.

	
Fit circle type	Least Squares Circle (LSC): Use least squares for circle fitting.
	Minimum Region Circle (MZC): Finds the minimum region circle.
	Minimum Circumscribed Circle (MCC): Finds the minimum circumscribed circle.
Reference plane	When the circle is located on an inclined plane, the edge points are projected onto the inclined plane by calling plane features, and then the circle fitting is performed.

Output parameters:

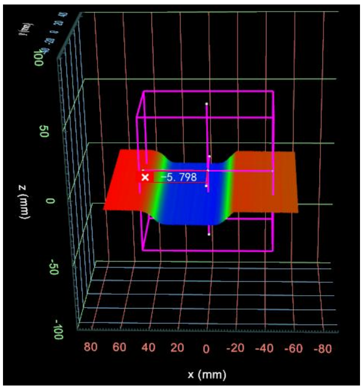
Parameter	**Describe**
X，Y	The position of the center of the circle.
Radius	The radius of the circle obtained by fitting.
Roundness	The maximum deviation minus the minimum deviation results in roundness.
Max error	The distance from the farthest point to the center of the circle minus the radius.
Min error	The distance from the closest point to the center of the circle minus the radius.

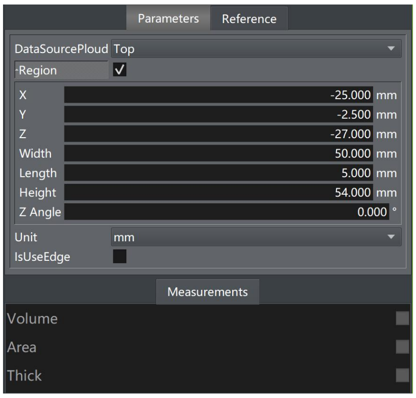
Feature output:

Parameter	**Describe**
Center of circle	Center of circle.
Circular	Fit the circle.

6.11.5 Surface Volume tool

The volume tool is used to determine the volume, area, and thickness of the area of interest.



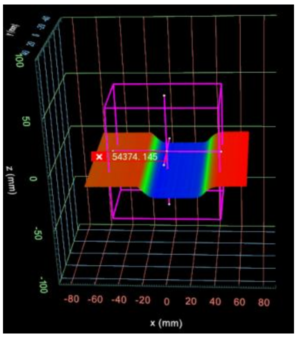
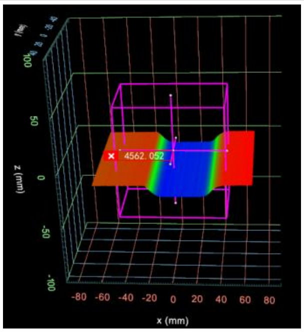
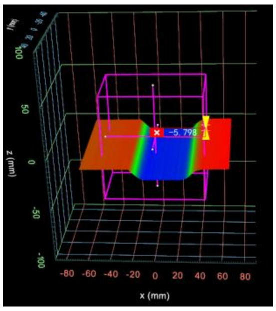
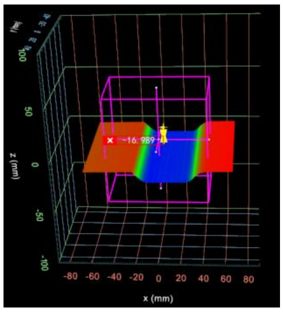
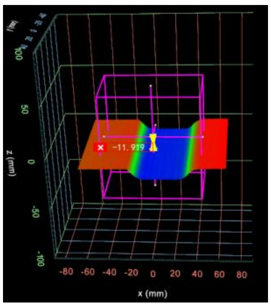
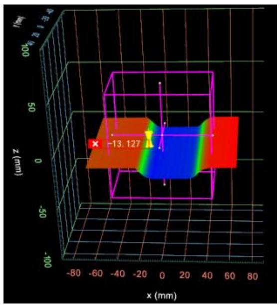


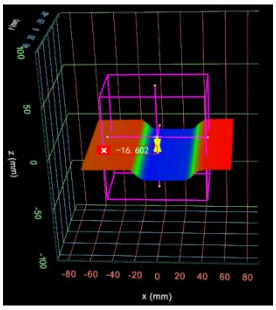
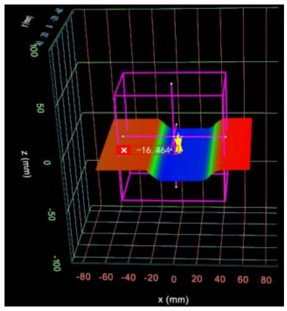
Input parameters:

Parameter	Describe
Region	Volume tool area of interest.
Volume tool area of interest.	Maximum value: Calculate the point cloud within the region relative to the Z maximum point in the Z=0 plane. Minimum value: Calculate the point cloud within the region relative to the Z smallest point in the Z=0 plane. Average value: Calculate the average value of the point cloud in the region relative to Z in the Z=0 plane. Median: Calculate the median in the point cloud within the region relative to Z in the Z=0 plane. 2D centroid: Calculate the centroid height of the point cloud in the XY plane within the region. 3D centroid: Calculate the spatial height of the point cloud within the region in XYZ space.

Output parameters:

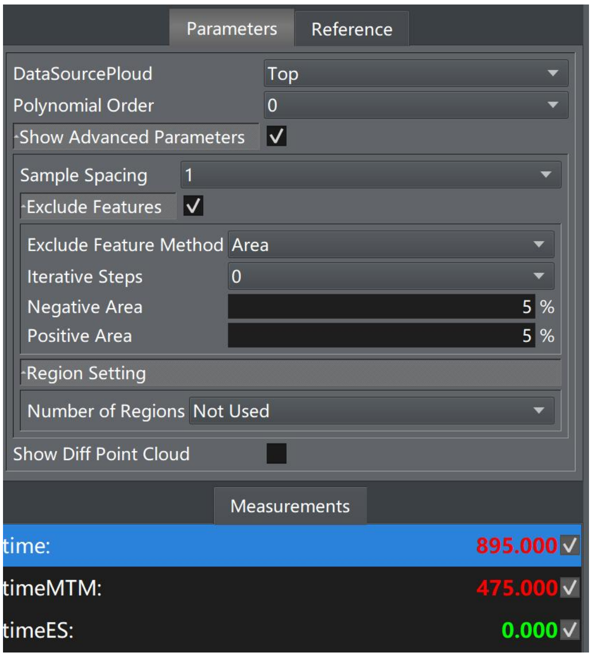
Parameter	Describe	Example

Volume	Measure volume in XYZ space.	
Area	Measure the area in the XY plane.	
Thick	Measure the thickness (height) of the sample.	  Maximum value Minimum value   Average value Median

		  2D Centroid 3D Centroid

6.11.6 surface Curvature tool

The surface tool performs polynomial fitting on the data points in the selected area regarding X and Y (polynomial order is defined by the user), which can remove surface curvature while preserving surface features or defects.



Input parameters:

Parameter	Describe
Polynomial order	The polynomial order used to fit a surface. The higher the order, the more complex the surface that can be fitted, but the longer the processing time.
show advanced parameters	Enable a series of advanced parameters.
Sample spacing	The sampling interval in the X and Y directions represents one point from every n points. A higher sampling interval can reduce processing time, but it will reduce fitting accuracy.
Exclude features	This option allows you to exclude surface features or details from participating in polynomial fitting. This option includes three parameters: negative area, positive area, and number of iterations.
Iterative steps	The number of repetitions of excluding feature steps. When the number of points in a certain iteration is insufficient, resulting in invalid fitting, the previous iteration result is used.
Negative	A point that represents a specific percentage of smaller/larger excluded fitting differences that

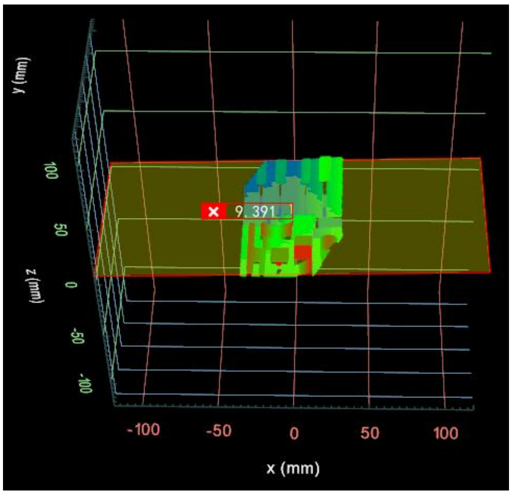
Area/Positive Area	are negative/positive.
Number of regions	Set and configure one or more restricted regions, and the tool will use valid points from all regions for polynomial fitting. If no area is used, the tool uses all valid points.

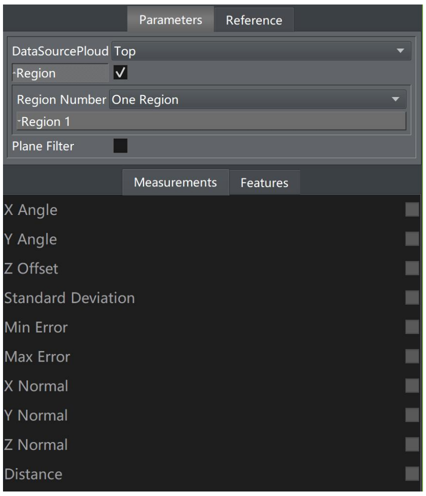
Output parameters:

Parameter	Describe
Time	Tool processing time.

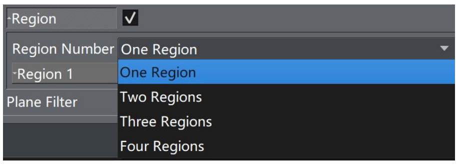
6.11.7 Surface Plane Tool

The plane tool is used to fit the plane of the region of interest.

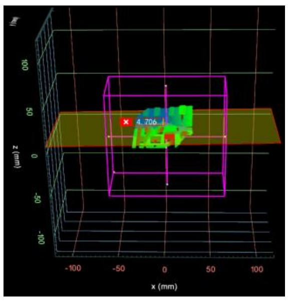


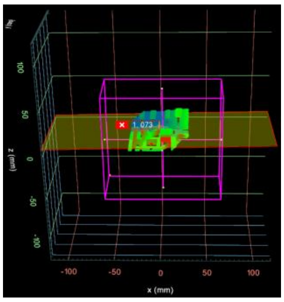
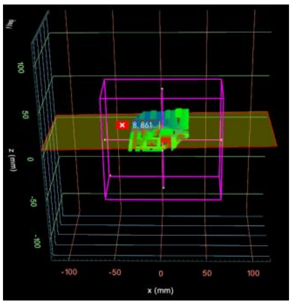
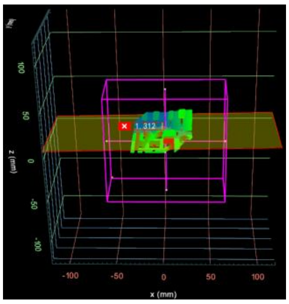
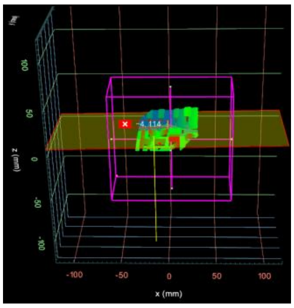
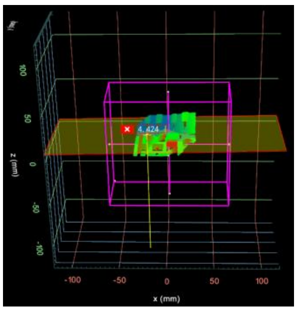


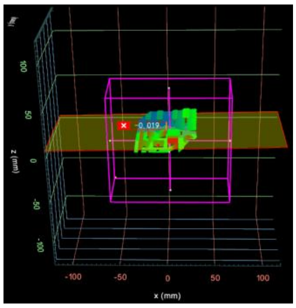
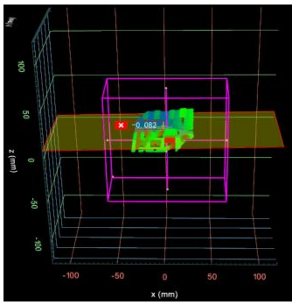
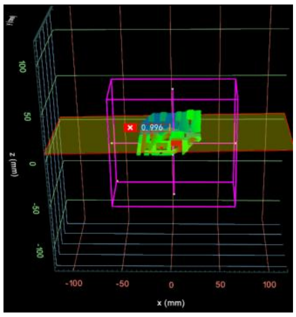
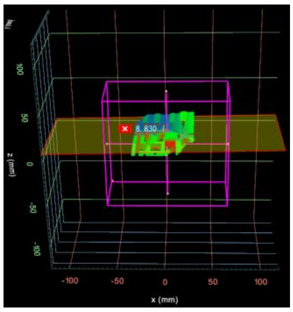
Input parameters:

Parameter	**Describe**
Region	Area of interest for flat tools. Up to 4 regions can be supported. 

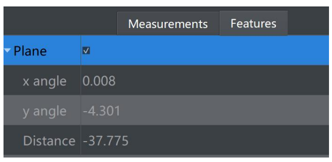
Output parameters:

Parameter	**Describe**	**Example**
X angle	The rotation angle of the point cloud fitting plane around the X-axis.	

Y angle	The rotation angle of the point cloud fitting plane around the Y-axis.	
Z offset	The coordinates of the intersection point between the point cloud fitting plane and the Z-axis.	
Standard deviation	The standard deviation from the point to the fitting plane.	
Min =error	The farthest point from above the plane to the plane.	
Max error	The farthest point from the bottom of the plane to the plane.	

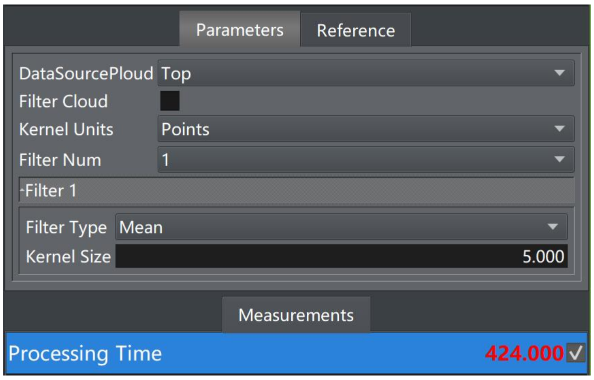
X Normal	The normal vector X of the point cloud fitting plane.	
Y Normal	The normal vector Y of the point cloud fitting plane.	
Z Normal	The normal vector Z of the point cloud fitting plane.	
Distance	The distance from the origin to the plane.	

Feature output:

Parameter	**Describe**	**Example**
Plane	Output the fitted plane as a feature.	

6.11.8 Surface Filter Tool

The point cloud filtering tool utilizes several commonly used point cloud filtering methods to perform simple filtering on point clouds, supporting up to 7 layers of filtering. The filtered point cloud can serve as an input source for other point cloud tools.



Input parameters:

<table>
<tr><th>Parameter</th><th colspan="2">Describe</th></tr>
<tr><td>Data source ploud</td><td colspan="2">Contourometer scans point cloud or other tool generated point cloud data.</td></tr>
<tr><td>Usage area</td><td colspan="2">Areas that require filtering calculations.</td></tr>
<tr><td rowspan="2">Kernel units</td><td colspan="2">Point: Use points as kernel units.</td></tr>
<tr><td colspan="2">mm: Using mm as the kernel unit, the kernel size is converted from mm to points based on the kernel size and point resolution.</td></tr>
<tr><td>filter Num</td><td colspan="2">The number of filtering times, supporting up to 7 layers of filtering.</td></tr>
<tr><td rowspan="4">Filter type</td><td>Mean filtering</td><td>Perform mean filtering on the point cloud based on the size of the kernel window.</td></tr>
<tr><td>Open operation</td><td>Perform open operations on the point cloud based on the size of the kernel window.</td></tr>
<tr><td>Closed operation</td><td>Perform a closed operation on the point cloud based on the size of the kernel window.</td></tr>
<tr><td>Expand</td><td>Vertical: The kernel window performs dilation filtering in a vertical direction.</td></tr>
</table>

		Horizontal: The kernel window performs dilation filtering along the horizontal direction.
		Symmetry: The kernel window is a symmetrical cross, and dilation filtering is performed according to this kernel.
	Corrosion	Vertical: The kernel window performs corrosion filtering in a vertical direction.
		Horizontal: The kernel window performs corrosion filtering along the horizontal direction.
		Symmetry: The kernel window is a symmetrical cross, and corrosion filtering is performed according to this kernel.
	Morphological gradient	Vertical: The kernel window performs morphological filtering along the vertical direction.
		Horizontal: The kernel window performs morphological filtering along the horizontal direction.
		Symmetry: The kernel window is a symmetrical cross, and morphological filtering is performed according to this kernel.
	Binarization	Set the Z value in the point cloud that is above the threshold as a numerical value, and set the value below the threshold as a numerical value.
	Normalization	Normalize within the range of maximum and minimum values of Z in the point cloud.
	Reverse	Invert the value of Z in the point cloud.
	Percentage threshold	According to the percentage of point clouds, points exceeding the high and low thresholds are removed, and only point clouds within this range are retained.
	Relative threshold	Remove points that exceed high and low thresholds, and only retain point clouds within this range.
		If a reference plane is used, point cloud processing is performed based on the distance from the reference plane.
	Cropping	Crop the point cloud and capture a portion of it.
	Mask	The point cloud data is masked to record whether the original point cloud data value

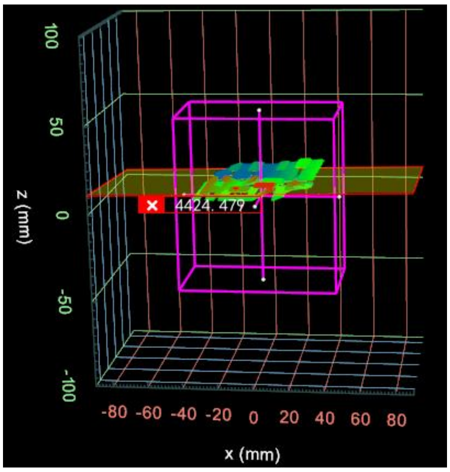
		is valid. If the point cloud value at a certain point is invalid, it will also be invalid after other filtering treatments.

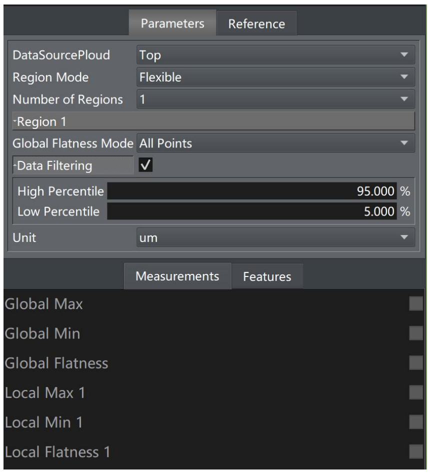
Output parameters:

Parameter	**Describe**
Processing time	Record the filtering time.

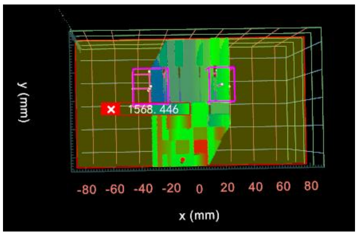
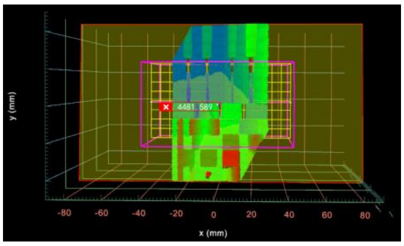
6.11.9 Surface Flatness Tool

The flatness tool is used to set multiple regions of interest for planar fitting, and calculate global and local maximum, minimum, and flatness (maximum minimum).



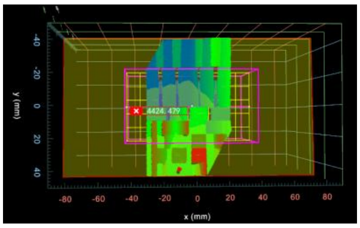
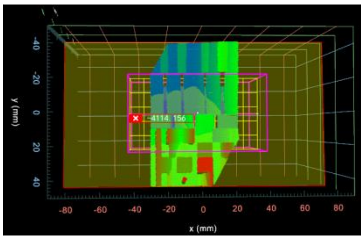
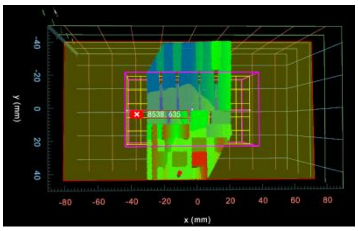
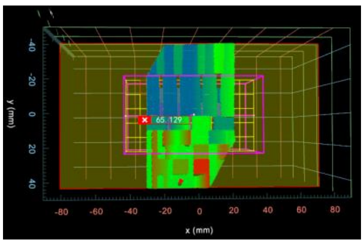


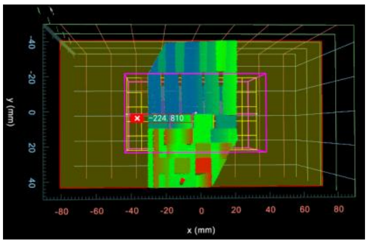
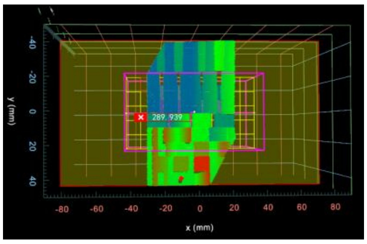
Input parameters:

Parameter	Describe	Example
Region mode	Random mode: Multiple regions of interest (up to 15) can be input on the point cloud to calculate flatness.	
	Grid mode: Calculate flatness by setting the area of interest of the grid and the width and length of each grid.	
Number of regions	When selecting random mode for region type, the number of regions of interest that can be selected.	
Grid area Grid width (X) Grid length (Y)	When selecting the grid mode for the region type, you can define the region of interest and the width and length of the grid.	

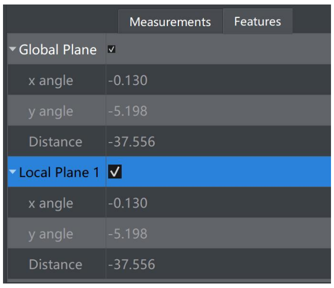
Global flatness mode	Set the point used to calculate global flatness.
	All points: Use all points within the region of interest for global flatness calculation.
	Average value calculation: Use the average value of points within the region of interest to calculate global flatness. If the region mode is random, there are at least four regions of interest; If the region mode is grid, it is also necessary to ensure that at least four grids can be generated.
Data filtering	Set the upper and lower percentage limits to filter point cloud data.
Unit	Set the unit of measurement results.

Output parameters:

Parameter	**Describe**	**Example**
Global max	The farthest point from above the plane to the plane.	
Global min	The farthest point from the bottom of the plane to the plane.	
Global flatness	Global Maximum - Global Minimum.	
Local max 1	The farthest point from the plane above a single area to the plane.	

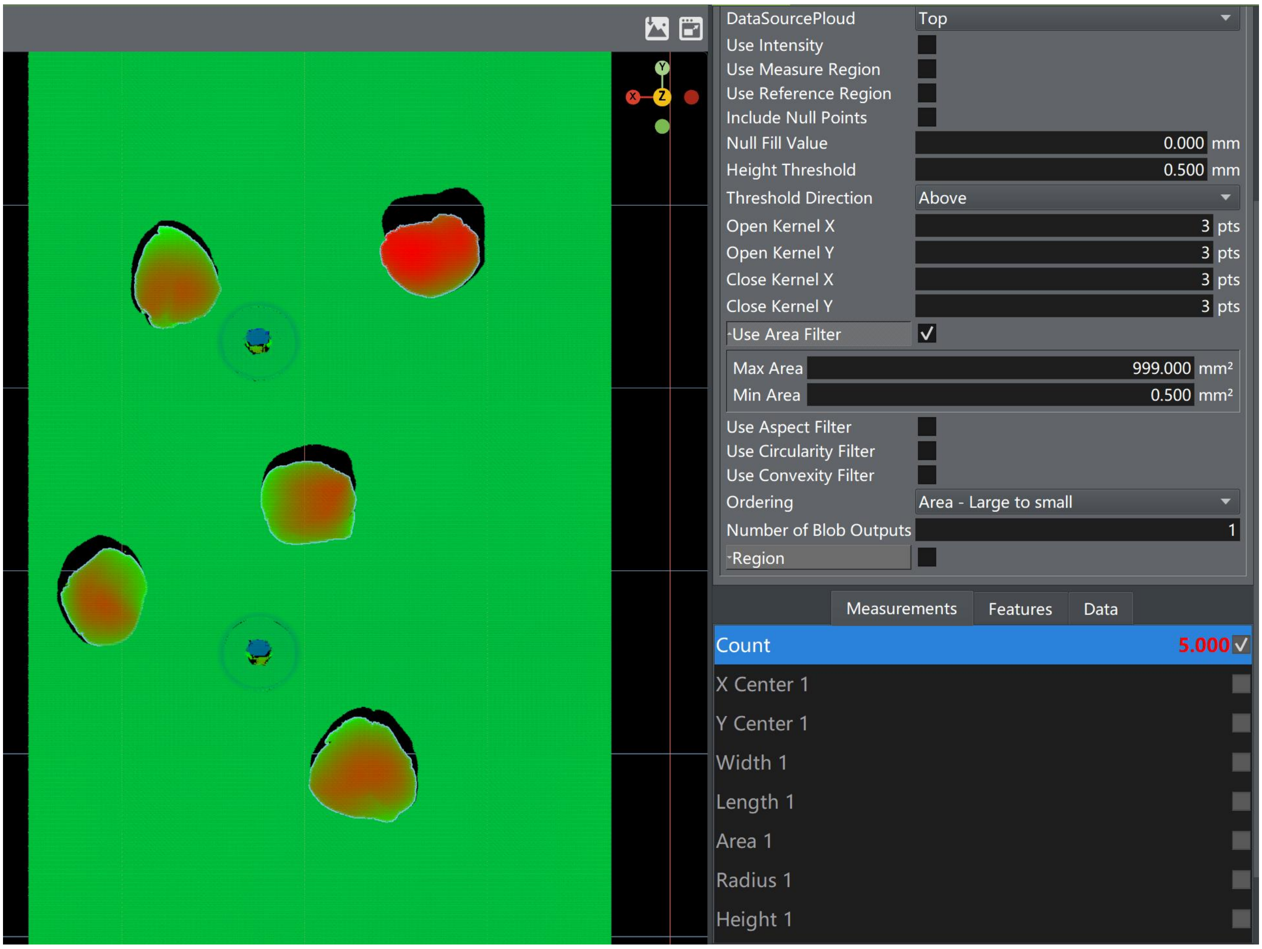
Local min 1	The farthest point from the plane above a single area to the plane.	
Local flatness 1	Local maximum in a single region - Local minimum in a single region.	

Feature output:

Parameter	Describe	Example
Plane	Output global and local planes as planar features.	

6.11.10 Surface Blob tool

The speckle tool can detect defects on relatively flat or uniform surfaces, such as protrusions, dents, or stains (using brightness mode). This tool first filters data based on height or brightness thresholds and reference values (determined by user-defined reference regions), then uses morphological options to process isolated parts, finally detects the contours of each part, and can exclude uninterested spots based on filters of different sizes and types.



Input parameters:

Parameter	Describe
Use intersity	If checked, brightness data will be used instead of height data, which is only valid when the point cloud has brightness information.
Use measure region	The range of interest used for spot detection is only within the user-defined range. If not checked, proceed throughout the entire point cloud.
Measure area	Select the desired type of measurement area, which can be either circular or rectangular.

type	The diameter of a circular area is equal to the smaller of its width and length.
Use reference region	The reference area is used to calculate the reference value, which is equal to the average of the height or brightness values of all effective points within the reference area. If unchecked, the reference value is equal to 0.
Reference area type	Same type as the measurement area.
Including null points	If checked, invalid points are considered valid points, and their value is determined by the invalid filling value.
Invalid fill value	When including invalid points is checked, the value of the invalid points. When using brightness is not checked, the invalid fill value is the height value, and when using brightness, the invalid fill value is the brightness value.
Height threshold Brightness threshold	When using brightness is checked, this item is the brightness threshold; Otherwise, it is the height threshold. When the value of a point is higher or lower than the reference value+height threshold, the point is considered within the spot, and the higher or lower value is determined by the direction of the threshold.
Threshold direction	Above: [reference value+height threshold] is the lowest filtered value. Below: [reference value+height threshold] is the highest filtered value.
Open kernel X Open kernel Y	Used to set the size of the morphological open operation window in the X and Y directions, respectively. X. When any value of Y is 0, this operation is not performed.
Close kernel X Close kernel Y	Used to set the size of the morphological closed operation window in the X and Y directions, respectively. X. When any value of Y is 0, this operation is not performed.
Use aspect filter	If checked, use the maximum and minimum areas to filter out spots that do not meet the requirements.
Use circularity filter	If checked, use the maximum and minimum ratios to filter out spots that do not meet the requirements. The ratio is the aspect ratio of the minimum circumscribed diagonal rectangle of the speckled contour.
Use convevexity filter	If checked, use maximum roundness and minimum roundness to filter out spots that do not meet the requirements.

	The roundness of the contour is determined by its area and circumference. The closer the contour is to a circle, the greater the roundness, and the roundness value range is 0-1.
Use convexity filtering	If checked, use maximum and minimum convexity to filter out spots that do not meet the requirements. The roundness of the contour is determined by its area and the area of its convex hull. The more convex the contour, the greater the convexity, and the range of convexity values is 0-1.
ordering	The sorting method for measurement and feature output. There are: Area: from large to small; Area: From small to large; Position: X increases; Position: X decreases; Position: Y increases; Position: Y decreases.
Number of spot outputs	The maximum allowable output quantity for measurement and feature output is 200.

Output parameters:

Parameter	Describe
Quantity	The total number of spots detected and filtered.
Area	Spot area.
X center Y center	The center position of the spot contour.
Length Width	The length and width of the minimum diagonal rectangle bounding box with spots are always greater than the width.

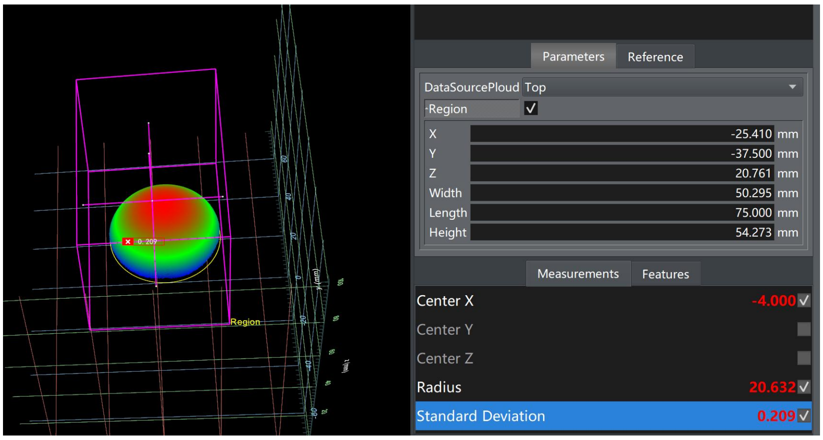
Feature output:

Parameter	Describe

Center point	Spot contour center point.

6.11.11 surface sphere tool

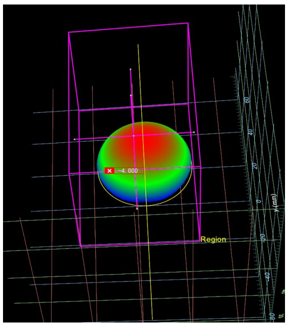
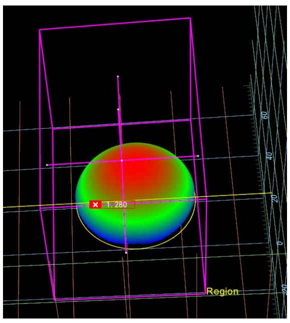
The sphere tool performs sphere fitting on point clouds within the region of interest and outputs relevant features.

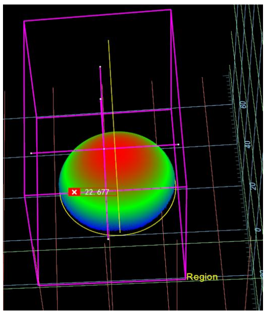
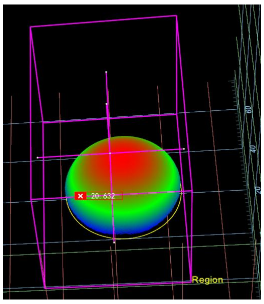


Input parameters:

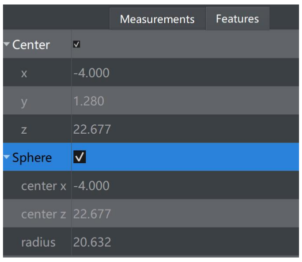
Parameter	Describe
Region	Sphere tool area of interest.

Output parameters:

Parameter	Describe	Example
Center X	The center coordinate X of the point cloud sphere fitting.	
Center Y	The center coordinate Y of the point cloud sphere fitting.	

Center Z	The center coordinate Z of the point cloud sphere fitting.	
Radius	The radius of the point cloud sphere fitting.	
Standard deviation	The standard deviation of point cloud sphere fitting.	

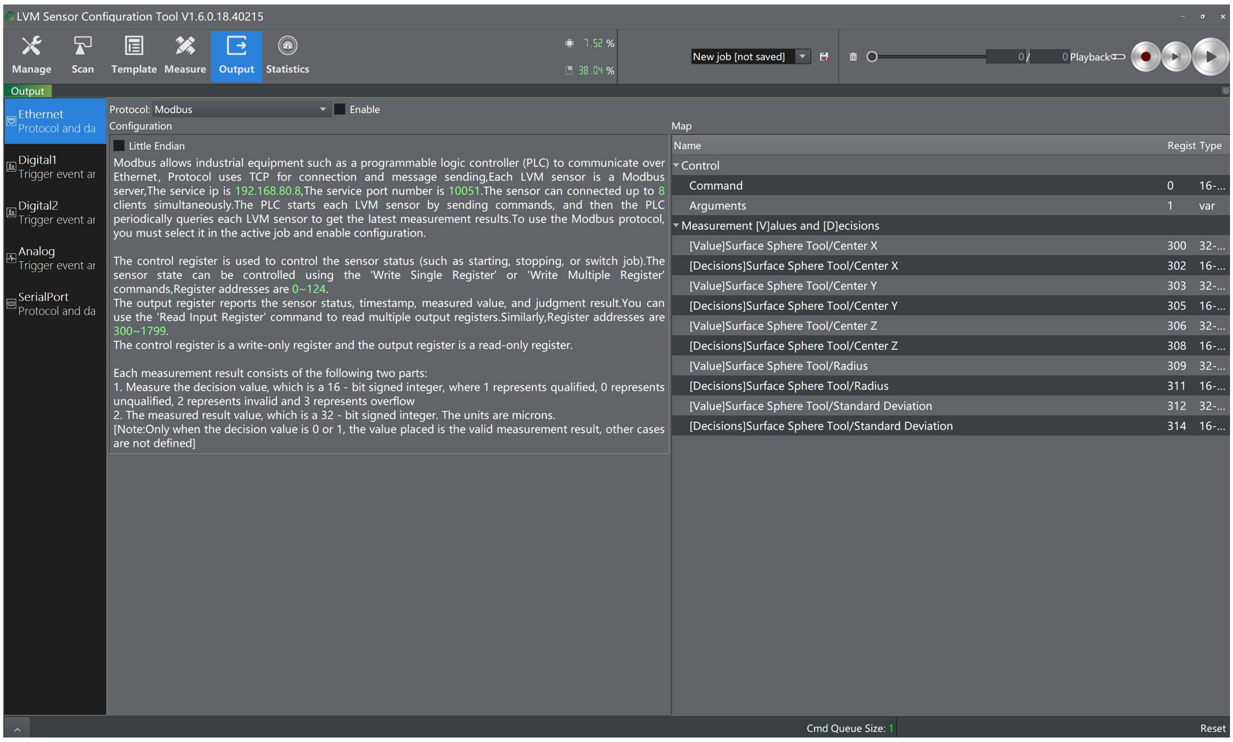
Feature output:

Parameter	Describe	Describe
sphere	Output the fitted ball as a ball feature.	

6.12 Result output

6.12.1 Overview of Output Page

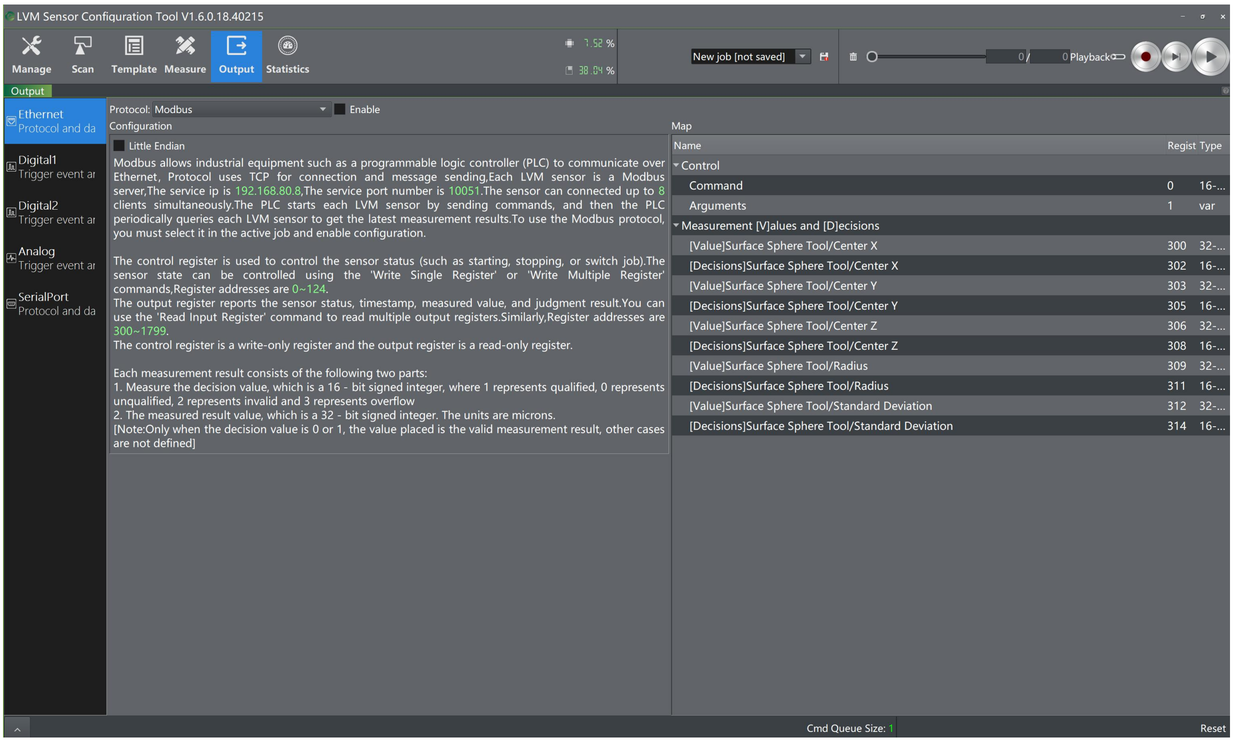
Sensors can output measurement data and results to external devices through Ethernet or serial ports, and set parameters on the output page, as shown in the following figure. If you enable output, you need to select the output interface and protocol on the page, and then check the "Enable" option.



6.12.2 Ethernet output

Sensors can accept control from external devices or send data and results to external devices through the TCP protocol. The supported protocols include Modbus TCP, ASCII, and Profinet.

■ Modbus TCP



The Modbus protocol uses TCP for connection and message sending, and each sensor is a Modbus server that can connect up to 8 clients simultaneously. The client, such as PLC, establishes a connection with the sensor through port number 10051. The PLC can send commands to turn on or off the sensor, and can also periodically query the sensor to obtain its measurement values and judgment results. The user manually selects the measurement and judgment results to be output in the "Measurement" panel of the measurement tool settings page.

（1）Frame structure

Modbus TCP The data frame is divided into two parts:MBAP+PDU

MBAP is the protocol message header, which is 7 bytes in length and consists of the following:

Field	**Length (Bytes)**	**Describe**
Transaction ID	2	The sequence number of a message usually needs to be added with 1 after each communication to distinguish different communication data messages.
Protocol identifier	2	00 00 express Modbus TCP Protocol.
Length	2	Represents the data length of the remaining portion of the message frame, including unit identifiers and data fields.
Unit identifier	1	Device address.

PDU is a protocol data unit composed of function code and data. The length of the function code is 1 byte, and the data length is variable, depending on the specific function. The sensor supports the following function codes:

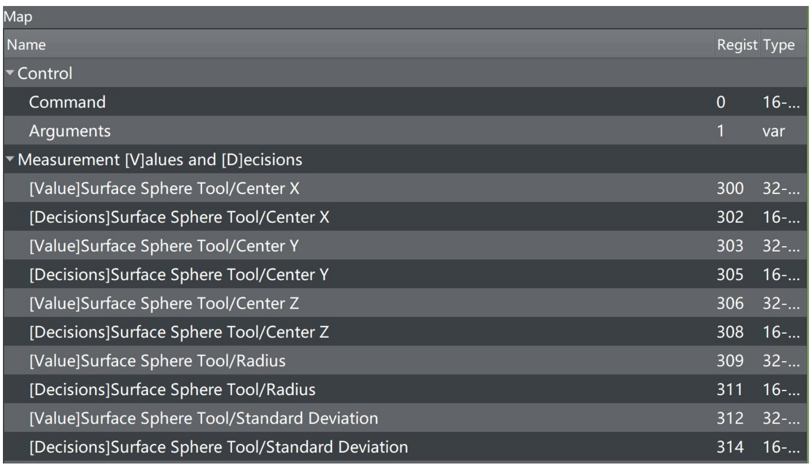
Function code	Describe
0x04	Read the input register.
0x06	Write a single holding register.
0x10	Write multiple holding registers.

（2）Registers

The measurement result data of the sensor includes 16 bit and 32 bit data. All data is sent in the big end format by default. If it needs to be changed to the small end byte order output, the corresponding settings can be opened. The Modbus register is 16 bit wide, and if it is 32 bit data, it will be dispersed into two consecutive registers. The specific register mapping information is as follows:

Register address	Name	Reading and writing	Describe
0~124	Control register	Write only	Registers used for Modbus control commands.
300~1799	Measurement and Decision Value Registers	read-only	A register used for outputting measurement and decision values.

After manually checking the "Measurement" panel on the measurement tool settings page, the user will automatically generate a register mapping table, as shown in the following figure:



Map

Name	Regist	Type
Control		
Command	0	16-...
Arguments	1	var
Measurement [V]alues and [D]ecisions		
[Value]Surface Sphere Tool/Center X	300	32-...
[Decisions]Surface Sphere Tool/Center X	302	16-...
[Value]Surface Sphere Tool/Center Y	303	32-...
[Decisions]Surface Sphere Tool/Center Y	305	16-...
[Value]Surface Sphere Tool/Center Z	306	32-...
[Decisions]Surface Sphere Tool/Center Z	308	16-...
[Value]Surface Sphere Tool/Radius	309	32-...
[Decisions]Surface Sphere Tool/Radius	311	16-...
[Value]Surface Sphere Tool/Standard Deviation	312	32-...
[Decisions]Surface Sphere Tool/Standard Deviation	314	16-...

- Control register

The control register is used to control the sensor status (such as start or stop). The sensor status can be controlled using the "Write Single Holding Register" or "Write Multiple Holding Registers" commands, with register addresses ranging from 0 to 124.

Register address	Name	Reading and writing	Describe
0	Command register	Write only	A 16 bit command, please refer to the table below for a list of available command values.

Command register list:

Command register value	Name	Describe
0	Stop scanning	Stop the sensor operation.
1	Start Scan	Start sensor operation.
2	Switching Jobs	Press the job index to switch jobs. This command requires writing multiple holding registers, with a function code of 0x10. Write 2 in register 0 and the job index number to switch to in register 1.

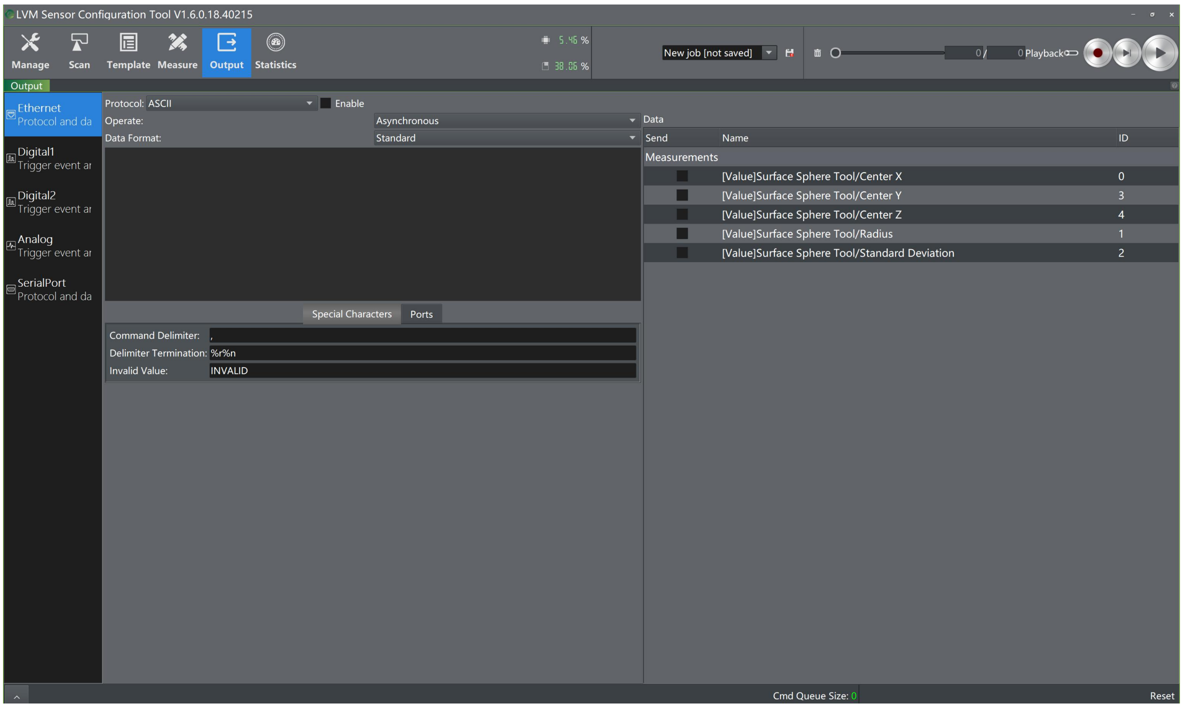
- Measurement value and decision value register

The measured value is a 32-bit signed integer value, dispersed into two consecutive registers, in units of μ m. The decision value is a 16 bit signed integer value. Only when the decision value is 0 or 1, does this register store a valid measurement result, and dividing the read result by 1000 is the actual measurement value.

Register address	Name	Type	Describe
300	Measurement value 0 high bit	16 bit	Measurement value.
301	Measurement value 0 low bit	16 bit	
302	Decision value 0	16 bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.

303	Measurement value 1 high bit	16 bit	Measurement value.
304	Measurement value 1 low order	16 bit	
305	Decision value 1	16 bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.
…	…	…	…
1799	Decision value 499	16 bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.

■ **ASCII**



Setting items	**Describe**
Operation mode	In asynchronous mode, data is sent as soon as it becomes available. In polling mode, users need to send request commands to obtain measurement results.
Data format	Standard format: As the default format, users can select the measurement items to be sent by checking the corresponding checkbox in the "Data" panel on the right. Marking and Additional Information: The user selects the corresponding checkbox in the

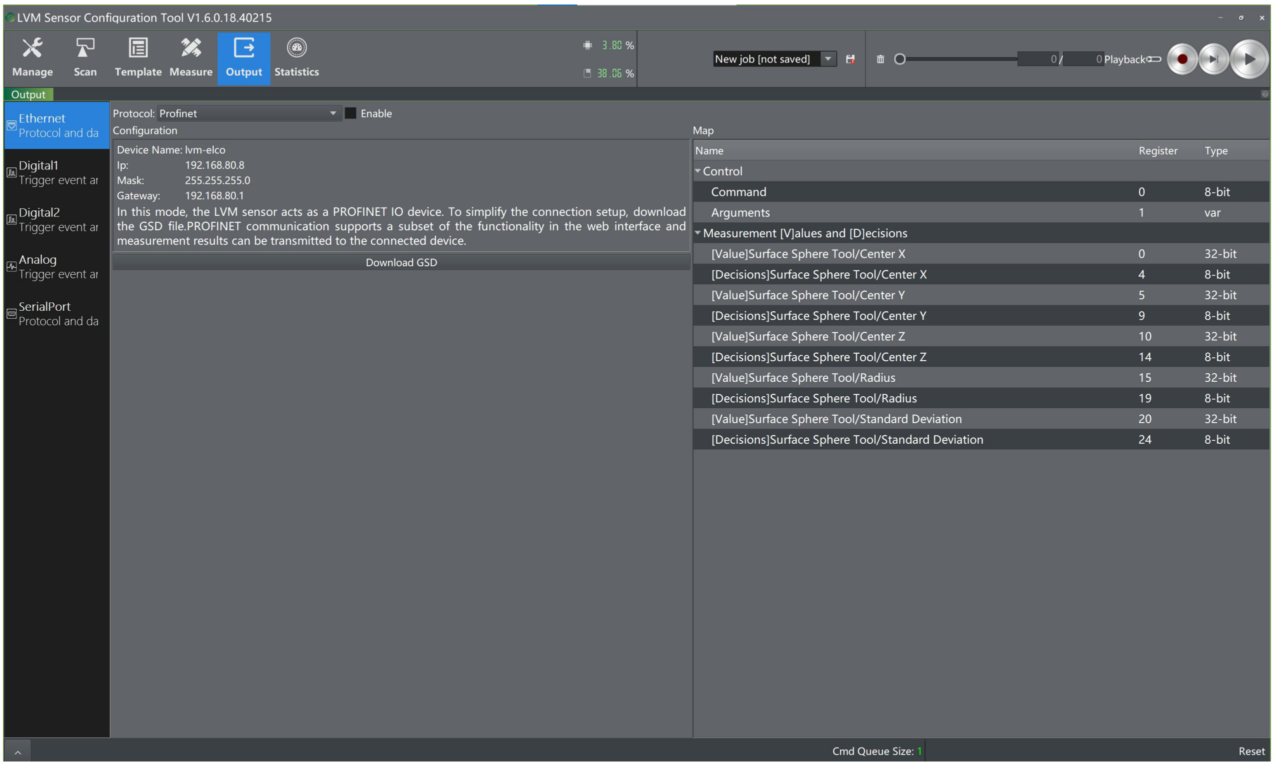
	"Data" panel on the right to select the measurement item to be sent, and outputs additional information such as timestamp and encoder value. Customization: Users create custom data formats in the editor using the formats listed in the "Replace Forms" section on the right. The separators between output items need to be consistent with the separators set in the special characters, otherwise the custom format is invalid.
Special characters	Set command delimiters, delimiter terminators, and invalid value characters.

The commands currently supported by the sensor are as follows:

Command	**Describe**	**Reply**
Start	Activate the sensor.	Success:Start OK Failed:Error
Stop	Stop the sensor.	Success:Stop OK Failed:Error
Result , Measurement ID, Measurement ID	Request the latest result of the specified measurement ID from the sensor.	Success:OK，Data String Failed:Error
SwitchJob, Job index number	Switch jobs.	Success:SwitchJob, Job index number OK Failed:Error

The delimiters and terminators for sending commands need to be consistent with the characters set in the special character page, otherwise the command will be invalid.

■ Profinet



Profinet is an industrial Ethernet network protocol that allows controllers such as PLCs to communicate with sensors. The sensor is a Profinet I/O device with a consistency level of A.

To simplify the usage process, click the "Download GSD File" button to download the GSD file for use with the user's PLC and other controllers.

The modules currently supported by the sensor include a control module and a measurement module, with a control module length of 10 bytes and a measurement module length of 800 bytes.

Register address	Name	Reading and writing	Describe
0~9	Control module register	Write only	Registers used for Profinet control modules.
0~799	Measurement module register	Read only	Measurement module register for Profinet.

- Control module

The control module is used to control the sensor status (such as start or stop). Module addresses are 0-9.

Register	Name	Reading and	Describe

address		writing	
0	Command register	Write only	An 8-bit command, please refer to the table below for a list of available command values.

Command register list:

Command register value	Name	Describe
0	Stop scanning	Stop the sensor operation.
1	Start scanning	Start sensor operation.
2	Switching Jobs	Press the job index to switch jobs. Write 2 in register 0, and write the job index number to be switched into register 1.

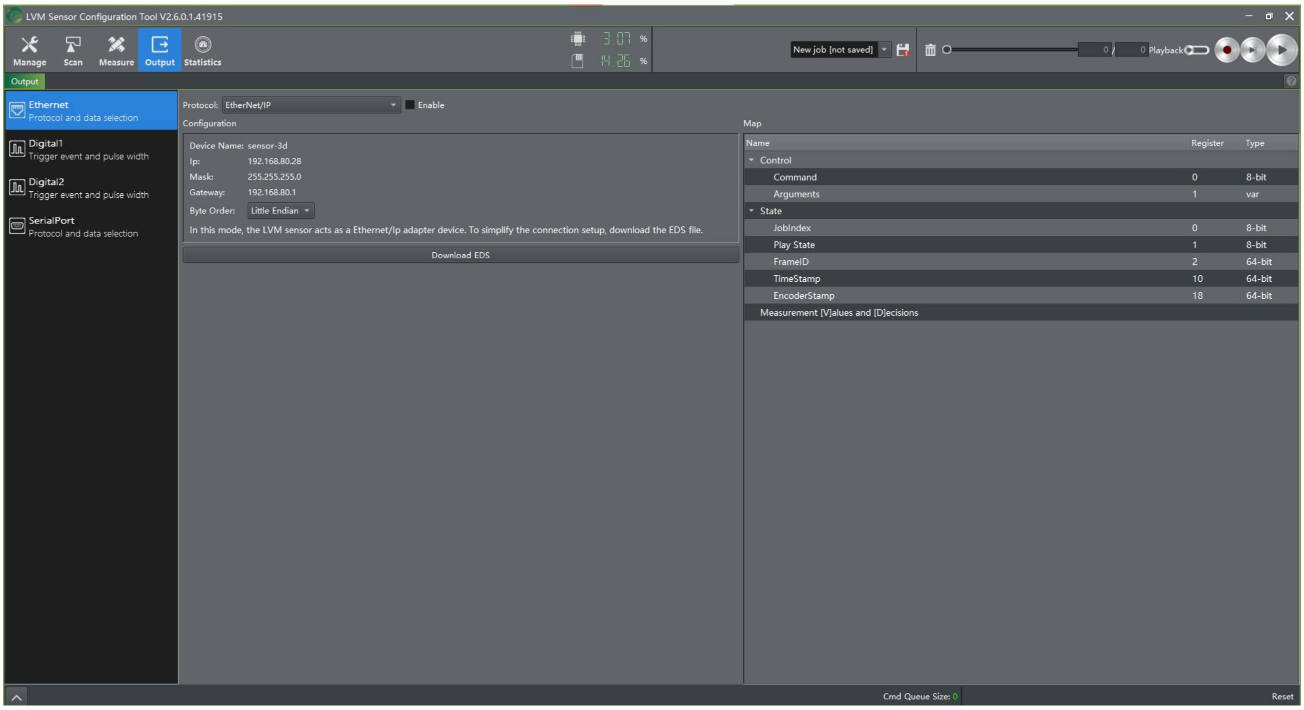
- Measurement module

The measurement and judgment results are only sent in the big end format. Each measurement plus judgment result occupies 5 bytes, so this module can accommodate up to 800/5=160 measurement plus judgment results.

Register address	Name	Type	Describe
0~3	Measurement value 0	32-bit	Measurement value.
4	Decision value 0	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.
5~8	Measurement value 1	32-bit	Measurement value.
9	Decision value 1	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.
10~13	Measurement value 2	32-bit	Measurement value.
14	Decision value 2	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.

…	…	…	…
799	Decision value 159	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.

■ Ethernet/Ip



Ethernet/Ip is an industrial Ethernet network protocol that allows PLC and other controllers to communicate with sensors. To simplify the process, click the "Download EDS File" button to download the EDS file for use with the user's PLC and other controllers.

The sensor now supports control module and measurement module. The length of control module is 32 bytes, and the length of measurement module is 320 bytes.

Register address	Name	Reading and writing	Describe
0~31	Control module register	Write only	Registers used for Ethernet/Ip control module.
0~319	Measurement module register	Read only	Registers for Ethernet/Ip measurement module.

- Control module

The control module is used to control the sensor status (such as start or stop). Module address are 0~31.

Register address	Name	Reading and writing	description
0	Command register	Write only	An 8-bit command. For a list of available command values, see the table below.

Command register list:

Command register value	Name	Describe
0	Stop scanning	Stop the sensor operation.
1	Start scanning	Start the sensor operation.
2	Switching Jobs	Switch the job by job index number. Write 2 into register 0 and write the job index number to be switched into register 1.

- Measurement module

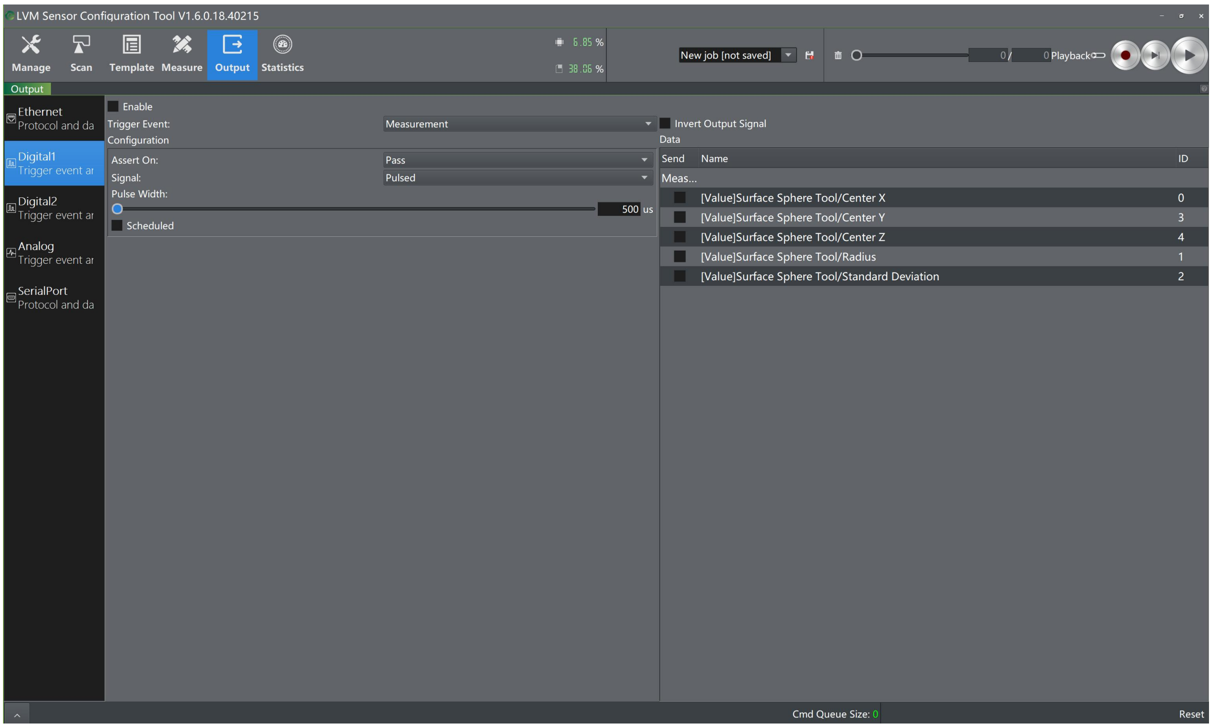
The measurement and judgment results are sent in the default big end format. Each measurement and judgment result occupies 5 bytes, so this module can accommodate up to 320 / 5 = 64 measurements + judgment results.

Register address	Name	Type	Describe
0~3	Measurement value 0	32-bit	Measurement value.
4	Decision value 0	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.
5~8	Measurement value 1	32-bit	Measurement value.
9	Decision value 1	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.
10~13	Measurement value 2	32-bit	Measurement value.
14	Decision value 2	8-bit	0 represents unqualified, 1 represents qualified,

			2 represents invalid, and 3 represents overflow.
...	...	...	...
319	Decision value 63	8-bit	0 represents unqualified, 1 represents qualified, 2 represents invalid, and 3 represents overflow.

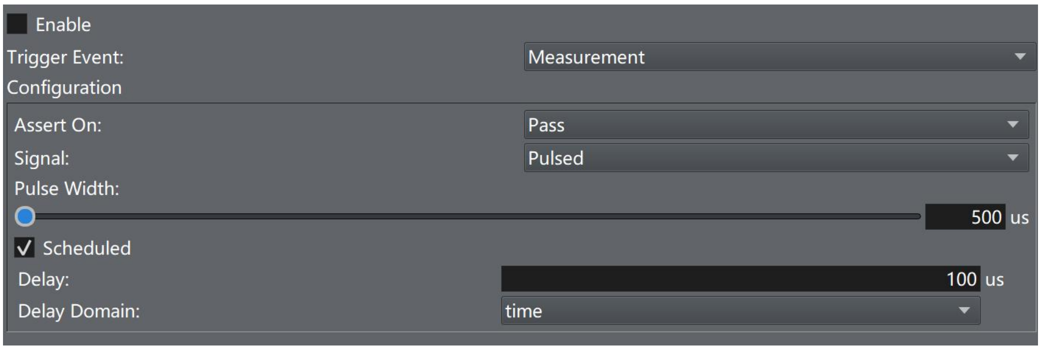
6.12.4 Digital output

Sensors can convert measurement judgment results, exposure timing, or calibration information into digital output pulses, which can be used to output PLC or control external devices. Each sensor supports two digital output channels.



Output Event Type: Measurement Result, Exposure Start, Exposure End, Calibration

1. Measurement results



If multiple judgment results are selected in the data list and "qualified" is selected for the corresponding results, the output signal is activated when all selected measurement items are qualified. When the corresponding result is selected as "unqualified or invalid", the output signal is activated when any one of the selected measurement items is unqualified or invalid. When "continuous" is selected for the corresponding result, the output signal is activated when there are results in the selected measurement item. Activate signal output only once per frame.

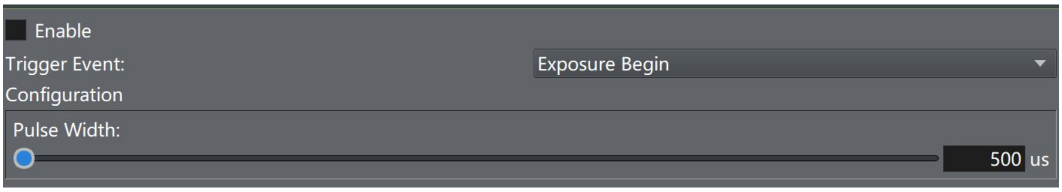
The signal type specifies whether the digital output is a pulse signal or a continuous signal. If set to "pulse", you need to specify the pulse width and delay method. If set to "continuous", its state remains unchanged until the next signal conversion.

The pulse width determines the duration of the digital output pulse (in milliseconds), which can be set when the signal type is pulse.

Delay output refers to scheduling mode, which can be selected when the signal type is pulse. The non delay mode means that the signal is output immediately after the measurement result is generated. The delay mode refers to the activation of the output after a period of time delay after the sensor exposure start signal is generated.

If you need to reverse the output signal, please select the Reverse Output Signal option.

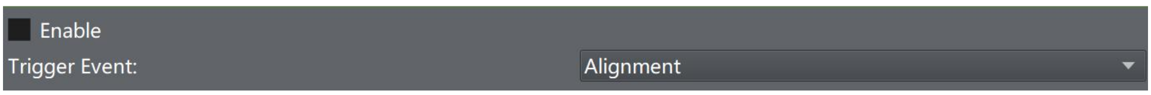
2. Exposure signal



The event type option can set the start or end of exposure. Set the pulse width option.

The pulse width determines the duration of the digital output pulse in milliseconds.

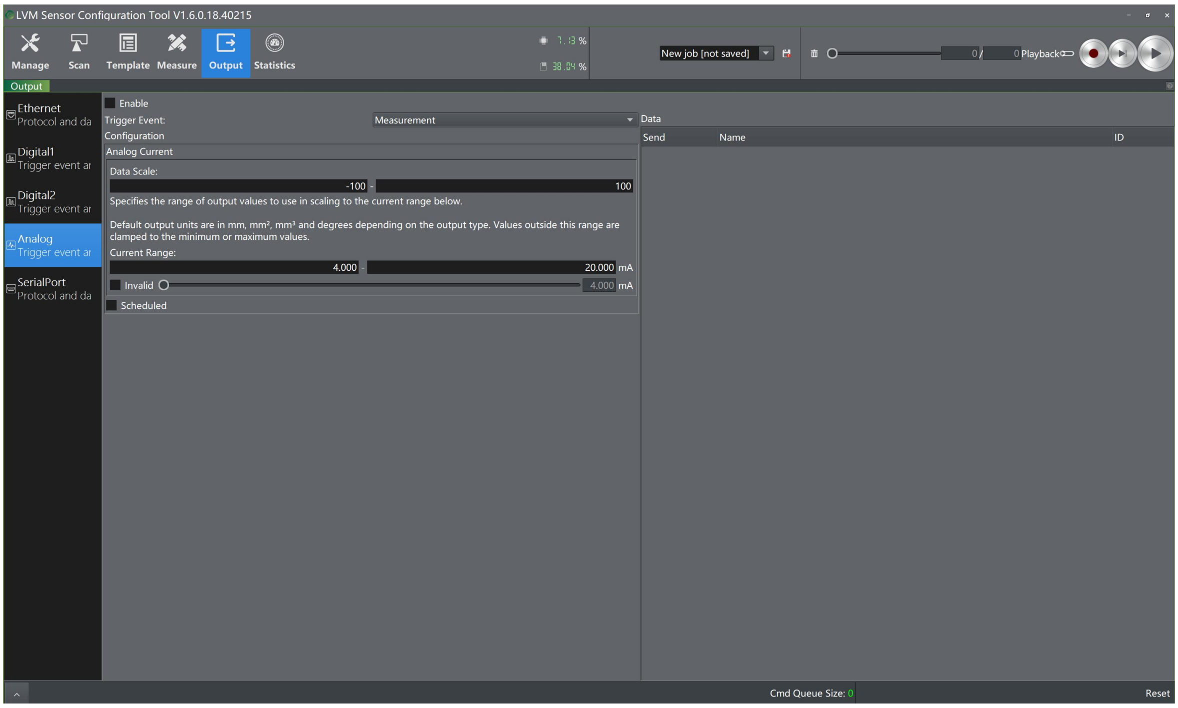
3. Calibration signal



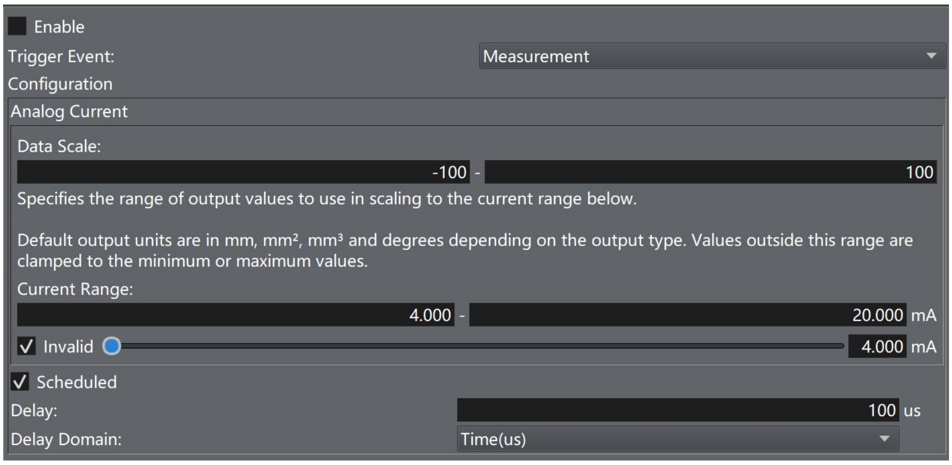
If the sensor is calibrated, the digital output status is "high", and if not calibrated, the digital output status is "low". The operation of the sensor does not affect the signal output.

6.12.5 Analog output

Sensors can convert measurement results into analog data output. Each sensor supports one analog output channel.



1. Output of measurement results



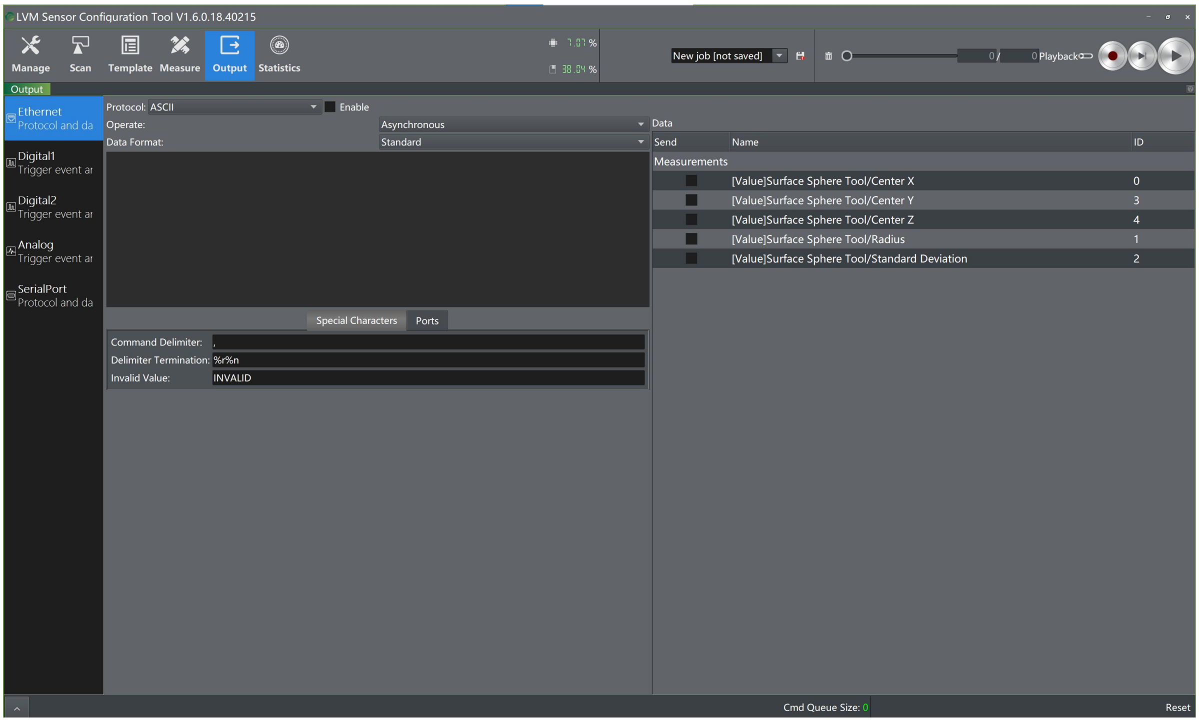
Select the measurement item to output from the analog quantity in the data list (only one item can be selected), specify the data range, and the value specified here determines how the measurement value is adjusted to the minimum and maximum current output. For size (such as distance) measurement, area measurement, and volume measurement, the units of data scale values are millimeters, square millimeters, and cubic millimeters, respectively; For angle results, the unit of data accuracy value is degrees.

Specify the current range and invalid current value. The value specified here determines the minimum and maximum current values in milliamperes. If Invalid is selected, the current value specified through the slider will be used when the measured value is invalid. If Invalid is not selected, when the measured value is invalid, the output retains the previous value.

Specify whether the output is instant or delayed. The analog signal can be activated immediately or at a predetermined time. If you need to delay the output, please select the delay option. Starting from the exposure of the sensor, after a specified delay time, the output becomes active.

6.12.6 Serial output

Sensors can send data and results to external devices through RS-485 serial port, and the supported protocol is ASCII.



Setting items	Describe
Baud rate	The rate of serial output.
Data format	Standard format: As the default format, users can select the measurement items to be sent by checking the corresponding checkbox in the "Data" panel on the right. Marking and Additional Information: The user selects the corresponding checkbox in the "Data" panel on the right to select the measurement item to be sent, and outputs additional information such as timestamp and encoder value. Customization: Users create custom data formats in the editor using the formats listed in the "Replace Forms" section on the right. The separators between output items need to be consistent with the separators set in the special characters, otherwise the custom format is invalid.

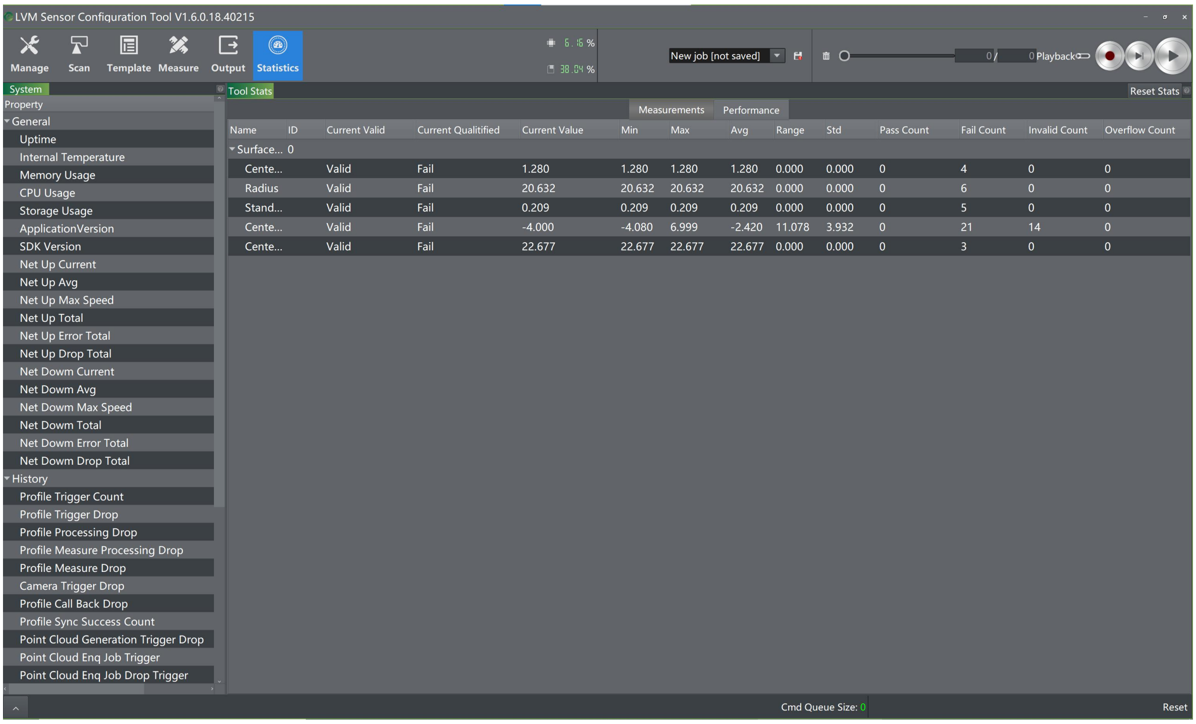
Special characters	Set command delimiters, delimiter terminators, and invalid value characters.

The sensor serial port ASCII communication uses the following connection settings:

Parameter	**numerical value**
Baud rate	9600，19200，38400，57600，115200，230400
Stop bit	1
Data bits	8
Parity check	Nothing

6.13 Status statistics

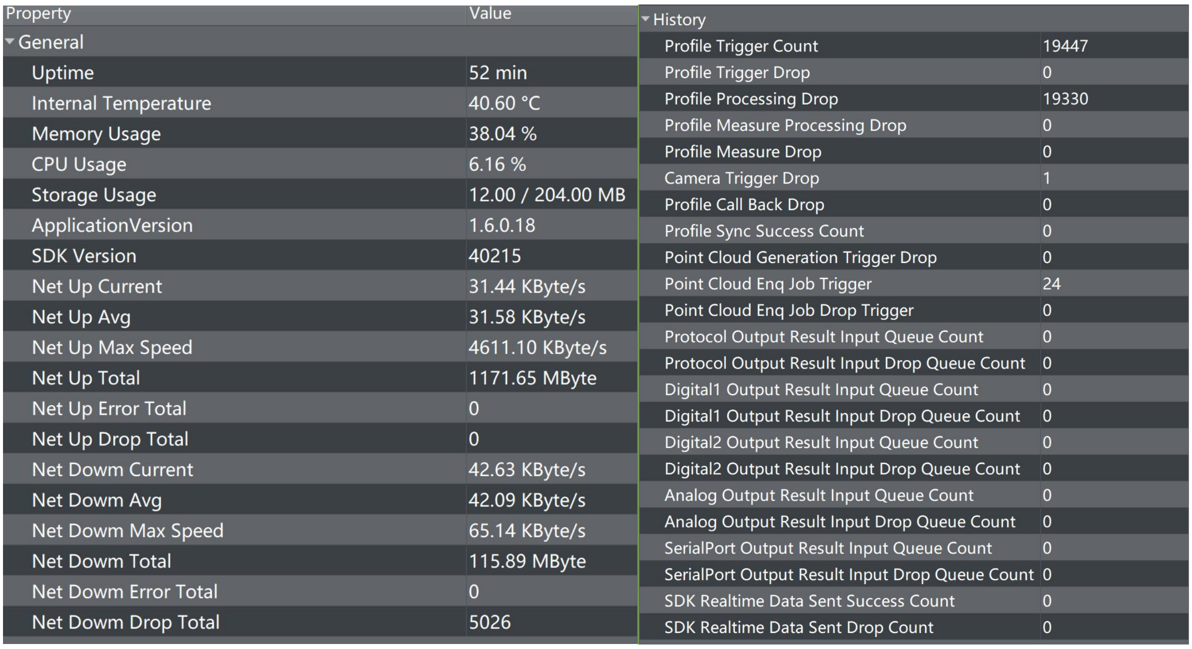
The statistics page mainly lists the current operating status of sensors, measurement results, and statistical data on the performance of measurement tools.



Element	Describe
System	Display system operation status information.
Tool statistics	Display measurement results and the performance of measurement tools.

6.13.1 System information

System information allows you to view system status information and system tracking information.



Property	Value
General	
Uptime	52 min
Internal Temperature	40.60 °C
Memory Usage	38.04 %
CPU Usage	6.16 %
Storage Usage	12.00 / 204.00 MB
ApplicationVersion	1.6.0.18
SDK Version	40215
Net Up Current	31.44 KByte/s
Net Up Avg	31.58 KByte/s
Net Up Max Speed	4611.10 KByte/s
Net Up Total	1171.65 MByte
Net Up Error Total	0
Net Up Drop Total	0
Net Dowm Current	42.63 KByte/s
Net Dowm Avg	42.09 KByte/s
Net Dowm Max Speed	65.14 KByte/s
Net Dowm Total	115.89 MByte
Net Dowm Error Total	0
Net Dowm Drop Total	5026

History	
Profile Trigger Count	19447
Profile Trigger Drop	0
Profile Processing Drop	19330
Profile Measure Processing Drop	0
Profile Measure Drop	0
Camera Trigger Drop	1
Profile Call Back Drop	0
Profile Sync Success Count	0
Point Cloud Generation Trigger Drop	0
Point Cloud Enq Job Trigger	24
Point Cloud Enq Job Drop Trigger	0
Protocol Output Result Input Queue Count	0
Protocol Output Result Input Drop Queue Count	0
Digital1 Output Result Input Queue Count	0
Digital1 Output Result Input Drop Queue Count	0
Digital2 Output Result Input Queue Count	0
Digital2 Output Result Input Drop Queue Count	0
Analog Output Result Input Queue Count	0
Analog Output Result Input Drop Queue Count	0
SerialPort Output Result Input Queue Count	0
SerialPort Output Result Input Drop Queue Count	0
SDK Realtime Data Sent Success Count	0
SDK Realtime Data Sent Drop Count	0

- **System status information**

Name	Describe
Boot time	The duration of time since the sensor is powered on or reset.
Internal temperature	The internal temperature of the sensor.
Memory load	Sensor memory utilization (MB used/total MB available).
CPU load	Sensor CPU utilization.
Storage load	Sensor flash utilization rate (MB used/total MB available).
Firmware version	Sensor firmware version.
SDK version	Sensor SDK version.
Network uplink speed	Sensor network uplink speed.
Average network uplink speed	The average upstream speed of the sensor network.
Maximum network uplink speed	The maximum upstream speed of the sensor network.
Total network uplink	The total amount of uplink in the sensor network.

Total number of network uplink error packets	The total number of uplink error packets in the sensor network.
Total number of network uplink packet losses	The total number of uplink packet losses in the sensor network.
Network downlink speed	Downlink speed of sensor networks.
Average speed of network downlink	The average downstream speed of the sensor network.
Maximum speed of network downlink	The maximum downstream speed of the sensor network.
Total network downlink	The total amount of downlink in the sensor network.
Total number of network downlink error packets	The total number of downlink error packets in the sensor network.
Total number of network downlink packet losses	The total number of downlink packet losses in the sensor network.

■ • **System tracking historical information**

Name	**Describe**
Number of light strip extraction times	Number of times the sensor light strip is extracted.
Number of frames lost in contour reconstruction	Number of frames lost in sensor contour reconstruction.
Number of contour reconstruction executions	Number of sensor contour reconstruction executions.
Number of successful contour joining tasks	Number of successful queue entry times for sensor contour measurement results.
Number of failed contour joining tasks	Number of failed sensor contour measurement results for queue entry.

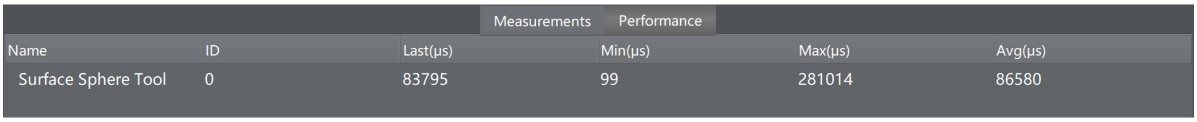
Number of camera triggering losses	Number of sensor camera triggering losses.
Number of missing contour callback responses	Number of missing sensor contour callback responses.
Number of successful contour synchronization attempts	Number of successful sensor contour synchronization attempts.
Outline entry point cloud drop frame	Number of frame drops for sensor point cloud contours.
Number of successful point cloud queue assignment attempts	The number of successful entry times for sensor point cloud measurement results.
Number of failed point cloud queuing operations	Number of failed sensor point cloud measurement results for team entry.
Ethernet output queue success count	The Ethernet protocol outputs measurement results and the number of successful queue entries.
Ethernet output queue failure times	Ethernet protocol outputs measurement results and the number of failed queue attempts.
Number 1 outputs the number of successful queue entries	Number 1 outputs the measurement result and the number of successful queue entries.
Number 1 Output Queue Failure Times	Number 1 outputs the measurement result and the number of failed attempts to join the queue.
Number 2 Output Queue Success Times	Number 2 outputs the measurement result of the number of successful queue entries.
Number 2 Output Queue Failure Times	Number 2 outputs the measurement result and the number of failed attempts to join the queue.
Number of successful queue entry attempts for analog output	Number of successful queue entry times for analog output measurement results.
Number of failed attempts to queue for analog output	Number of failed attempts to enter the queue based on analog output measurement results.

Serial protocol output queue success times	The serial protocol outputs measurement results and the number of successful queue entries.
Serial protocol output queue failure times	The serial protocol outputs measurement results and the number of failed queue attempts.

6.13.2 Measurement tool result statistics

The measurement tool statistics information can be viewed for measurement result statistics and performance statistics, and the reset statistics button can reset the tool statistics routine.

- **Measurement Statistics**

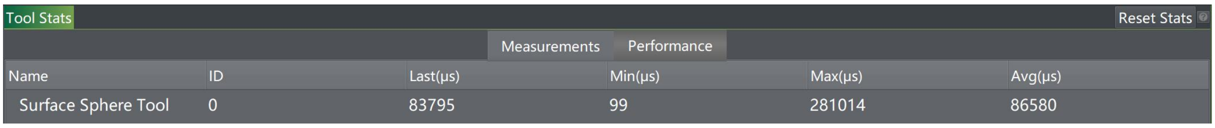


Name	**Describe**
Validity	Is the measurement valid.
Measurement result	Whether the measured value is qualified.
Current value	Current measurement value.
Minimum value	The minimum value calculated.
Maximum value	The maximum value calculated.
Average value	The average value calculated.
Range	Measure the difference between the maximum and minimum values.
Standard deviation	The standard deviation of the measured value.
Number of passes	The number of qualified measurements.
Number of nonconformities	The number of non conformities in the measurement results.
Invalid number of	Number of invalid measurements.

times	
Number of overflows	Number of times the measurement result overflows.

■ **Performance statistics**

Performance statistics display the performance statistics of all measurement tools added in the measurement panel.



Name	**Describe**
Previous（μS)	The last execution time of the tool.
Minimum value（μS)	The minimum execution time for tool execution.
Maximum value（μS)	The maximum execution time of the tool.
Average（μS)	The average execution time of the tool.

7 LVM accelerator

The LVM sensor is a multifunctional device that integrates scanning, measuring, and control functions into a single unit. However, to achieve high scanning rates and measurement performance in very dense data scenarios, users hope to use accelerators for acceleration. By transferring processing functions to dedicated processing devices within the system, the LVM accelerator can enhance the sensor's processing capabilities. This accelerator can be used to speed up one or more independent sensors.

Our acceleration solutions include: PC-based acceleration software (available as a stand-alone application)

7.1 Advantages of using accelerators

◆ The acceleration effect is obvious. Because the output protocol of the accelerated sensor is the same as that of the not accelerated sensor, the SDK and PLC applications do not need to make any changes to control the accelerated sensor and receive operational status information and data.

- The measurement delay on the sensor has been accelerated and shortened. This can shorten the cycle time. This means that more targets can be scanned by the sensor in a given period of time.
- The memory of the accelerated sensor is limited only by the memory of the accelerated device. Therefore, the accelerated sensor can process large 3D point clouds more efficiently.

7.2 Differences after accelerator use

- After the acceleration sensor, the value of system status information and system tracking information is still the value of the sensor, rather than from the acceleration PC.

(See page P183 for details of the system information)

- An accelerator logo has been added to the front interface of the acceleration sensor to indicate the operation status, and other interfaces are basically the same as those on the non-accelerated sensors.
- After the sensor is accelerated, it sends data directly to the acceleration device. The user must use the IP address of the acceleration device (not the IP address of the sensor) to access the front-end interface of the sensor.

7.3 Software usage premise

7.3.1 Accelerator management application

After the sensor software is installed, the accelerator management software is "Accelerator".

Note: The firmware version of the sensor to be accelerated must match the version of the accelerator application.

7.3.2 System requirements and usage conditions

1. Minimum system requirements

The following lists the minimum system requirements for using LVM accelerator PC applications to accelerate a single sensor:

① PC:

- Processor: IntelCorei3 or equivalent product (32 or 64-bit)
- lRAM：4GB
- Hard drive: 128GB
- Operating system: Windows7 or higher version (32 or 64 bits)
- To speed up multiple sensors or increase the speed of the system, you can use a computer with higher system configuration.

② **Graphics card**

The LVM contour sensor accelerator is currently not using a computer graphics card.

2. Preconditions for accelerator use

- When running an accelerator application on a PC, third-party applications may repeatedly consume system resources in unpredictable ways.
- Limit Windows background processes, such as disk optimization (fragmentation sorting) or virus scanning, or set execution plans so that they do not interfere with the scan session, and strictly speaking, if you use an accelerator, you need to turn off the computer system hibernation.
- Ensure that there is sufficient overhead in the system resources. Users can use the Windows Task Manager and Resource Monitor applications to check PC resources. When using accelerators, network bandwidth requirements are in excess of gigabits, and users are advised to always reserve at least 20% of network bandwidth, CPU, memory, and disk space.
- When saving the operation, after clicking the save operation button, it must be transmitted to the accelerator and then back to the sensor, which will cause a delay when the operation synchronizes with the sensor;

(In order to avoid the problem of job loss caused by restarting immediately after saving the job without synchronizing the sensor, users should execute the restart sensor operation after saving the job. It is recommended that users delay the restart operation for a period of time!)

- To verify the stability and reliability of the system, long-term testing can be performed.

7.3.3 Ports required for accelerator

- Accelerator required port number: 18991;
- For each sensor that is accelerated, the port number increases by 4.

(For example, if the port number of one sensor is 18991-18994, if there are multiple sensors, the port number increases by 4 for each sensor)

7.4 Accelerator protocol output

Note: 1. The accelerator does not support the PROFINET protocol.

- Output protocols based on Ethernet (ASCII and Modbus) are also the same as those on not accelerated sensors and are fully supported.

2. The accelerator supports digital, analog, and serial output of sensors.

- However, because the output must be transmitted to the accelerator and then back to the sensor, network latency can affect performance.

3. After the sensor is accelerated, it will send data directly to the acceleration device. The user must use the IP address of the acceleration device

◆ (Instead of the sensor's IP address) access the front end interface of the sensor.

7.5 Accelerator software usage

Accelerator management software (Accelerator) is installed together with sensor application software. This article takes version V2.6.0.1 as an example.

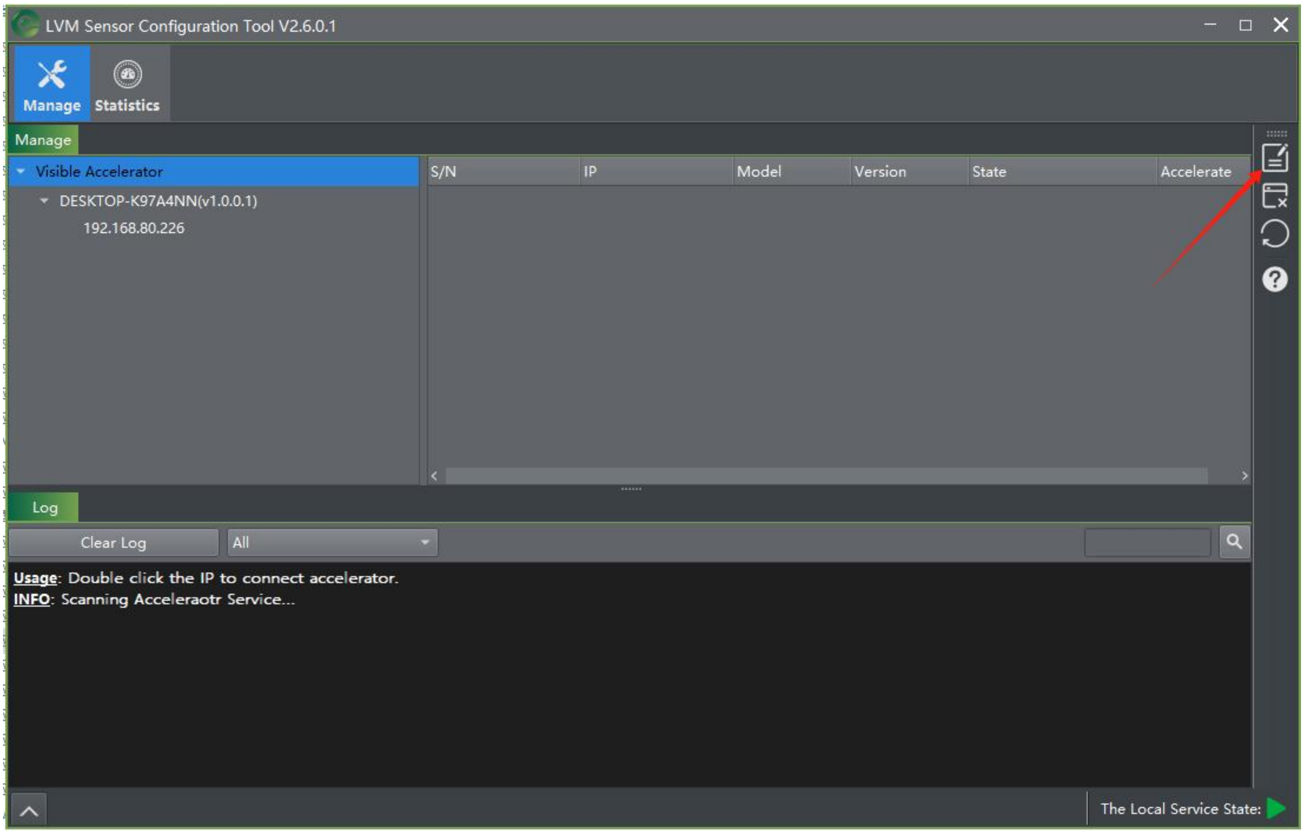
◆ **Note: When using the accelerator, you must read it carefully and ensure that all the above (page 187) 7.3 software-based usage requirements are met before normal use;**

7.5.1 Accelerator and sensor combination

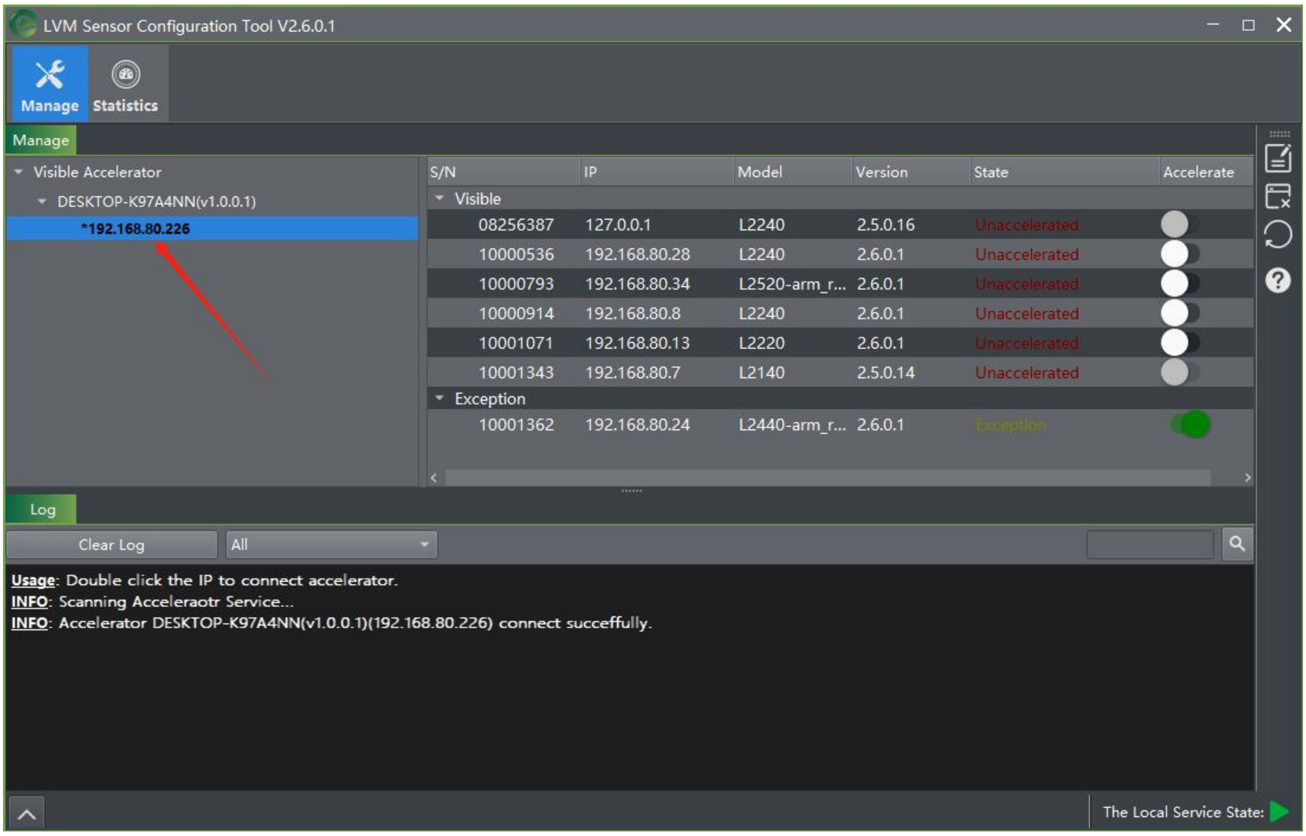
The accelerator application can speed up one or more independent single sensors selected by the user.

◆ Double-click to open the "Accelerator" software.

◆ Click the first icon in the toolbar on the right to register the local service;



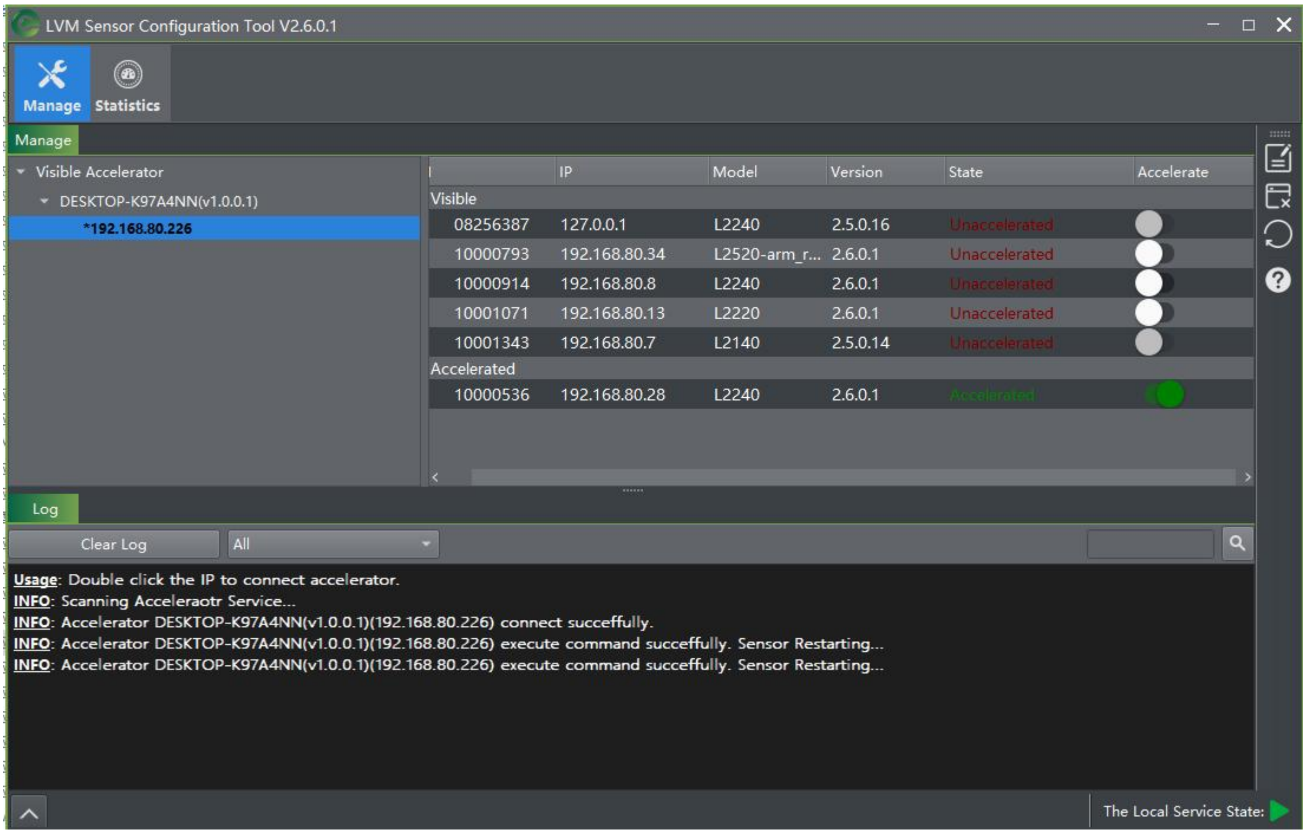
◆ Double-click an IP address to connect to the accelerator;



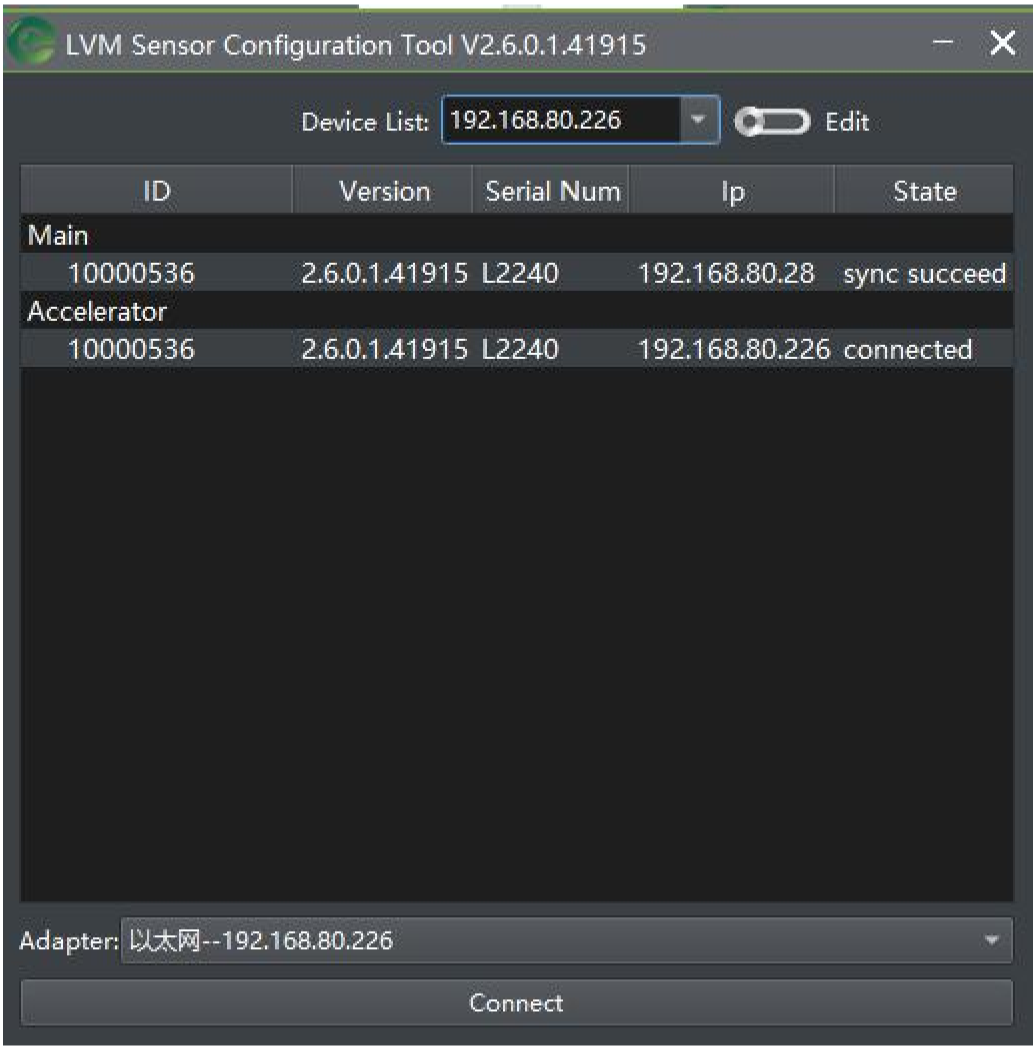
◆ At this point, the "Visible sensors" list on the page shows all the sensors currently online that can be combined with the accelerator;

S/N	IP	Model	Version	State	Accelerate
Visible					
08256387	127.0.0.1	L2240	2.5.0.16	Unaccelerated	
10000536	192.168.80.28	L2240	2.6.0.1	Unaccelerated	
10000793	192.168.80.34	L2520-arm_r...	2.6.0.1	Unaccelerated	
10000914	192.168.80.8	L2240	2.6.0.1	Unaccelerated	
10001071	192.168.80.13	L2220	2.6.0.1	Unaccelerated	
10001343	192.168.80.7	L2140	2.5.0.14	Unaccelerated	

◆ In the sensor list, click the "Accelerate" button on the right to accelerate the target device, such as sensor IP192.168.80.28. After clicking the "Accelerate" button, the sensor will automatically restart and wait for tens of seconds before the sensor changes to accelerator mode.

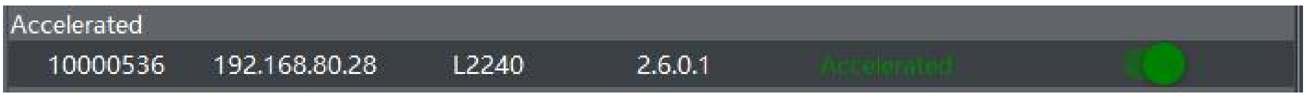


- After the accelerator and sensor are successfully connected, the IP address of the sensor connection becomes the IP address of the accelerator. The front end display of the sensor software tool is as follows:



7.5.2 Restore independent equipment

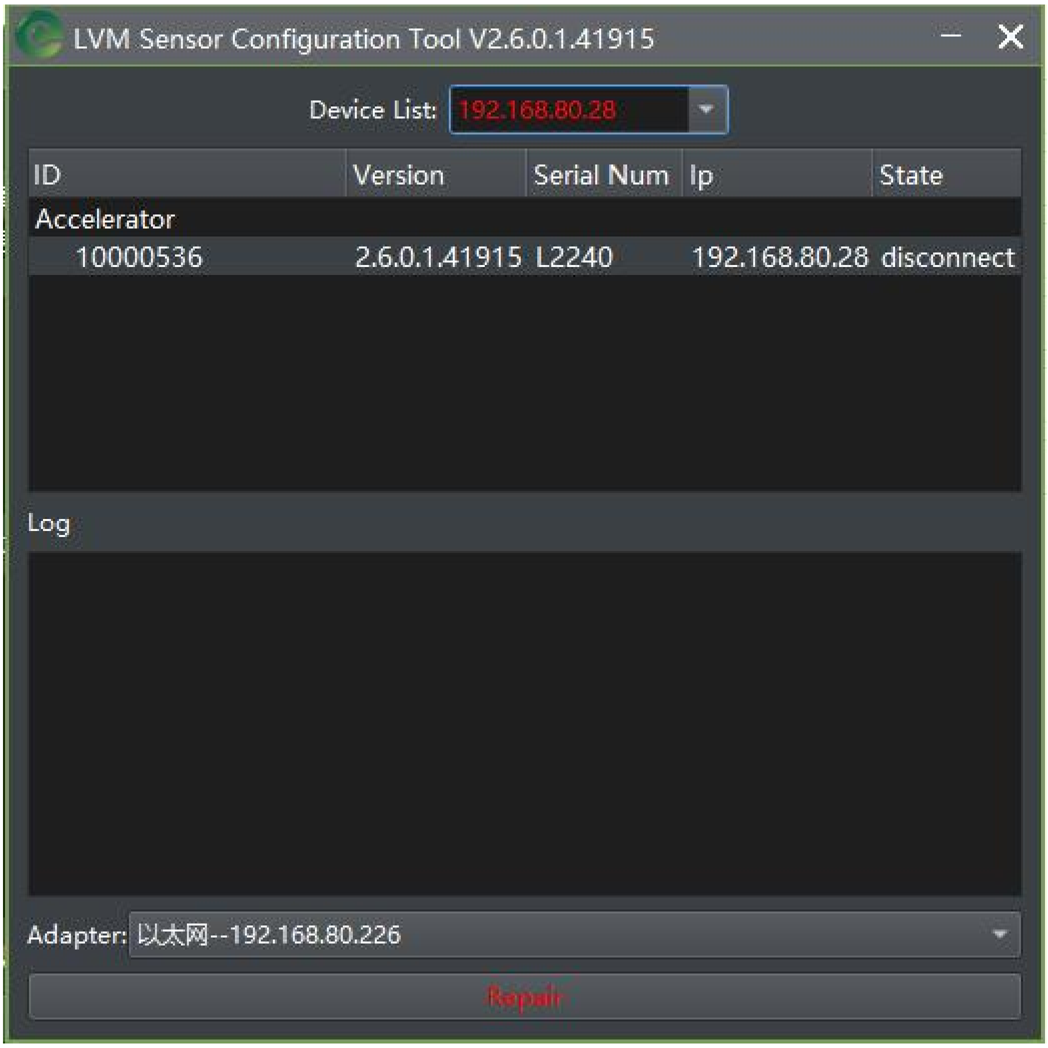
If you need to unbind the combined accelerator from the sensor, you need to select the already combined device in the "Accelerate" list at the front end of the accelerator and click the button on the right. After clicking the "Accelerate"



button, the sensor will automatically restart and wait for dozens of seconds before the sensor becomes a single sensor mode.

7.5.3 Other functions

- Stop accelerator service (right toolbar)
  - Stop the accelerator service and remove all accelerated sensors. At this time, the sensor will enter an abnormal state and can be restored by the sensor software.



- Restart accelerator service (right toolbar)
    - Restart the accelerator service and restart all accelerated sensors.
- Multi-sensor accelerator usage process
    1. To be carried out before the formation of a multi-sensor system;
    2. The main sensor that accelerates the expectation;
    3. The accelerated sensor is used as the main sensor and other sensors are combined into a multi-sensor system.

7.5.3 SDK applications

The SDK application can still control the accelerated sensor in the same way as the unaccelerated sensor;

(But you need to connect the network address of the accelerator at this time)