DOBOT

DobotVisionStudio

User Guide

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Shenzhen Yuejiang Technology Co., Ltd.

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1. **Updates**

Version	Description
DobotVisionStudio 4.1.2	Updates: ● Update contents ● Add Dobot Panel
DobotVisionStudio 4.1.1	Updates: ● Supplement contents ● Modify some bugs
DobotVisionStudio 4.1.0	Updates: ● Remove the M1 robot algorithm module ● Add N-point calibration module to directly obtain the Dobot arm coordinate ● Upgrade dongle - imVS-VM-6100 + is recommended ● Add functions of other algorithm moduls to optimize the overall performance
DobotVisionStudio 1.4.0	Improve steps of demo
DobotVisionStudio 1.3.2	Modify some bugs
DobotVisionStudio 1.3.0	Updates: ● Add the description on DobotStudio ● Add the wait time tool ● Add the speed ratio tool ● Add the Dobot arm orientation tool of DobotM1
DobotVisionStudio 1.2.0	Original version

2. **Product Introduction**

2.1 **Overview**

DobotVisionStudio software integrates various algorithm components of machine vision. It is designed to quickly combine algorithms to find, measure the object and detect defection and so on, suitable for a variety of application scenarios.

The DobotVisionStudio software features a powerful library of visual analysis tools, which can be used to build machine vision application solutions without programming. It can meet the needs of vision applications such as visual positioning, measurement, detection and identification. It has rich functions, stable performance and friendly user interface.

2.2 **Characteristics**

- Easy to Use: With drag-and-drop component, you can build a visual application without programming.

- User-Friendly Interface: Provides clear, simple and visualized user interfaces.

- Flexible Display: Maximally save the limited screen display space.

- Wide Compatibility: Supports multiple operation systems including Windows 7/10 (32/64-bit).

2.3 **Operating Environment**

Make sure that the computer on which you install the client software at least meets the minimum requirements.

    📖NOTE

- We recommend adding the software to the allowlist of the antivirus software or closing the antivirus software, in case of being recognized as virus.

- Dongle is required for running this software. Before using it, please install the dongle driver and relevant machine vision drivers.

Recommended

- Operating System: Microsoft Windows 7/10 (64-bit Chinese-English operating system)

- .NET Running Environment: .NET4.6.1 and above

- CPU: Intel Core i7-6700 3.4 GHz or above. i9-10900K or above is recommended for using CPU related deep learning functions.

- Memory: 8 GB or above

- NIC: Intel i210 and above

- Graphics Card: 1 GB or above. 6 GB or above is recommended for using GPU related deep learning functions.

- USB Interface: USB3.0 interface is required.

- Software-enabling Configuration: Dongle or authorization file specialized for algorithm

platform

Minimum

- Operating System: Microsoft Windows 7/10 (64-bit Chinese-English operating system)

- .NET Running Environment: .NET4.6.1 and above

- CPU: Intel 3845 or above

- Memory: 4GB

- NIC: Gigabit Ethernet

- Graphics Card:1 GB or above. 6 GB or above is recommended for using GPU related deep learning functions.

- USB Interface: USB3.0 interface is required.

- Software-enabling Configuration: Dongle or authorization file specialized for algorithm platform

Refer to the table below for dongle models and corresponding functions.

Models and Functions	Location	Recognition	Deep Learning	Calibration	Contraposition	Image Processing	Color Processing	Defect Detection
IMVS-VM-1100 VM-6100-S	No	Yes	No	No	No	No	No	No
IMVS-VM-2100 VM-6200-S	Yes	No	No	No	No	No	No	Yes
IMVS-VM-4100 VM-6400-S	Yes	No	No	Yes	Yes	No	No	No
IMVS-VM-6100 VM-6600-S	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
IMVS-VM-7100 VM-6700-S	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Refer to the table below for dongle and supported camera quantity.

Models and Functions	Dongle without suffix (Four cameras supported)	Dongle with SE suffix (Two cameras supported)	Dongle with PRO suffix (No limitation for camera quantity)
IMVS-VM-1100 VM-6100-S	Yes	No	Yes
IMVS-VM-2100 VM-6200-S	Yes	No	Yes

IMVS-VM-4100 VM-6400-S	Yes	No	Yes
IMVS-VM-6100 VM-6600-S	Yes	Yes	Yes
IMVS-VM-7100 VM-6700-S	Yes	No	Yes

📖NOTE

- The dongle model of IMVS-VM-6100-EDU supports two cameras and two flows only, and supports TCP communication only.

2.4 **DobotVisionStudio Installation**

The installation steps are shown below.

Double-click the installation package to install the software, as shown below. Click **Next.**
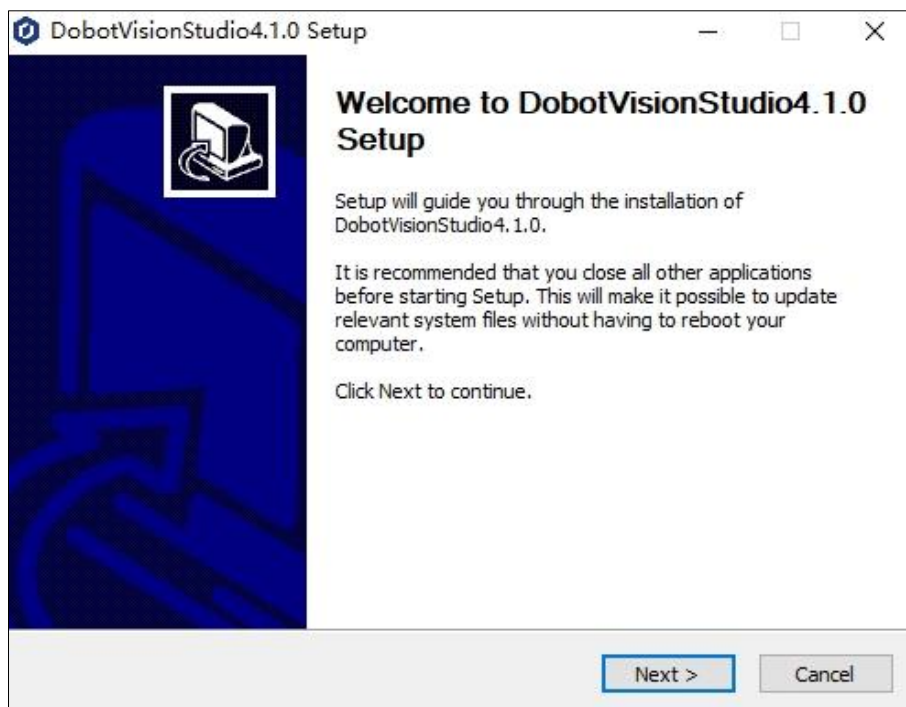
Choose components that you want to install (Hard Encryption and relevant components are chosen by default). After confirming the settings, click Next to set the installation path. Then click Next to start the installation.
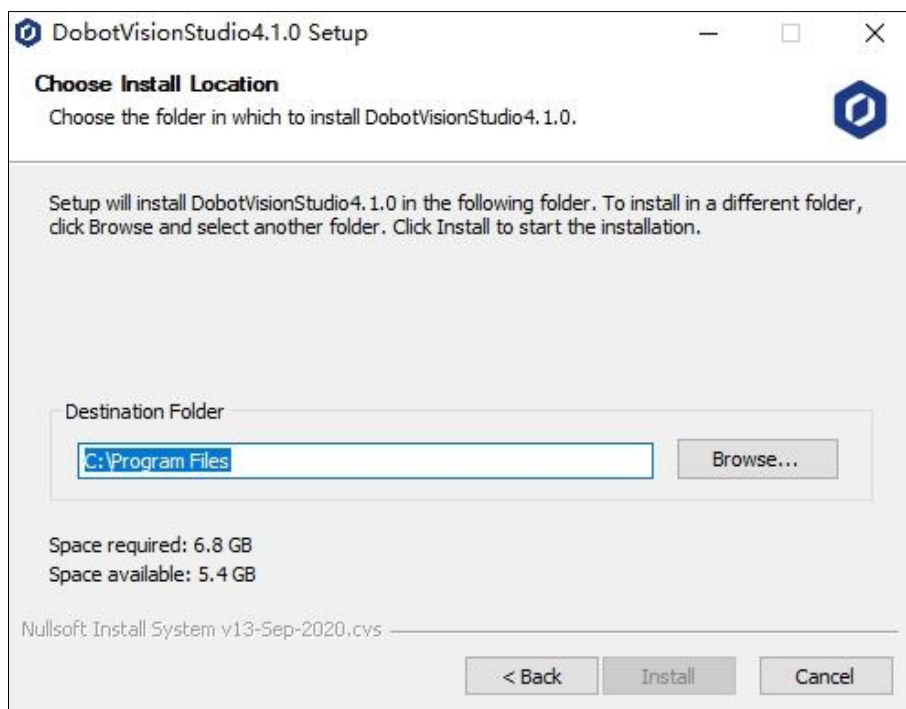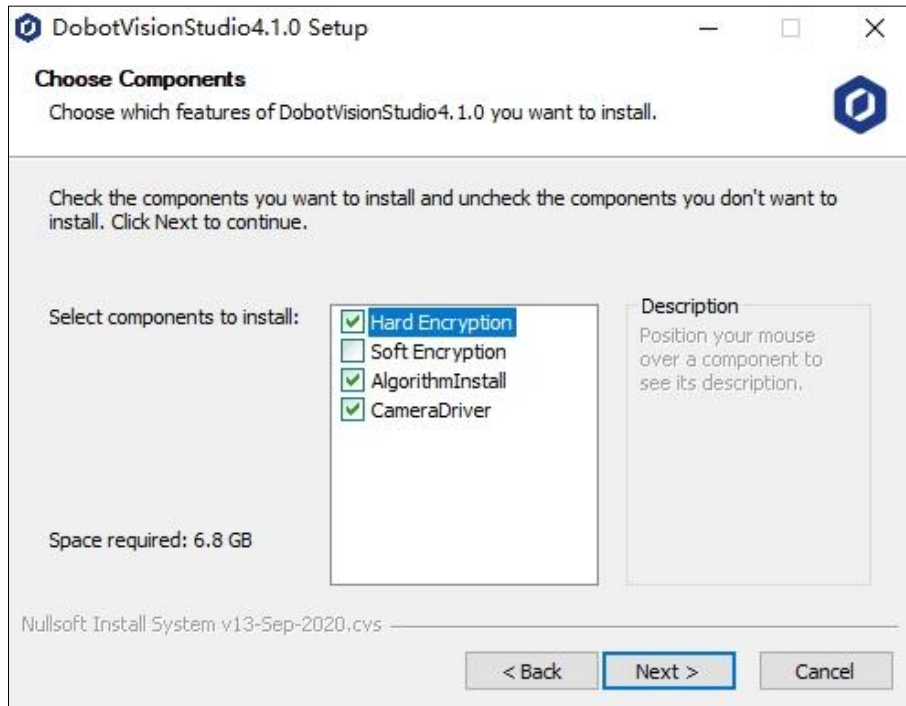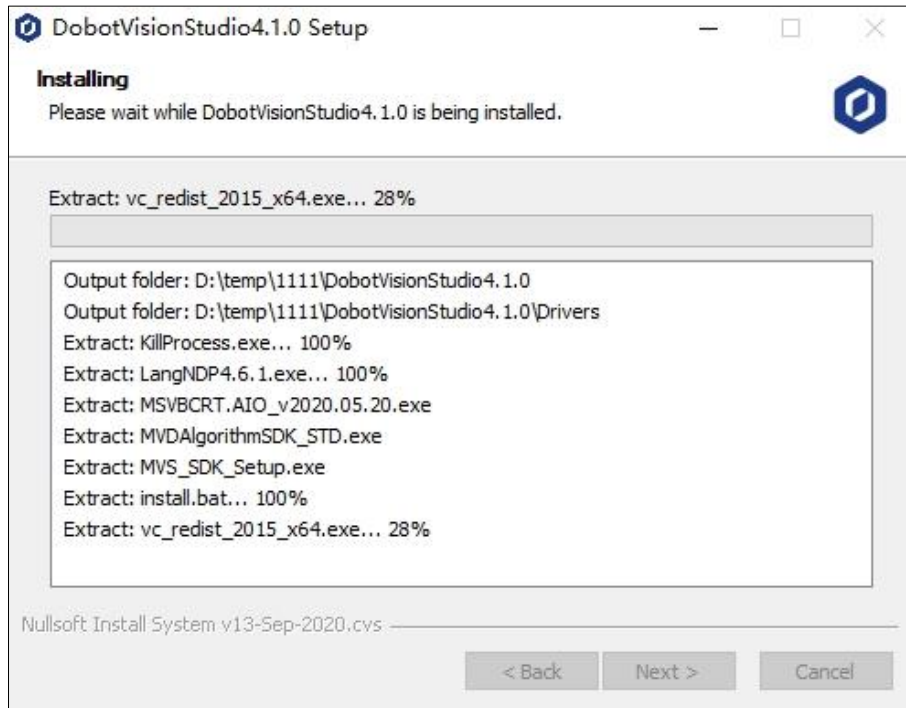
After the installation is completed, choose whether to open DobotVisionStudio, and click Finished, as shown below.
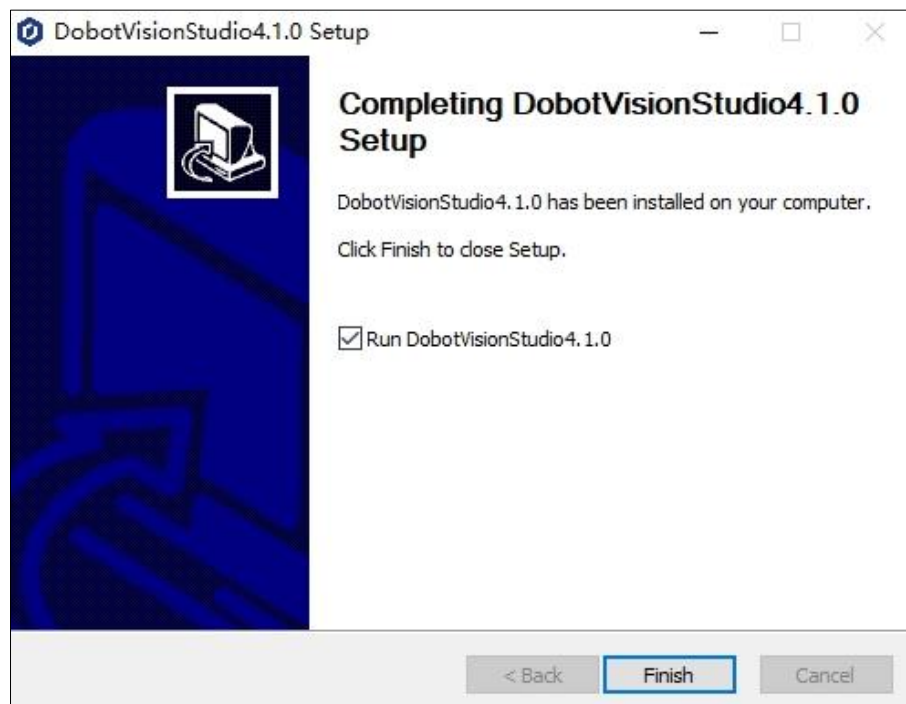
3. **Software Interface**

3.1 **Welcome Page**

Double click [icon] to start the software, and the welcome page will pop up.
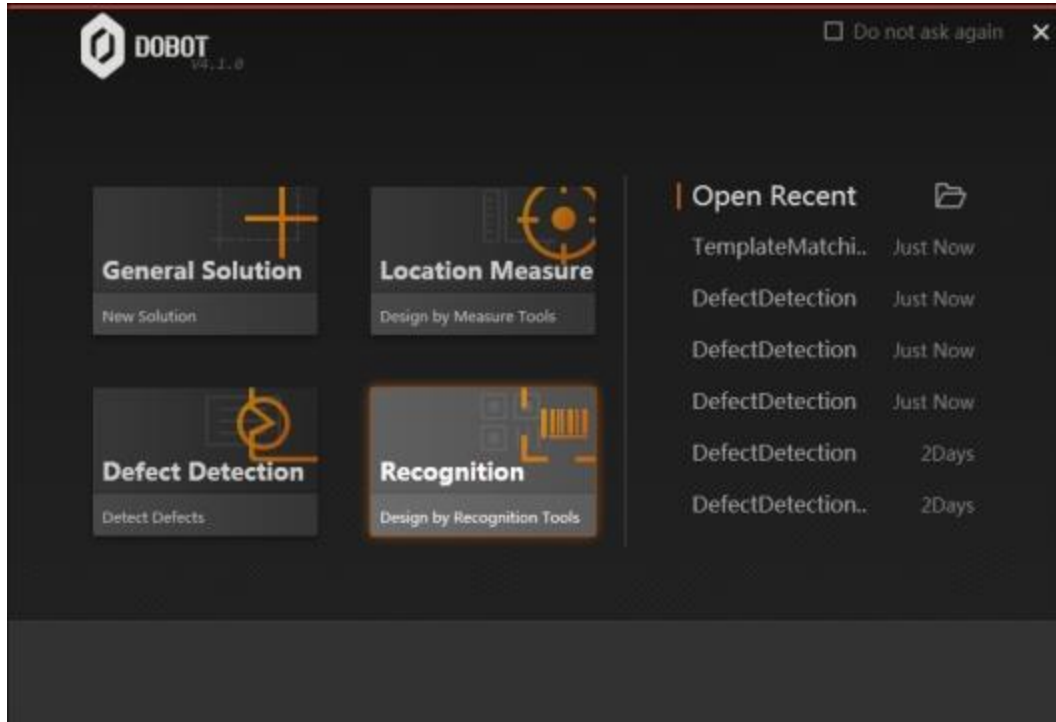
- There are four modules selectable: General Solution, Location & Measure, Defect Detection, and Recognition. General Solution includes the three latter modules. You can choose a module according to the edit type.
- Open Recent: Open the recently-used solutions. Do not ask again: Enter the main page after you open the software
- Do not ask again: Once you tick it, you will directly enter the main page after opening the software

3.2 **Home Page**

You can choose any of the modules to enter the home page of DobotVisionStudio. The home page is shown as follows:
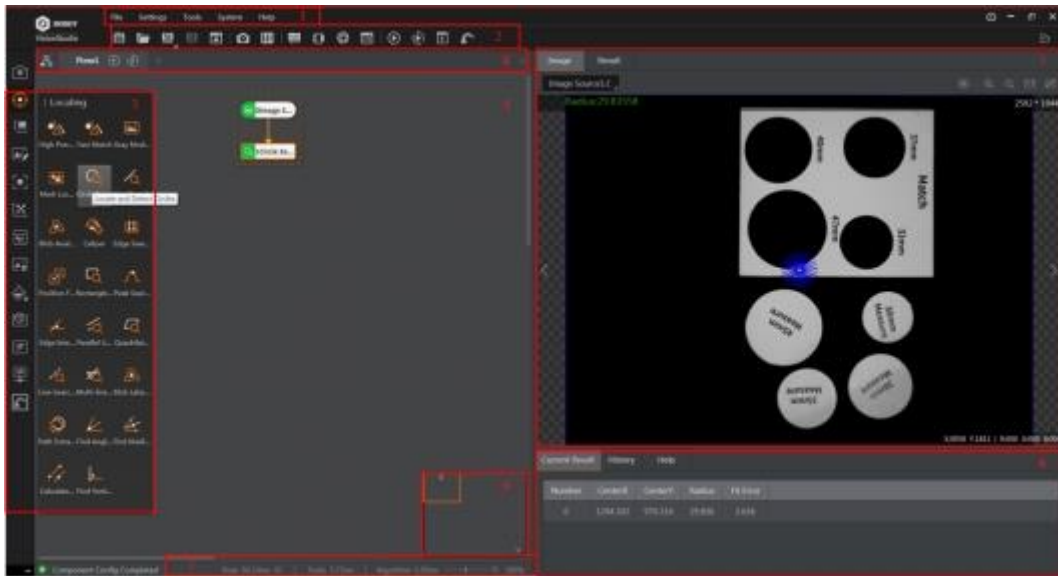
- Area 1: Menu Bar. It includes File, Settings, System, Tools, and Help.

- Area 2: Control Toolbar. It provides quick operations for the software, including file saving, file open, camera management, controller management, etc.

- Area 3: Tool Box. It includes image collection, positioning, measurement, identification, calibration, position, image processing, color processing, defect detection, logic tools, communication, etc.

- Area 4: Flow Process. You can edit the flow here.

- Area 5: Image. Image is displayed here.

- Area 6: Results. You can view current results, history results, and help information

- Area 7: Status. It displays flow time, tool time, and algorithm time.

- Area 8: Flow Toolbar. it provides quick operations for flows.

- Area 9: Overview, It provides an overview of the flow.

3.3 Menu

The menu is shown as below, including File, Settings, Tools, System and Help.
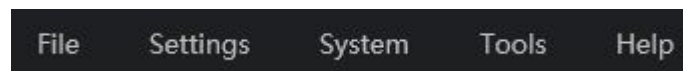
3.3.1 File

In File menu, you can make new solutions, open solutions, open solution examples, save or save as solutions, import flow files with .prc format, and exit the software according to actual demands.
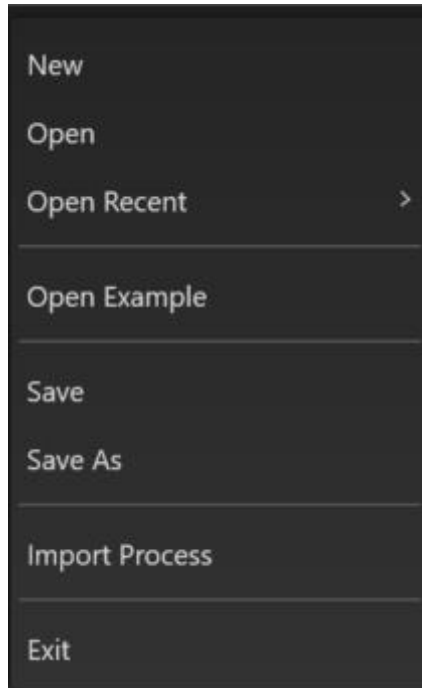
- New: Create a new solution. After clicking, you can select whether to save the current solution.

- Open: Open a solution that was created and saved earlier.

- Open Recent: Open a recently solution.

- Open Example: Open the software example solution, mainly including the common visual solution that has been built.

- Save: Save the current algorithm solution with the suffix of. Sol. You can set encryption when you save the file, as shown in the following figure.

- Save As: Save the currently configured algorithm solution to a specified path. You can set encryption when you save the file.

- Import Process: Import process files in. PRC format into the solution.

- Exit: Exit the DobotVisionStudio software.

3.3.2 **Settings**

Authority Settings

By enabling encryption and setting the administrator password, you can enable the administrator permissions, and the administrator control option will appear in the upper right corner of the main interface. By enabling encryption, you can also reset the administrator password. In authority interface, you can also enable permissions for technician and operator, and set corresponding password. Technicians can obtain the authority opened by an administrator, and operators can only click the buttons of the front-end running interface.
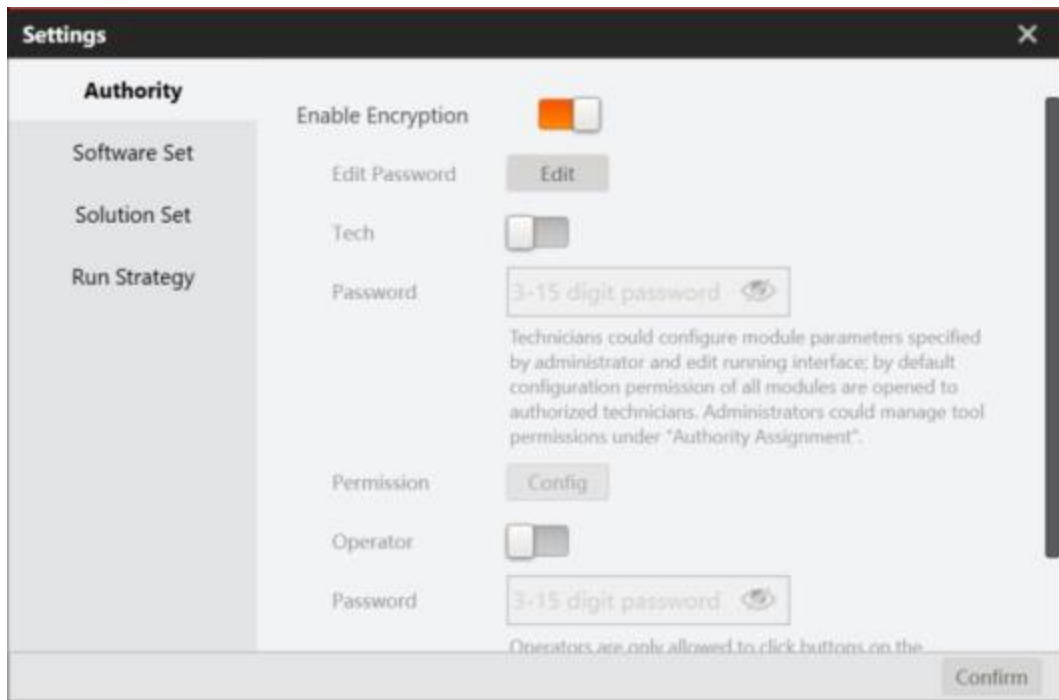
The administrator can assign authority to technicians, as shown below. Tick **Open All Tools** can open configuration permissions of all modules. You can also customize the permissions which need to be opened.
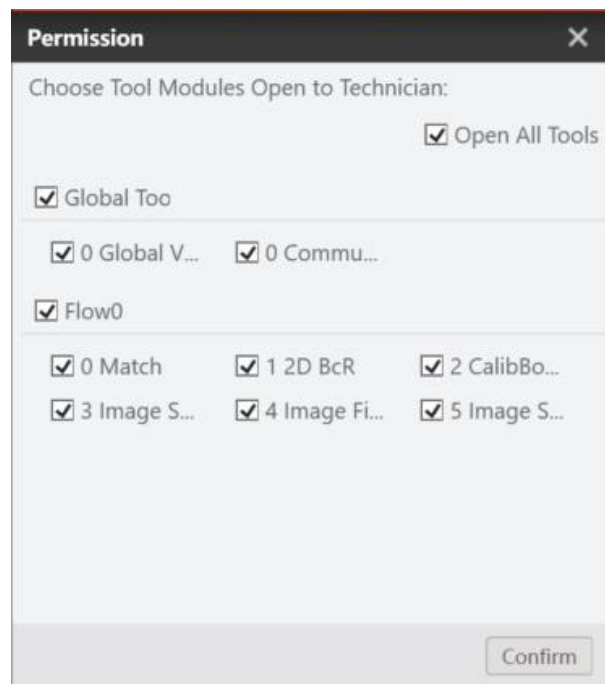
Software Settings
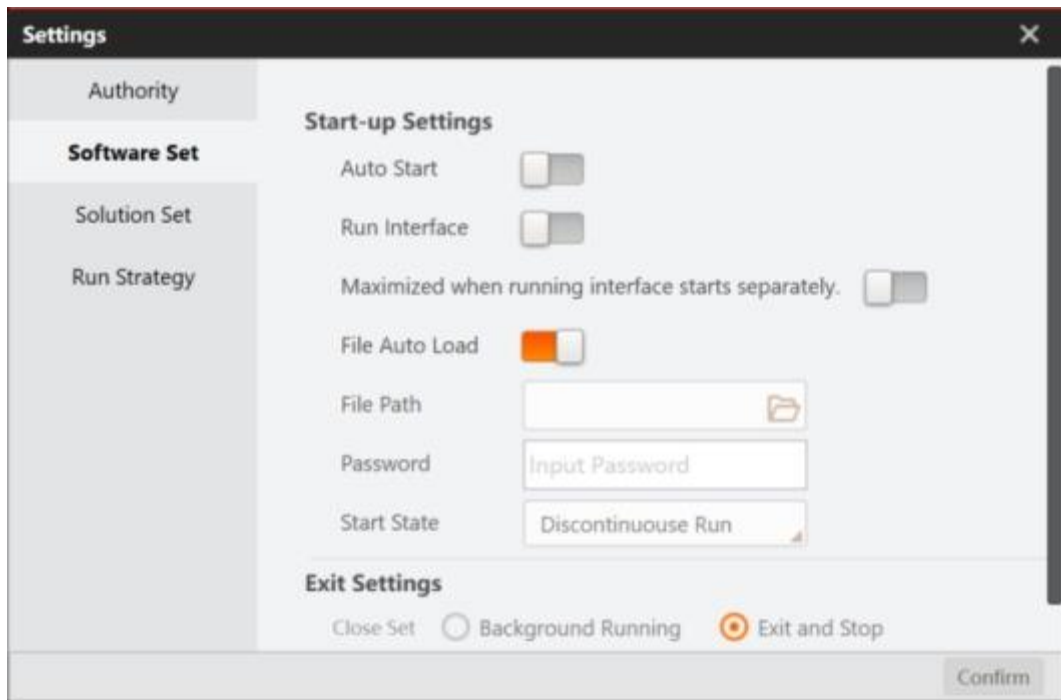
Start-up Settings	
Auto Start	After the function is enabled, the software will automatically start when the PC starts.
Start Time Delay	After startup, the software starts after the set time delay
Run Interface	After the function is enabled, the software will go to the running interface.
Maximized when running interface starts separately	After the function is enabled, the software will go to the running interface and the interface is in max. status.
File Auto Load	After the function is enabled, the software will automatically load configured files. You need to enter file path, password and start state.
File Path	Path where the target scheme is stored
Password	Enter a correct password if it has been set
Start State	There are two states: continuous run and discontinuous run
Select Identity	After you select the identity, you will open the running interface with the configured identity every time. Different identities correspond to different permissions
Exit Settings	
Background Running	Close the software and continue to run in the background
Exit and Stop	After closing the software, exit the software and stop running

Solution Settings

If you want to use communications to switch solutions, you need to establish communications and set related parameters as follows.
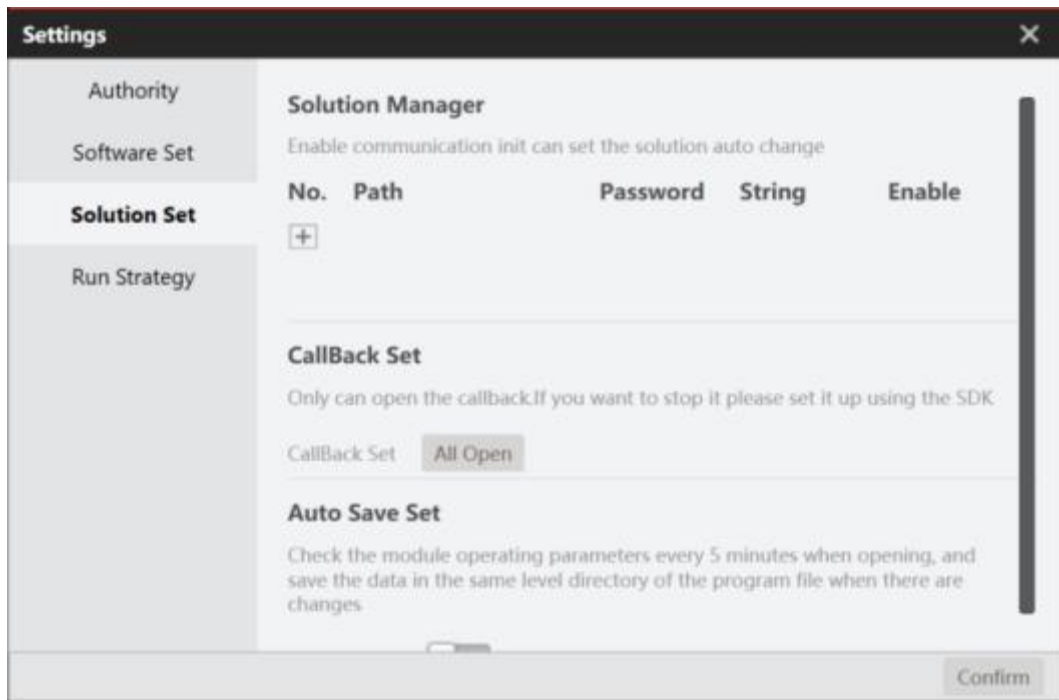
Solution Settings	
Path	It sets the saving path of solutions.
Password	When a password is set for the target solution, the correct password is entered here before communication can switch solutions.
String	Only when the string sent by the communication is successfully verified with communication strings can solutions switch be triggered.
Enable	It refers to the communication switch control.
Callback Set	The callback can only be opened here, and the callback of solutions is supported after opening. To close the callback, you need to set it through the SDK.
Auto Save Set	After enabling auto save, the software will check running parameters every five minutes. If the parameters are updated, all data will be saved in the same directory of the solution files.

You can also set password when saving solutions.
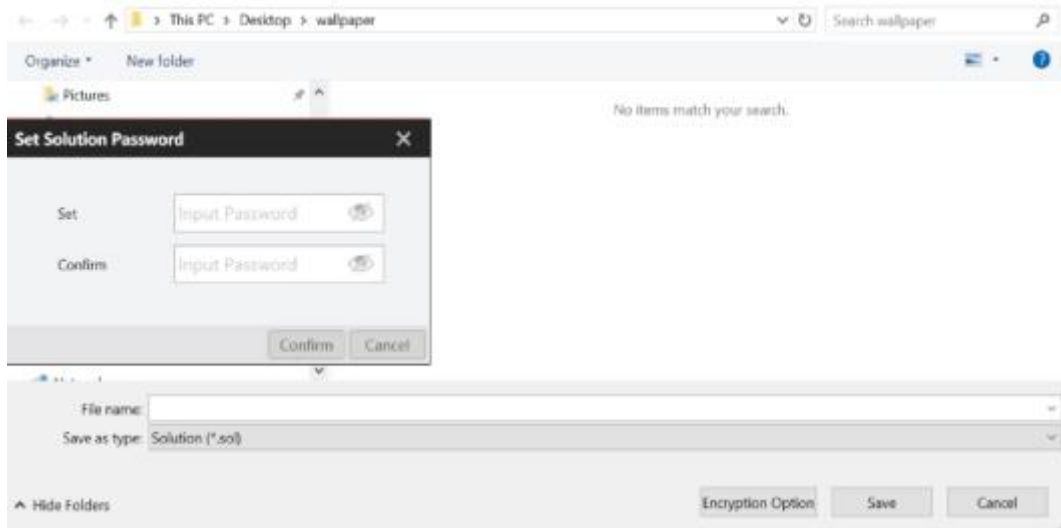
Running Strategy

The operating mode includes normal mode and diagnostic mode. If the software occupies too much system resources, prompt interfaces will pop up under diagnostic mode.

The strategy mode includes default mode and custom mode. Customized thread allocation is recommended in case of big process time consuming fluctuations or high CPU usage caused by feature match. Allocating CPU cores based on the number of concurrent is recommended when the process calculation is large and there are lots of branches. A single core is recommended when there is no branch. CPU configuration reads the number of CPU cores automatically. The parallel calculation of model match algorithm changes with the configuration of running strategy. By default, the parallel calculation of algorithm is turned off and will only be turned on in custom mode as shown below.
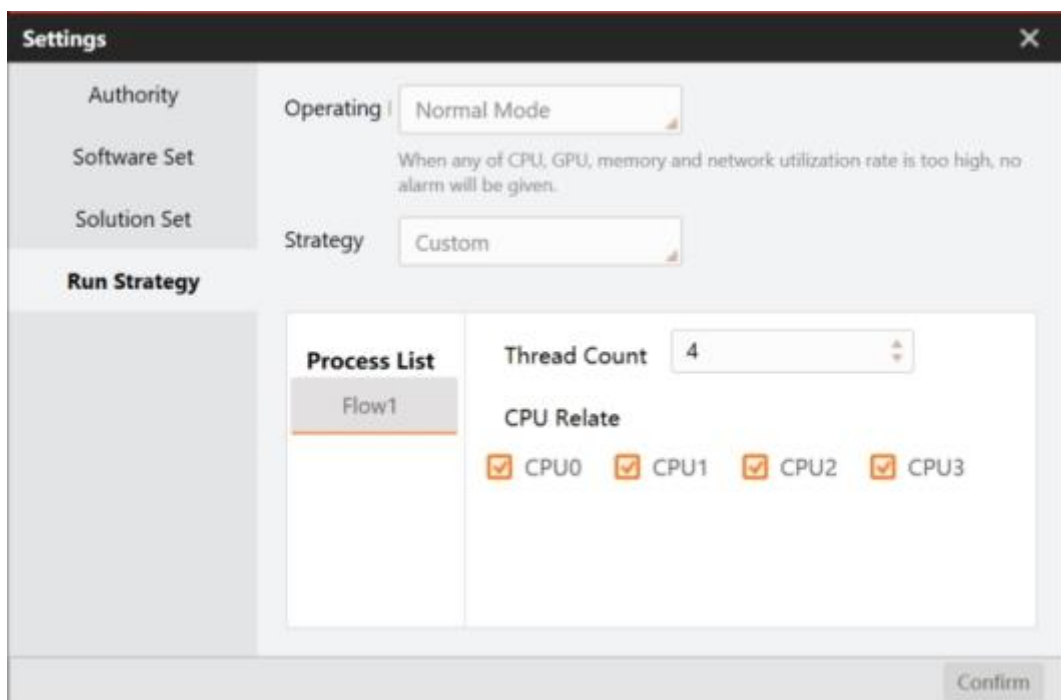
3.3.3 **System**

You can find **Log**, **Communication Management**, **Controller Management** and **Camera Set** in System menu.
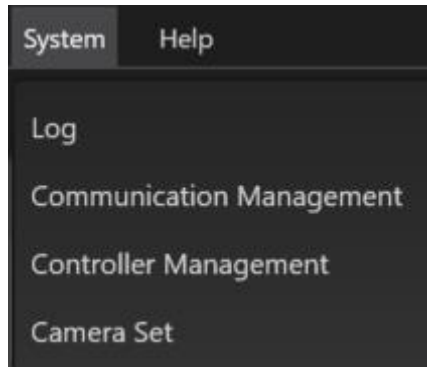
- Log: View the log information in the running process of software
- Communication Management: see Communication Management for details.
- Controller Management: see Controller Management for details.
- Camera Set: See Camera Management for details.

3.3.4 **Tools**

Create One-Click Calibration Guide

The step-by-step guide helps you quickly complete the complex operation process of one-click calibration. After selecting the calibration mode, click **Create** and you will see the corresponding guide on the interface. You need to follow the guide to generate the calibration file, which is used for converting pixel coordinates to physical coordinates and usually used with calibration conversion module. Refer to N-Point Calibration for details.

The one-click calibration guide includes three types: static calibration, dynamic calibration and mapping calibration. Static calibration is usually used to generate calibration files of the calibration plate. Dynamic calibration is usually used to generate N-point calibration files and N image calibration files. Mapping calibration is used to generate mapping calibration files.
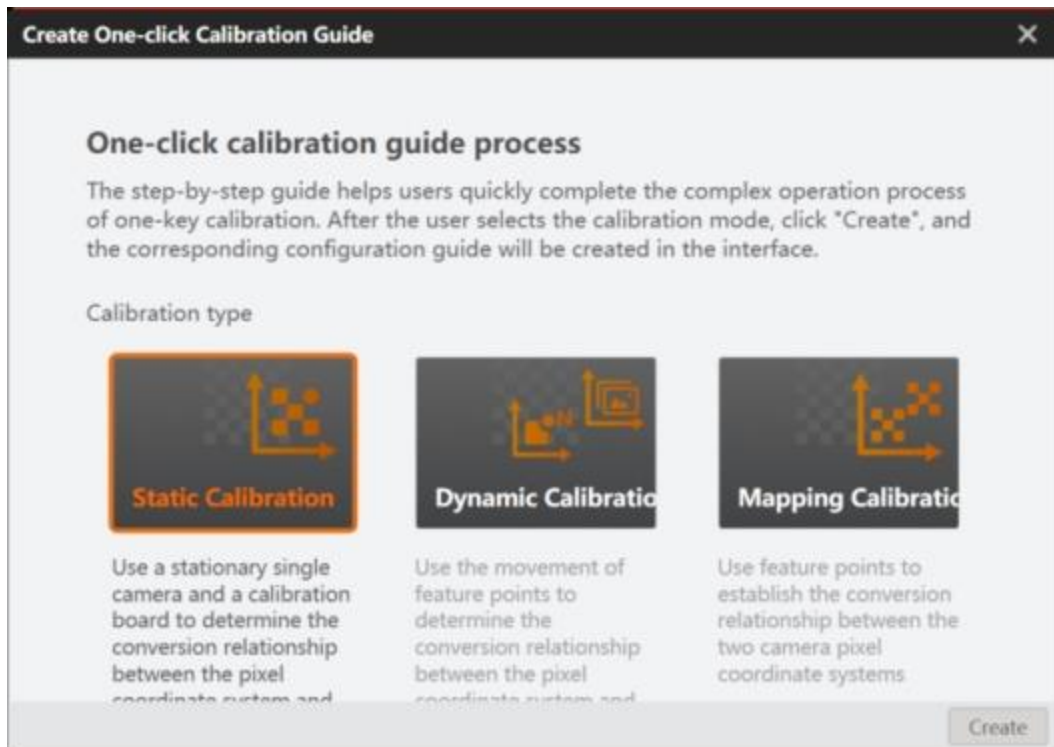
- **Static Calibration**

The static calibration uses a stationary single camera and a calibration board to determine the conversion relationship between the pixel coordinate system and the physical coordinate system.

Steps:

1. Go to **Tools** and click **Create One-Click Calibration Guide**.

2. Click **Static Calibration** and click **Create**.

3. Click **Config** to enter communication management, add communication devices according to actual demands, and enter **Trigger Signal**.
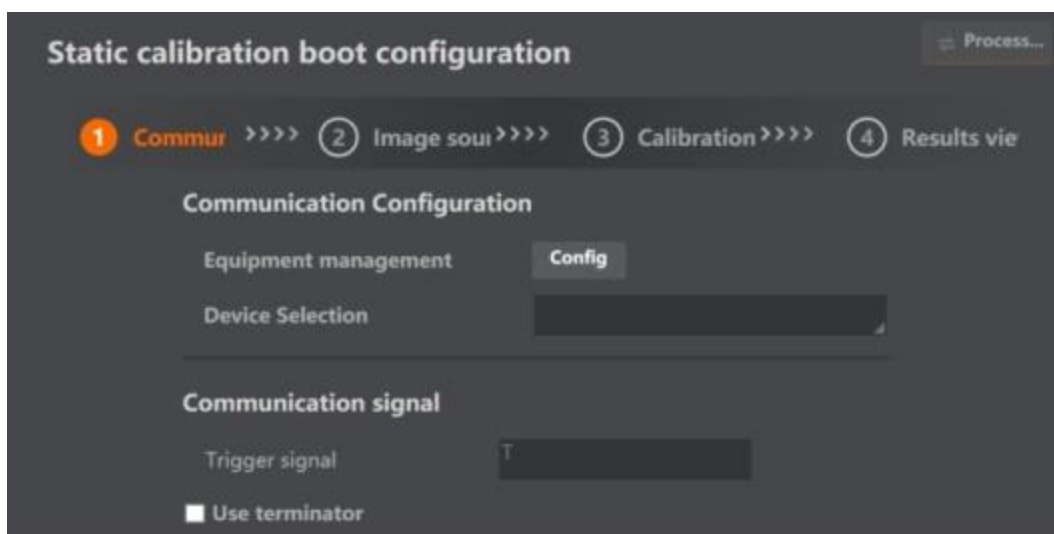
4. Click **Config** to add global camera, and click **Image Source Config** to select image sources form local, camera image or SDK.

5. Click **Calibration Board** to calibrate.

6. View results.

⬛NOTE

- The static calibration supports using calibration board to calibrate only.

- **Dynamic Calibration**

The dynamic calibration is used for N-point calibration and N-image calibration file generation. The process of dynamic calibration creation is the same as that of static calibration.

Steps:

1. Click **Dynamic Calibration** and click **Create**.

2. Click **Config** to enter communication management, add communication devices according to actual demands.

3. Enter **Start Signal**, **Calibration Signal**, and **End Signal**.

⬛NOTE

- X/Y in calibration signal stands for physical coordinates, and R stands for angle.
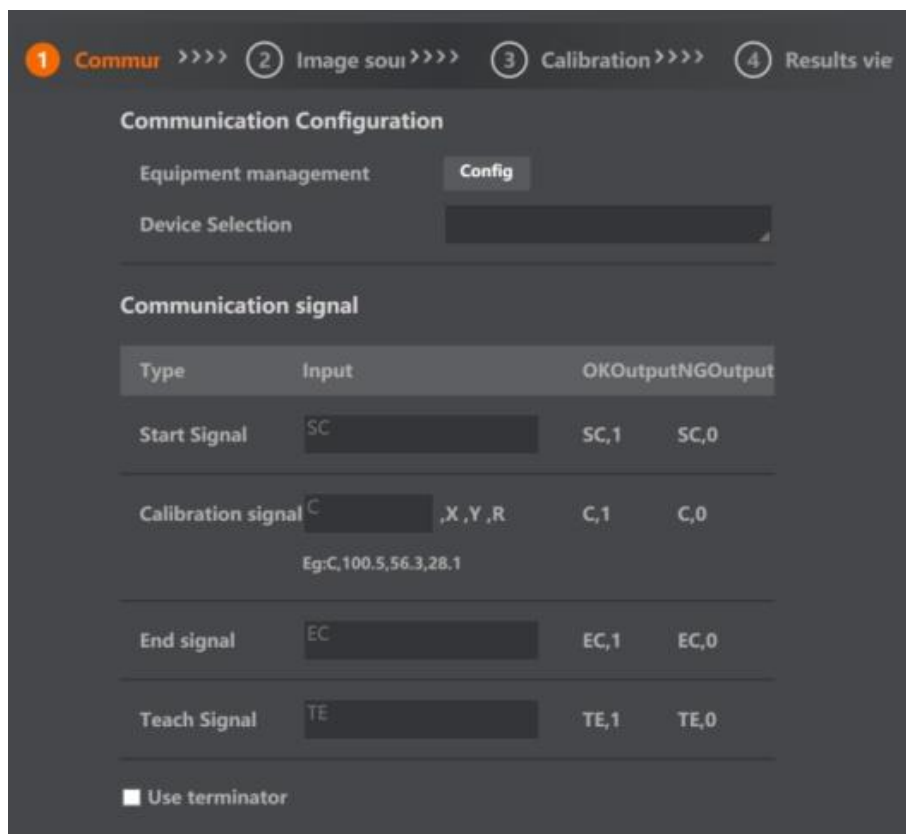
4. Click **Next Step**, and click **Config** to add global camera, and click **Image Source Config** to select image sources.

5. Select the calibration method. Dynamic calibration supports N-point calibration and N-image calibration.

6. View results.

- **Mapping Calibration**

Steps:

1. Click **Mapping Calibration** and click **Create**.

2. Click **Config** to enter communication management, add communication devices according to actual demands.

3. Enter **Main Camera Trigger Signal, Secondary Camera Trigger Signal, and Mapping Signal** according to actual demands.
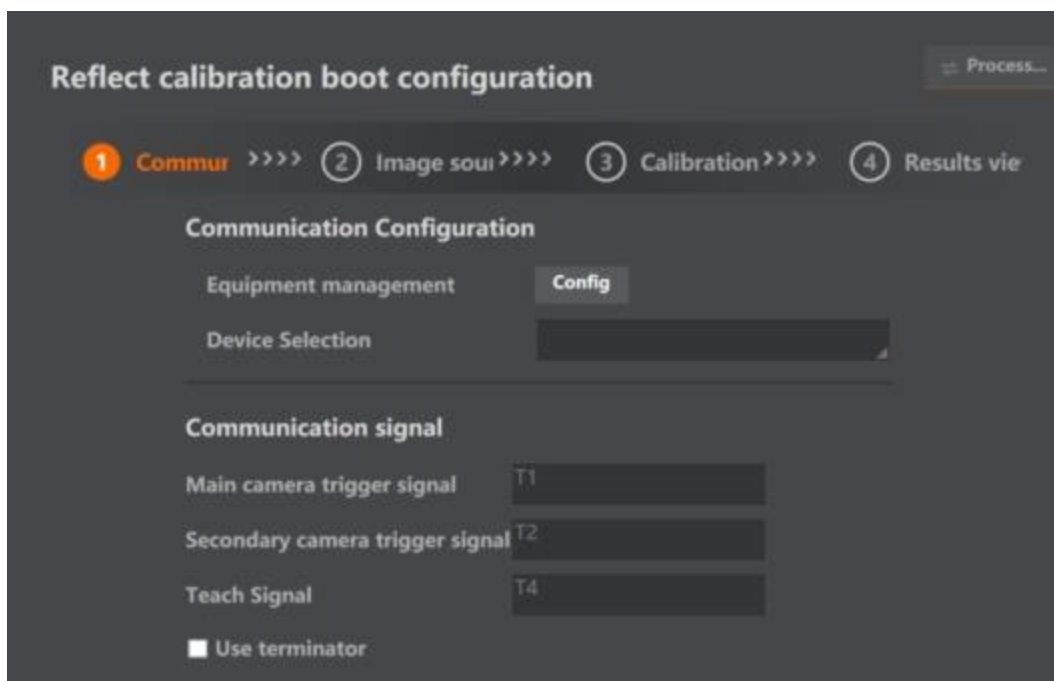
4. Click **Next Step**, and click **Config** to add global camera, and select image sources for main and secondary cameras.

5. Select the calibration method.

📖NOTE
- The default calibration method is mapping calibration.

6. View results.

Operating Environment Detection Tool

This tool is used to detect the operating environment, .net and other files. You can go to the installation directory and find drivers folder to install related components again if lost.

Calibration Board Generate Tool

This tool is used to customize the type of calibration board, the number of rows and columns of the calibration board, CAD and other parameters to generate images of calibration board. The image path is in:\VM\VisionMaster4.1.0\Applications\Tools\Demo.

Custom Module Generate Tool

This tool is used to help users develop customized modules.

Steps:

1. Go to **Tools** and click **Custom Module Generate Tool**.

2. Select VM version. It is recommended to use the VM4.X.

3. Enter module name, and check image source and position correction in basic input according to actual demands.

☵NOTE

- The module name supports English contents only.

4. Check module status and output image in basic output according to actual demands.

5. Click **Add** in customized input and output to add contents.

- Parameter name: The underlying name of parameter, and it supports English contents only.

- Display name: The displayed name of parameter.

- Parameter type: It includes float, int and string.

- Input/output: It sets input or output.

☵NOTE

- You can click delete, insert, export and import to execute related operations.

6. Click **Customized Output** to output results.

7. Click **Next** and check ROI type and shield area in basic parameters according to actual demands.

8. Click Add to add customized running parameters.

- Parameter type: It includes float, int, enumeration, string, bool, floatBetween and intBetween.

- Parameter name: The underlying name of parameter, and it supports English contents only.

- Display name: The displayed name of parameter.

- Edit: You can set related contents of parameters. Regarding float and int, you can set their max. value, min. value and default value. Regarding enumeration, you can set

displayed name and enumeration value. Regarding String, you can set max. length and default value. Regarding bool, you can set true and false. Regarding floatBetween and intBetween, you can set their parameter name, displayed name, min. value, max. value and default value.

- Edit Status: After finishing settings in edit, the edit status displays Yes. Otherwise, it displays No.

📖NOTE

- Before creating XML and project files, you need to finish editing and make sure that the edit status is Yes.

9. Click Edit in template settings interface to edit the template according to actual demands.

10. Click **Create XML**, **Create C++Project**, or **Create C#Project** to save files.

- Create XML: It creates a file folder named after customized template name.
- Create C++Project: It creates a file folder named after Proj_template name.
- Create C#Project: It creates a file folder named after CsProj_template name.

📖NOTE

- It is recommended to put the xml and project files in the same directory.

11. Compile the C++ and C# project files, and create the corresponding dll.

12. Put dll, xml and png into the same folder, and put the folder into Module(sp)\x64.

📖NOTE

- Each vision module is composed of 10 to 11 files. Among them, CalculatorModuleControl.dll corresponds to configuration functions.

CalculatorModule.dll	2021/8/27 10:40	应用程序扩展	661 KB
CalculatorModule.xml	2021/8/27 10:40	XML 文档	2 KB
CalculatorModule_NormalLogo.png	2021/8/27 10:40	Kankan PNG 图像	1 KB
CalculatorModule_StateLogo.png	2021/8/27 10:40	Kankan PNG 图像	1 KB
CalculatorModuleAlgorithm.xml	2021/8/27 10:40	XML 文档	1 KB
CalculatorModuleAlgorithmTab.xml	2021/8/27 10:40	XML 文档	3 KB
CalculatorModuleControl.dll	2021/8/27 10:40	应用程序扩展	63 KB
CalculatorModuleCs.dll	2021/8/27 10:40	应用程序扩展	14 KB
CalculatorModuleDisplay.xml	2021/8/27 10:40	XML 文档	2 KB
CalculatorModuleImageEnable.png	2021/8/27 10:40	Kankan PNG 图像	2 KB
ToolItemInfo.xml	2021/8/27 10:40	XML 文档	1 KB

13. Open the software again, and you can view the customized module in the corresponding category.

3.3.5 **Help**

You can find **Language**, **Help**, **Version**, **More** and **Welcome Page** in this menu.
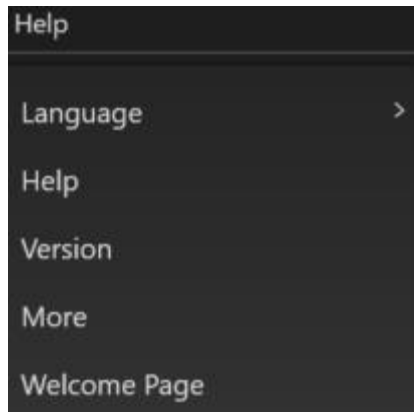
- Click **Language** to switch language between Chinese and English.

- Click **Help** to view the user guide of the software.

- Click **Version** to view the software version related information.

- Click **Welcome Page** to display the welcome page.

3.4 Control Toolbar

- Save: Click to save the solution.

- Open: Click to open the solution.

- Undo: Click to undo the current operation.

- Redo: Click to cancel the undo operation. All operations supporting undo and redo functions increase memory consumption during the natural operation (operation data needs to be cached). Creating, loading and saving operations will clear all cache generated during undo and redo operations

- Locking: Click to lock the interface. Adding, deleting and moving modules or wires are not supported once the locking protection is enabled

- Camera Set: Click to create global cameras. The names of the global cameras can also be changed. See Camera Management for details.

- Controller Management: Click to add controllers. See Controller Management for details.

- Global Variable: Click to add global variables. You can set name, type and current value of variables. See Global Variables for details.

- Communication Management: Click to add the device and set the communication protocol and other parameters. TCP, UDP and serial communication are supported. See Communication Management for details.

- Global Trigger: Click to add event trigger or string trigger. See Global Trigger for details.

- Global Script: Click to open the global script window. See 3.13Global Script for details.

- Once: Click to execute the flow once. Work for all flows.

- Continuous: Click to execute the flow continuously.

- Operation Interface: Click to display the operation window. You can customize the display interface based on your needs. See 3.14Operation Interface for details.

- Dobot: See Dobot Panel for details.

- File Path: display the solution name. Click to open the path where the solution is saved.

📖NOTE

- The Once, Continuous and Stop operations in the toolbar work for all flows. To control a single flow, click the run control button in the flow.

3.5 Tool Box

3.5.1 Tool Box Introduction

Tool box includes different vision tools, including acquisition, location, measurement, image generation, recognition, deep learning, calibration, calculation, image processing, color processing, defect detection, logical tools, communication, etc., as shown in Area 3 of Home Page.

- Acquisition includes Image Source, Multiple Image Acquisition, Image Output, Image Buffer, and Light Source.

- Location, measurement, image generation, recognition, deep learning, calibration, calculation, image processing, color processing, defect detection and logical tools are all visual processing tools, which can be combined with corresponding algorithm modules.

- Communication supports sending/receiving data, and camera IO output. Only Dobot visual controller is supported in IO communication.

3.5.2 Tool Application

Select the tool that you want to use and drag it to the process editing area. Connect the relevant tools according to the logical requirements of the project, and double-click the configuration parameters, as shown in the figure below.
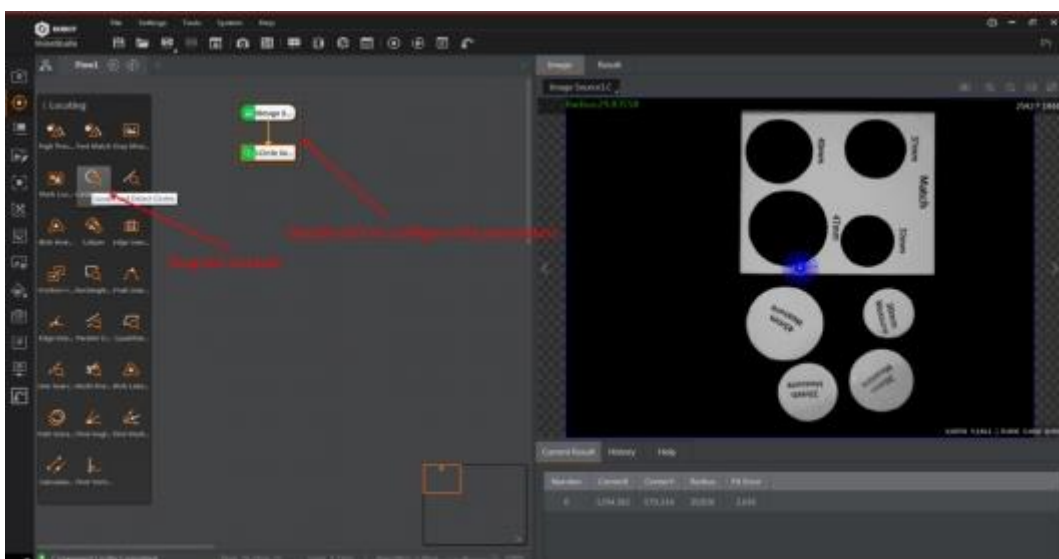
This section describes only general parameters. The parameter settings of specific tools will be described in the follow-up sections.

Basic Parameters

You can set some basic parameters in Basic params, generally including the selection of image input source and ROI settings, as shown in the figure below.
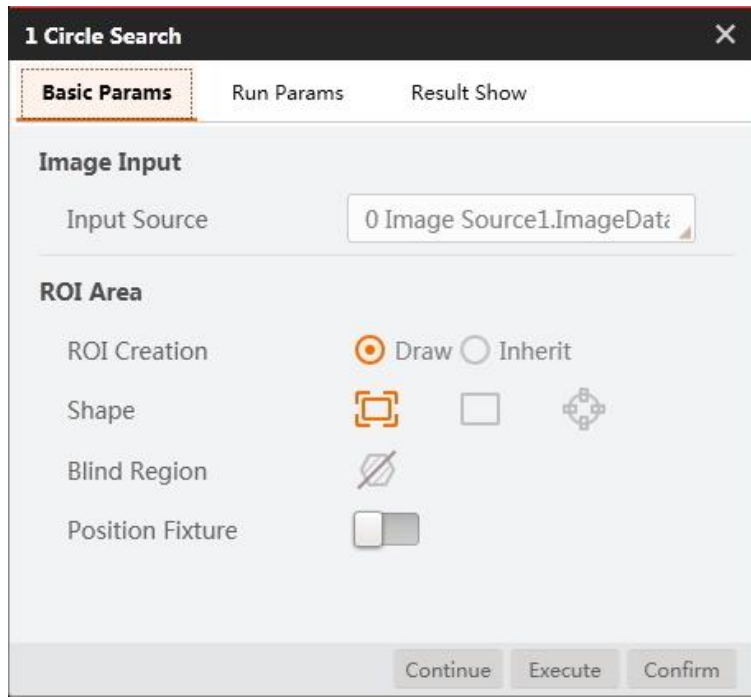
- Image input: Select the input source of the image processed by this tool from the drop-down list according to your own needs.

- ROI area: There are two ways to create ROI area: draw and inherit. After you set it, the corresponding tool will only process images in ROI region.

- Draw: You can customize the drawing area, including three shapes, full selection, selecting rectangle ROI, and selecting circle ROI. In some modules you can also customize the polygon ROI with up to 32 vertices.

- Inherit: You can inherit a ROI of previous modules, which can be inherited by a circular region and circle parameters or a rectangular region and rectangular parameters.

  - If you select rectangle ROI, you can set or view the center point coordinates, height, width, and angle, as shown in the following figure.
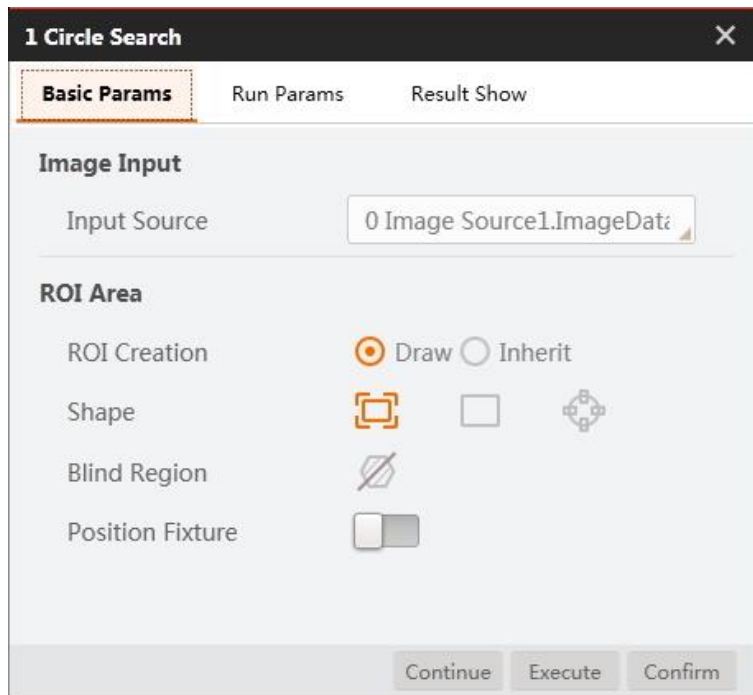
You can also customize circle ROI, as shown below.
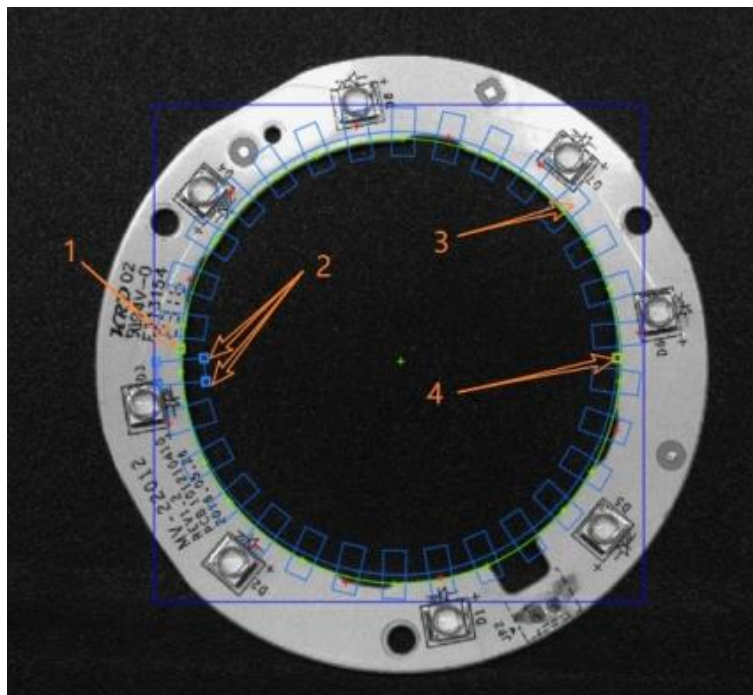
The position of arrow 1 can be rotated and scaled by changing the curvature, and is based on the other edge vertex. Arrow 2 can be used to zoom in and out the inner and outer rings. The position of arrow 3 is used to translate the ring. The position of arrow 4 is used to change the radian of the ring.

- If you select circle ROI, you can set the center point coordinates, radius, starting angle, angle range, number of calipers, and caliper width and height.

📖NOTE

- When you use ROI, the search direction of all tools is the direction of the ROI area, that is, the ROI area is regarded as an XY coordinate system, and ROI arrow direction is the positive direction of X axis. Top to bottom means finding a line from top to bottom along the Y-axis. Left to right means finding a line from left to right along the X-axis, as shown in the figure below.
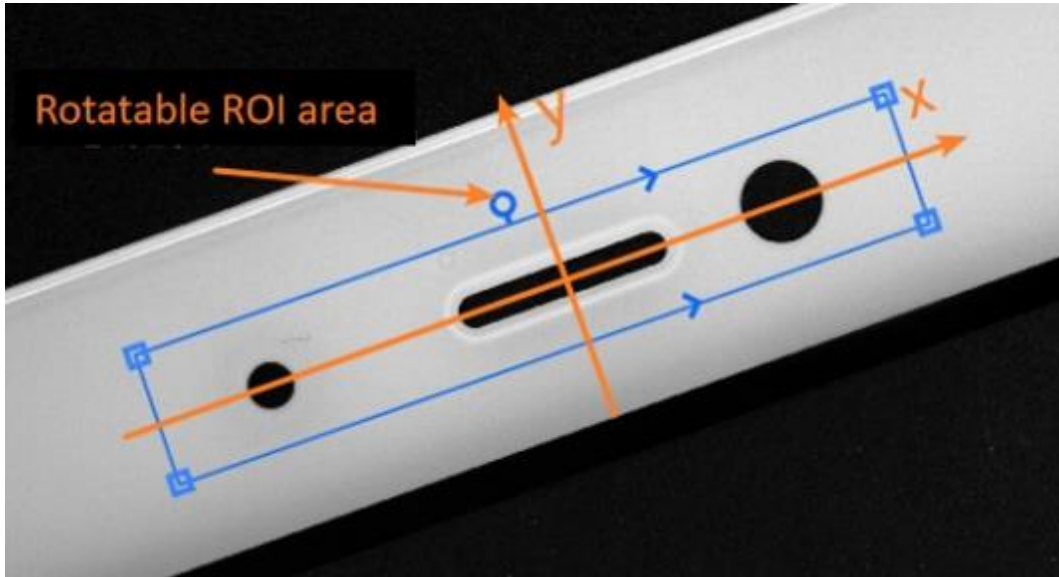
- Mask area: You can customize polygon mask area with up to 32 vertices. The image in the mask area is not processed.
- Position correction: It can be used with position correction tools. See Position Correction for specific usage.

Running Parameters

Running parameters involve parameter settings the of many tools. The running parameters of different tools are described in different chapters.

Result Display

Result Display includes result judgment, image display, text judgment and the preceding item display. Take circle search as an example.
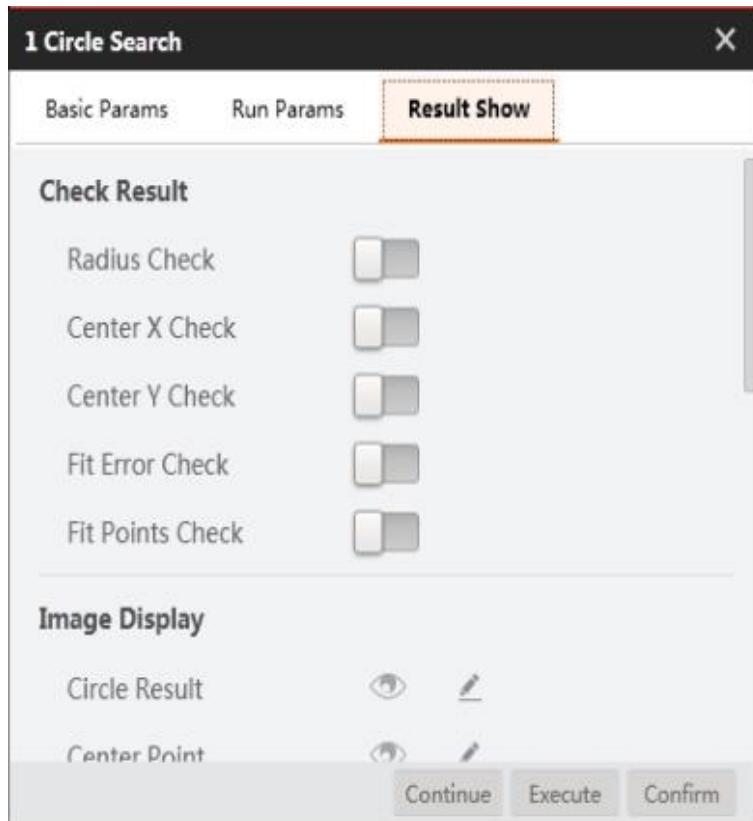
- Check Result: Judge the output result of the algorithm, which will affect the status of the module. Take radius judgment as an example. If radius judgment is enabled, the radius range of the target circle can be set. The default range is 0 to 99999.

- Image display: It displays the algorithm result in the image. This function is enabled by default. Click to close it. Click to set the color of OK and NG. The color of OK determines the contour color of the fitting circle in the circle search result.

- Text display: You can set the text display content, OK color, NG color, size, transparency and position coordinates.

Module Result

All the output results of the module are displayed in Module Result. The corresponding results can be linked to in the format tool. See Module Result for details.

3.6　Result Display

3.6.1　Module Result

The module result displays all output results, as shown below.

You can click to view and bind data with corresponding global variable.
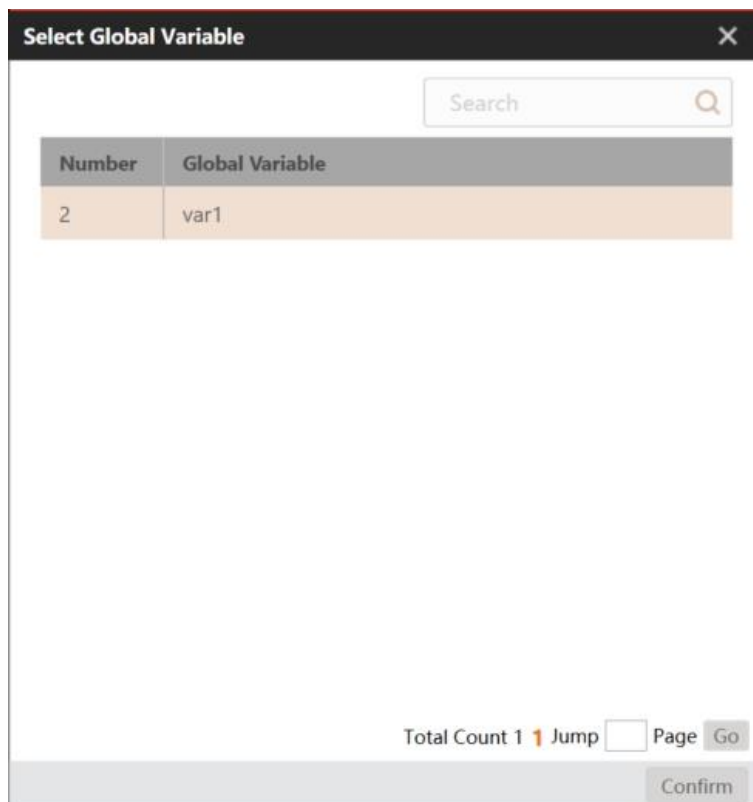
Different modules have different results. See each module for specific data.

3.6.2   Result Display Area

The result display area includes Current Result, History and Help.

Current Result

This area displays the operation result of the latest module.

History

This area displays the operation history of modules.

Help

This area explains the tool function and operation steps briefly.

3.7 Flow Management

3.7.1 Flow Operation

The software supports creating multiple sub flows without interfering each other. You can also perform data interaction and logical design through Global Script, Data Queue, Global Variables, as shown below.
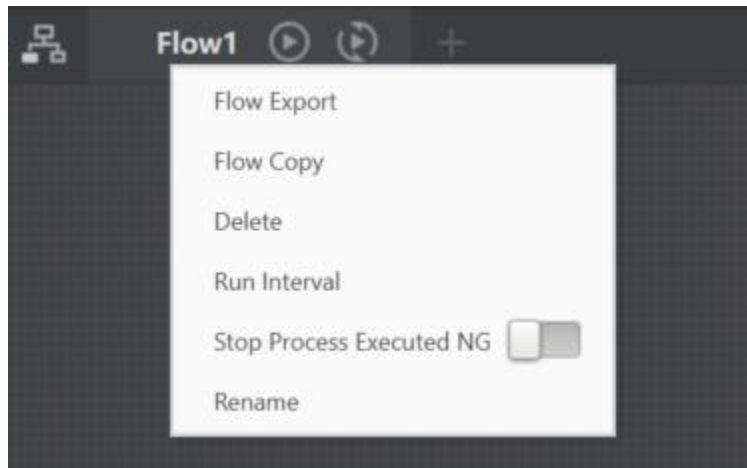
Right click the flow index, and you can execute the following operations:

Flow operation	
Flow Export	Export flow files with .prc format.
Flow Copy	Copy the information of current flow and create a new one, and import the copied information into the new flow.
Delete	Delete the selected flows
Run Interval	The interval between two consecutive runs of a process. The unit of interval is ms.
Stop Process Executed NG	When you execute flows continuously, if NG occurs, the process will stop.
Rename	Rename the flow.

3.7.2 Multi-Flow

The multi-flow has the features of multi-function, high efficiency, and executing asynchronously. Creating multiple flows can meet your demands for different functions or sequences, and you can also combine multiple flows via Data Queue or Global Variables.

Main Flow

In multi-flow process, you can click to display all sub flows you have created as shown below.

You can click one or more specified flows to run, or directly check the operation times and the time it takes to run once. You can right click a single flow to delete it, set continuous running time and rename the flow.

Click to enable or disable the flow.
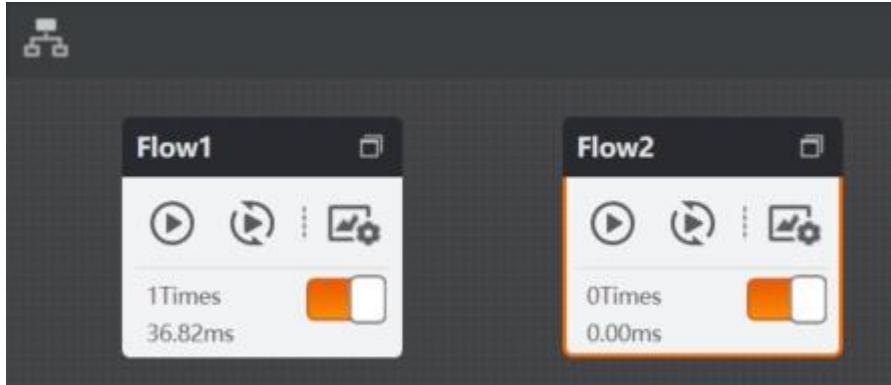
In main-flow page, you can click to edit output parameters as shown below.
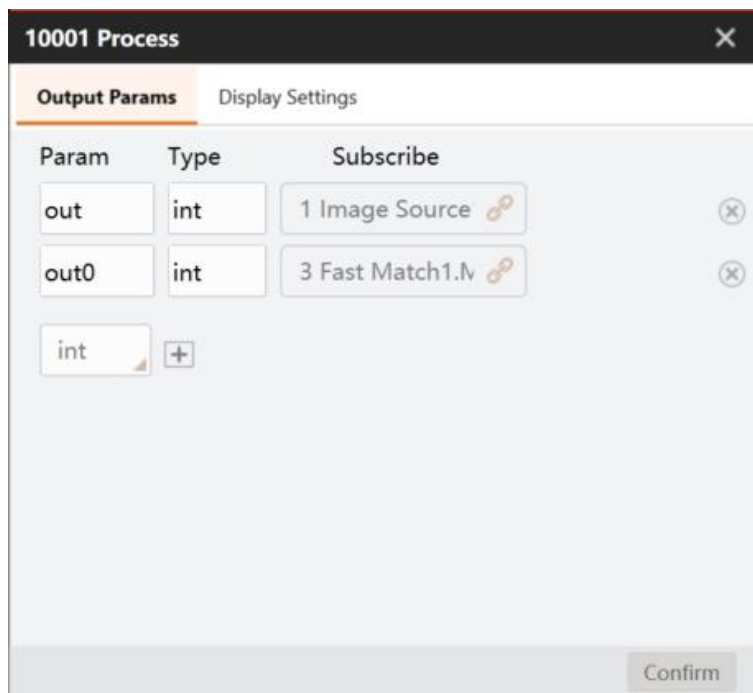
Click **Display Settings** to set display related parameters as shown below.
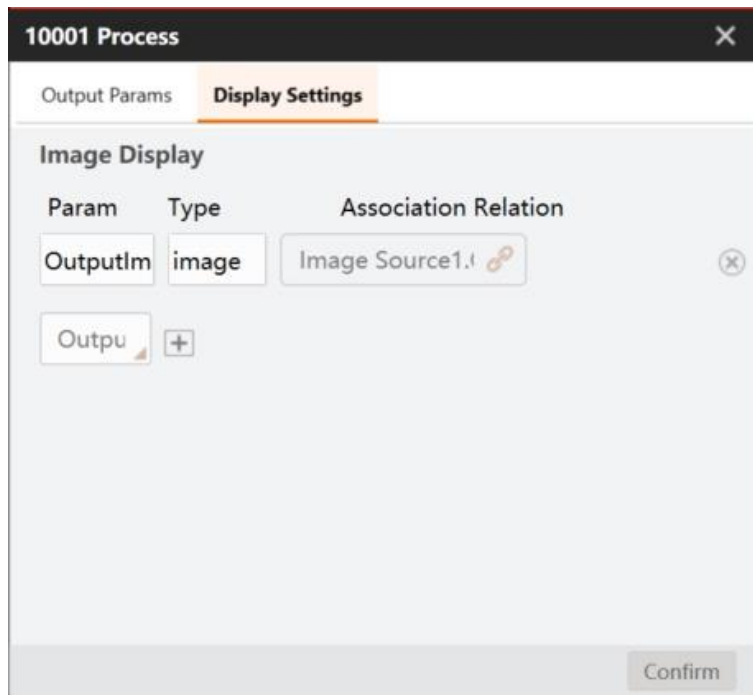
3.8 Camera Management

Click to add global camera, and set parameters according to actual demands after connection.

Multiple processes can share a global camera, and it is best to have a execution order between processes. If multiple processes are executed at the same time and share the same global camera, they will be queued to acquire data.

When software is selected as trigger source, you can click to trigger the camera to acquire images once, and click to let the camera to acquire images continuously.

The specific parameters and settings are as follows.

Common Parameters	
GenTL Camera	After enabling it, you need to import .cit format file, and search the cameras supporting genicam protocol.
Choose Camera	You can select camera in the same network segment, including GigE area/line scan camera and U3V camera, and third-party cameras
Reconnect Time	When the camera is disconnected due to network factors, the module will be reconnected during the time.
Image Width, Image Height	You can view the width and height of connected camera.
Pixel Format	Mono 8/10/12, RGB 8 and YUV formats are supported.
Frame Rate	You can set the max. frame rate of camera here.
Actual Frame Rate	It refers to the actual frame rate of camera.
Exposure Time	It refers to the exposure time of camera. Exposure affects the brightness of images.

Gain	You can increase gain to improve brightness without increasing exposure time.
Gamma	The camera supports Gamma correction, which provides a non-linear output mapping mechanism. Gamma value between 0 and 1: When image brightness increases, dark area becomes brighter. Gamma value between 1 and 4: When image brightness decreases, dark area becomes darker.
Line Rate	It refers to the line rate of line scan camera.

Trigger Settings	
Trigger Source	Software trigger means that DobotVisionStudio triggers the camera. Hardware trigger means using external hardware to trigger the camera.
Trigger Delay	After the configured trigger delay time, the program starts to respond.
IO Control	
IO Option	It selects IO port.
IO Mode	It includes input and strobe.
Smart Camera IO Control	
IO Selector	Select IO output port.
IO Source	It includes off and software triggering. Off means that output is disabled.
IO Inverter	After you enable it, the electrical signal level will be reversed.
Output Delay	Set the delay time of output, and its unit is us.
Duration	It refers to the duration of IO signals
Smart Camera Light Control	
Lighting Enable	After you enable it, the light source will be opened.
Lighting Mode	It includes strobe and constant.
Lighting Duration	It refers to the duration of the strobe.
Lighting Delay	It refers to the delay time of light output.
Lighting Precharge	It refers to the precharge time of light trigger.

3.9 Controller Management

You can set the light source and IO devices, as shown below.

Click ![+] to add a device. You can select the added device and right-click to rename or delete this device.
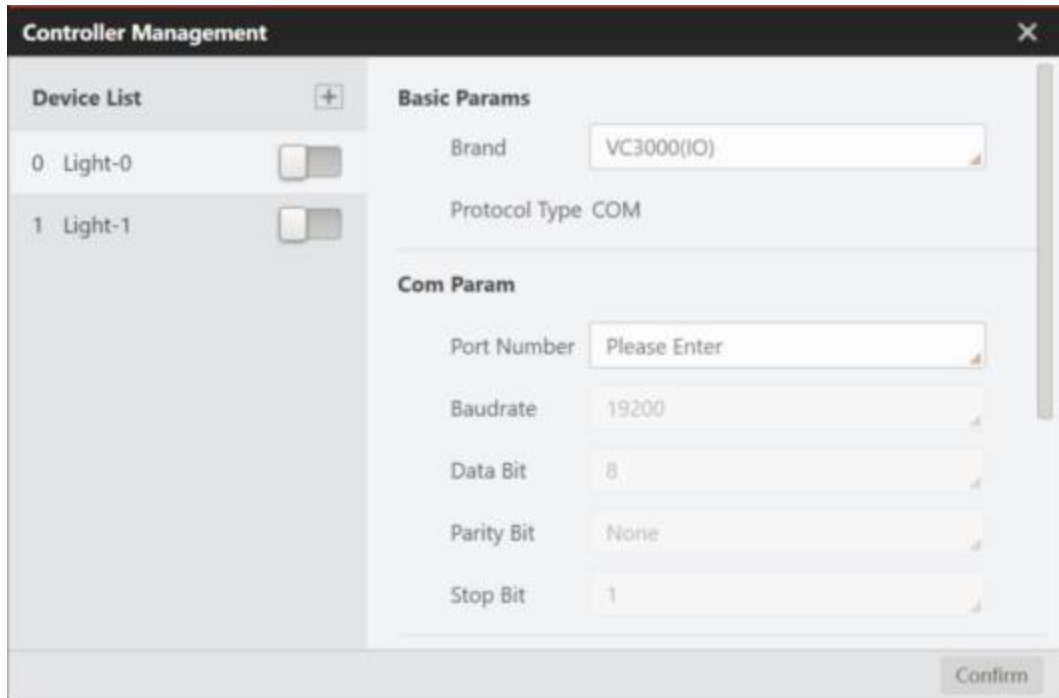
Currently, eight brands are supported: DPS2, MV-AP1024-2T, MV-LEVD, VB2200, VC3000(Light), VC3000(IO), VC4000, and GPIO. For protocol, only COM is supported.

☍NOTE

- For specific parameters, refer to the actual one you got.

If DPS2, MV-AP1024-2T, MV-LEVD are selected as brand, you need to set communication parameter and light parameters.

Communication Parameters	
Port Number	It refers to the port number.
Baud Rate	The common baud rate includes 4800, 9600, 115200, etc.
Data Bit	It includes 6/7/8.
Parity Bit	It includes odd/event/none.
Stop Bit	A stop bit is a character in asynchronous communication that lets a receiver know that the byte being transmitted has ended.
Light Parameters	
Channel Enabled	After enabling it, you can turn on the corresponding light.
Channel Brightness	It sets the light brightness. 0 stands for closing light. The larger the value, the brighter the light is.

If VB2200 is selected as brand, you need to set communication parameter, IO parameters, and light parameters.

Communication Parameters	
Port Number	It refers to the port number.

Baud Rate	The common baud rate includes 4800, 9600, 115200, etc.
Data Bit	It includes 6/7/8.
Parity Bit	It includes odd/event/none.
Stop Bit	A stop bit is a character in asynchronous communication that lets a receiver know that the byte being transmitted has ended.

IO Parameters	
Output Type	It includes output when NG and output when OK.
Send Interval	It refers to the sending interval ranging from 0 ms to 100 ms.
IO Port	You can select IO port according to actual demands.
Polling Enable	After enabling it, you can set its polling interval.
Delay Time	It sets the delay time of outputted signal.

Light Parameters	
Channel 1 Enabled	After enabling it, you can turn on the corresponding light.
Channel Brightness	It sets the light brightness. 0 stands for closing light. The larger the value, the brighter the light is.
Light State	It includes on and off.

If VC3000 (Light) is selected as brand, you need to set communication parameter and light parameters.

Communication Parameters	
Port Number	It refers to the port number.
Baud Rate	The common baud rate includes 4800, 9600, 115200, etc.
Data Bit	It includes 6/7/8.
Parity Bit	It includes odd/event/none.
Stop Bit	A stop bit is a character in asynchronous communication that lets a receiver know that the byte being transmitted has ended.

Light Parameters	
Channel 1 Enabled	After enabling it, you can turn on the corresponding light.
Channel Brightness	It sets the light brightness. 0 stands for closing light. The larger the value, the brighter the light is.
Light State	It includes on and off.
Edge Type	It includes rising edge type and falling edge type.
Duration	It sets the duration of light state, and the unit is ms.

If VC300(IO) is selected as brand, you need to set communication parameter and IO parameters.

Communication Parameters	
Port Number	It refers to the port number.
Baud Rate	The common baud rate includes 4800, 9600, 115200, etc.
Data Bit	It includes 6/7/8.
Parity Bit	It includes odd/event/none.
Stop Bit	A stop bit is a character in asynchronous communication that lets a receiver know that the byte being transmitted has ended.
IO Parameters	
Output Type	It includes output when NG and output when OK.
Output Polarity	It selects output polarity, including PNP and NPN.
Send Interval	It refers to the sending interval ranging from 0 ms to 100 ms.
IO Port	You can select IO port according to actual demands.
Polling Enable	After enabling it, you can set its polling interval.
Delay Time	It sets the delay time of outputted signal.

If VC4000 is selected as brand, you need to set communication parameter, IO parameters and light parameters.

Communication Parameters	
Port Number	It refers to the port number.
Baud Rate	The common baud rate includes 4800, 9600, 115200, etc.
Data Bit	It includes 6/7/8.
Parity Bit	It includes odd/event/none.
Stop Bit	A stop bit is a character in asynchronous communication that lets a receiver know that the byte being transmitted has ended.
IO Parameters	
Output Type	It includes output when NG and output when OK.
Output Polarity	It selects output polarity, including PNP and NPN.
Send Interval	It refers to the sending interval ranging from 0 ms to 100 ms.
IO Port	You can select IO port according to actual demands.
Polling Enable	After enabling it, you can set its polling interval.
Delay Time	It sets the delay time of outputted signal.
Light Parameters	
Channel 1 Enabled	After enabling it, you can turn on the corresponding light.
Channel Brightness	It sets the light brightness. 0 stands for closing light. The larger the value, the brighter the light is.
Light State	It includes on and off.
Edge Type	It includes rising edge type and falling edge type.
Duration	It sets the duration of light state, and the unit is ms.

If GPIO is selected as brand, you need to set IO parameters.

IO Parameters	
Output Type	It includes output when NG and output when OK.
Output Polarity	It selects output polarity, including PNP and NPN.
Duration	It sets the duration of signal output, and the unit is ms.
Polling Enable	After enabling it, you can set its polling interval.
Delay Time	It sets the delay time of outputted signal.

📖NOTE
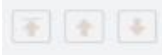
- GPIO is the VC3000's motherboard IO.

3.10 Global Variables

Global variables are variables defined outside all functions. They can be called or modified by all flows in the solution. Variable names, types, and current values can be customized. It is valid in the entire project file. You can click ![var] in the control toolbar to open it. After enabling initialization, you can send fixed-format string to set the initial value of global variables (such as variable var0, send SetGlobalValue: var0=0, and the variable value can be set to 0). Global variables have an overwrite update mechanism, which means old data will be overwritten when new data comes in.

The main functions of the global variables are shown below:

- Click **Add** to add new global variables.
- Click **Import/Export** to import or export global variables in fixed-format files.
- Search: You can enter variables name to search global variables.
- ![buttons] allows you to adjust the position of global variables.
- Click **Save** to save the current global variables you added.
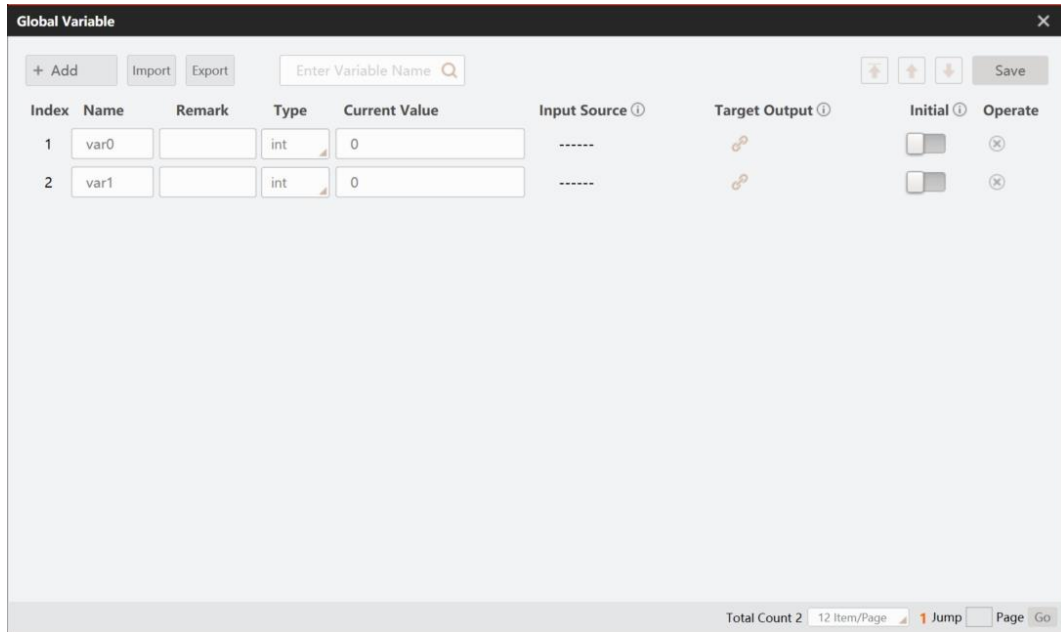
After adding variables, you need to set relevant information of variables.

In result module, you can bind data with corresponding global variables.
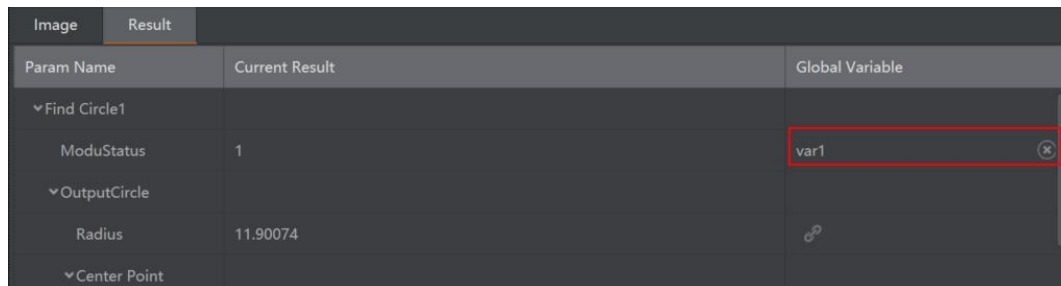
When global variables bind with target parameters, multiple selections are supported. Global variables support initializing multiple global variables at a time of communication, as shown in the following figure.
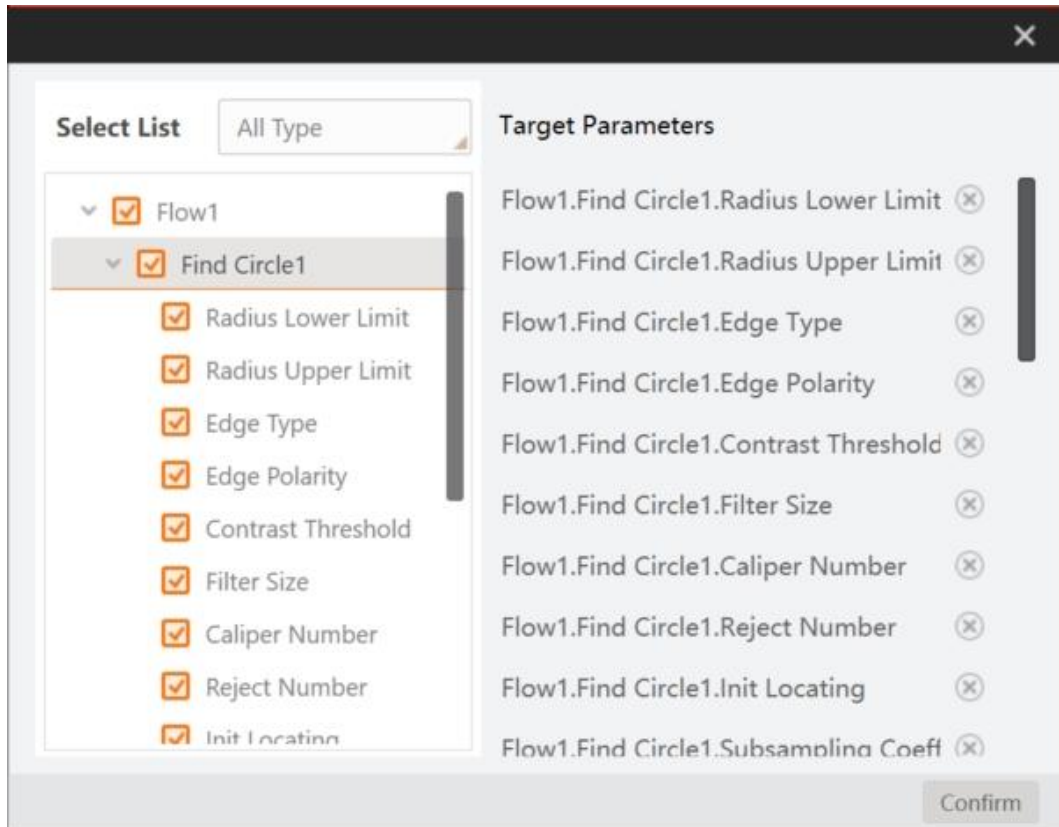
3.11 Communication Management

Communication is an important channel connecting the algorithm platform and external devices. The algorithm platform supports both reading and writing of external data. When the communication is established, the software can send process results to the outside or trigger the camera to acquire images or operate software via strings sent by the external devices.

3.11.1 Device Management

The device management allows you to add different communication protocols and set corresponding parameters. TCP, UDP, serial port, Modbus, PLC, and other communication protocols are supported. The specific configuration is as follows.
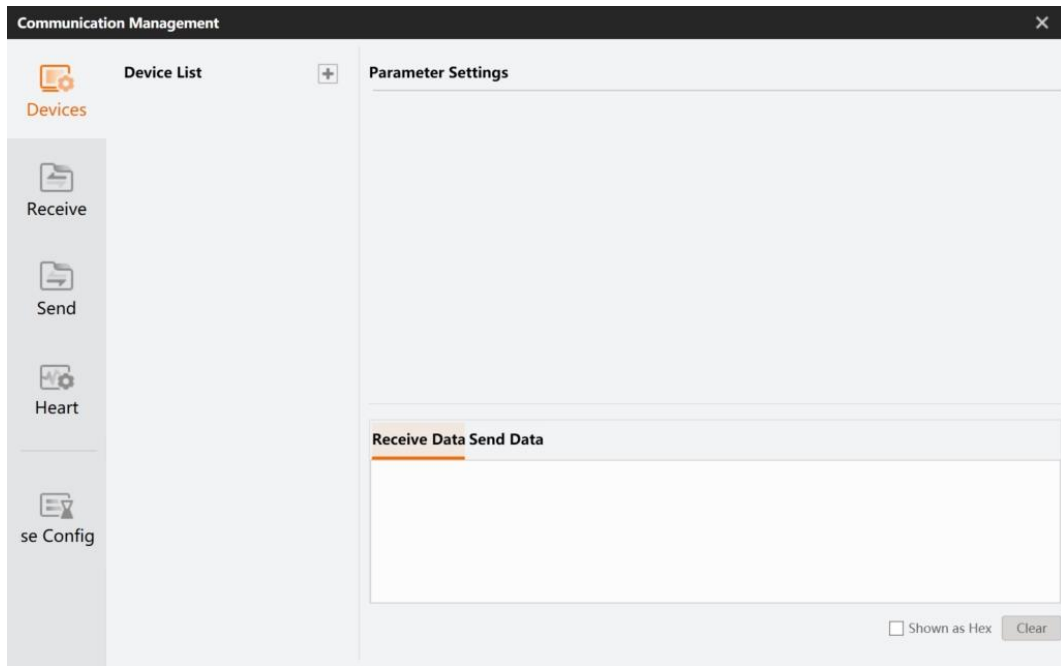
Click to add communication protocol.

TCP Communication

TCP communication includes TCP client and TCP server.
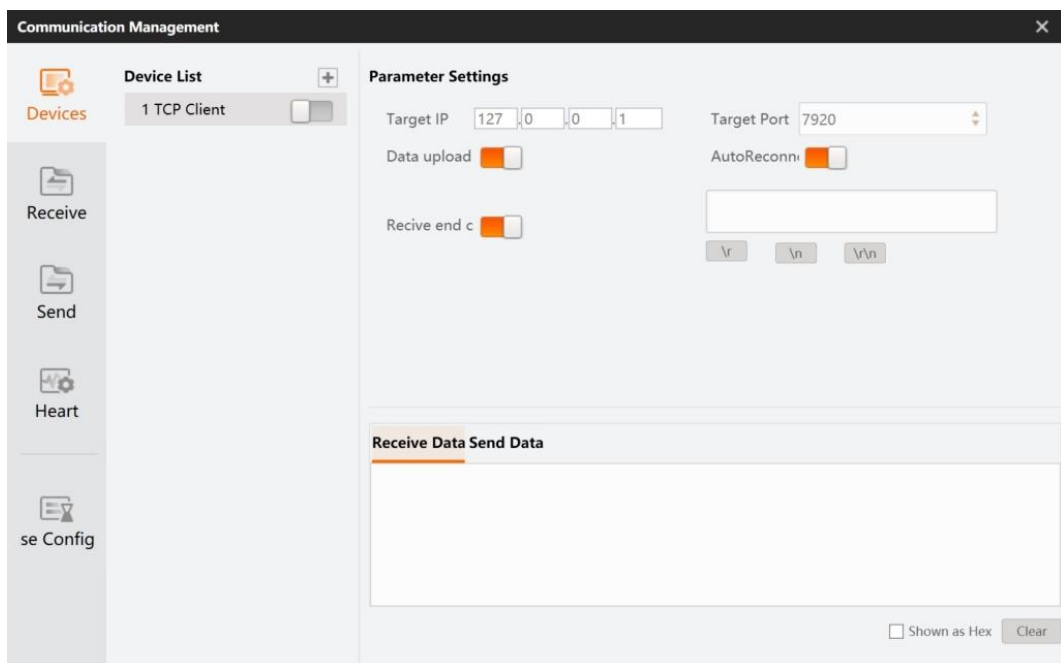
TCP Client	
Target Port	It refers to the port No. of the TCP server.
Target IP	It refers to the IP address of the TCP server.

Data Upload	After enabling, data will automatically upload.
Auto Reconnect	After enabling, the software will automatically connect the server.
Receive End Character	After enabling, the software will check if terminator is received or not. If the terminator is not received in the process of receiving data, the software will continue to receive data from the buffer until the terminator is received.
Send Data	It is used to test if the communication is established or not. Only strings are supported.
Receive Data	It is used to test if the communication is established or not.
TCP Server	
Local Port	It refers to the port No. of the local TCP.
Local IP	It refers to the IP address of the local TCP.
Data Upload	After enabling, data will automatically upload.
Auto Reconnect	After enabling, the software will automatically connect the server.
Receive End Character	After enabling, the software will check if terminator is received or not. If the terminator is not received in the process of receiving data, the software will continue to receive data from the buffer until the terminator is received.
Send Data	It is used to test if the communication is established or not. Only strings are supported.
Receive Data	It is used to test if the communication is established or not.

UDP Communication
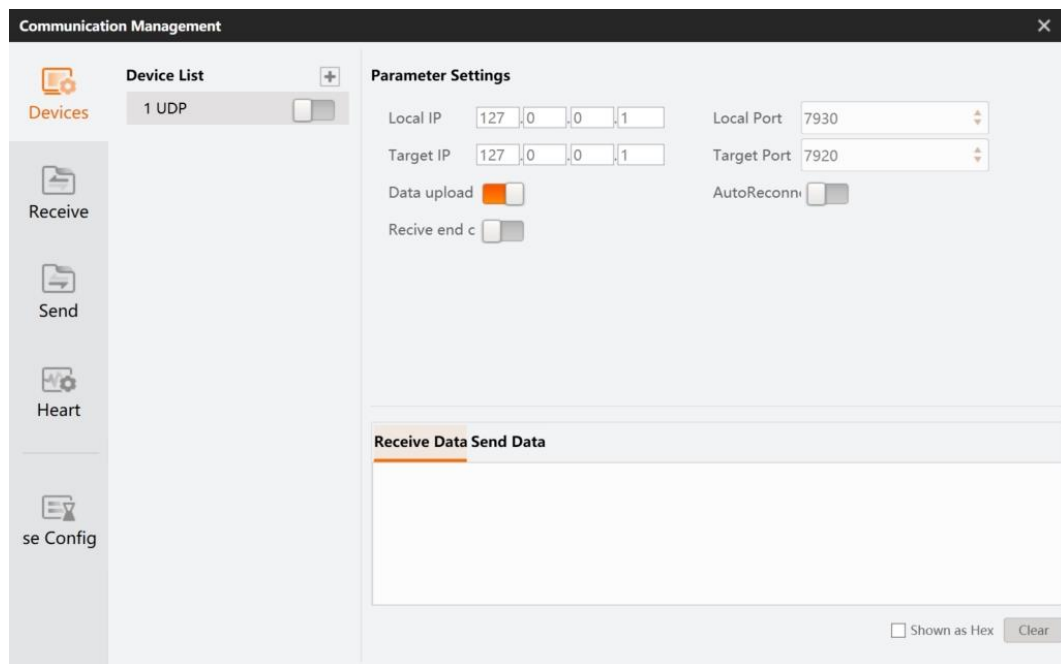
UDP Communication	
Local Port	It refers to the port No. of the device.
Local IP	It refers to the IP address of the device.
Target Port	It refers to the port No. of the target device.
Target IP	It refers to the IP address of the target device.
Data Upload	After enabling, data will automatically upload.

Auto Reconnect	After enabling, the software will automatically connect the server.
Receive End Character	After enabling, the software will check if terminator is received or not. If the terminator is not received in the process of receiving data, the software will continue to receive data from the buffer until the terminator is received.
Send Data	It is used to test if the communication is established or not. Only strings are supported.
Receive Data	It is used to test if the communication is established or not.

Serial Port Communication

Serial communication means that the serial port sends and receives bytes bit by bit. Although byte serial communication is slow, the serial port can use one cable to send data while using another cable to receive data. The serial communication protocol the content of data package, including the start bit, body data, check bit and stop bit. Data can be received and sent normally only when both parties agree on a consistent data packet format.

Before serial communication, you need to make sure that the serial cable is connected. Then you can check the port number in device manager. Some settings are shown as below.
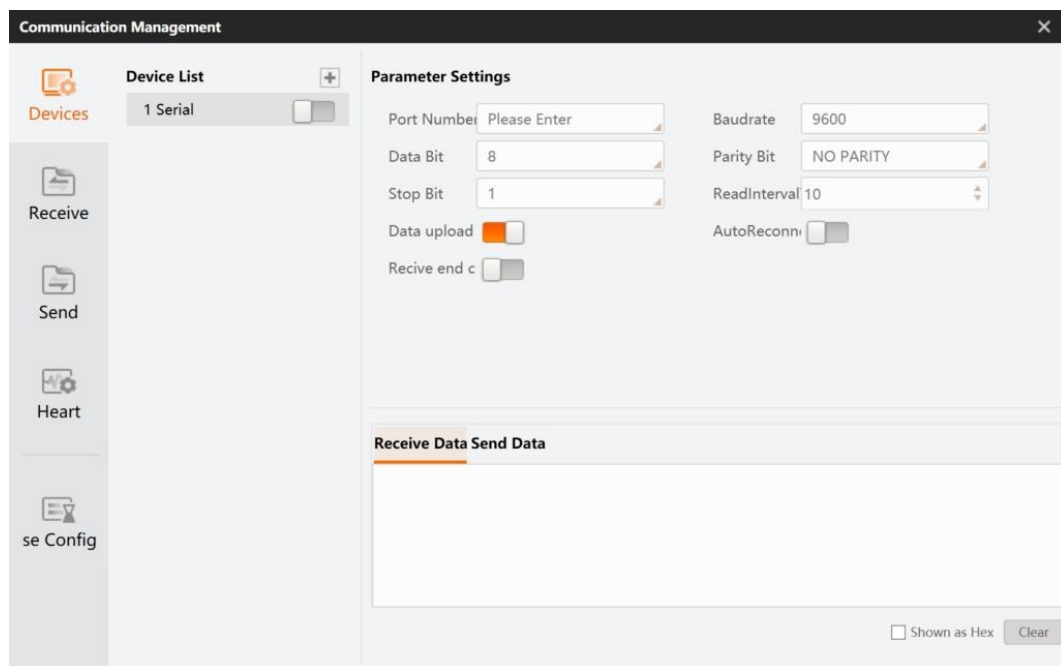
Serial Port Communication	
Port Number	The serial port of the PC.
Baudrate	The common baud rate includes 4800, 9600, 115200, etc.
Data Bit	It includes 6/7/8.
Parity Bit	It includes odd/event/none.
Stop Bit	A stop bit is a character in asynchronous communication that lets a receiver know that the byte being transmitted has ended.
Read Interval	You can set read interval here.
Data Upload	After enabling, data will automatically upload.
Auto Reconnect	After enabling, the software will automatically connect the server.

	After enabling, the software will check if terminator is received or not. If the
Receive End Character	terminator is not received in the process of receiving data, the software will continue
	to receive data from the buffer until the terminator is received.

PLC Communication

When using PLC communication, you need to establish the corresponding TCP or serial communication in the PLC device. Then you can create the PLC communication in Devices to establish connection. The PLC type supports Mitsubishi (Mitsu), KEYENCE (Keyence), Panasonic (Mewtocol) and Omron (Omronl), etc.
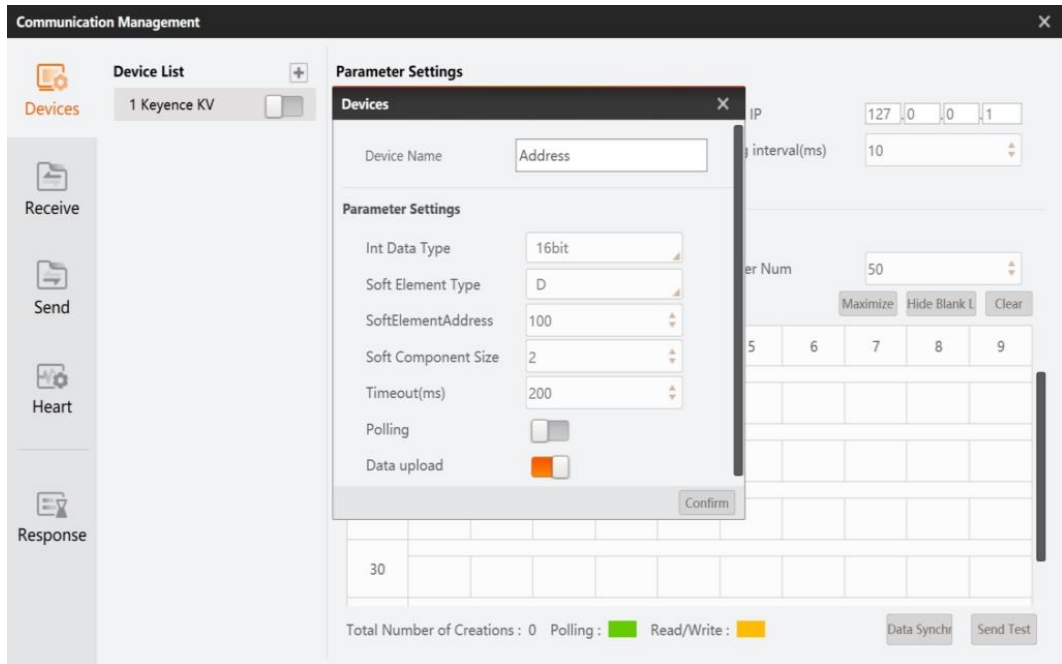
KEYENCE PLC Communication Parameters	
Data Type	It includes 16-bit and 32-bit.
Soft Element Type	Only D is supported.
Soft Element Address	It is the register address.
Soft Component Size	its range is between 1 and 128.
Timeout	It is the polling timeout.
Polling	After enabling, the device will read information in a polling way.
Data Upload	After enabling, data will automatically upload.
Mitsubishi PLC Communication Parameters	
Frame Format	It includes 3E, 3C-3 and 4C-5.
Data Code	ASCII and binary.
Data Type	It includes 16-bit and 32-bit.
Soft Component Type	X/Y/M/D are supported.
Soft Component Address	its range is between 0 and 65535.
Soft Component Size	its range is between 1 and 128.

Timeout	It is the polling timeout.
Polling	After enabling, the device will read information in a polling way.
Data Upload	After enabling, data will automatically upload.
Panasonic PLC Communication Parameters	
Station No.	Set it according to according to actual demands.
Data Type	It includes 16-bit and 32-bit.
Soft Component Type	Only D is supported.
Soft Component Address	It is the register address.
Soft Component Size	its range is between 1 and 128.
Timeout	It is the polling timeout.
Polling	After enabling, the device will read information in a polling way.
Data Upload	After enabling, data will automatically upload.
OMRON PLC Communication Parameters	
Data Type	It includes 16-bit and 32-bit.
Soft Component Type	Only D is supported.
Soft Component Address	It is the register address.
Soft Component Size	its range is between 1 and 128.
Timeout	It is the polling timeout.
Polling	After enabling, the device will read information in a polling way.
Data Upload	After enabling, data will automatically upload.
Inovance PLC Communication Parameters	
Station No.	Set it according to according to actual demands.
Data Type	It includes 16-bit and 32-bit.
Soft Element Type	Only D is supported.
Soft Component Address	It is the register address.
Soft Component Size	its range is between 1 and 128.
Timeout	It is the polling timeout.
Polling	After enabling, the device will read information in a polling way.
Data Upload	After enabling, data will automatically upload.
Ethernet/IP CIP Communication Parameters	
Slot No.	its range is between 0 and 256.
Data Type	It includes 16-bit and 32-bit.
Communication Address	Set it according to according to actual demands.
Polling	After enabling, the device will read information in a polling way.
Timeout	It is the polling timeout.
Data Upload	After enabling, data will automatically upload.

Modbus Communication

Modbus is a master/slave protocol. One node is the master node, and the other nodes that use Modbus protocol in communication are slave nodes. Currently the algorithm platform only supports the master station.

To use Modbus communication, you need to establish a communication connection first. Then you can create Modbus communication in Devices to establish connection, as shown in the following figure.

Modbus supports TCP and serial ports. Different communication modes require different communication parameters. For details about how to set the parameters, see TCP and Serial Port communication.
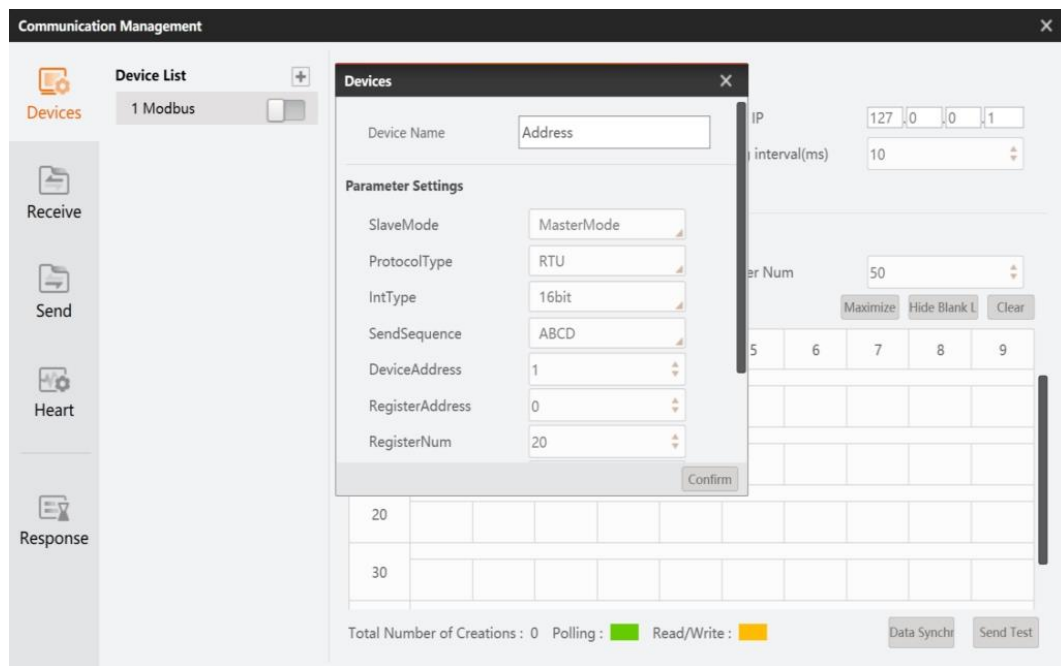
Mitsubishi PLC Communication Parameters	
Function Code	It includes read/keep register, read/input register, and write multiple registers.
Main/Sub Mode	Main is supported only.
Protocol Type	It includes RTU and ASCLL.
Data Type	It includes 16-bit and 32-bit.
Send Sequence	It includes four types: "ABCD""BADC""DCBA""CDAB"
Device Address	The sub device address.
Register Address	Set it according to according to actual demands.
Register Number	Set it according to according to actual demands.
Polling	After enabling, the device will read information in a polling way.
Data Upload	After enabling, data will automatically upload.

3.11.2 **Receive Event**

In communication management, receiving event can analyze and configure the data received by communications to parse a piece of data into the required value. It can also reassemble the received data or customize the data and send it back to the communication device. See Communication Trigger Flow for specific cases. You can configure corresponding parameters in this interface, as shown below.
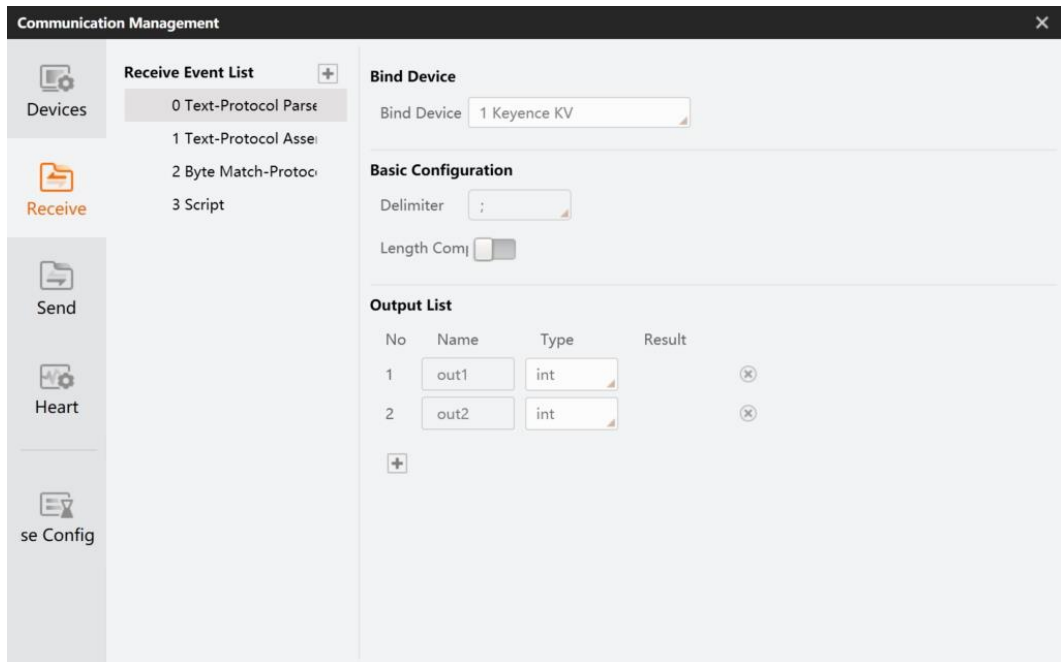
Click ⊞ in Receive Event List to add corresponding event.
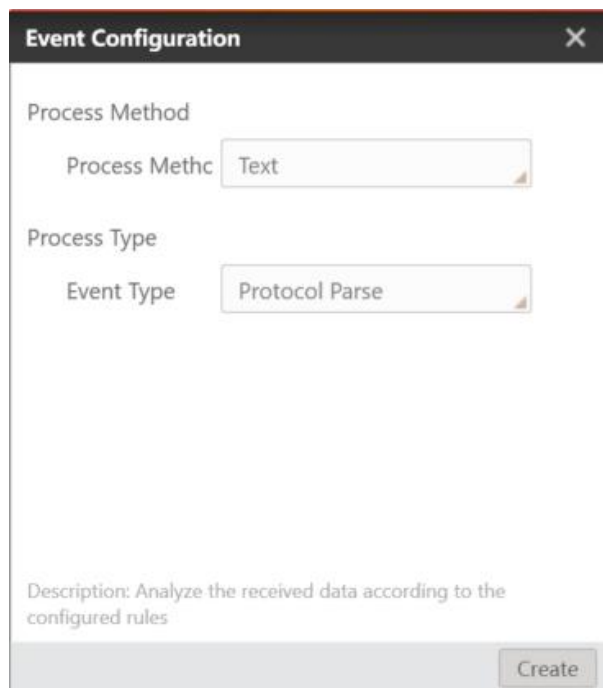
Create Event	
Process Method	It includes text, byte match and script.
Event Type	It includes protocol parse and protocol assembly. The protocol parse is to obtain the divided data according to the delimiter via the received data, and protocol assembly is to assemble data according to a given delimiter.

Currently, four types of events are available: text-protocol parse, text-protocol assembly, byte match-protocol assembly, and script.

Text-Protocol Parse	
Bind Device	Select the communication devices.
Delimiter	Delimiter is used to divide the received data
Character Length Compare	After the function is enabled, the software will automatically compare the length of received data. If the length of the received character is not equal to the configured length, the received data will not be configured to the output list and will not respond to the corresponding event trigger (The delimiter also represents a length).
Character Length	Set the character length.
Output List	Set and display the received data
Text-Protocol Assembly	
Bind Device	It selects the communication devices.
Delimiter	Delimiter is used to divide the data to be sent
Character Length Compare	After the function is enabled, the software will automatically compare the length of received data. If the length of the received character is not equal to the configured length, the received data will not be configured to the output list and will not respond to the corresponding event trigger (The delimiter also represents a length).
Character Length	Set the character length.
Parse List	Set received data and compare with configured data.
Reply to Device	After the function is enabled, after receiving the data sent from the communication device and being assembled, send the assembled data back to the communication device
Delimiter	Delimiter is used to separate the data replied to the device
Assembly List	The data in the assembly list can be uploaded to upper, or replied to the device.
Byte Match-Protocol Assembly	
Bind Device	Select the communication devices.
Character Length Compare	After the function is enabled, the software will automatically compare the length of received data. If the length of the received character is not equal to the configured length, the received data will not be configured to the output list and

	will not respond to the corresponding event trigger (The delimiter also represents a length).
Character Length	Set the character length.
ASCII to Hexadecimal	After the function is enabled, the software will convert data into hexadecimal type.
Rule List	It can convert received data into a data type according to certain rule, and compare data with configured value.
Byte Start and End	It sets the start and end position of byte.
Type	It parses and converts the received data into this type of data in a certain order.
Sequence	It parses and converts the received data into a specified type of data in this order.
Input Box	Enter data here.
Reply to Device	After the function is enabled, send the assembled data back to the communication device once receiving the data sent from the communication device and being assembled
Delimiter	Delimiter is used to separate the data replied to the device
Reply List	Set data replied to the communication.
Script	
Bind Device	Select the communication devices.
Reply to Device	After the function is enabled, send the assembled data back to the communication device once receiving the data sent from the communication device and being assembled
Delimiter	Delimiter is used to separate the data replied to the device
File Path	Select configured script files.
Assembly List	Display data in the script.

3.11.3 Send Event

In communication management, you can set the corresponding parameter types for the sending event, and subscribe sending event and customize parameters via Send Data. See Communication Trigger Flow for specific cases. You can configure corresponding parameters in this interface, as shown below.
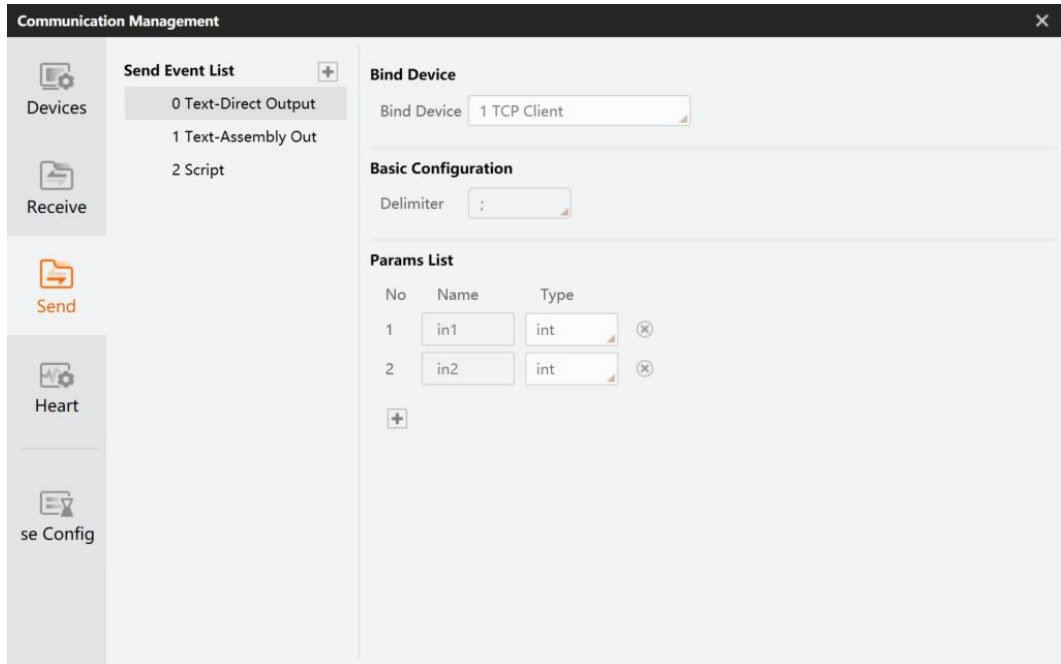
Click by Send Event List to add the receiving event.
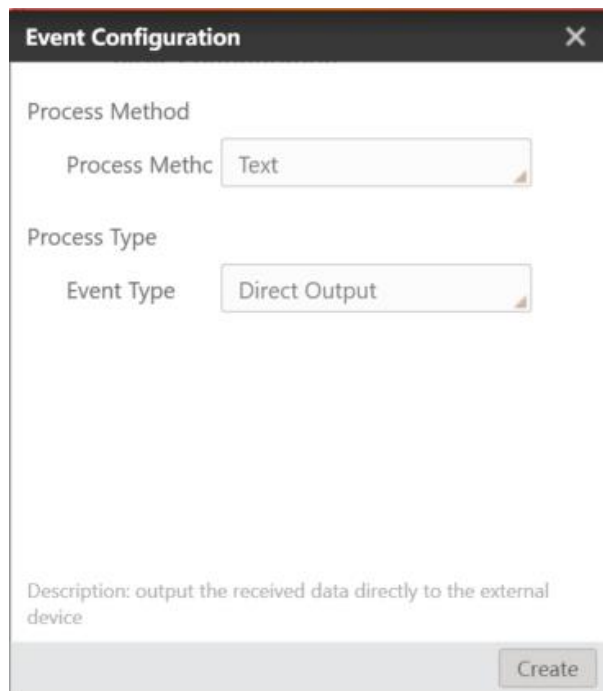
Create Event	
Process Method	It includes text and script.
Event Type	It includes direct output and assembly output.

Currently, three types of events are available: text-direct output, text-assembly output, and script.

Text-Direct Output	
Bind Device	Select the communication devices
Delimiter	Divides the received data by delimiter

Parameter List	Sets sent data and type

Text-Assembly Output	
Bind Device	Select the communication devices
Parameter List	Set sent data and type
Delimiter	Divide the received data by delimiter
Assembly List	Assemble sent data

Script	
Bind Device	Select the communication devices
Path	Select configured script files
Assembly List	Display data in the script

3.11.4 Heartbeat Management

You can configure the communication heartbeat in this page, as shown below.
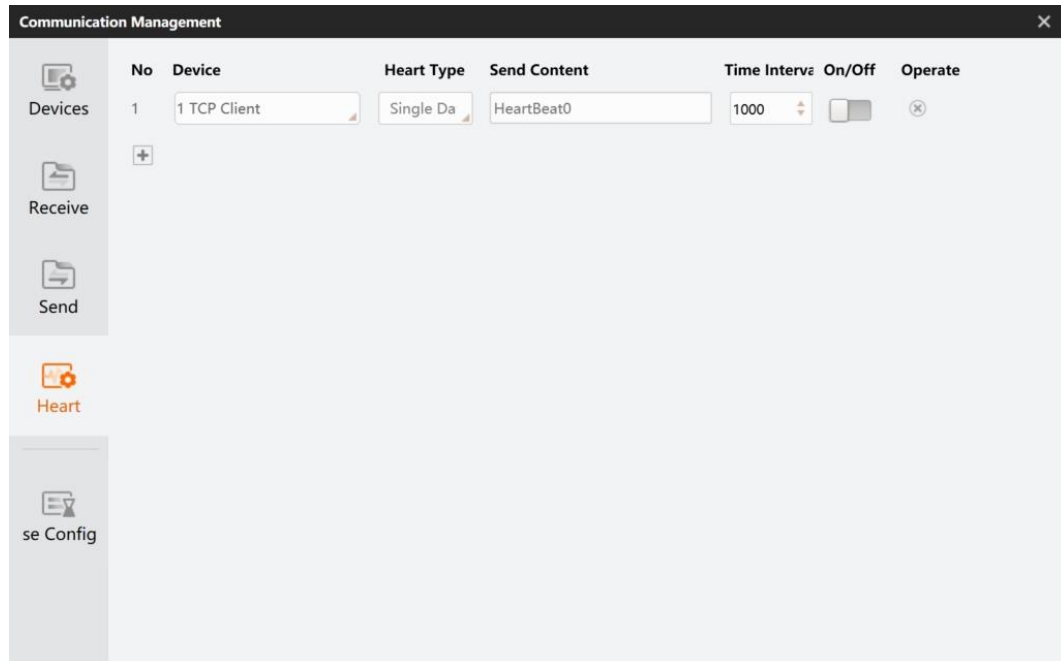
Heartbeat Management Parameters	
Device	Selects the corresponding communication device.
Heartbeat Type	It includes single data and multiple data. Single data supports sending single data continuously, and multiple datum support sending two data in loop.
Send Content	Set the contents to be sent (PLC and Modbus supports sending integer data only).
Time Interval	It refers to the time interval between sending data two times, and the unit is ms.
On/Off	After being enabled, the communication heartbeat is turned on.
Operate	You can click to delete the item.

3.11.5 **Response Settings**

You can set parameters of loading solution, flow control and camera response in **Response** panel.

- Load solution: After the function is enabled, the software will trigger specific contents if the solution is loaded successfully.

- Flow control: After the function is enabled, the software will trigger specific contents if the mode of flow is changed (busy or idle).

- Camera response: After the function is enabled, the software will trigger specific contents if the mode of camera is changed (disconnected or connected).
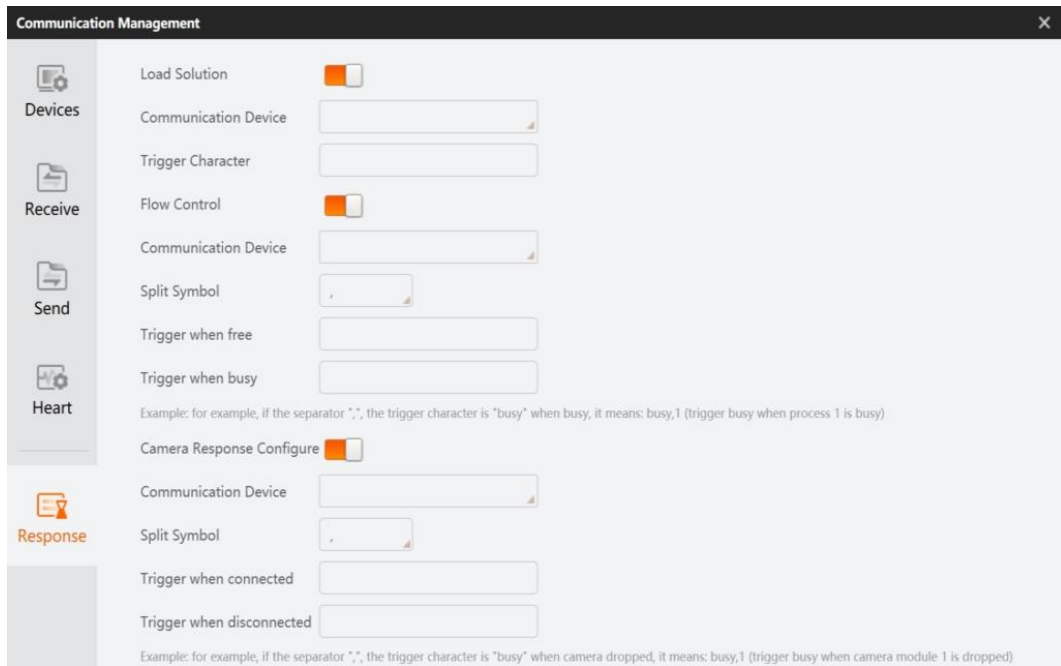
The parameters that need to be configured for various functions are different. All communication devices need to be set separately. You can select the communication mode that has been configured in **Device.** For other parameter descriptions, refer to the table below.

Load Solution	
Trigger Character	The characters sent by the communication after loading solution, for example A (PLC and Modbus supports sending integer data only).
Flow Control	
Split Symbol	Select the delimiter between data and flow No.
Trigger when Free	Set the contents sent by communication when flow is free, for example A (PLC and Modbus supports sending integer data only). The content is {configured strings}{split symbol}{flow ID}.
Trigger when Busy	Set the contents sent by communication when flow is busy, for example A (PLC and Modbus supports sending integer data only). The content is {configured strings}{split symbol }{flow ID}.

Camera Response Configuration	
Split Symbol	Select the delimiter between data and camera No.
Trigger when Connecting	Set the contents sent by communication when the camera connects, for example A (PLC and Modbus supports sending integer data only). The content is {configured strings}{split symbol }{camera ID}.
Trigger when Disconnecting	Set the contents sent by communication when the camera disconnects, for example A (PLC and Modbus supports sending integer data only). The content is {configured strings}{split symbol }{camera ID}.

3.12 Global Trigger
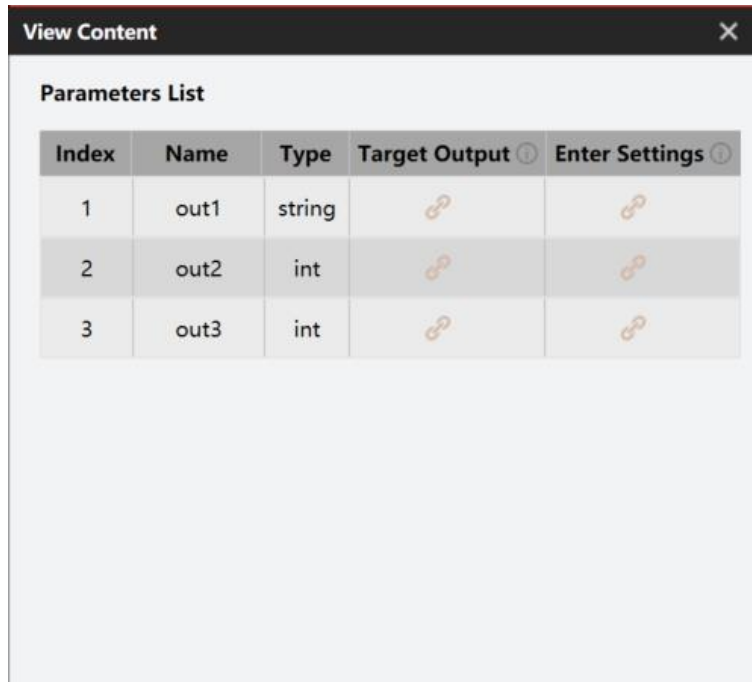
The global trigger includes event trigger and string trigger. After receiving trigger signal, the software can switch solutions, execute processes and modules.

Event Trigger

Event trigger can respond to commands like executing process, module, and module action according to the configured event after meeting the configured conditions, thus achieving accurate control of the operation. For the configuration of event trigger, see Receive Event. Execute process means triggering the process to run, and execute module means separately executing the subscription module. At present, execute module action only supports clearing the calibrated point of N-point calibration module. For specific cases, see Communication Trigger Flow. The following figure shows how to configure event trigger.
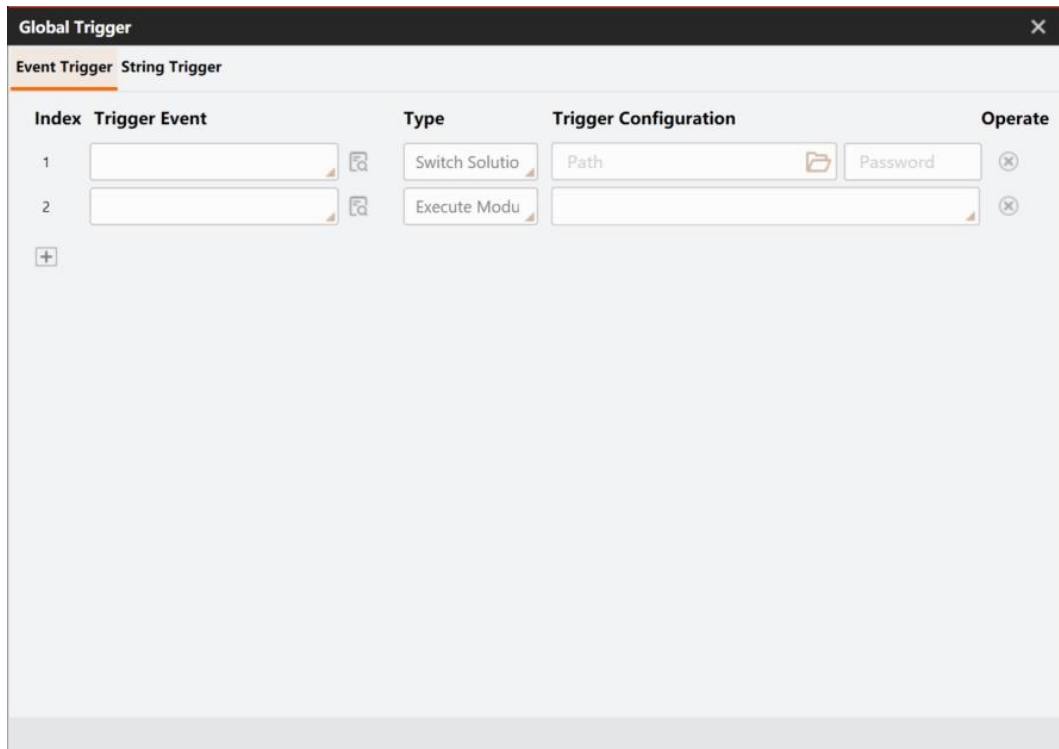
Click to configure event parameters. The **Target Output** is the running parameters of the binding module, and the **Enter Settings** is the input parameters of the binding module, as shown in the following figure.

Trigger Settings	
Trigger Event	It is used to trigger process or module action by subscribing corresponding Receive Event.
Trigger Command Type	It includes switching solution, executing process, executing module, and executing module action.
	Switch solution: Switch solution after receiving trigger once.
	Execute process: Execute single process after receiving trigger once.
	Execute module: Execute single module after receiving trigger once.
	Execute module action: Execute one action in the module, and N-point calibration is supported only.
Trigger Settings	Execute module and execute module action need to subscribe modules to be executed, and execute process needs to subscribe ID of process.
Trigger Action	You need to configure this parameter only when the trigger command type is execute module action. Currently, only N-point calibration is supported.

String Trigger

By setting string trigger, you can execute process, module and module actions. Execute process means triggering the process to run, and execute module means separately executing the subscription module. At present, execute module action only supports clearing the calibrated point of N-point calibration module. The following figure shows how to configure string trigger.
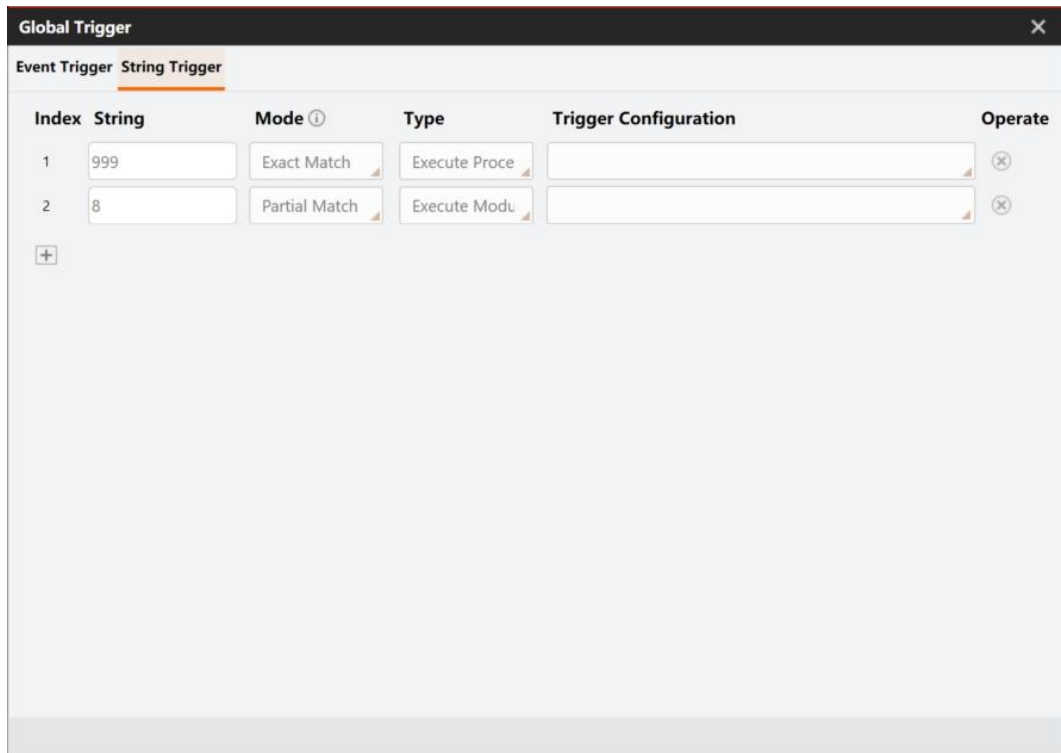
Trigger Settings	
Trigger String	It is used to trigger process or module action by setting characters.
Match Mode	It includes exact match, partial match and mismatch.
	Exact match: Only when the software receives the same trigger string, it will trigger actions.
	Partial match: If the sent strings contain trigger string, it will trigger actions.
	Mismatch: Any data can trigger action if mismatch is selected as match mode.
Trigger Event	It is used to trigger process or module action.
Trigger Command Type	It includes switching solution, executing process, executing module, and executing module action.
	Switch solution: Switch solution after receiving trigger once.
	Executing process: Execute single process after receiving trigger once.
	Executing module: Execute single module after receiving trigger once.
	Execute module action: Execute one action in the module, and N-point calibration is supported only.
Trigger Settings	Executing module and executing module action need to subscribe modules that to be executed, and executing process needs to subscribe process's ID.
Trigger Action	Only the executing module action need to configure this parameter. Currently, only N-point calibration is supported.

3.13 Global Script

3.13.1 Overview

Global script is available in controlling the running sequence of multiple flows, setting module parameters dynamically, and triggering the communication. It supports C# language, and calls C# API of DobotVisionStudio SDK. It can perform logical control of multiple flows, modify variable parameters, receive communication data, and so on.

Click to open the global script window, and click to set password for it.
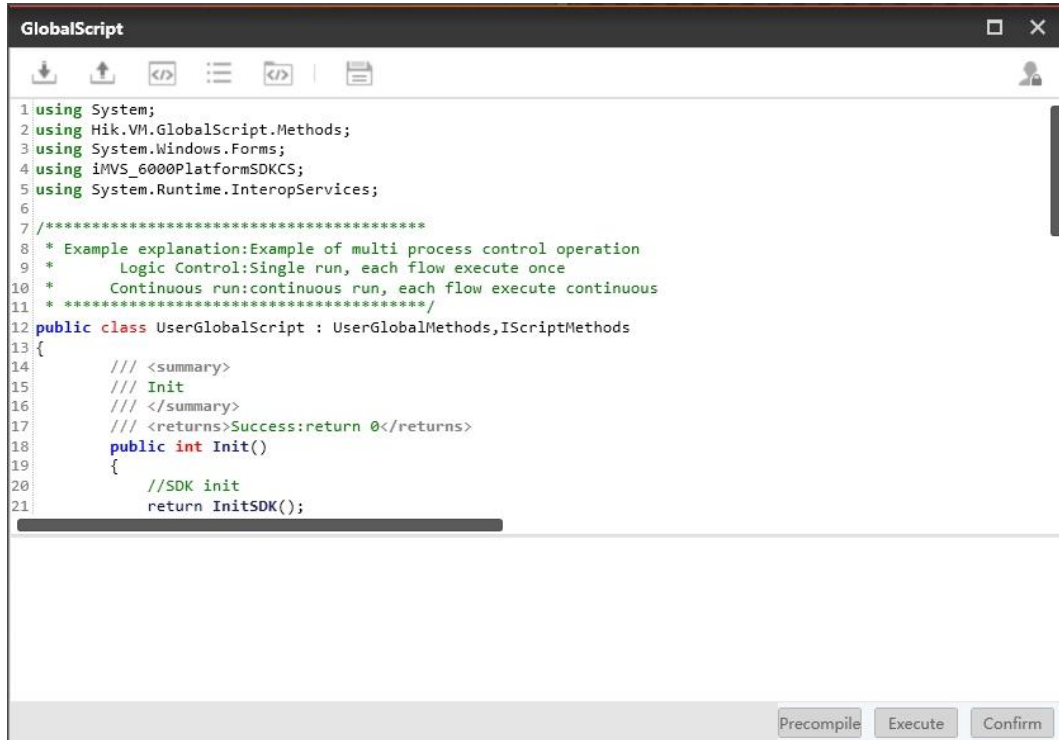
Global script	
	Import saved .cs files
	Export generated .cs files
	Open a demo
	Open the directory of the global script
	Add reference assembly
	Save the script program
	Set password for encrypting the global script
Init()	Initialization function. This function is only executed once when the editing is successful.
Process()	This function responds to the Runoperation.

3.13.2 **Debug Global Script via Visual Studio**

1. Click [icon] to open the directory of the global script, and open GlobalUserScript.sln with Visual Studio. Set the breaking point in the program and generate a solution.
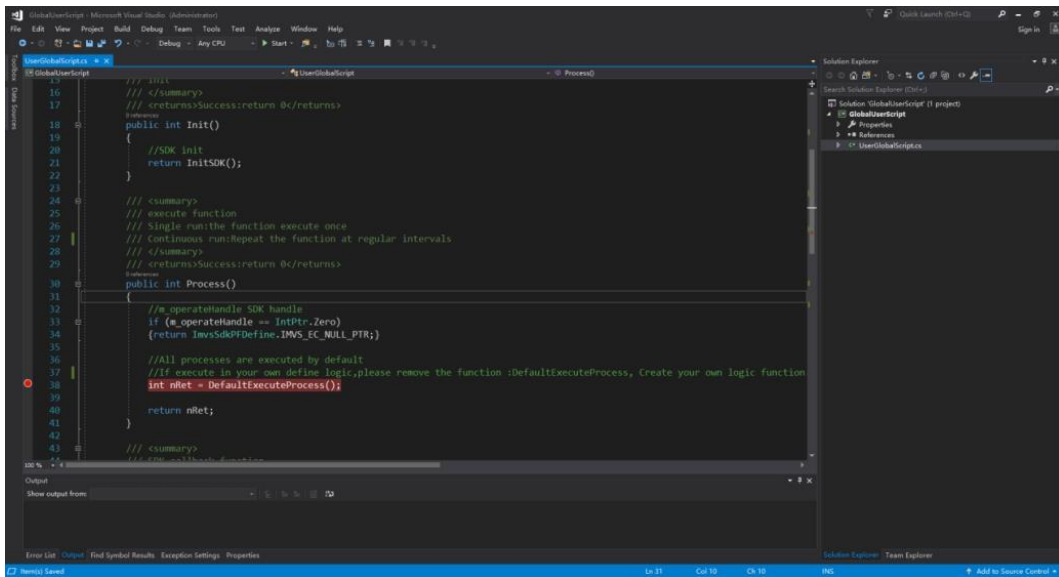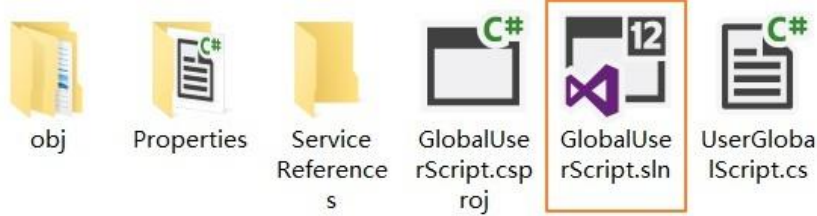
2. Add the global script to the process and click Attach.
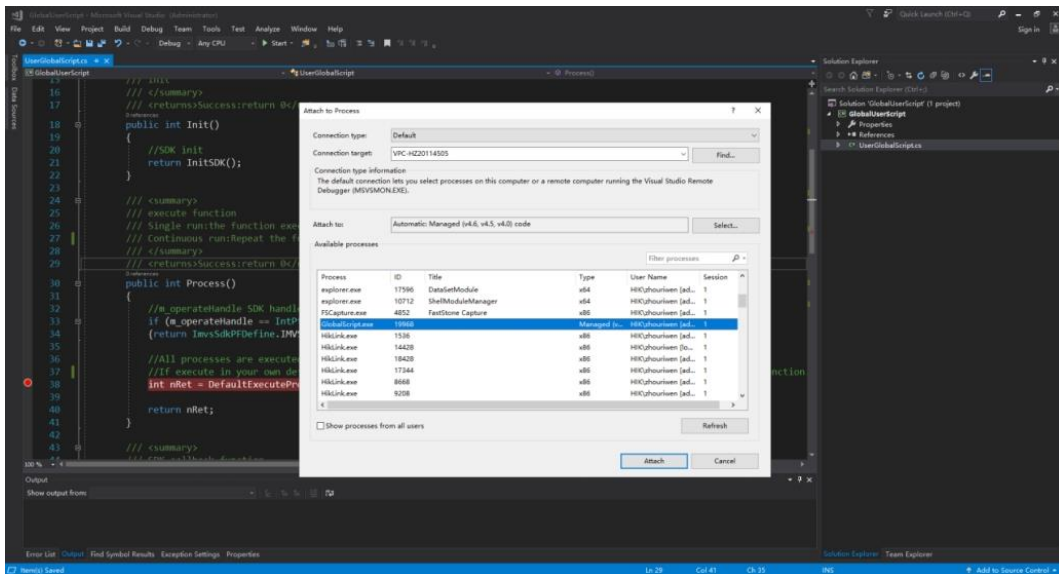
3. Click Once in DobotVisionStudio to check whether it runs to the breaking point.

The result is as follows after you click **Once.**
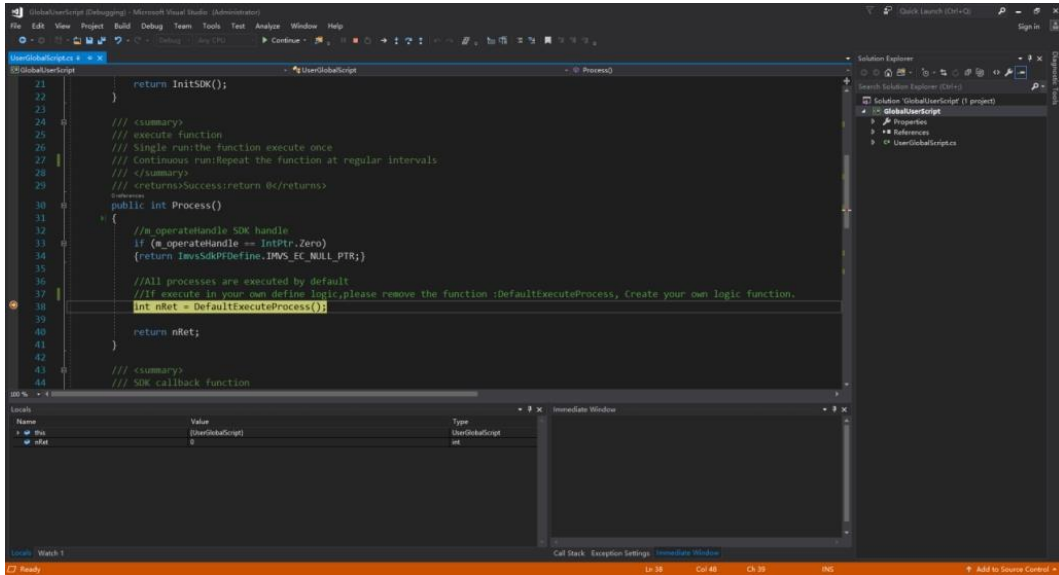
If it enters the breaking point, the global script can be debugged by VS.

3.13.3 **Add Assembly**

Click to open reference assembly, as shown below. You can click **Add** to add other assembly according to actual demands.

 NOTE

- Only C# assembly can be added.
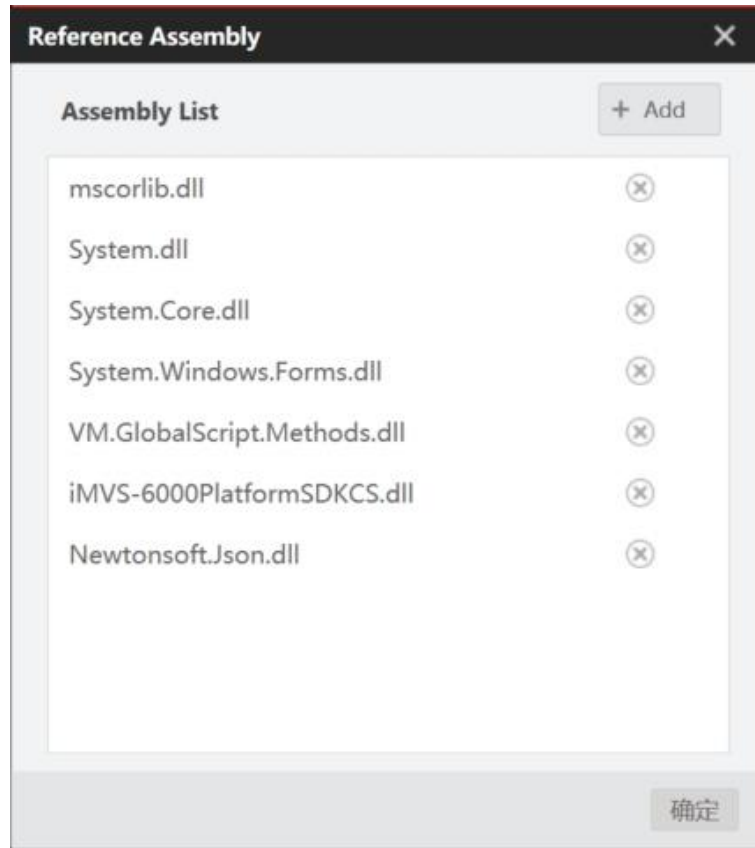
Click **Add** in the upper right corner to dynamically add assemblies as required. Only C# assemblies are supported. Find the.dll you want to add in the path of the third-party assemblies. You can call it in the global script after adding.

3.13.4 **Usage**

The global script supports calling the C# version of the algorithm platform SDK. For specific interface function, refer to *DobotVisionStudio Algorithm Platform SDK User Manual.* In addition, the global script provides the data interface of global variable module, continuous running time setting interface, debug interface, etc.

Global variable related interface:

Description	Get int type variable value of global variable.		
Function	Int GetGlobalVariableIntValue(string paramName, ref int paramValue)		
/	Parameter Name	Data Type	Description
Input	paramName	string	variable name
Output	paramValue	Int	variable value
Returned Value	Success: 0; Failure: error code excluding 0		

Description	Get float type variable value of global variable.		
Function	Int GetGlobalVariableFloatValue(string paramName, ref float paramValue)		
/	Parameter Name	Data Type	Description
Input	paramName	string	variable name

Output	paramValue	float	variable value
Returned Value	Success: 0; Failure: error code excluding 0		

Description	Get string type variable value of global variable.		
Function	Int GetGlobalVariableStringValue (string paramName, ref string paramValue)		
/	Parameter Name	Data Type	Description
Input	paramName	string	variable name
Output	paramValue	string	variable value
Returned Value	Success: 0; Failure: error code excluding 0		

Description	Set int type variable value of global variable.		
Function	Int SetGlobalVariableIntValue (string paramName, int paramValue)		
/	Parameter Name	Data Type	Description
Input	paramName	string	variable name
Output	paramValue	Int	variable value
Returned Value	Success: 0; Failure: error code excluding 0		

Description	Set float type variable value of global variable.		
Function	Int SetGlobalVariableIntValue (string paramName, int paramValue)		
/	Parameter Name	Data Type	Description
Input	paramName	string	variable name
Output	paramValue	float	variable value
Returned Value	Success: 0; Failure: error code excluding 0		

Description	Set string type variable value of global variable.		
Function	Int SetGlobalVariableIntValue (string paramName, int paramValue)		
/	Parameter Name	Data Type	Description
Input	paramName	string	variable name
Output	paramValue	string	variable value
Returned Value	Success: 0; Failure: error code excluding 0		

Global script continuous running time setting interface:

Description	Get global script continuous running interval.
Function	Uint GetScriptContinusExecuteInterval ()
Returned Value	Success: interval value; Failure: -1

Description	Set global script continuous running interval.		
Function	void SetScriptContinusExecuteInterval (uint nMilliSecond)		
/	Parameter Name	Data Type	Description
Input	nMilliSecond	unit	interval, unit: ms
Returned Value	None		

Communication related interface:

Description	Initialize global communication.
Function	bool StartGlobalCommunicate ()
Returned Value	Success: true; Failure: false

Description	Register communication receive event
Function	Void UnRegesiterReceiveCommunicateDataEvent ()
Returned Value	None

Description	Cancel communication receive event.
Function	Void RegesiterReceiveCommunicateDataEvent()
Returned Value	None

Description	Communication data receive event.		
Function	void UserGlobalMethods_OnReceiveCommunicateDataEvent(ReceiveDataInfo dataInfo)		
/	Parameter Name	Data Type	Description
Output	dataInfo	ReceiveDataInfo	CommunicateType
			int DeviceIndex
			int DeviceAddressIndex
			byte[] DeviceDat
Returned Value	None		

Debug interface:

Description	Print information into DebugView.		
Function	void ConsoleWrite(string content)		
/	Parameter Name	Data Type	Description
Input	Content	string	Print content
Returned Value	None		

3.14 Operation Interface

3.14.1 Overview

The operation interface is designed for the operation and usage for operators. You can customize the operation interface according to your needs to realize multiple functions like operation control, display, parameters settings, and exporting programs. The exported programs are divided into exe and vmCodeProject.
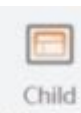
3.14.2 **Interface Configuration**

Click [F] to open the front running interface, then enter the editing interface, as shown below.
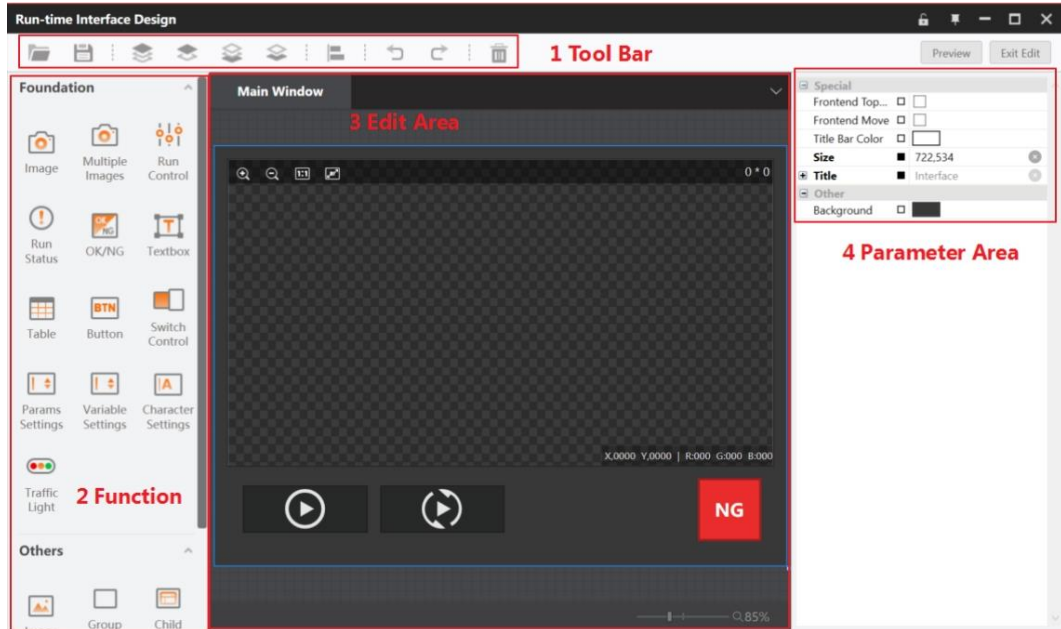
Tool bar	
📁	Click it to open saved ones.
💾	Save the operation interface you edited.
📑 📑 📑 📑	It includes in the top, up, bottom and next layer of the editing area.
▤	It is used to align multiple function tools in the editing area, Press Ctrl and select multiple function tools to align them.
↶ ↷	Cancel and undo cancellation.
🗑	Delete function tools.

Function Tools			
Icon	Function	Main Parameters	
Image	It is used to link image information	Layout	Sets dimension and margin.
		Data Linking	Sets parameters
		Auxiliary Line	Displays effects and results
	It is used to link multiple images' information	Layout	Sets dimension and margin.
		Data Linking	Sets parameters.

Icon	Description	Parameter	Detail
Multiple Images		Auxiliary Line	Displays effects and results.
Run Control	It is used to control the operation of all flows and single flow.	/	/
Run Status	It is used to display operation status of flows	/	/
OK/NG	It is used to display the operation result of flows: OK or NG.	/	/
Textbox	It is used to customize text and link with output data.	Format String	It is recommended to link data and display text.
		Data Type	Data type includes string, int and float.
		Data Source	It refers to the data source of displayed text.
		Display Text	After setting data linking, the displayed text will update automatically.
		Front	It customizes front and size.
Table	It is used to output data in a table when feature match meets multiple targets or Blob creates data.	Row and Column	It defines row and column in the table.
		Column Name	It defines column name.
		Column Width	it defines column width.
		Data Type	Data type includes string, int and float.
Button	Click it to set parameters for different modules	Data Source	It includes parameter configuration and parameter reset. Parameter configuration can configure the function module parameters in the main process. Parameter reset only supports variable reset in variable calculation.
		Data Source	Parameter reset can only link variable calculation parameter reset. Parameter configuration can configure all module parameters, global variables, camera management, light source

			management and communication management.
Switch Control	It is used to enable or disable switch.	Data Source	It can link controllers with switch.
Params Settings	It is used to adjust operation parameters.	Data Source	It needs to link with int or float type operation parameters.
Variable Settings	It is used to adjust values in variable calculation.	Data Source	It needs to link with var0.
Character Settings	It is used to adjust operation parameters and global variable.	Data Source	It needs to link with STRING type operation parameters.
Traffic Light	It is used to display the status of configured modules.	Data Source	It is used to link with traffic light in the process.
Image	It is used to add local images.		
Group Box	It is used to create the group box.		
Child Interface	It is used to edit child interface.		
Tab Control	It is used to create new tab. Press Alt and you can drag other controllers into tab.		

Edit Area	
	Click it to zoom in the image.
	Click it to zoom out the image.
1:1	Click it to let the image restore to the original status.
	Click it to have a full screen.

X,0000 Y,0000	Display the coordinate information of the cursor location on the image.
R:000 G:000 B:000	Display the R/G/B information of the cursor location on the image.

📖NOTE

- You can click 📌 to top the operation interface.

- You can click 🔓 to lock the operation interface.

3.14.3 Export Program

Exporting program can reduce the occupation of resources, and it supports secondary development. You can click **Export** to export, as shown below.
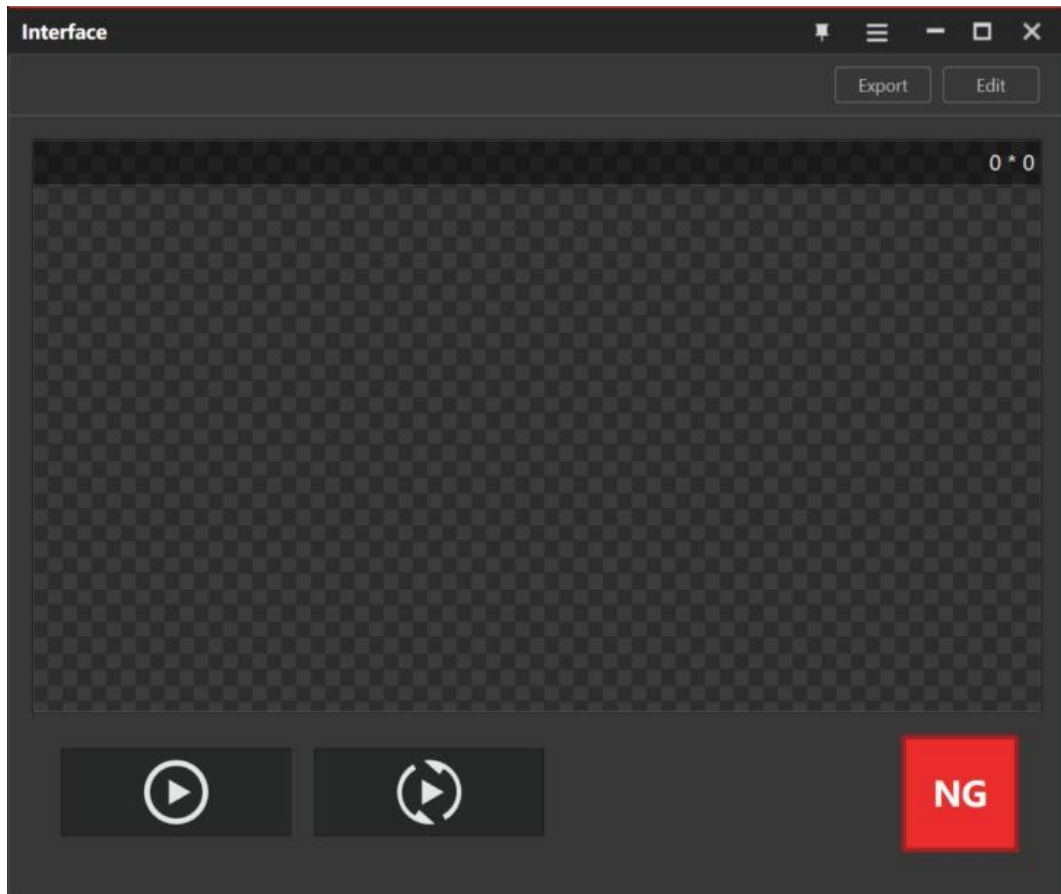
You need to enter name, select icon, type (exe, vmCodeProject, and exe+ vmCodeProject) and storage path before exporting.
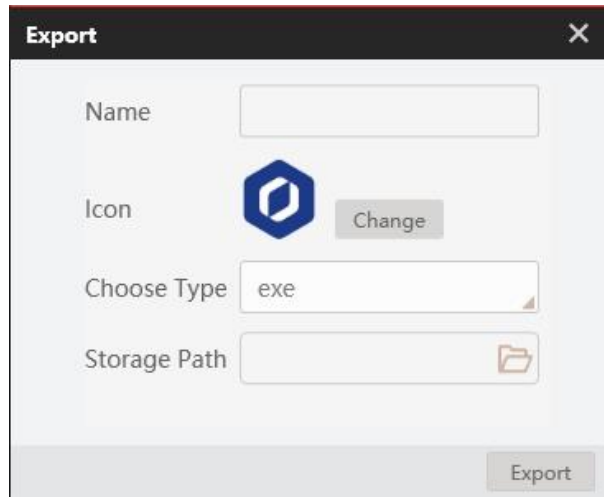
The specific information of program for exporting exe and vmCodeProject are as follows:

Public_Release files include main program files, as shown below.

3.15 **Data Queue**

The queue is a first-in-first-out linear table. Its end that allows insertion is called the tail of the queue, and the other end that allows deletion is called the head.
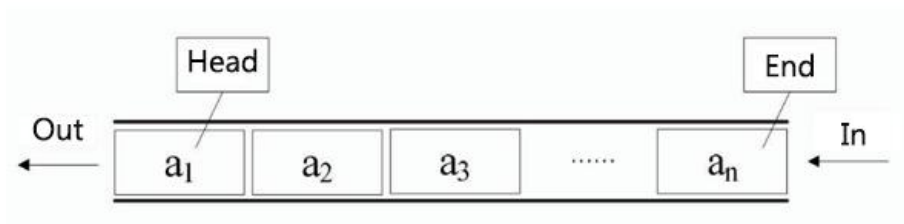
Click in DobotVisionStudio to enter the interface of multi-flow, and drag to set up one or multiple data queues.
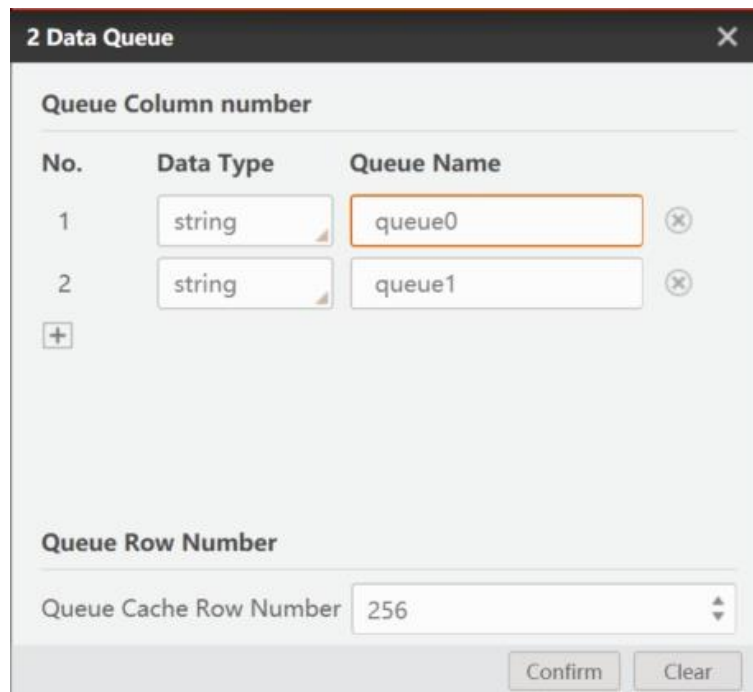
Data queue	
No.	Queue index
Data Type	It includes int, float and string.
Queue Name	It refers to the name of queues.
Queue Cache Row Number	It refers to the max. quantity of queues.

In the process, you can use the function of sending data to send data to the data queue. The data can be cached in the queue when not taken out.
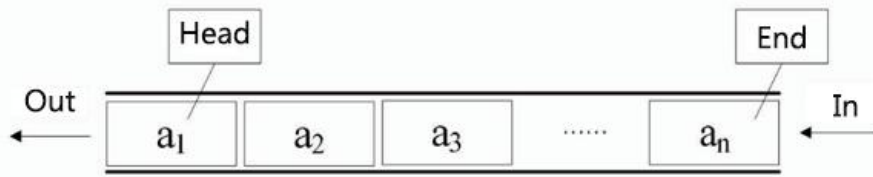
When multiple processes send data to the data queue for comprehensive processing, to ensure that the order of data combination is not disrupted, the data cannot be taken out if any of the queue is blank.

3.16 Flow Time

The software supports recording time consumed in tool operation and algorithm operation. You can go to the home page of the software, and click ⬛ as shown below.
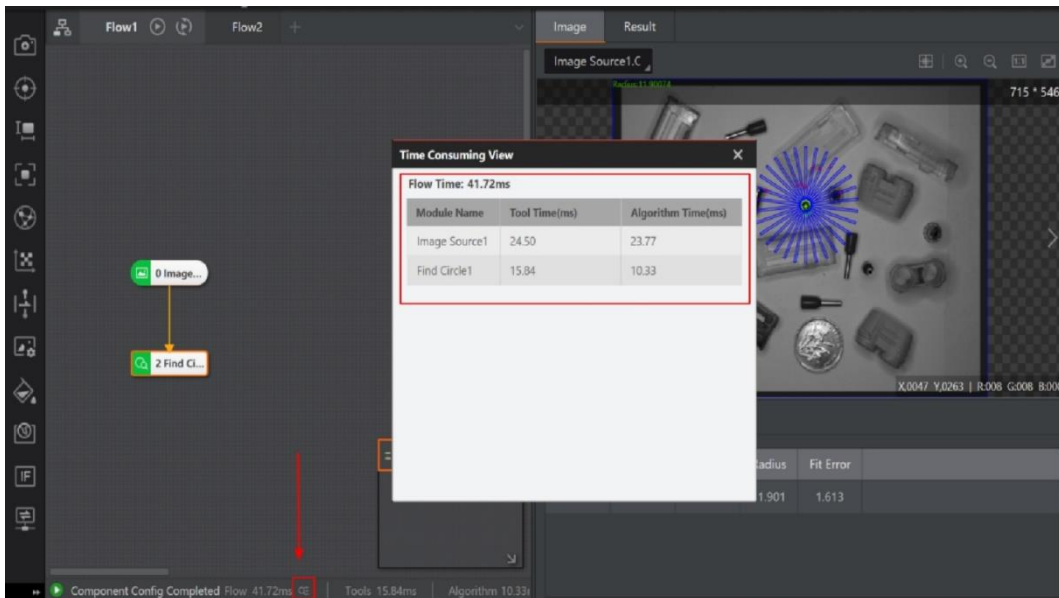
Click the position in the figure above to open Time Consuming View, where you can view the tool and algorithm time of each module as well as the entire process.

3.17 Dobot Panel

The Dobot panel shows Magician settings by default, as shown in the figure below.
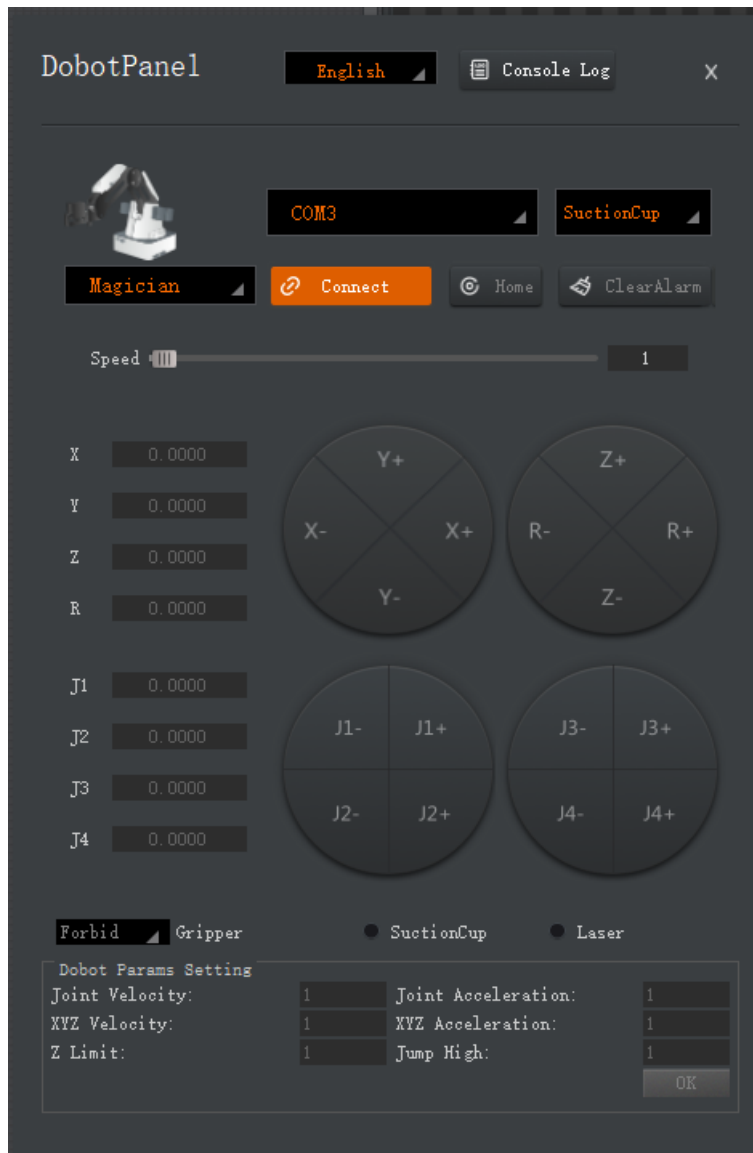
You can click **Magician** in the upper left to select CR or MG400/M1Pro, as shown in the figures below.
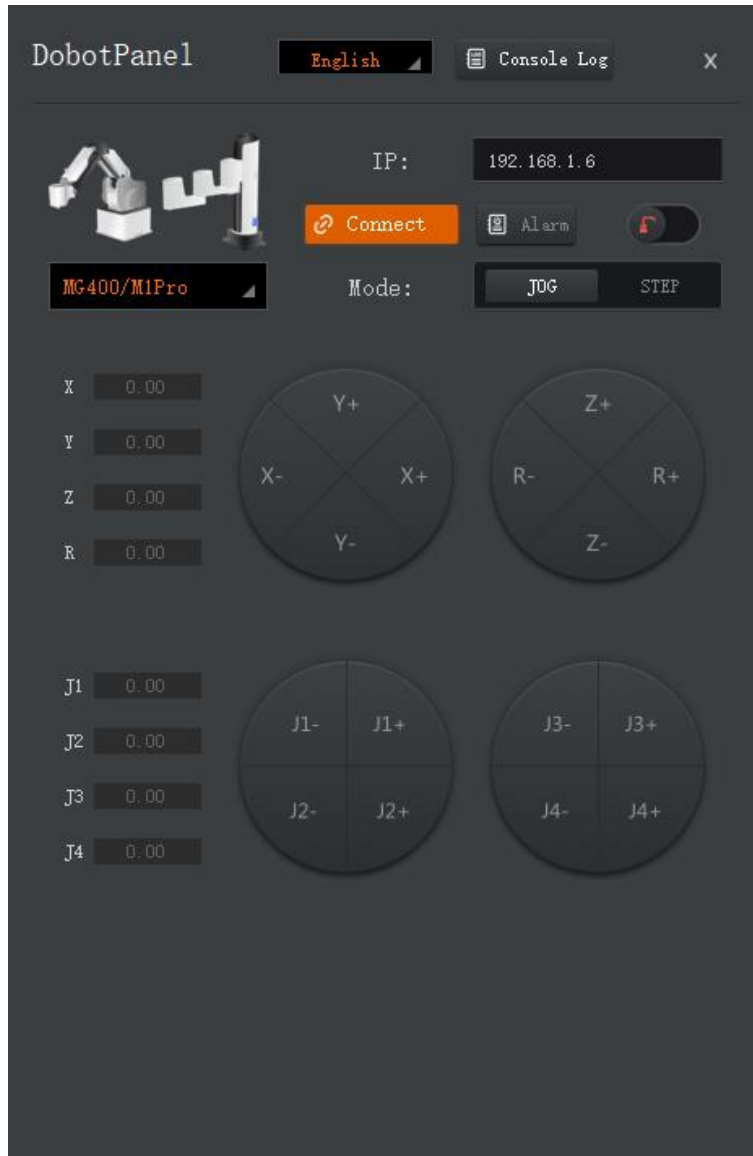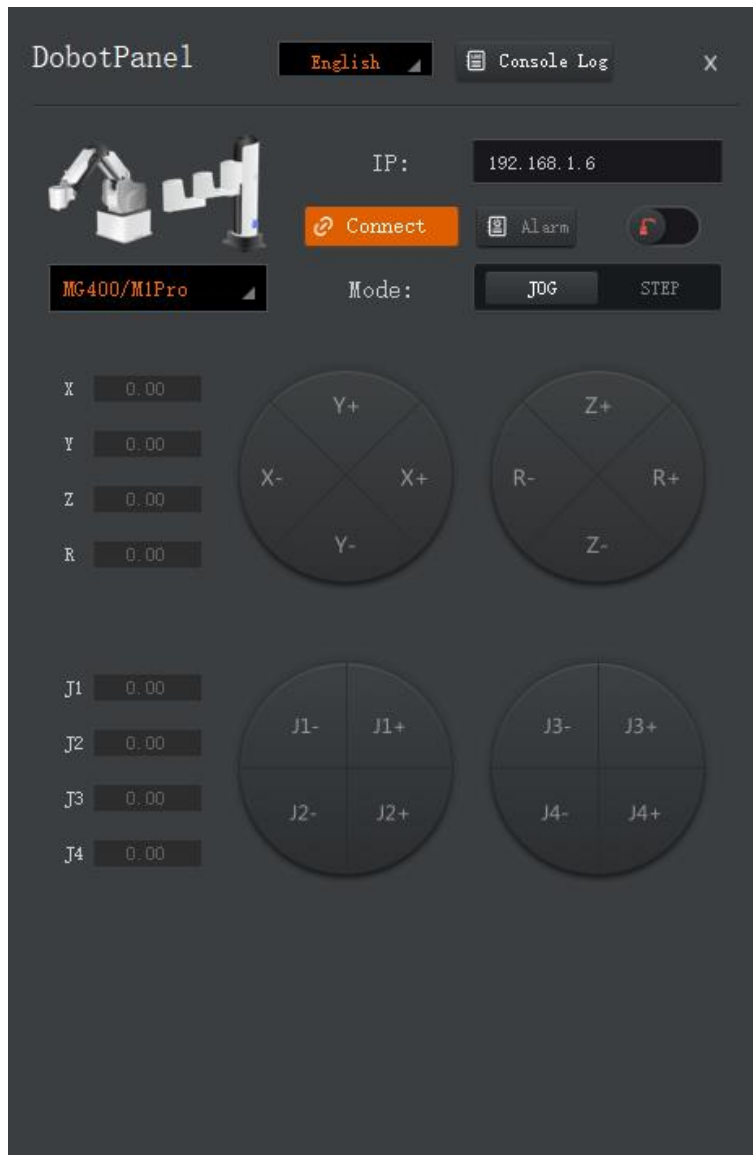
4. **Vision Tools**

The software supports multiple vision tools. You can directly drag the tools needed from the tool box.

The vision tools have different categories, including acquisition, location, measurement, image generation, recognition, deep learning, calibration, calculation, image processing, color processing, defect detection, logical tools and communications.

4.1 **Acquisition**

You can set image sources and save images through acquisition. Image sources can be obtained from loading local images and linking to camera for images.

4.1.1 **Image Source**

Drag the **Image Source** module to the process editing area. The image can be loaded from local or obtained from camera.

When selecting SDK for the image source, you can only set the image data by calling the SDK interface as shown below.
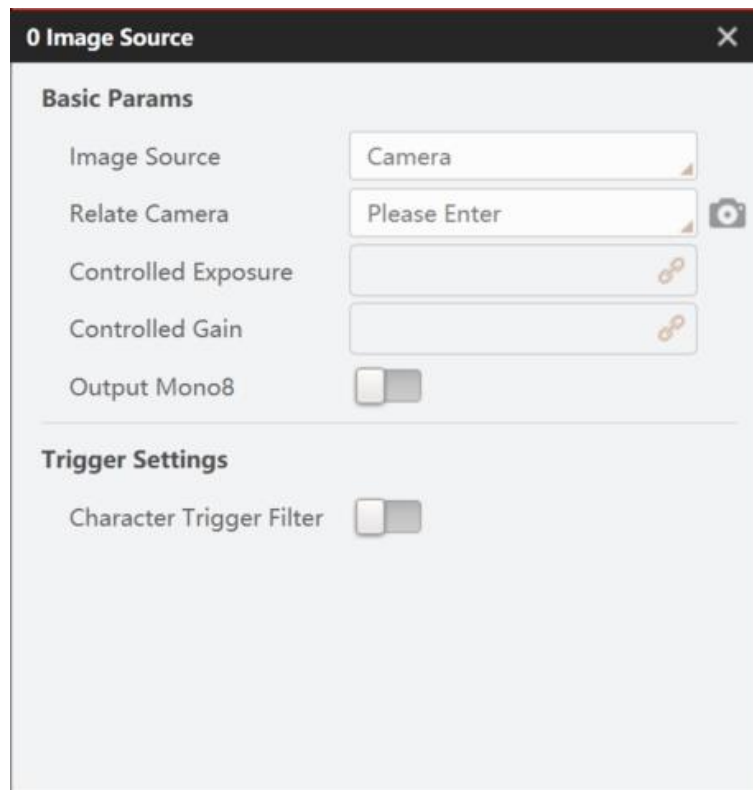
When you select **Local Image** in **Image Source**, **Current Results** changes to **General Parameter** in the result display area. You can click on the upper right to load an image, click to load an image folder, and click to delete all images. At the same time, you can double-click

the module to set parameters, which mainly include pixel format, fetch interval, solution-saved images and trigger settings.

Basic Parameters	
Pixel Format	The pixel format can be set to Mono8 or RGB24.
Fetch Interval	You can set the time interval between two image fetches and the unit is ms.
Solution-saved Image	You can set whether to save the local images when saving solutions.
Auto Switch	Switch to the next image automatically after enabling auto switch.
Character Trigger Filter	1. The external communication can control the function module after character trigger filter being turned on.
	2. Input character: select the source of input character.
	3. Trigger character: Any character transmitted can trigger the process when no character is set. After the character is set, only the character transmitted in accordance with the set character can trigger the process.

Before selecting **Camera** as the image source, you need to click [camera icon] in Toolbar to create a global camera.

Image Source Parameters	
Connected Camera	The global camera created before connection
Exposure Control	When this function is used in conjunction with a script, you can use some logics to control the exposure value as needed; in addition to binding the script output, it can also bind other module data output, but only the float type data.
Gain Control	Refer to Exposure Control
Output Mono8	It can output a gray image while outputing the color image after being enabled.

⚠ NOTICE

- It is necessary to set general parameters of the camera when the preview is stopped, and it is recommended to adjust the parameters on the MVS client before synchronizing to the VisionMaster client.
- Only the camera supporting multicast can perform real-time streaming.
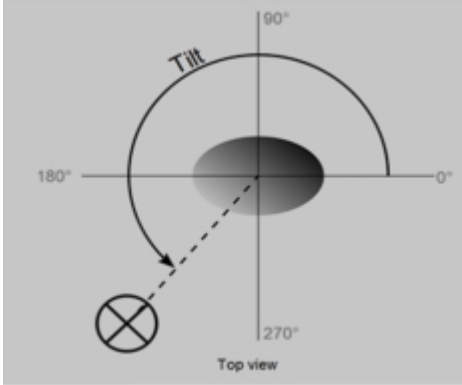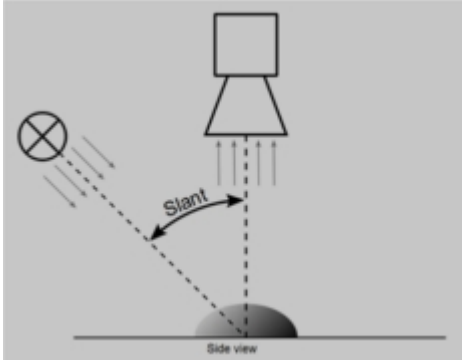
4.1.2 **Multi-image Acquisition**

Drag this module to the process editing area. You can get local images data or multiple images with different angles and brightness captured by camera and light source after double-clicking corresponding configured parameters.
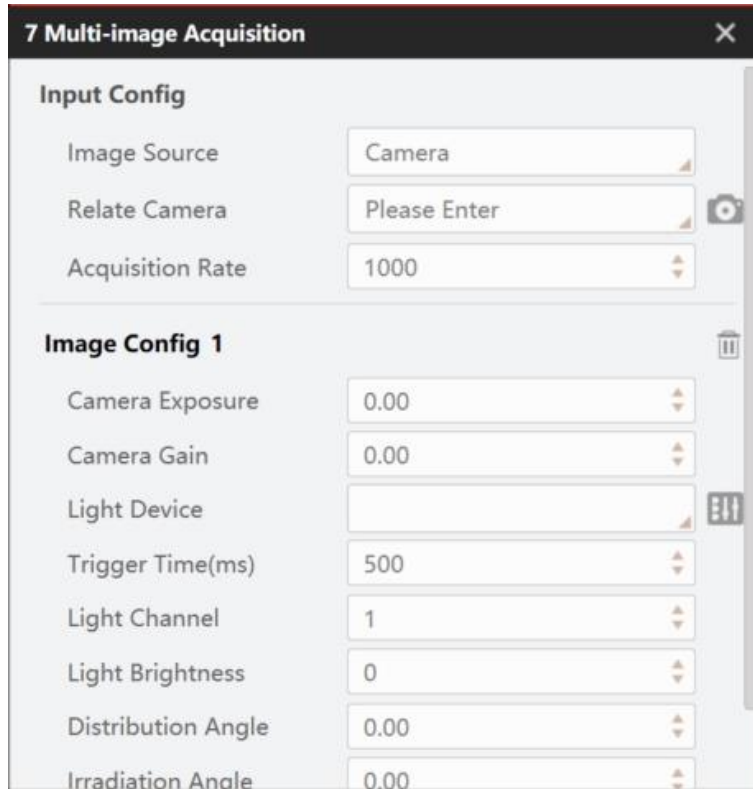
Before selecting **Camera** in the image source, you can click in the toolbar to create global camera. Refer to Camera Management for details.

Input Configuration	
Image Source	It can be set as local image or camera image.
Associated Camera	If the Image Source is set as camera, the corresponding global camera can be associated.
Fetch Intervals	You can set the time interval between two image fetches and the unit is ms.
Fetch Quantity	If the Image Source is set as local image, the fetch quantity can be set here from 3 to 8.
Image Path	You can set the path of image.
Image Configuration	
Camera Exposure	Improve the brightness by increasing exposure.
Camera Gain	Without increasing the exposure value, improve the brightness by increasing gain.
Light Source Device	The associated corresponding light source device can be set.
Trigger Time (ms)	Trigger time of light source can be set.
Light Source Channel	The corresponding light source channel can be selected.
Light Source Brightness	The corresponding light source brightness of the corresponding channel can be controlled.
Distribution Angle	As shown in the figure (Refers to the distribution of the multiple cameras.)

Illumination Angle	As shown in the figure (Refers to the erection of the camera.)

 NOTICE

- Set the common parameters of the camera when stopping the preview. It is recommended to adjust the parameters on the MVS client before synchronizing them to the VisionMaster client.
- Only cameras that support multicast can obtain stream in real time

4.1.3 Image Output

Drag the **Image Output** module to the process editing area. Double click and configure the corresponding parameters. You can run the process and save the global camera images, local images or the images processed by the image processing tool. The specific parameters are as shown below.
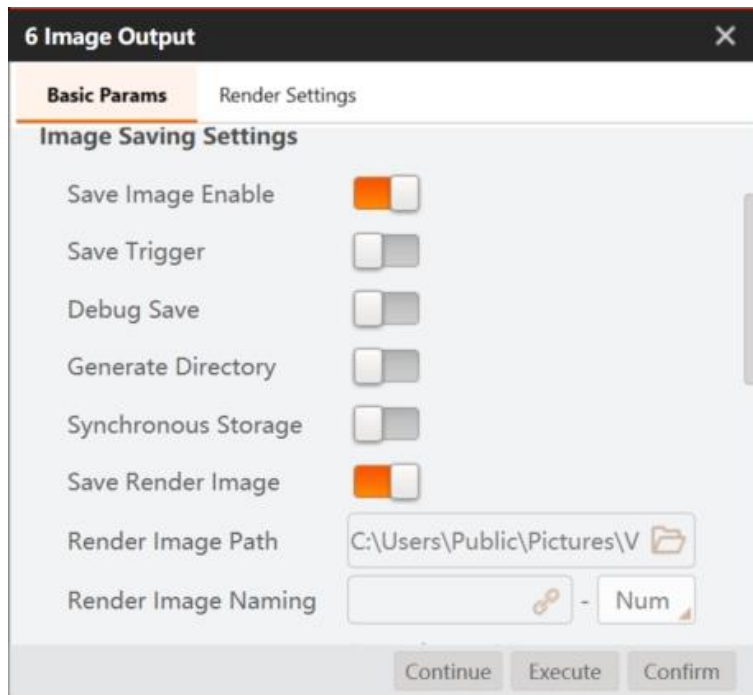
Output Image	
Input Source	Select the saved image source, mainly including images from image source in the solution or images processed by other modules.
Save Image Enable	It is off by default, at this time, the output image module only realizes the function of output image, and the specific parameters of the module can be configured by opening save image enable. At the same time, the image can be stored.
Save Trigger	Trigger variable binds with the condition testing results generally and stores the image s according to storage conditions.
Debug Save	Save the binary data.
Generate Directory	After enabling, you can create a folder according to the month and date, and save the images in the created folder.
Synchronous Storage	After enabling, you can storage images in real time.
Save Render Image	After enabling, you can save the rendered images in the rendering path.
Render Image Path	Path of custom storage the rendering.
Render Image Naming	You can set the name for render image.
Render Image Cache	It is the max. image quantity can be storage in cache.
Save Original Image	After enabling, you can save the original image in the original image path.
Original Image Path	Path of custom storage the original image.
Original Image Naming	You can set the name for original image.
Original Image Cache	It is the max. image quantity can be storage in cache.
Number of Images Buffer	The maximum number of images in the buffer queue when storing images asynchronously.
Save Mode	You can choose to cover the previous image or stop saving the image when the maximum storage quantity is reached or the disk space is insufficient.
Disk Freespace	Set the remaining space of the target disk. If the remaining disk space reaches the

	set value, it will be stored according to the mode set by the storage mode.	
Storage Unit	Optional MB or GB.	
Max. Storage Days	Set the time of automatically deleting the storage images.	
Save Format	BMP and JPEG	
File Naming	You can customize the prefix or set module data as the prefix before subscription, and the serial number of date as the suffix, such as IMG-1. The naming format will change with the module status when adopting trigger saving image, such as IMG-OK-1.	
Pixel Format	Optional Mono8 or RGB24	
Image Magnification Type	Original Image Size	
	Interface Size	Images and fonts are stored according to the size of the interface.
	Custom Magnification	When saving the image, the line width magnification refers to the line width of the positioning box, and the font width refers to the magnification of the font.
Rendering Parameters		
Text Setting Content	You can choose to store the text information rendered on the image in the hard disk.	
Color	You can change the color of the rendering information.	
Word Size	You can change the word size of the rendering information.	
Position X/Y	You can change the location of horizontal and vertical coordinates of the rendering information.	
Previous Storage Settings	When the previous item storage enabled, the output result of the previous module can be stored, such as outputting the image containing the circle search result and other text information.	

4.1.4 Image Buffer

Image buffer can be used for debugging functions of solutions. When some sample images are misjudged, the image buffer can be used to cache the image.

When this function is enabled, the process can cache one image at a time, and a maximum of 15 images can be cached. The new image cache will overwrite the previous image. The data source of the subsequent processing module can be bound to anyone of the 15 cached images, which facilitates the traceability of the process of program debugging.

In Image Buffer, 0 means disable, 1 means enable, and 1 is selected by default when there is no binding data. The specific usage is shown as below.
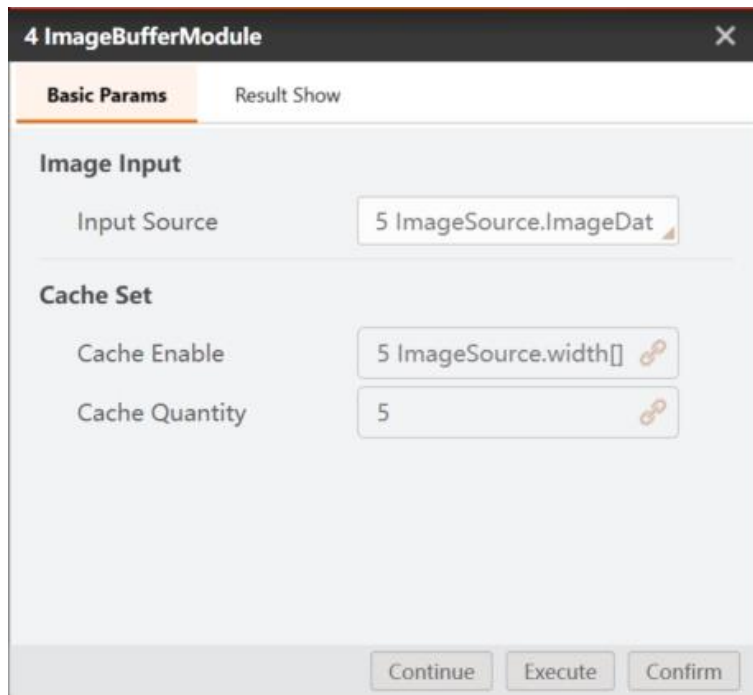
4.1.5 **Light Source**

Refer to Controller Management for light source creation. After the light source is successfully created, you can directly call the light source in the module of process.

- Set Light Source to be Constant: Enable the light source, adjust the brightness and put the light source module in front of the light source module.

- Set Light Source to be Strobe: Put one light source module in front of and behind the light source respectively. Use format module to output OK or NG. Enable the former light source, and disable the latter light source.
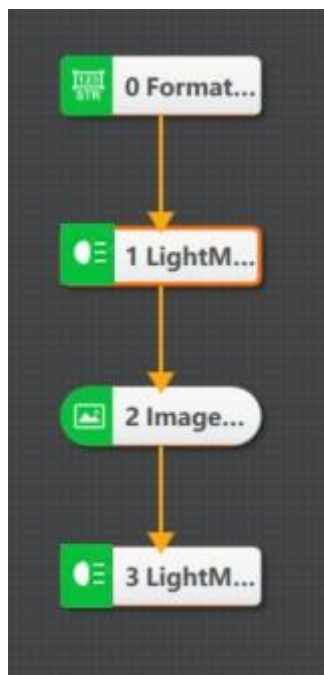
Channel Parameters	
Output Type	It is optional to output when OK and when NG.
Trigger Character	It refers to whether the subscription module status triggers the light source. OK or NG can be input manually according to the output type.
Trigger Time	Duration of constant light source after trigger.

⚠ NOTICE

After setting the triggering time for the light source module, do not trigger the second time within the set time after the first trigger, otherwise the light source will be turned off in advance.

4.2 **Location**

The positioning tools mainly include 20 tools in the figure below, and are mainly used to locate or detect some features in the image.
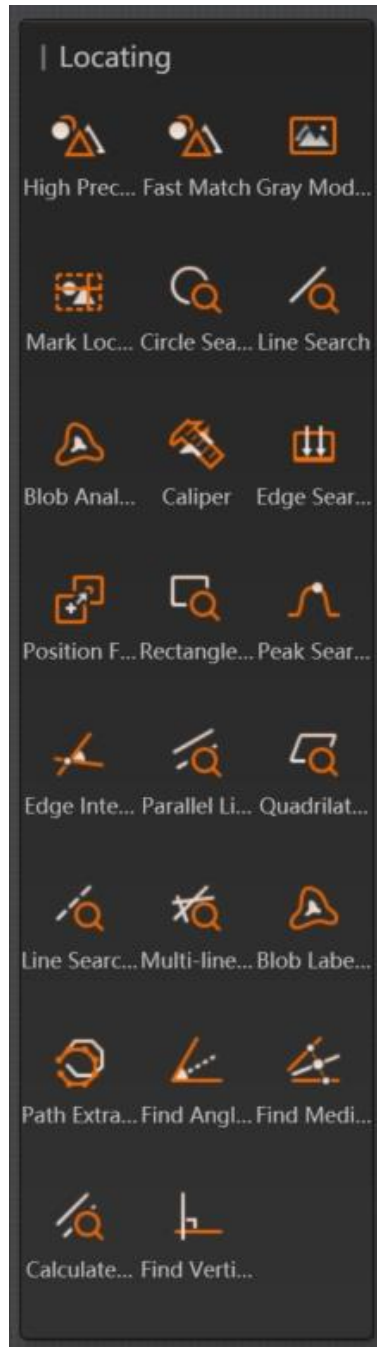
4.2.1 Feature Match

Overview

Feature matching is divided into fast match and high-precision match. This tool uses the edge features of the image as the template, confirms the search space in accordance with the preset parameters, and searches targets that are similar to the template among images. This tool can be used for locating, calculating and verifying. Double-click feature matching module to set parameters. These parameters include basic parameters, feature template, operation parameters, result display, etc. For basic parameters and result display, you can refer to Tool Application. This section introduces feature template and operation parameters.

High-precision match has higher precision and more refined setting features, but it consumes longer time than fast match, as shown below.
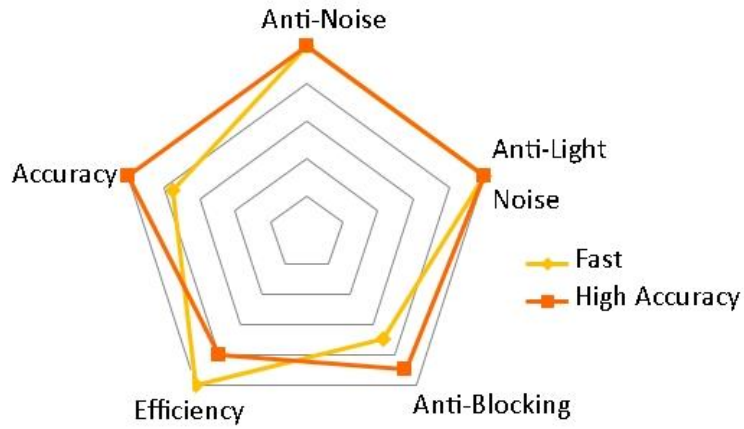
Algorithm Principle

Template matching refers to the handling method of searching the corresponding mode in an image. At a word, the template is a known and small image, and template matching means searching the target in the big image, as shown below.
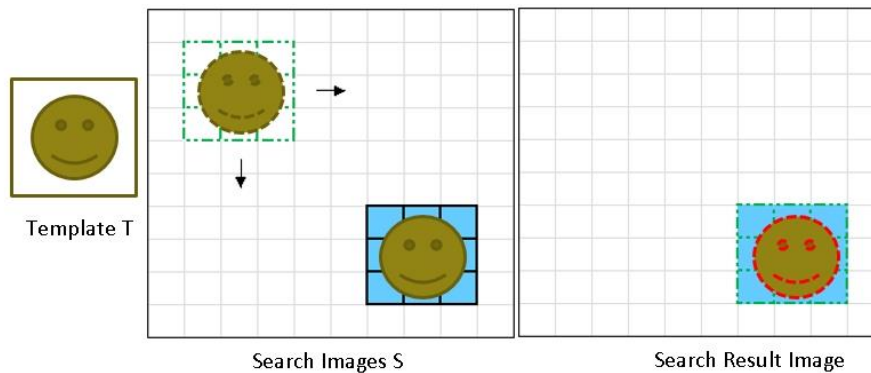
$$L^* = \arg\max_{L}(S(l_i))$$

$l_i \in L = \{l_1, l_2, \cdots\}$

l_i means position $x, y, \theta, size_o, size_x, size_y$

Fast Match

1. Feature Template

The feature template is used to extract image features. For initial use, you need to edit its template. Select the template area that needs to be edited, and click the training model after setting parameters, as shown below. You can enable **Template Image Saving** to save the template image when saving the template.
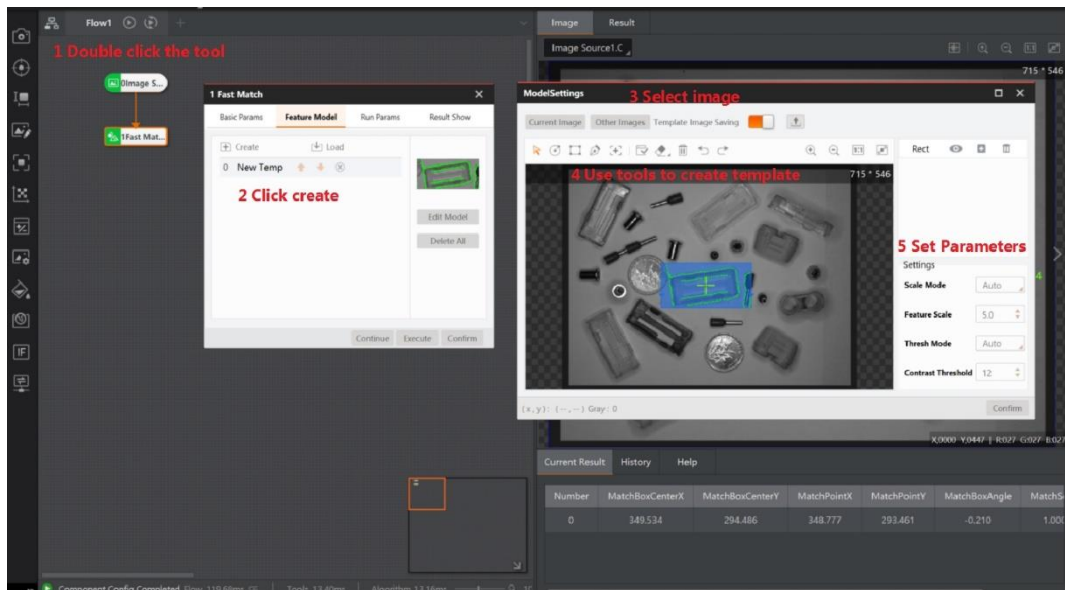
The shortcuts shown in area 4 mean moving image, creating fan circle mask, creating rect mask, creating polygon mask, selecting model match center, building model, erasure contour point, clearing all model ling area, undo and back from left to right.

Template Match

- **Match Point:** it is used to create location standard. Click **Select Model Match Center**, and set match point by yourself.

- **Scale Mode:** when its auto mode can meet demands, it will not adjust. If not, it will switch to manual mode.

- **Roughness scale:** the higher the roughness scale parameter, the greater feature scale, and its respective edge points will be sparse. But, in this way, it can speed up feature matching speed, and the range is 1 to 20 by default. When the value is 1, it means the finest. After adjustment, the contour point quantity will change, as shown below.

Feature Scale =1 · · · · · · · · · Feature Scale=4 · · · · · · · · · Feature Scale=8

- **Threshold Mode:** when its auto mode can meet demands, it will not adjust. if not, it will switch to manual mode.

- **Contrast Threshold**: it means the contrast value. It is related with feature points and gray value of background. The larger the value, more feature points will be eliminated, and the range is 1 to 255 by default.

2. Running Parameters

It is used to set parameters of feature match in order to set search space. The targets in specific search space can be searched only, as shown below.

(1) Basic Parameters

- **All Search Mode:** all the templates are matched after enabling and output the optimal results.

- **Min. Match Score:** the match score means the similarity between feature template and target in searched images. It is also called as similarity threshold. Only when the target's similarity reaches similarity threshold, it can be searched out. The max. value is 1 which means totally matched, and it is 0.5 by default.

- **Max. Match Number:** it is the max. target quantity can be searched. It is 1 by default and the range is 1 to 200.

- **Match Polarity:** polarity means the color transition from feature image to background. When the edge polarity of the searched target does not match with feature template polarity, but you want to make sure the target is searched, then you need to set match polarity as ignored. if not, you can set as considered, and search time can be reduced.

- **Angle Range:** it means the angle changing range when comparing the target and created template. If you want to search the proactive target, and then you need to set respectively, and the default range is -180° to 180°.

- **Scale Range:** it means scale changing range when comparing the target and created template. If you want to search the target with same scale changing, and then you need to set respectively, and the default range is 1.0 to 1.0.

(2) Advanced Parameters

- **Max. Overlap Rate:** when searching for multiple targets, two detected targets overlapping with each other, and the maximum overlap ratio allowed by the matching frames is overlap threshold. The larger the value, the greater the degree of overlapping between the two targets. The range is 0° to 100° and it is 50 by default.

Matching with Template   Result

- **Sort:**
    - Sort by score in descending order: sorted by the score of the feature match in descending order.
    - Sort by angle in descending order: in descending order of relative angular deviation in the current result.

- Sort by X from small to large: the current result has the X coordinate of the matching box center. According to the X coordinate, the order is rounded up from small to large. When the X coordinates are the same, then is sorted by Y from big to small, and the Y axis has the same operation with X axis.

- X is from small to large, and Y is from small to large too: the current result has the matching box center X/Y coordinates. According to the X coordinate, the order is rounded up from small to large. When the X coordinates are the same, then the order is sorted according to Y from small to large.

- **Threshold Type:**

  - Automatic threshold: it automatically determines the threshold parameter according to the target image.

  - Template threshold: it uses the contrast threshold of the template as the contrast threshold in matching phase.

  - Manual threshold: it uses the threshold set by the user as the threshold parameter for searching.

- **Clutter Considered:** If mottle considered is enabled, the algorithm will consider the mottle feature. If the feature has burrs, the score will decrease.

- **Extension Threshold:** it is the ratio that the portion of missing feature compared with the complete feature when the image is incompletely displayed at the edge of the image. When the searched target appears in the edge of the image, the extension threshold can make sure the image is found. As long as the value of setting extension threshold is larger than 30, it is guaranteed that the top target graph can be searched.

- **Timeout Control:** When the time exceeds the time set by the overtime control, the search will stop and no search result will be returned. The value range of overtime control is 0 ms to 10000 ms, and 0 means that the overtime control is disabled.

- **Contour Enabled:** if contour enabled is enabled, the contour feature points of the template are displayed. If it is disabled, the feature points are not displayed, and only the matching frame is displayed, which can reduce operation time.

3. Output Results

- **Matching Box Center X:** X coordinate of matching box center.

- **Matching Box Center Y:** Y coordinate of matching box center.

- **Matching Point X:** X coordinate of matching point.

- **Matching Point Y:** Y coordinate of matching point.

- **Angle:**

Example: Build the feature template with Image 1, take matching point as original point. Matching point changes with the target image. Angle is the rotation angle of the matched target image compared with the feature image. After clockwise rotation, the angle is positive; After counterclockwise rotation, the angle is negative. The angle change of the target image with No. 3 compared with the feature image is 110.192°.

Number	MatchBoxCenterX	MatchBoxCenterY	MatchPointX	MatchPointY
0	1336.462	529.727	1335.977	529.828
1	1174.891	279.995	1174.779	280.477
2	869.608	200.528	869.868	200.949

- **Scale:** the consistency scale change multiple of the matching target relative to the created template.

- **Score:** match score.

High-Precision Match

1. Feature Template

The feature template of high-precision match is similar to that of fast match. Create the feature template in accordance with the specific methods of fast match above, and the specific parameters are listed as below.

Template Match

- **Match Point:** it is used to create location standard. Click **Select Model Match Center**, and set match point by yourself.

- **Scale Mode:** when its auto mode can meet demands, it will not adjust. if not, it will switch to manual mode.

- **Roughness scale:** the higher the roughness scale parameter, the greater feature scale, and its respective edge points will be sparse. But, in this way, it can speed up feature matching speed, and the range is 1 to 20 by default.

- **Threshold Mode:** when its auto mode can meet demands, it will not adjust. if not, it will switch to manual mode.

- **Contrast Threshold**: it means the contrast value. It is related with feature points and gray value of background. The larger the value, more feature points will be eliminated, and the range is 1 to 255 by default.

2. Running Parameters

You can set parameters of high-precision feature match in order to set search space. Only the targets in specific search space can be searched, as shown below.

(1) Basic Parameters

- **All Search Mode:** all the templates are matched after enabling and output the optimal results.

- **Min. Match Score:** the match score means the similarity between feature template and target in searched images. It is also called as similarity threshold. Only when the target's similarity reaches similarity threshold, it can be searched out. The max. value is 1 which means totally matched, and it is 0.5 by default.

- **Max. Match Number:** it is the max. target quantity can be searched. It is 1 by default and the range is 1 to 200.

- **Match Polarity:** polarity means the color transition from feature image to background. When the edge polarity of the searched target does not match with feature template polarity, but you want to make sure the target is searched, then you need to set match polarity as ignored. if not, you can set as considered, and search time can be reduced.

- **Angle Range:** it means the angle changing range when comparing the target and created template. If you want to search the proactive target, and then you need to set respectively, and the default range is -180° to 180°.

- **Scale Range:** it means scale changing range when comparing the target and created template. If you want to search the target with same scale changing, and then you need to set respectively, and the default range is 1.0 to 1.0.

(2) Advanced Parameters

- **Max. Overlap Threshold:** when searching for multiple targets, two detected targets overlapping with each other, and the maximum overlap ratio allowed by the matching frames is overlap threshold. The larger the value, the greater the degree of overlapping between the two targets. The range is 0° to 100° and it is 50 by default.

- **Sort:**
    - Sort by score in descending order: sorted by the score of the feature match in descending order.
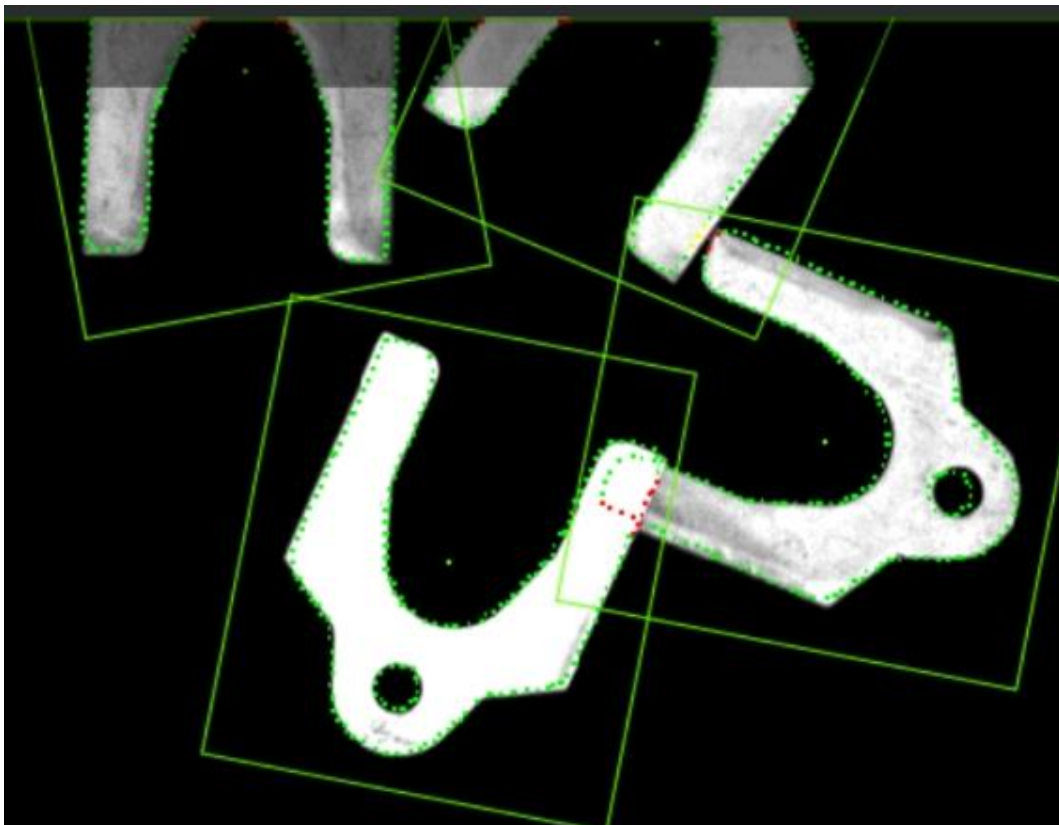   - Sort by angle in descending order: in descending order of relative angular deviation in the current result.
    - Sort by X from small to large: the current result has the X coordinate of the matching box center. According to the X coordinate, the order is rounded up from small to large. When the X coordinates are the same, then is sorted by Y from big to small, and the Y axis has the same operation with X axis.
    - X is from small to large, and Y is from small to large too: the current result has the matching box center X/Y coordinates. According to the X coordinate, the order is rounded up from small to large. When the X coordinates are the same, then the order is sorted according to Y from small to large.

- **Threshold Type:**
    - - Automatic threshold: it automatically determines the threshold parameter according to the target image.
    - - Template threshold: it uses the contrast threshold of the template as the contrast threshold in matching phase.
    - - Manual threshold: it uses the threshold set by the user as the threshold parameter for searching.

- **Clutter Considered:** If mottle considered is enabled, the algorithm will consider the mottle feature. If the feature has burrs, the score will decrease.

- **Extension Threshold:** it is the ratio that the portion of missing feature compared with the complete feature when the image is incompletely displayed at the edge of the image. When the searched target appears in the edge of the image, the extension threshold can make sure the image is found. As long as the value of setting extension threshold is larger than 30, it is guaranteed that the top target graph can be searched.

- **Timeout Control:** When the time exceeds the time set by the overtime control, the search will stop and no search result will be returned. The value range of overtime control is 0 ms to 10000 ms, and 0 means that the overtime control is disabled.

- **Contour Enabled:** if contour enabled is enabled, the contour feature points of the template are displayed. If it is disabled, the feature points are not displayed, and only the matching frame is displayed, which can reduce operation time.

3. Output Results

- **Matching Box Center X:** X coordinate of matching box center.

- **Matching Box Center Y:** Y coordinate of matching box center.

- **Matching Point X:** X coordinate of matching point.

- **Matching Point Y:** Y coordinate of matching point.

- **Angle:** it is the same as the output angle of fast feature match, you can refer to fast feature match.

- **Scale:** the consistency scale change multiple of the matching target relative to the created template.

- **Scale X/Y:** zoom multiple along X/Y direction, the result output in the high-precision only.

- **Score:** match score.

4.2.2 Greyscale Match

Greyscale match is used to build template bases on greyscale of each pixel, and matches objects that have similar greyscales. It can realize precise matching and locating when there are multiple similar objects and their greyscales are quite different, or images are blurred with unclear contour points.
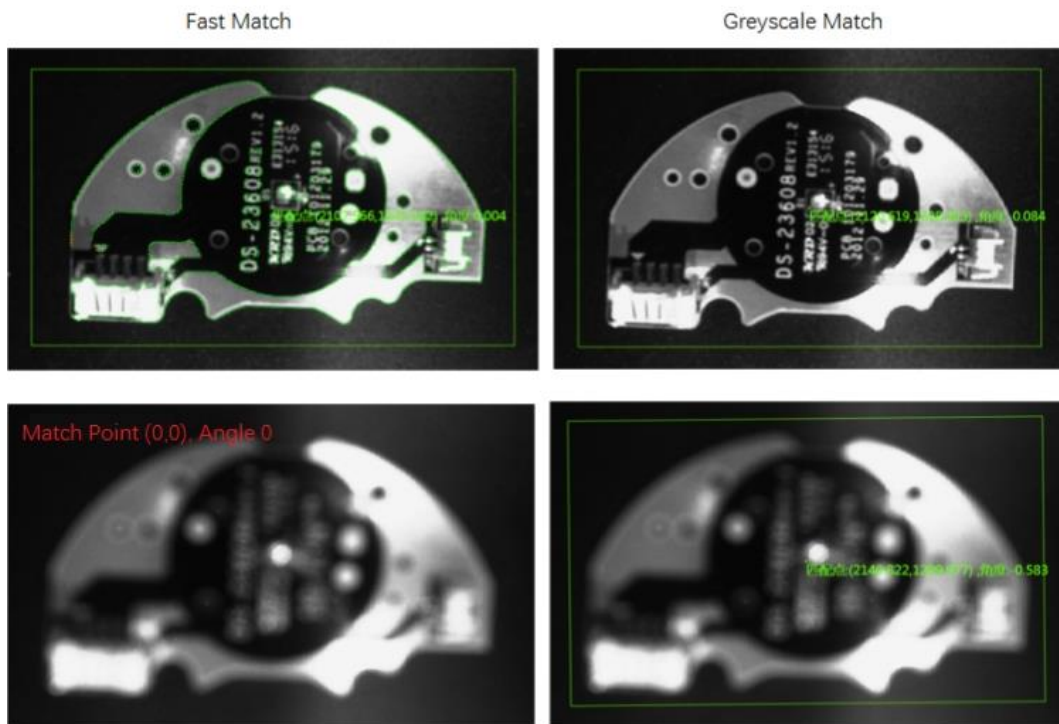
The main modeling process, using method and parameter configuration of greyscale match are the same as those of Feature Match. Part of parameters are listed as follows.

- **Template Configuration**

- **Numb Level:** Use the template to build the highest numb level, the higher level, the faster search speed and larger match missing probability. However, the numb level is not recommended to be below 3, the defaulted value is 5 and the range is from 1 to 8.

- **Run Parameter**

    - **Min. Match Score:** Match score (similarity threshold) refers to the similarity between the feature template and the target searched in the image. Only when the object similarity reaches the threshold, it can be searched. The maximum value is 1, which represents certainty.

    - **Max. Match Number:** The maximal number of objects that are allowed to be found. The defaulted value is 1 and the range is from 1 to 200.

    - **Angle Step:** In matching with angle freedom degree, the angle step refers to the angle step of each rotation when searching. The greater the value, the faster the speed and larger match missing probability. The defaulted value is 8.

    - **Angle Range:** Refers to the angle changing range of the wait-for-matched object and created template. Set corresponding settings to search an object with rotation changes. The defaulted range is from -180° to 180°.

    - **Max. Overlap Ratio:** Refers to the maximal overlapping ratio of objects' matching boxes when these two objects are overlapped. The greater the value, the lager the overlapping range. The range of it is from 0 to 100.

    - **Sort Type:** Sort by Score, Angle, X, Y, etc.

    - **Match Polarity:** Polarity refers to the transition situation of greyscale module images and internal matched images. When the transition situation of the searched image color disagrees with the template image, selecting Ignored to ensure the target can be found. However, generally you should select Considered.

    - **Overtime Control:** Controls the searching time. When the time exceeds the set time, searching stops, no result will be sent back. The value ranges from 0 to 10000 (ms), 0 represents disable this function.

4.2.3 Mark Location

Mark location tool includes cross positioning and rectangular positioning and it mainly applies to the locating of cross image and rectangular image, as shown below.
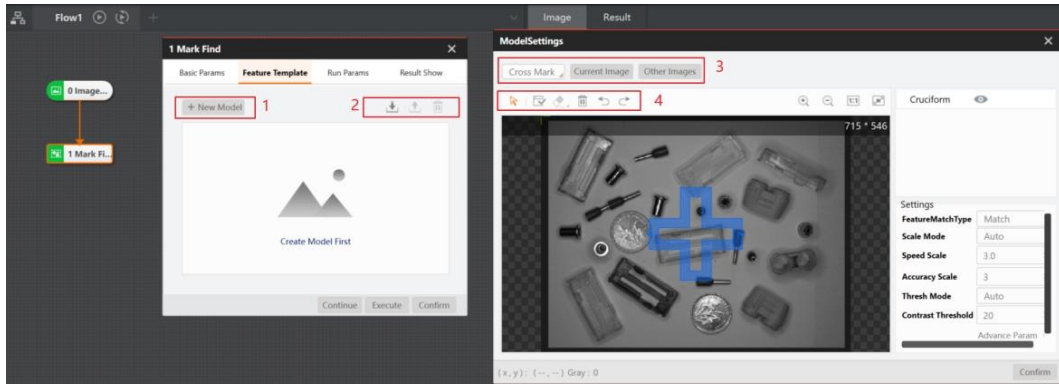
⚠ NOTICE

The cross mask includes the hollow cross and solid cross. Select mask graphic according to the shape of graphic and the edge of detected graphics must be included in the blue area of drawing ROI when you draw the cross/rectangular ROI.

Feature Template

You can extract the image features by creating the feature template. For initial template configuration, you need to click **New Model,** as shown below.
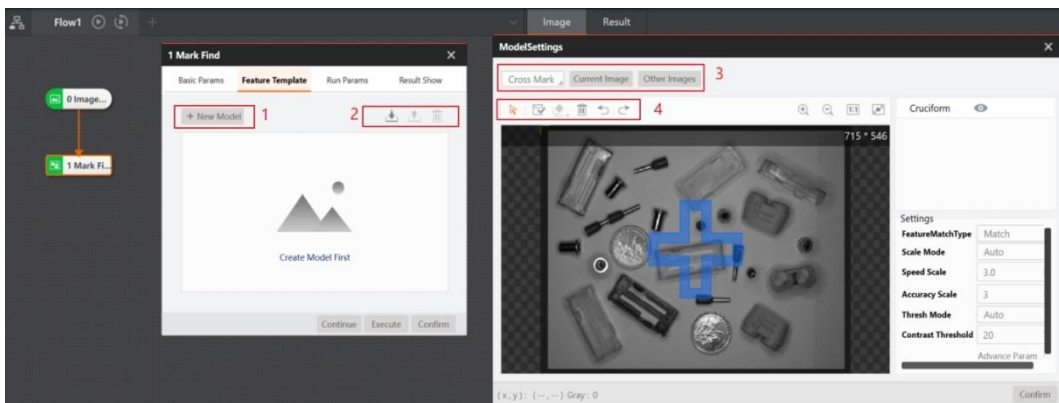
1. You can configure the parameters of graphics location module and feature templates by double-clicking graphics location module. Click **New Model** in Area 1 when you create templates for the first time and create a new template.

2. You can click ⬇ and 🗑 in Area 2 for loading and deleting the template created.

3. Area 3 is for selecting mask shape. You can select cross shape masks when positioning the cross image, and select rectangle masks when positioning the rectangle image.

4. Move image, generate model, erase contour points, clear the mask of erasing contour points, cancel and back are the operations in order from left to right in Area 4.

Template Match

- **Location Mode:** Fast location and high precision location can be selected, and the selection basis refers to feature match.

- **Scale Mode:** it includes auto mode and manual mode. When its auto mode can meet demands, it will not adjust. If not, it will switch to manual mode.

- **Roughness scale:** the higher the roughness scale parameter, the greater feature scale, and its respective edge points will be sparse. But, in this way, it can speed up feature matching speed, and the range is 1 to 20 by default. When the value is 1, it means the finest. After adjustment, the contour point quantity will change, as shown below.

- **Fine Scale:** only supports the positioning mode of selecting high precision, which represents the fine degree of extracted feature particles. It is less than or equal to the rough ness scale, which is only an integer. When the fine scale value is 1, the fine degree is the largest, the number of edge points is the largest, and the precision is the highest.

- **Threshold Mode:** when its auto mode can meet demands, it will not adjust. if not, it will switch to manual mode.

- **Contrast Threshold**: it means the contrast value. It is related with feature points and gray value of background. The larger the value, more feature points will be eliminated, and the range is 1 to 255 by default.

- **Rotation Angle:** It means the angle threshold between the mask and the image to be detected. If the result is not successfully matched during modeling, it is recommended to increase the rotation angle.

- **Rotation Step:** the range is 0.1 ° to 1 °, and it is recommended to use the defaulted value.

- **Projection Interval:** the range is 1 to 10. If the number of matching points detected during modeling is small, it is recommended to increase the projection interval

- **Mark Type:** According to the selection of the tested image, when the image is a hollow cross, the mark type selects a hollow cross in principle, vice versa.

Running Parameters

You can configure various parameters of the graphics positioning module and restrict the positioning conditions, so as to better meet your needs.

(1) Basic Parameters

- **Min. Match Score:** the match score means the similarity between feature template and target in searched images. It is also called as similarity threshold. Only when the target's similarity reaches similarity threshold, it can be searched out. The max. value is 1 which means totally matched, and it is 0.5 by default.

- **Max. Match Number:** it is the max. target quantity can be searched. It is 1 by default and the range is 1 to 200.

- **Match Polarity:** polarity means the color transition from feature image to background. When the edge polarity of the searched target does not match with feature template polarity, but you want to make sure the target is searched, then you need to set match polarity as ignored. if not, you can set as considered, and search time can be reduced.

- **Angle Range:** it means the angle changing range when comparing the target and created template. If you want to search the proactive target, and then you need to set respectively, and the default range is -90° to 90°.

- **Scale Range:** it means scale changing range when comparing the target and created template. If you want to search the target with same scale changing, and then you need to set respectively, and the default range is 1.0 to 1.0.

(2) Advanced Parameters

- **Location Type:** direct mapping and secondary correction can be selected. Direct mapping takes short time, low precision, and secondary correction takes long time and high precision.

- **Max. Overlap Threshold:** when searching for multiple targets, two detected targets overlapping with each other, and the maximum overlap ratio allowed by the matching frames is overlap threshold. The larger the value, the greater the degree of overlapping between the two targets. The range is 0 to 100 and it is 50 by default.

- **Sort:**
    - Sort by score in descending order: sorted by the score of the feature match in descending order.
    - Sort by angle in descending order: in descending order of relative angular deviation in the current result.
    - Sort by X from small to large: the current result has the X coordinate of the matching box center. According to the X coordinate, the order is rounded up from small to large. When the X coordinates are the same, then is sorted by Y from big to small, and the Y axis has the same operation with X axis.
    - X is from small to large, and Y is from small to large too: the current result has the matching box center X/Y coordinates. According to the X coordinate, the order is rounded up from small to large. When the X coordinates are the same, then the order is sorted according to Y from small to large.

- **Threshold Type:**
    - Automatic threshold: it automatically determines the threshold parameter according to the target image.
    - Template threshold: it uses the contrast threshold of the template as the contrast threshold in matching phase.
    - Manual threshold: it uses the threshold set by the user as the threshold parameter for searching.

- **Clutter Considered:** If mottle considered is enabled, the algorithm will consider the mottle feature. If the feature has burrs, the score will decrease.

- **Extension Threshold:** please refer to the configured parameters of feature matching.

- **Timeout Control:** When the time exceeds the time set by the overtime control, the search will stop and no search result will be returned. The value range of overtime control is 0 ms to 10000 ms, and 0 means that the overtime control is disabled.

- **Contour Enabled:** if contour enabled is enabled, the contour feature points of the template are displayed. If it is disabled, the feature points are not displayed, and only the matching frame is displayed, which can reduce operation time.

Results Display

You can set several judgment conditions of the results in **Results Display.**

- **Quantity Judgment:** After opening, you can set the quantity range of matching results. If the number of matching results is within the quantity range, the module is OK; and if it is not within the quantity range, the module is NG.

- **Angle Judgment:** After opening, you can set the angle range of matching results, and the range is -180 ° to 180 ° by default. If the angle of output results is within the quantity range, the module is OK; and if it is not within the angle range, the module is NG.

- **X Scale Judgment:** in the output results, if X scale is within the range, the module is OK, otherwise the module is NG.

- **Y Scale Judgment:** it is the same as **X Scale Judgment**.

- **Score:** it is similar score and means the degree of similarity degree of template and image detected.

- **Matching Point X/Y Judgment, Center Point X/Y Judgment:** X coordinate of matching point.

- **Text Display:** Text content, color, font size and location displayed can be edited.

- **Output Results:** you can refer to the **Feature Matching**.

4.2.4   Circle Search

The tool of circle search detects multiple edge points first, and then fits them into a circle. This tool is used for location and measurement of circles. The basic parameters and result display have been explained in Tool Application. This section mainly describes the running parameters.
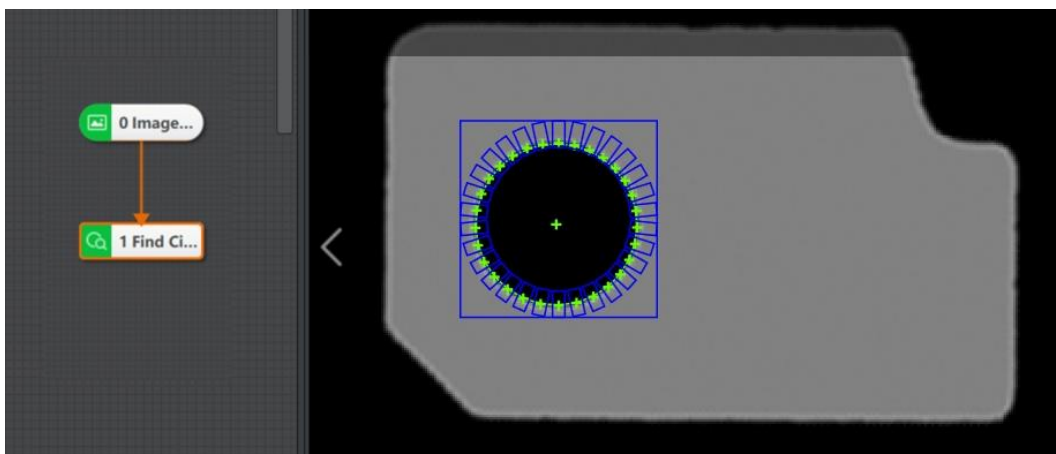
Running Parameters

- **Sector Radius:** it means the radius of inner and outer circle of the ring ROI.

- **Edge Type:**

- **Strongest Edge:** only the edge point set with the largest gradient in the scanning range is detected and fitted into a circle.

- **Last Edge:** only the edge point set with the largest distance from the center of the circle within the scanning range is detected and fitted into a circle.

- **First Edge:** only the set of edge points with the smallest distance from the center of the circle within the scanning range is detected and fitted into a circle.

- **Edge Polarity:** it has three modes, including dark to light, light to dark and any.

  - Dark to light: it means that the transition from the area with a low gray value to the edge of the area with a high gray value.

  - Light to dark: it means the transition from the area with a high gray value to the edge of the area with a low gray value.

  - Any means both edges are detected.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Calipers Number:** it is used to scan ROI area quantity of edge points, as shown below.

- **Reject Number**: It means that the number of minimum points that have high error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with the parameter of distance to remove.

- **Initial Locating**: If it is enabled, combined with the circular location sensitivity and subsampling coefficient settings, this parameter can roughly determine that the center of the area closer to the circle in the ROI area used as the initial circle center, which is convenient for subsequent fine circle search. If the initial location is disabled, the ROI center is the initial circle center by default. Under normal circumstances, the previous module of finding circle is position correction, it is recommended to disable this parameter.

- **Subsampling Coefficient:** it is also called downsampling, which means that the number of sampling points is decreased. For an image of N*M, if the subsampling coefficient is K, then one dot is taken every K points of each row and column in the original image to create an image. Therefore, the larger the subsampling coefficient, the more sparse the contour points will be, and the less detailed contour will be. It is recommended that the value should not be set too large.

- **Circle Locating Sensitivity:** it is used to eliminate the interference points. The larger the value, the stronger the ability to eliminate noise interference, but it is also easy to cause the initial location of circle failure.

- **Distance to Remove**: It means that the maximum pixel distance from the outlier to the fit circle. The smaller the value, the more points are excluded.

- **Projection Width**: In the ROI, several edge points are distributed in a circle to search for the ROI. This parameter describes the width of the area where the edge points are scanned for the ROI. Increase the value within a certain range to obtain more stable edge points.

- **Initial Fit**: It has two types, including global and partial fit.

  - Partial: Local optimization is to fit the circle according to the local feature points. If the local feature more accurately reflects the position of the circle, the local optimization is adopted, otherwise the global optimization is adopted.

  - Global: circle fit with the found global feature points.

- **Fit Mode**: It has three types, including least squares, huber and tukey.The three fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, the least squares, Huber and Tukey can be used step by step.

⚠ NOTICE

You can use this tool to search only one circle at one time. If you want to search multiple circles, it is recommended to use it together with the loop function.

4.2.5 Line Search

The tool of line search is used to search a line with certain features in the image. It forms feature point groups using known feature points, and then fits into a line. The basic parameters and result display have been explained in Tool Application. This section mainly describes the running parameters. For the parameters not mentioned, refer to Circle Search.
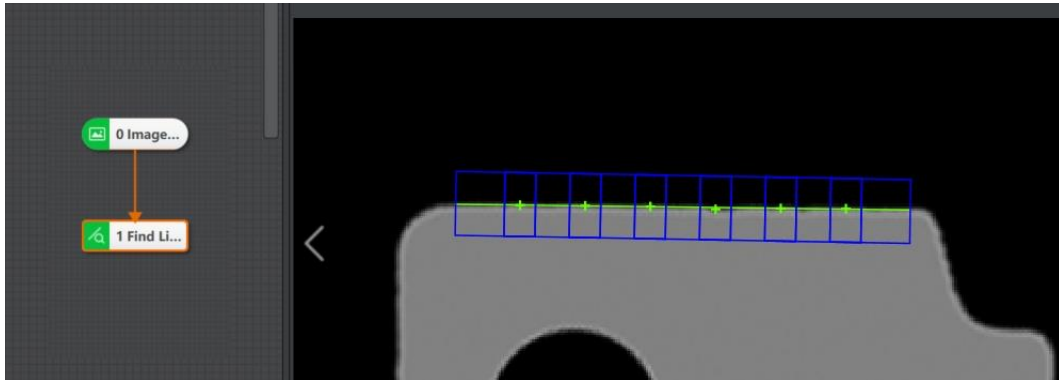
Running Parameter

- **Edge Type**: It includes strongest edge, last edge and first edge.

    - Strongest Edge: find the edge point group with the largest gradient threshold, and then fit it into a straight line.

    - Last Edge and First Edge: find the first / last line that meets the condition.

- **Edge Polarity:** it has three polarities, including dark to light, light to dark and any.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Filter Size:** It can filter the noise. The larger the value, the stronger the anti noise ability, and the less the number of edges obtained. At the same time, it may also cause the target edge to be screened out.

- **Caliper Number**: The edge points are clamped by multiple calipers to define the number of calipers.

- **Revert Find Orient**: After enabling it, the software will revert the information of line start point and line end point.

- **Angle Normalization**: After enabling, the angle of outputted line is -90° to 90°. if it is not enabled, the angle of outputted line is -180° to 180°.

- **Reject Number**: Refer to Find Circle.

- **Distance to Remove**: Refer to Find Circle.

- **Projection Width**: It is the caliper width, several searched edge points are arranged in order in the ROI. This parameter describes the width of the area where the edge points are scanned for the ROI.Increase the value within a certain range to obtain more stable edge points .
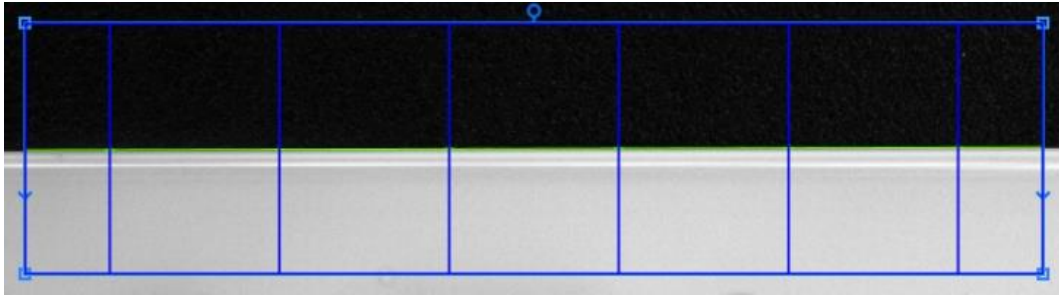
- **Initial Fit**: Refer to Find Circle.
- **Fit Mode**: Refer to Find Circle.

Output Result

- **Starting Point X/Y**: X and Y coordinates of the starting point of the line
- **End Point X/Y**: X and Y coordinates of the end point of the line
- **Line Angle**: The angle of the line relative to the horizontal line
- **Fit Error**: The RMS error calculation method is adopted for the straight line fit error. As shown below, d is the distance between the fit point and the standard straight line, and n is the number of fit points.

$$\sqrt{\frac{\sum_{i=1}^{n}(d_i)^2}{n}}$$

4.2.6 Blob Analysis

Blob analysis is a process of detecting, locating, or analyzing a target object in an image area where the pixel is at a limited gray level. The Blob tool provides information about certain features of the target object in the image, such as presence, quantity, position, shape, orientation and topological relations between blobs. The basic parameters and result display have been explained in Tool Application. This section mainly describes the running parameters.
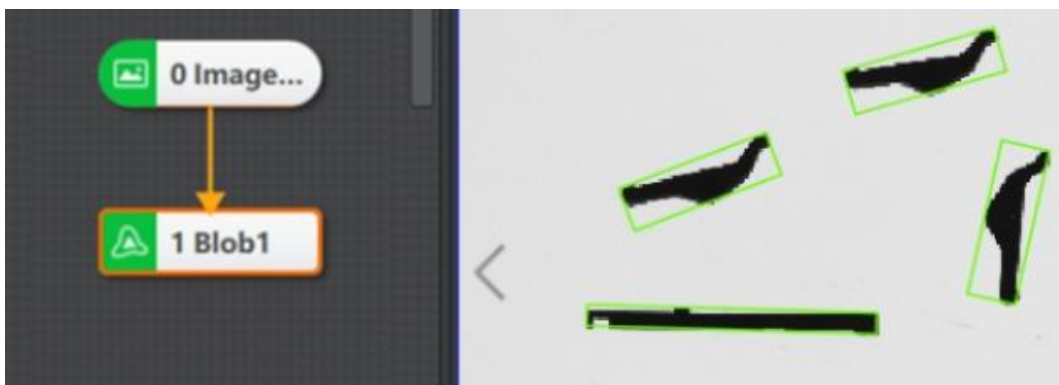
Running Parameters

- **Threshold Mode:** When the input image is a binary image, it is optional to not execute binarization. In other cases, there are five options, including single threshold, double threshold, auto threshold, soft threshold (fixed) and soft threshold (relative).

  - Single threshold:

    1. darker than background: [0, low threshold -1] blob target of gray value is detected.

    2. lighter than background: [low threshold, 255] blob target of gray value is detected.

  - Double threshold: when the high threshold is higher than the low threshold, the target gray range is [low threshold, high threshold]. When the low threshold is set higher than the high threshold, the target gray range is [0, high threshold] and [low threshold, 255].

  - Single threshold, double threshold or auto threshold

    1. Low threshold: it is used to set lower limit of threshold.

    2. High threshold: it is used to set upper limit of threshold.

  - Soft threshold (fixed):

    1. Lighter than background: the number of copies set between high and low thresholds is divided into softness as the transition area. The area between [low threshold, 254] is set to 1.

    2. Darker than background: The area between [0, low threshold] is set to 1.

  - Soft threshold (relative): blobs with fuzzy target edges and indistinct features can be considered.

- **Polarity:** it has two modes, including dark blobs, light background, and light background dark background.

  - Dark blobs, light background is that the feature image pixel value is lower than the background pixel value.

  - Light background, dark background is that the feature image pixel value is higher than the background pixel value.

- **Threshold Range:** it is used to set the lower limit and upper limit of threshold. The target whose edge threshold within the threshold range, and it can be found in Blob area.

- **Number of Fund Blobs** : it is used to set the number of Blob graphs to find.

- **Min. Hole Area:** it refers to the minimum non-Blob area size in Blob area. If the parameter is not larger than this value, the hole padding is the Blob.

- **Contour Output Enable:** Blob contour is displayed when enabled.

- **Blob Image Output:** do not output the Blob analysis image after disabled.

- **Enable:** If the current feature is enabled, the feature is used for blob filtering. If it is closed, the feature will not be used for blob filtering.

  - Area: the area of the target image.

  - Contour: the circumference of the target image.

- Major and minor axis: the length and width of the smallest area of circumscribed rectangle, as shown below.
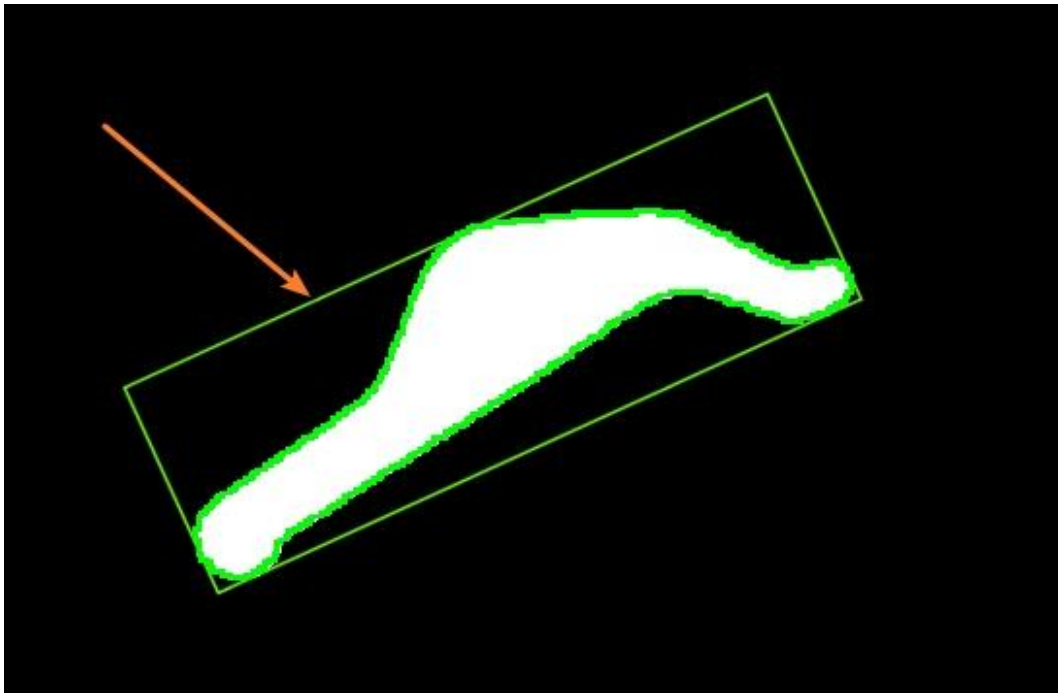
- Circularity and rectangularity: the similarity to a circle or rectangle.
- Barycenter offset: absolute pixel offset between Blob barycenter and center of circumscribed rectangle of Blob minimum area.
- Axis ratio: short axis and long axis of box.
- Sort feature: it has several characteristics, such as area, perimeter, circularity, rectangularity, connected domain center x, connected domain center y, box angle, box width, box height, rectangular upper left vertex x, rectangular upper left vertex y, second-order center distance, principal axis angle, axis ratio, etc.
- Sort mode: ascending, descending and non sorting are used in combination with the sorting feature.

- **Connectivity:** In image processing, the object we are interested in is usually a combination of interconnected pixels. Therefore, in order to obtain an area, we must calculate all the connected areas that are contained in the area after division. On a rectangular pixel grid, there are two definitions of connectivity. The first one is that the two pixels have a common edge, that is, one pixel is above, below, to the left or to the right of the other pixel, which is called 4-connectivity. The second definition is the extension of the first definition. The adjacent pixels on the diagonal line are also included, which is called 8-connectivity. The relation between these two kinds of connectivity is shown below.

- **Min. Overlap Rate**:
  - This parameter is used to filter Blob and filter out some Blob intersecting ROI.

- Specific filtering method: if the minimum overlap rate is set to 50, and the blob area inside the ROI is less than 50% of its overall area, it will be filtered in the result, and the filtered Blob will not be displayed in the result.

- This parameter can be set to 100 if it is pasted with ROI, that is, it is not regarded as the target drawing

Running Result

- **Total Area**: sum of all Blob areas in the obtained results.

- **Area**: the area of a Blob in the obtained results.

- **Perimeter**: number of edge pixels

- **Barycenter X/Y**: X/Y coordination of Blob barycenter

- **Angle**: angle of Blob to Blob minimum circumscribed rectangle

- **Major/ Minor Axis**: major axis / minor axis of minimum circumscribed rectangle

- **Roundness / Rectangularity**: Blob area divided by Blob minimum circumscribed circle area / Blob area divided by Blob minimum circumscribed rectangle area.

⚠ NOTICE

The Blob analysis module supports the use of multiple ROIs, but when two ROIs are connected, the two ROIs will be regarded as one ROI. Therefore, if each ROI needs to be processed separately, it needs to be implemented circularly.

4.2.7   **Caliper**

The caliper is a visual tool that measures the width of a target object, edge location, the location of the feature or edge pair, and the distance between edge pairs. Unlike other visual tools, the caliper requires the user to confirm the approximate area of the measurement or position, and the target object or edge feature. The caliper tool can position edge or edge pair via different edge modes. The basic parameters and result display have been explained in Tool Application. This section mainly describes the running parameters.
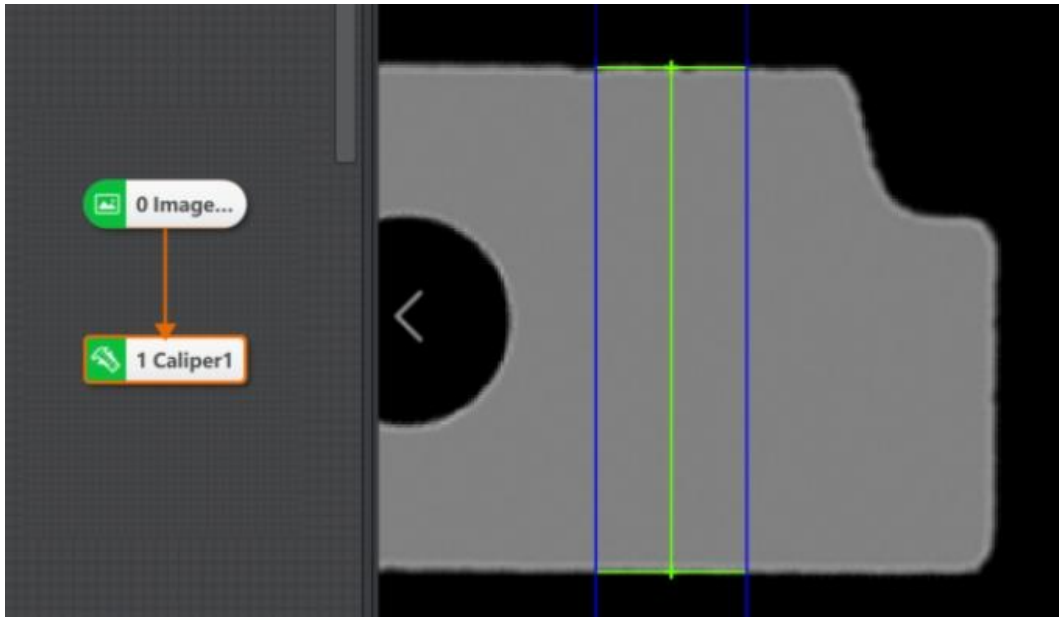
Running Parameter

- **Edge Mode:** it includes single edge and edge pair modes.

  - Single edge mode detects the edge position in the specific area and can be used to locate, count and verify the presence or absence.

  - Edge pair mode detects edge spacing in a specific area.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Edge Polarity:** it has three modes, including dark to light, light to dark and both.

- **Edge Pair Width:** it means that the size of the pixel spacing of the edge pairs that are expected to be output. Adjusting this parameter separately cannot directly screen out the expected edge pairs. Only when one or more score methods, including current position normalization score, relative position normalization score, space score, space gap score and relative space gap score, are enabled, adjusting this parameter is meaningful.

- **Max. Result Number:** it is the maximum number of edge pairs expected to be output. If the logarithm actually found is greater than this parameter, the edge pair of this parameter is output according to the score from high to low. Otherwise, the actual edge pair quantity is output.

- Sort Method: score ascending, score descending, direction forward and direction reverse. The results are sorted according to the selected type.

- **Projection Direction:** it includes from top to bottom and from left to right.

- From top to bottom means that the edge point is searched in the left and right direction relative to the search ROI. If the search ROI is rotated by 90°, and then the edge point is searched from bottom to top direction.

- Left to right means that the edge point is searched in the top and bottom direction relative to the search ROI. If the search ROI is rotated by 90°, and then the edge point is searched from left to right direction.

- Projection is to project a whole edge into a pixel, so the direction of finding the edge and the projection direction must be in the horizontal direction and the vertical direction, as shown in the following figure.
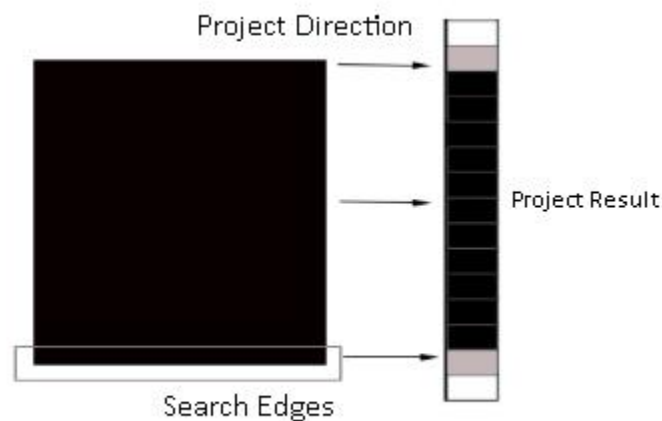
- **Blurred Edge**: Turn on this enable to enhance the extraction ability of the candidate edge point set, with more candidate point sets, so that the target edge points can be extracted more likely in the "image with more interference points" or "image with blurred edges" scene, but the time consumption increases significantly.

- **Score Enable**

  - Single Edge

    1. **Contrast Score Enable:** it is scored by edge contrast or edge pair contrast. The user can execute contrast score on the candidate edges. The edge contrast here reflects the intensity of the grayscale change at the edge. The maximum score is 1.0, which is equivalent to an edge contrast of 255 (the maximum value of the edge contrast). If it is the search mode of edge pair, the average contrast of the two edges is used as the scoring factor.

    2. **Position Score Enable:** it is scored by the absolute position difference of the edge or edge pair center relative to the center of the ROI area.

    3. **Relative Position Score Enable**: it is scored by the absolute position difference (positive or negative) of the edge or edge pair center relative to the center of the ROI area.

    4. **Gray Score Enable**: score by regional projection gray mean value.

    Each score enabling has six parameters, including curve type, starting point, midpoint, ending point, highest value, and lowest value of score. Curve type includes

descending and ascending. The target edge point has the highest score by setting these six parameters.

- **Edge pair mode**

  - Normalized Position Score Enable: it is scored by the absolute position difference of the edge or edge pair center relative to the center of the ROI area. The denominator of normalization is the edge pair width.

  - Normalized Relative Position Score Enable: it is scored by the position difference of the edge or edge pair center relative to the center of the ROI area. The denominator of normalization is the edge pair width.

  - Spacing Score Enable: it scores in accordance with actual distance of edge pair / edge pair width.

  - Spacing Difference Enable: it scores by single edge in accordance with (actual distance of edge pair - edge pair width) / edge pair width.

  - Relative Spacing Difference Enable: it scores by both edges in accordance with (actual distance of edge pair - edge pair width) / edge pair width.

Output Result

- **Edge Point Coordinates X/Y**: start and end coordinates of edges or edge pairs

- **Edge Polarity**: 1 means from black to white, 2 means from white to black.

- **Measured Width**: caliper spacing of edge pairs

- **Score**: The caliper tool defines the score calculation method, maps the mapping score with the original scores of several judgment benchmarks, and then calculates the overall score of edge pattern candidates by taking the n-th power root of the product of the mapping score. For example, if four scoring methods are defined, the caliper tool multiplies the four scores and takes the fourth root of the result.

- **Edge Status**: 1 means searched, 2 means searching failed.

4.2.8 Edge Search

The tool of edge search is used to search edge with certain features in the image. The basic parameters and result display have been explained in Edge Distance.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti-noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Edge Polarity:** it has three polarities, including dark to light, light to dark and any.

- **Edge Type**: it includes strongest edge, last edge, first edge and all.

- **Find Direction**: it includes top to bottom and left to right.

- **Min. Edge Score**: find the minimum score of the edge. The edge with a score lower than the minimum score will be filtered out.

- **Max. Result Number**: maximum number of searching.

- **Sort Method**: score ascending, score descending, direction forward and direction reverse. The results are sorted according to the selected type.

4.2.9 Position Correction

The tool of position correction is used to assist positioning and precise positioning, and modify target motion deviation. It establishes the reference of position deviation according to match points and match frame angle in the template matching result, and then realize ROI coordinate rotation deviation of detection box according to the relative position deviation of running point and fiducial point in the template matching result, as shown below.
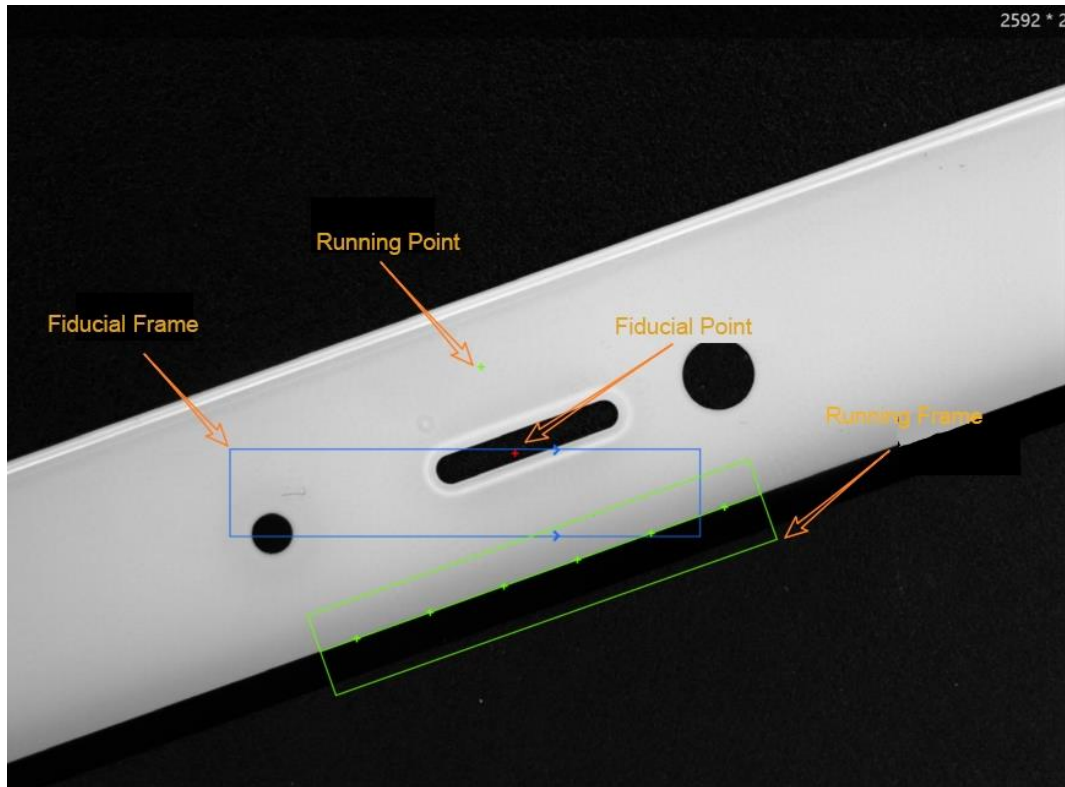
Fiducial point and fiducial frame are the match point and match frame when you create the reference. Running point and running frame are the match point and match frame when the target image is matching with features. The pixel deviation of image can be determined according to fiducial point and running point, and angle deviation can be determined according to fiducial frame and match frame. Thus, the ROI area can keep up with the changing of image angle and pixel.

The position correction figure is shown below.
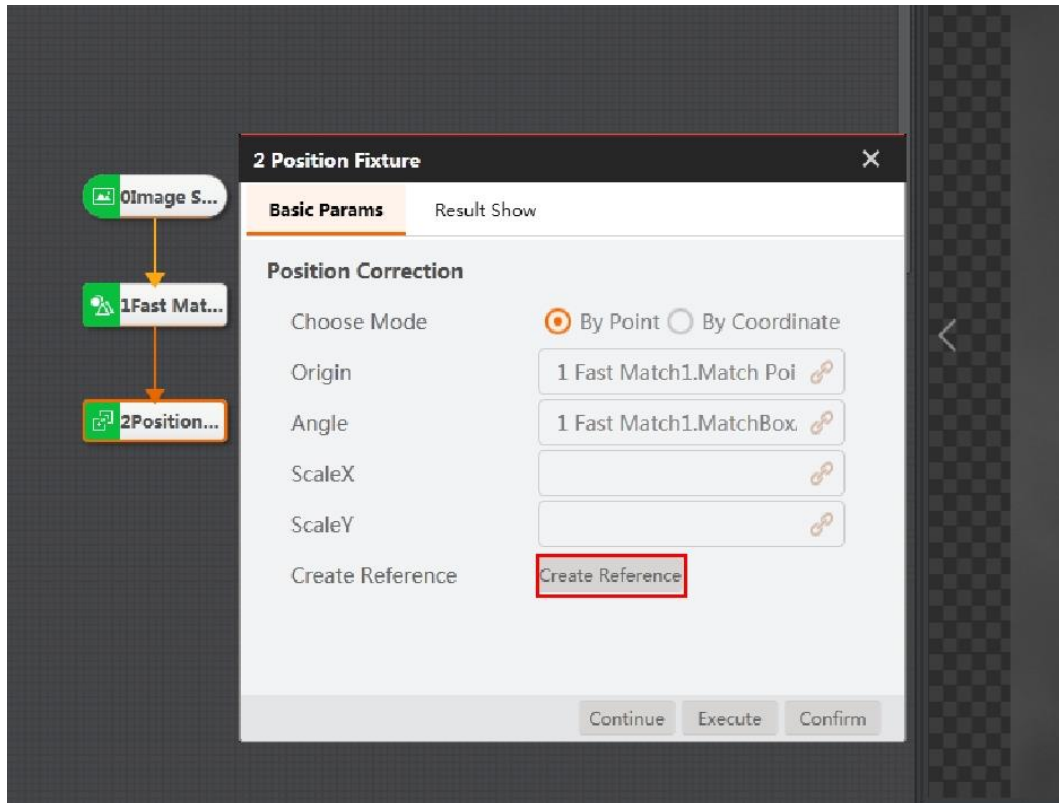
There are two ways to correct position: position correction by point and position coordinate by coordinate. For by point, the position of the point has been determined. For by coordinate, X and Y are used to determine the position of the point. Please note that whether for a point or a coordinate, its position information is transmitted from the previous module, and its role is to determine the pixel and angle deviation.

📖NOTE

- When using fast feature matching and position correction, you do not need to be subscribe the scale parameters. In this case, the position correction of images with the same resolution but different sizes cannot be realized. When you use high-precision feature matching and position correction, the position correction module automatically subscribes the scale to realize the position correction of images with the same resolution but different sizes.

The following are images before and after position correction.

Before Position Correction   After Position Correction
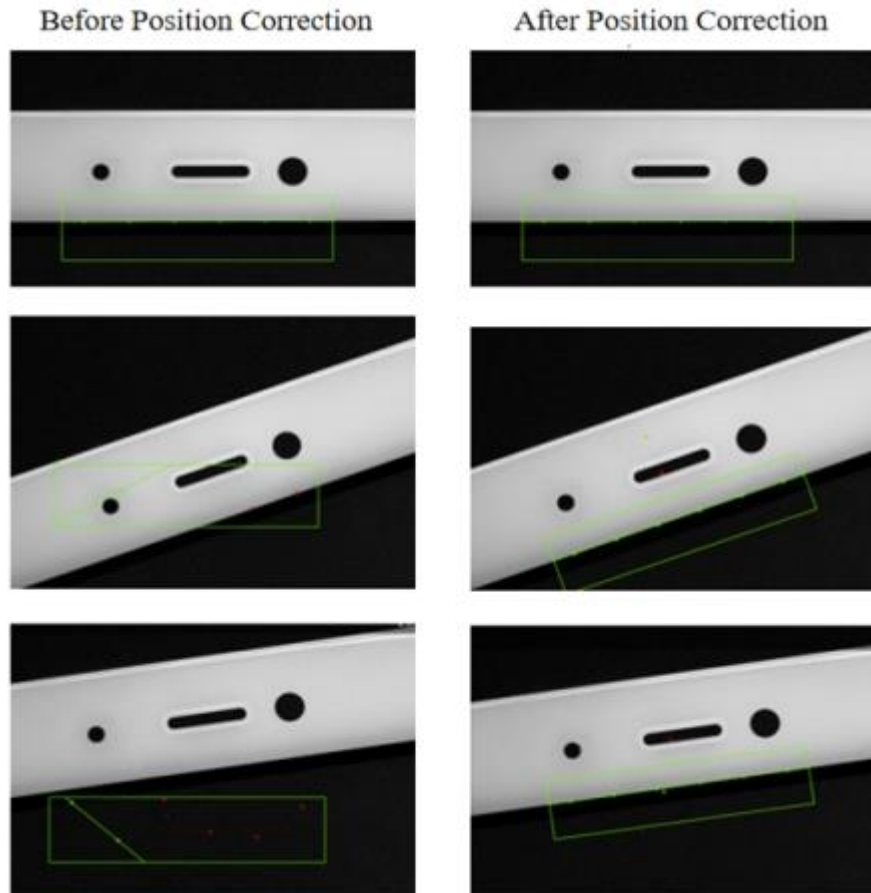
4.2.10 Rect Search

The tool of rect search is used to detect the rectangle in the target image. The basic parameters and result display have been explained in Tool Application, and running parameters have been explained in previous sections. This section displays a solution, as shown below.
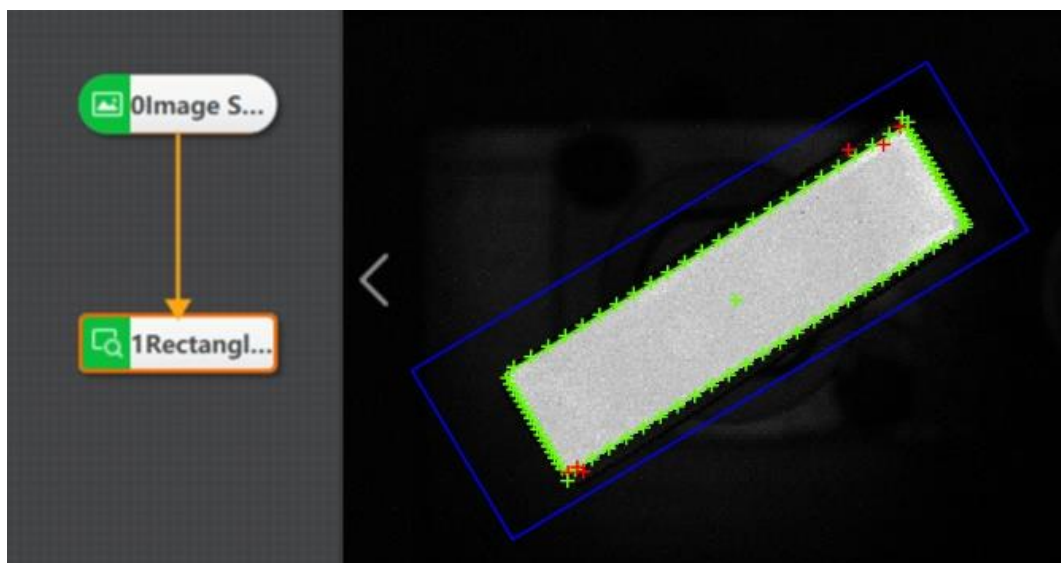
Detection Parameter

- **Edge Pair Type**: see Spacing Detection for details.

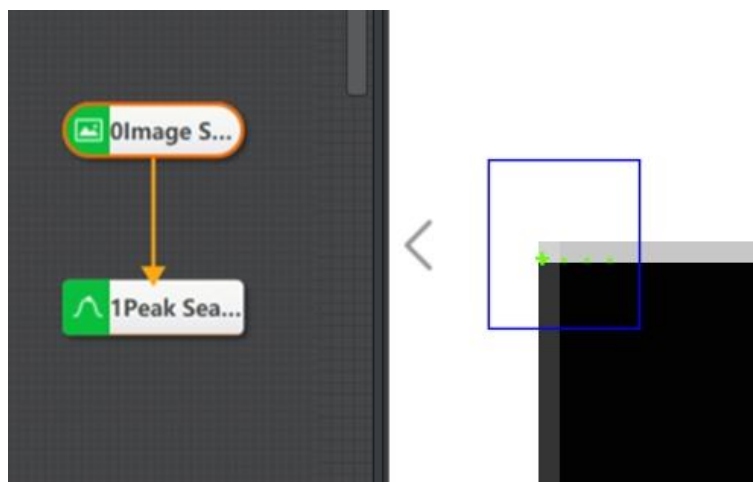- **Edge Polarity**: it has three polarities, including dark to light, light to dark and any.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Caliper Number**: used to scan number of ROI areas of edge points.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Projection Width**: In the ROI, several edge points are distributed in a circle to search for the ROI. This parameter describes the width of the area where the edge points are scanned for the ROI. Increase the value within a certain range to obtain more stable edge points.

- **Reject Number**: It means that the number of minimum points that have high error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with the parameter of distance to remove.

- **Distance to Remove**: It means that the maximum pixel distance from the outlier to the fit circle. The smaller the value, the more points are excluded.

- **Initial Fit**: see Find Circle for details.

- **Fit Mode**: It has three types, including least squares, huber and tukey. The three fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, the least squares, Huber and Tukey can be used step by step.

4.2.11 Peak Search

The tool of peak search is used to detect the peak of an object in specific area, as shown below.

Detection Parameter

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Edge Polarity:** it has three modes, including dark to light, light to dark and any.

- **Scan Width:** it is used to describe the area width of searching edge point ROI, and the min. value is 1. Within certain range, increasing this value can reduce the quantity of edge points.

Detection Results

- **Peak X/Y:** generate the X/Y coordination of the peak.

- **Peak Score:** Edge points, peak and their scores in peak detection are calculated by internal caliper. Refer to caliper tool for the definition of scores.
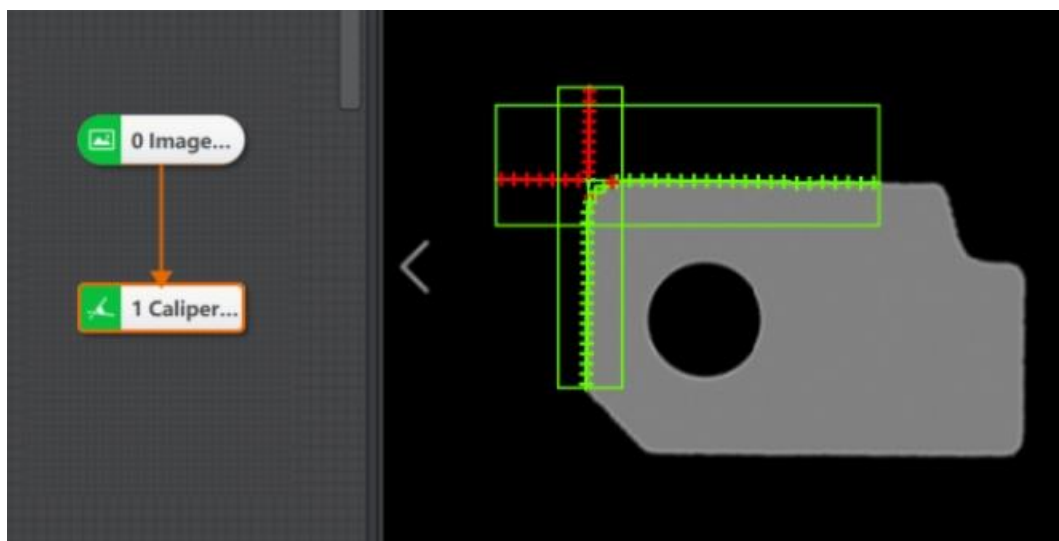
- **Peak Polarity:** it is edge polarity: light to dark and dark to light.

- **Peak Distance:** it is the distance from the peak to one side of the ROI area, corresponding to the search direction in the operation parameters.

- **Edge Number:** the number of edge points.

4.2.12 Edge Intersection

The tool of edge intersection is used to search the intersection of two edges, and the search direction and polarity can be set according to the required intersection. When the two edges intersect, the intersection is the target to be searched. When they do not intersect, the intersection is the intersection of their extension lines. The basic parameters and result display have been explained in the Tool Application. This section mainly describes part of the parameters.
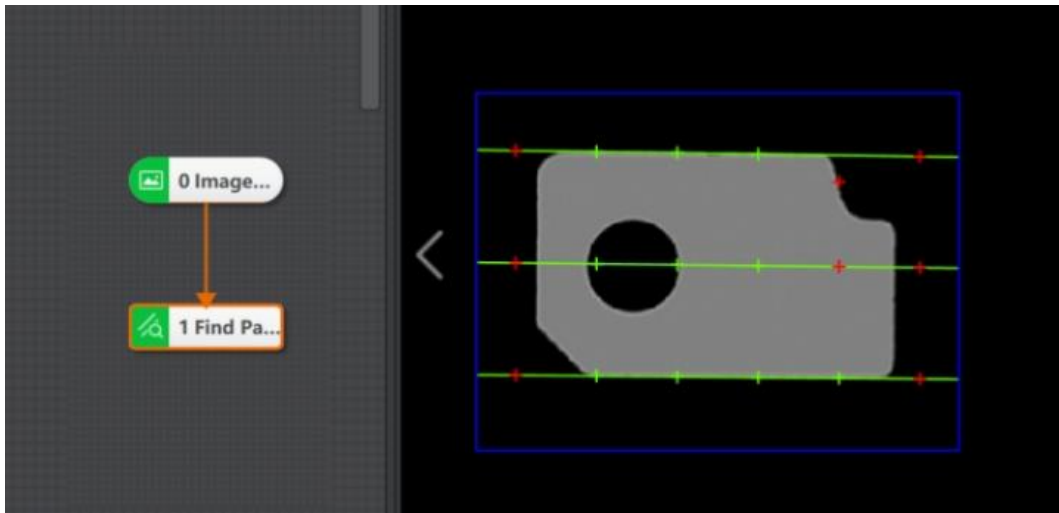

Edge Parameter

- **Edge Type**: it has the strongest, the first and the last edge.

- **Edge Polarity:** it has three modes, including dark to light, light to dark and any.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Calipers Number:** it is used to scan ROI area quantity of edge points.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Projection Width**: In the ROI, several edge points are distributed in a circle to search for the ROI. This parameter describes the width of the area where the edge points are scanned for the ROI. Increase the value within a certain range to obtain more stable edge points.

- **Reject Number**: It means that the number of minimum points that have high error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with the parameter of distance to remove.

- **Distance to Remove**: It means that the maximum pixel distance from the outlier to the fit circle. The smaller the value, the more points are excluded.

- **Initial Fit**: see Find Circle for details.

- **Fit Mode**: It has three types, including least squares, huber and tukey. The three fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, the least squares, Huber and Tukey can be used step by step.

- **ROI Area:** setting one or two ROIs is available. When setting one, it is to find the intersection of two lines in one ROI area. When setting two, it is to find the line in two ROI areas separately, and then find the intersection of these two lines.

- **Search Mode:** edge1 search mode is to find the line in ROI 1 area, and edge 2 search mode is to find the line in ROI 2 area.

Output Result of Intersection

- **Edge Intersection X/Y**: X/Y coordination of edge intersection

- **Line Starting and End X/Y**: X/Y coordination of line starting and end.

- **Line 0/1 Angle:** the angular offset of lines 0 and 1 from the horizontal.

4.2.13 Parallel Lines Search

The tool of parallel lines search is used to find lines that are approximately parallel within the tolerance angle range. The centerline of the two parallel lines is also displayed in the middle, as shown below. The running parameters have been explained in Line Search. This section mainly describes part of the parameters.

- **Edge Pair Type:** see Spacing Detection for details.

- **Edge Polarity:** it has three modes, including dark to light, light to dark and any.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti-noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Calipers Number:** it is used to scan ROI area quantity of edge points.

- **Max. Angle Tolerance:** if the angle of target lines is smaller than this parameter value, the target lines will be determined as parallel lines. Otherwise, the target lines will be determined as non-parallel lines.

- **Reject Number**: It means that the number of minimum points that have high error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with the parameter of distance to remove.

- **Distance to Remove**: It means that the maximum pixel distance from the outlier to the fit circle. The smaller the value, the more points are excluded.

- **Filter Size:** it is used to filter noise. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Projection Width**: In the ROI, several edge points are distributed in a circle to search for the ROI. This parameter describes the width of the area where the edge points are scanned for the ROI. Increase the value within a certain range to obtain more stable edge points.

- **Initial Fit**: see Find Circle for details.

- **Fit Mode**: It has three types, including least squares, huber and tukey. The three fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, the least squares, Huber and Tukey can be used step by step.

4.2.14 Quadrilateral Search

The tool of quadrilateral search is used to find linear edges in the specified quadrilateral areas. After the function is enabled, the system outputs the start point and end point information of lines, and the central point information of the quadrilateral.
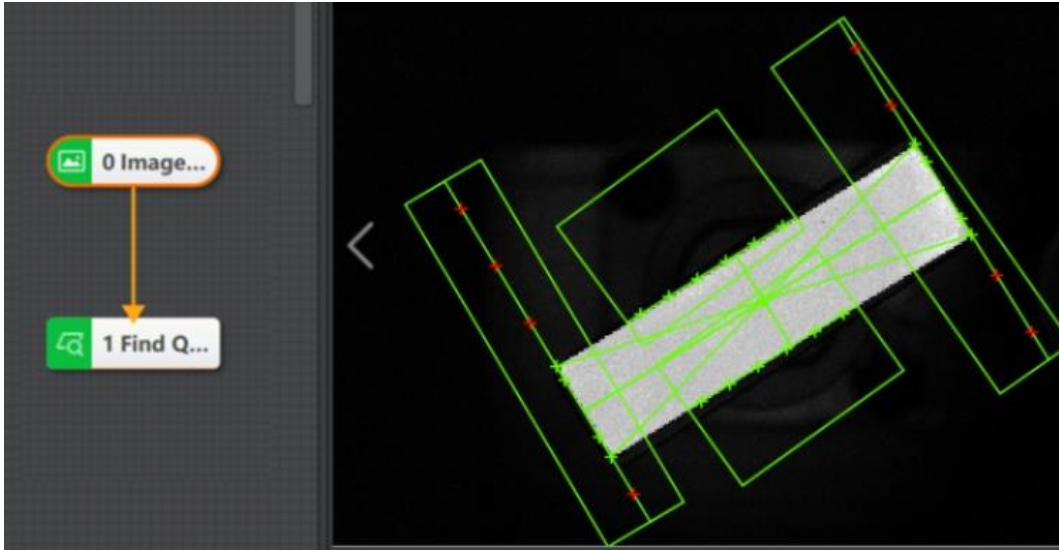

Running Parameters

- **Select Edge:** It is used to select the edge 0, 1, 2, 3, and set its corresponding parameters after selecting the edge.

    - **Edge Type**:

        - Strongest Edge: find edge point set with the largest gradient threshold and fitted into a line.

        - Last Edge/First Edge: find the last edge/the first edge that meets the demands.

    - **Edge Polarity:** it has three modes, including dark to light, light to dark and any.

- **Edge Threshold:** the edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Filter Size:** it is used to filter noise. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Calipers Number:** the edge points are clamped by multiple calipers to define the number of calipers.

- **Projection Width**: refer to Find Line.

- **Reject Number**: see Find Circle for details.

- **Distance to Remove**: see Find Circle for details.

- **Initial Fit**: see Find Circle for details.

- **Fit Mode**: see Find Circle for details.

4.2.15 **Line Group Search**

With the tool of line group search, you can find out multiple lines, and generate multiple edge points. Then, the multiple edge points generated are combined to a line. It supports creating multiple ROI areas and multiple sets of parameters, as shown follow.
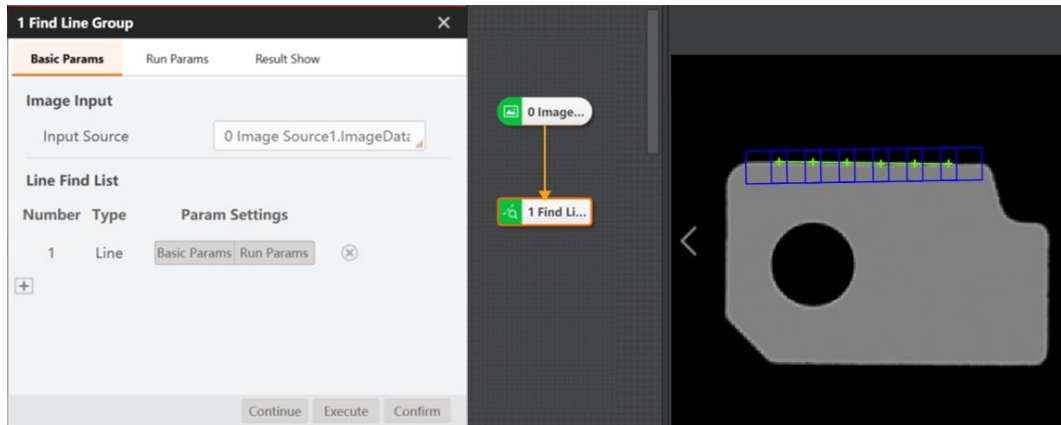
4.2.16 **Multi-line Search**

With the tool of multi-line search, you can find out multiple target lines in one image. The related information of these multiple lines may also be output in the result.

Basic Parameters

- **Filter Kernel Half Width**: For edge enhancement and noise suppression, the minimum value is 1. When the edge is blurred or there is noise interference, increasing this value will help to make the detection result more stable, but if the edge is too close to the edge, it will affect the accuracy of the edge position or even lose the edge. This value should be set according to the actual situation.

- **Projection Length:** This value determines the number of areas used for gradient field projection. A smaller value allows the tool to analyze the image with finer granularity, but it may

take more time to execute the tool. A higher value can improve the execution speed of the tool, but the edge of the tool you want to find may not be detected.

It is generally recommended that this value be at least as large as the set filter size.

- **Absolute / Relative Edge Threshold:** Only edge points whose edge gradient threshold is greater than the extraction threshold are detected.

- **Edge Polarity:** Four kinds of edge polarity are available: From White to Black, From Black to White & From White to Black, From Black to White & From White to Black, and From Black to White/From White to Black. & indicates that in the same line segment, both polarities of the point set need to be considered, / indicates that in the same line segment, if the point set has two polarities, either one can be used for fitting.

- **Edge Angle Tolerance:** The maximum allowable angle difference between the gradient direction of the edge point and the direction perpendicular to the fitting line (the normal direction of the fitting line). By increasing this value, the tool may take more consideration of the edge points, thereby changing the position of the found line segment.

- **Edge Distance Tolerance:** It refers to the max. allowable distance between the edge point and the line. When the edge distance tolerance is increased, it is allowed the tool to consider more edge points and change the position of the discovery line.

- **Max. Line:** The maximum target line quantity.

- **Coverage Rate:** It refers to the min. percentage of actual edge point quantity in planed edge point quantity. The value is larger, the line with higher coverage rate may be outputted.

📖NOTE

- High coverage rate does not mean that there are many edge points covered, which should be comprehensively considered in combination with the actual length of straight line segment.

- **Linear Rotation Tolerance:** The amount of rotation of the found line segment and the tolerance of the defined gradient search direction. A lower value forces the tool to locate segments that are more parallel to the gradient search direction.

- **Fit Mode**: The two fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, Huber and Tukey can be used step by step.

4.2.17 Blob Label Analysis

BLOB label analysis module adds two output results: category tag and tag value, based on the function of Blob module. It is usually used together with the module of scientific research outputting multi category information, such as DL image segmentation.
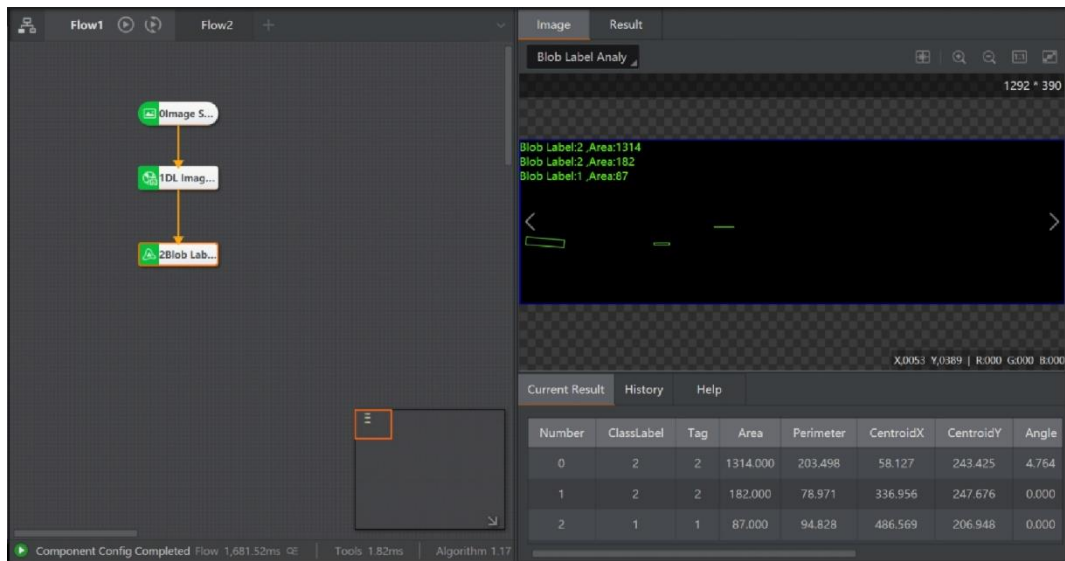
Basic Parameters

- **Category Name:** It is usually used with DL image segmentation. Subscribe to the category name of DL image segmentation, or manually output a group of category names.

- **Gray Value**: It is usually used with DL image segmentation. Subscribe to the gray value of DL image segmentation, or manually output a group of gray value.

Running Parameters

- **Number of Fund Blobs**: it is used to set the number of Blob graphs to find.

- **Area Enable**: After enabled, it is limited to find the area range of Blob.

- **Contour Enable**: After enabled, the module show the Blob contour.

- **Blob Image Output**: After disabled, the image after Blob analysis do not output any more.

- **Perimeter, Short Axis, Long Axis, Circularity, Rectangularity, Barycenter Offset, Axis Ratio**: see BLOB Analysis for details.

- **Axial Ratio Range**: short axis of box: long axis of box

- **Sort Feature**: it has several characteristics, such as area, perimeter, circularity, rectangularity, connected domain center x, connected domain center y, box angle, box width, box height, rectangular upper left vertex x, rectangular upper left vertex y, second-order center distance, principal axis angle, axis ratio, etc.

- **Sort Mode**: ascending, descending and non sorting are used in combination with the sorting feature.

- **Connectivity:** In image processing, the object we are interested in is usually a combination of interconnected pixels. Therefore, in order to obtain an area, we must calculate all the connected areas that are contained in the area after division. On a rectangular pixel grid, there are two definitions of connectivity. The first one is that the two pixels have a common edge, that is, one pixel is above, below, to the left or to the right of the other pixel, which is called 4-connectivity. The second definition is the extension of the first definition. The adjacent pixels on the diagonal line are also included, which is called 8-connectivity.

- **Min. Overlap Rate**:

  - This parameter is used to filter Blob and filter out some Blob intersecting ROI.

  - Specific filtering method: if the minimum overlap rate is set to 50, and the blob area inside the ROI is less than 50% of its overall area, it will be filtered in the result, and the filtered Blob will not be displayed in the result.

  - This parameter can be set to 100 if it is pasted with ROI, that is, it is not regarded as the target drawing.

⚠ NOTICE

The blob tag analysis module supports the use of multiple ROIs, but when two ROIs are connected, the two ROIs will be regarded as one ROI. Therefore, if each ROI needs to be processed separately, it needs to be implemented circularly.

4.2.18 Path Extraction

The path extraction module can be used to take points or search edge points at equal intervals on the drawn path. This module is generally used with feature match and position correction modules, as shown in the following figure.
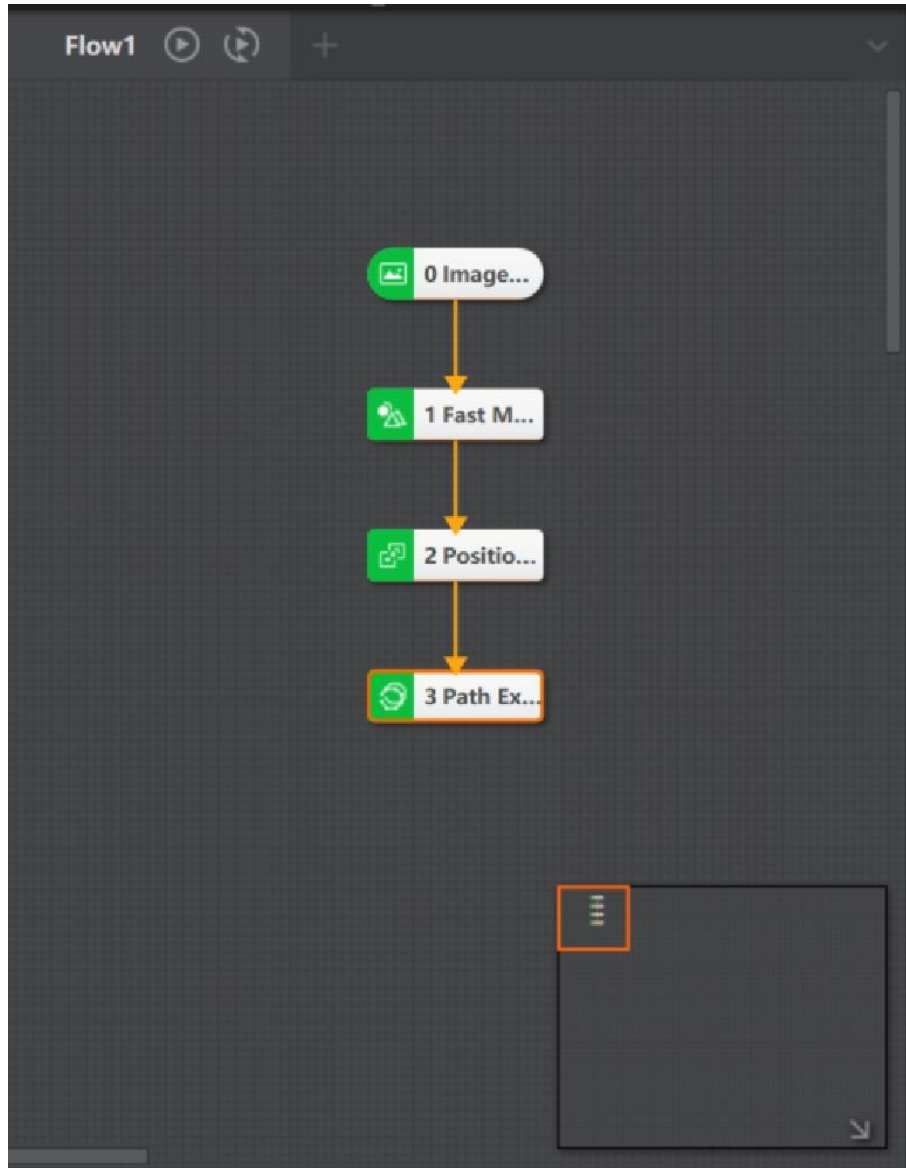
The main steps of path extraction are as follow:

1. Double-click the Path Extraction module. Select **ModelSettings**, and click **Edit Model** as follow:
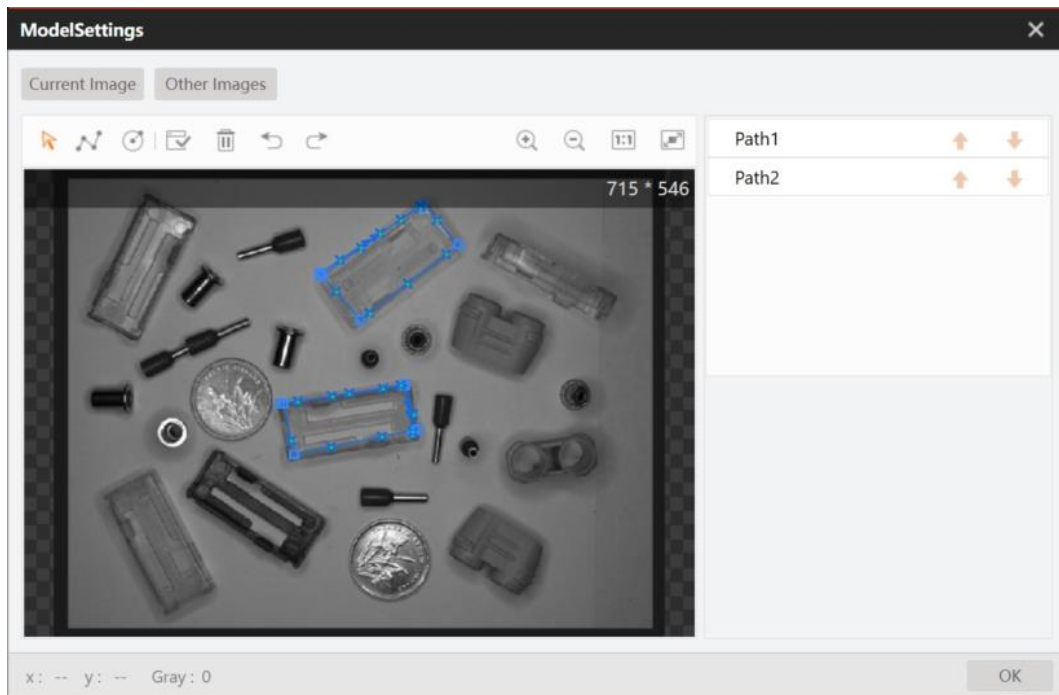
The image selected when you configure the template should be consistent with the image selected when you create the feature matching template. Use and to draw the polyline and arc path to be extracted. Click to generate model, and finally click **OK** to complete the template.

📖NOTE

- You can draw multiple paths and set their corresponding parameters according to actual demands. You can also change the order of the paths.

Training Parameter

- **Number of Path Points**: The number of path points on the extracted path in the template, ranging from 2 to 300, can be selected according to the demand.

- **Position Offset**: The offset of path points can be set according to the actual demand, ranging from -1000 to 1000.

- **Edge Polarity:** it has three polarities, including dark to light, light to dark and any.

  - From Dark to Light: The edge of a region that transitions from a low gray value to a high gray value.

  - From Light to Dark: The edge of a region that transitions from a high gray value to a low gray value.

  - Any: Both edges above can be detected.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger

the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Caliper Height**: Find ROI at several edge points of ROI distribution. This value describes to scan edge points to find the area height of ROI. When the edge search is not accurate, the value can be increased appropriately.

- **Caliper Width**: Increasing this value within a certain range can obtain more stable edge points.

- **Filter Size:** it is used to filter noise, and the larger the value is, the stronger the anti noise ability is, the less the number of edges is, and at the same time even the target edge points are screened out.

- **Position Offset**: The offset of path points can be set, ranging from -1000 to 1000

2. Select the extraction method in the operation parameters. Different extraction methods lead to different functions of this module and different parameters in model training. Therefore, the extraction method is selected according to the demand.

Running Parameter

- **Extraction Method**: It includes taking points at equal intervals and finding edge points.

  - Taking Points at Equal Intervals: Obtain the corresponding number of glue spots in the template at equal interval in the operation result, and the detection parameters cannot be changed by default.

  - Finding Edge Points: The operation results are displayed as the edge points near the template, and the detection parameters can be changed by yourself.

- **Ouput Arc Params**: You need to set this parameter when selecting taking points at equal intervals as extraction method. After enabling it, if there is an arc trajectory, the center and angle of the arc will be output in the result of the arc trajectory.

⚠ NOTICE

- This module is used in conjunction with the position correction module. You should create the fiducial point of position correction on an image. Run the process, and double-click the position correction module and manually click to create the fiducial point.

- When the model training parameters are consistent with the operation parameters, the operation parameters shall prevail during the operation of the module.

- When using this module, first select the extraction method in the operation parameters. Then configure the template, and move and delete the path points in the template after generating the template.

4.2.19 **Find Angle Bisector**

The angle bisector finding module is used to find the angle bisector between the two lines.

Prerequisite:

Drag the Find Angle Bisector module to the process editing area. Complete the connection with other modules and ensure that other relevant modules have been connected with the module before, such as Line Search.

Steps:

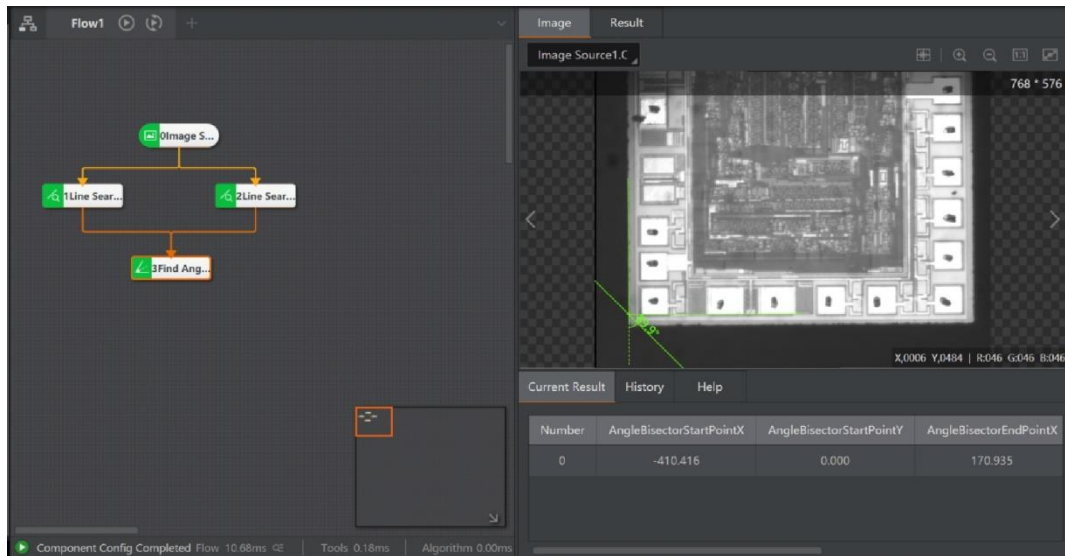1. Double-click **Find Angle Bisector** module to enter the parameter edit window as shown below.
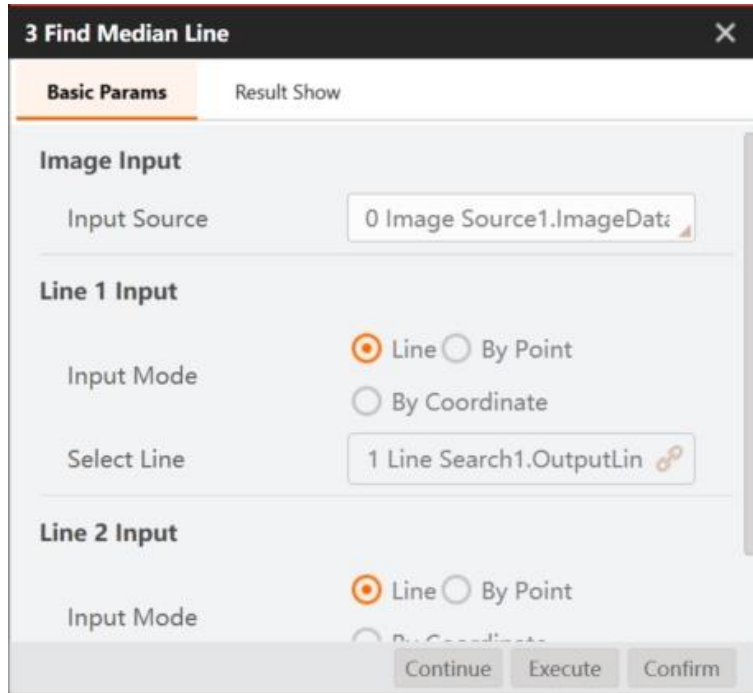
2. Select the image data source in **Input Source**

3. Subscribe the input source of Line 1 and Line 2 respectively. There are three kinds of input sources for lines: by line, by point and by coordinate.

- **By Line:** Directly subscribe a line from the results of the previous module.

- **By Point**: Need to subscribe two points from the results of the previous module as the start point and end point of the line.

- **By Coordinate**: Need to subscribe four coordinates from the results of the previous module as the X and Y coordinates of the start point and the end point respectively.

⚲NOTE

- After selecting one mode to subscribe a data source, when you switch to the other two modes, the module will automatically get the corresponding data source of the other modes.

4. Switch to Result Display of the module and set the specific module, color and transparency of the image.

5. Click **Execute** or **Continue** to view the operation results as shown below.

4.2.20 **Find Median Line**

The Find Median Line module is used to find the median points of the start point and the end point of the two lines respectively, and generate the median line according to the two median points.
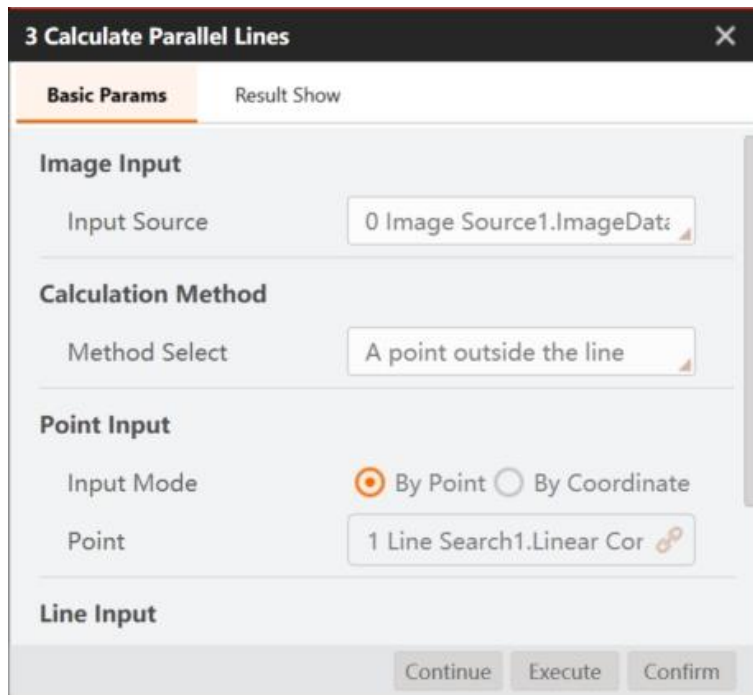
Prerequisite:

Drag the Find Median Line module to the process editing area. Complete the connection with other modules and ensure that other relevant modules have been connected with the module before, such as Line Search.

Steps:

1. Double-click **Find Median Line** module to enter parameter edit window, as shown below.
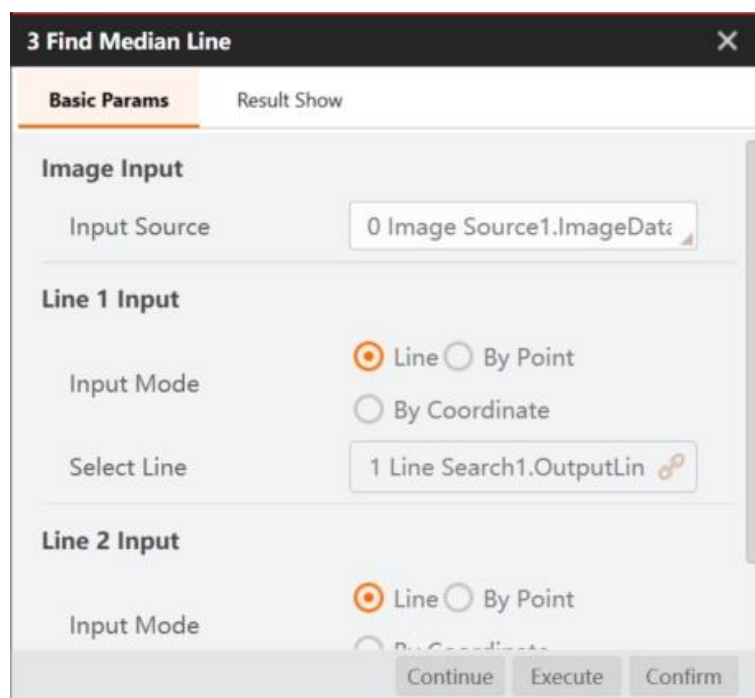
2. Select the image data source in **Input Source**

3. Subscribe the input mode for Line 1 and Line 2 respectively. There are three kinds of input modes: by line, by point and by coordinate.

- **By Line:** Directly subscribe a line from the module results of the previous module.

- **By Point**: Need to subscribe two points from the module results of the previous module as the start point and end point of the line.

- **By Coordinate**: Need to subscribe four coordinates from the module results of the previous module as the X and Y coordinates of the start point and the end point.

☐NOTE

- After you select one method to subscribe a data source, when you switch to the other two methods, the module will automatically get the corresponding data source of the other methods.

4. Switch to the result display of the module and set the specific module, color and transparency of the image display.

5. Click **Execute** or **Continue** to view the operation results as shown below.
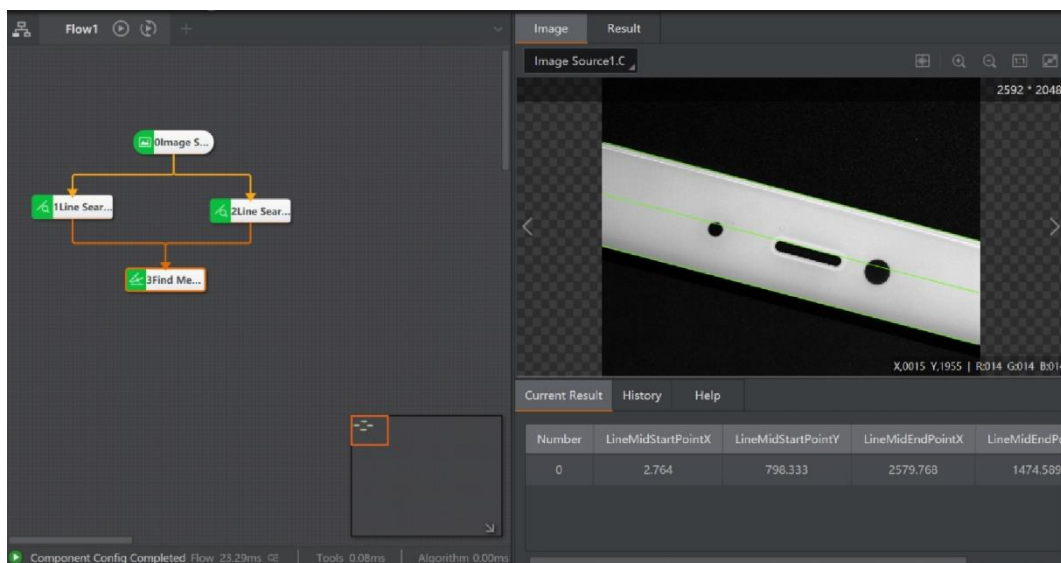
4.2.21 **Calculate Parallel Lines**

The calculate parallel lines module is used to find parallels, which can be calculated based on a line and a certain distance, or based on a line and a point.

Prerequisite:

Drag the Calculate Parallel Lines module to the process editing are. Complete the connection with other modules and ensure that other relevant modules have been connected with the module before, such as Line Search.

Steps:

1. Double-click Calculate Parallel Lines module to enter parameter edit window.

2. Select the image data source in **Input Source**.

3. Select the method of finding vertical lines in **Calculation Method** according to the actual situation. There are two methods.

- **A point outside the line:** Obtain the parallel line of the selected line based on the selected point.

- **A distance from the line**: Obtain the upper and lower parallel lines based on the selected line according to the set distance.

4. When selecting **A distance from the line** in Calculation Method, you need to subscribe the data source of line input and fill in the specific value of the spacing, as shown in the figure below. The spacing parameter is in pixels.
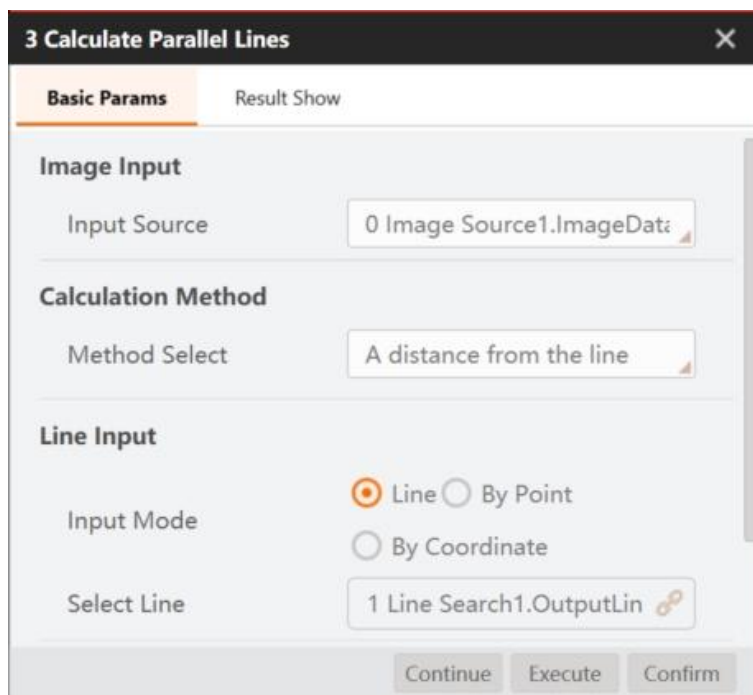
5. When selecting **A point outside the line**, you need to subscribe the data sources of point input and line input respectively.

☐NOTE

- The subscription method of lines and points is similar to that of the find angle bisector module. See Find Angle Bisector for details.

6. Switch to Result Display of the module and set the specific module, color and transparency of the image.

7. Click **Execute** or **Continue** to view the operation results as shown below. The following figure shows the operation results when a distance from the line is selected.
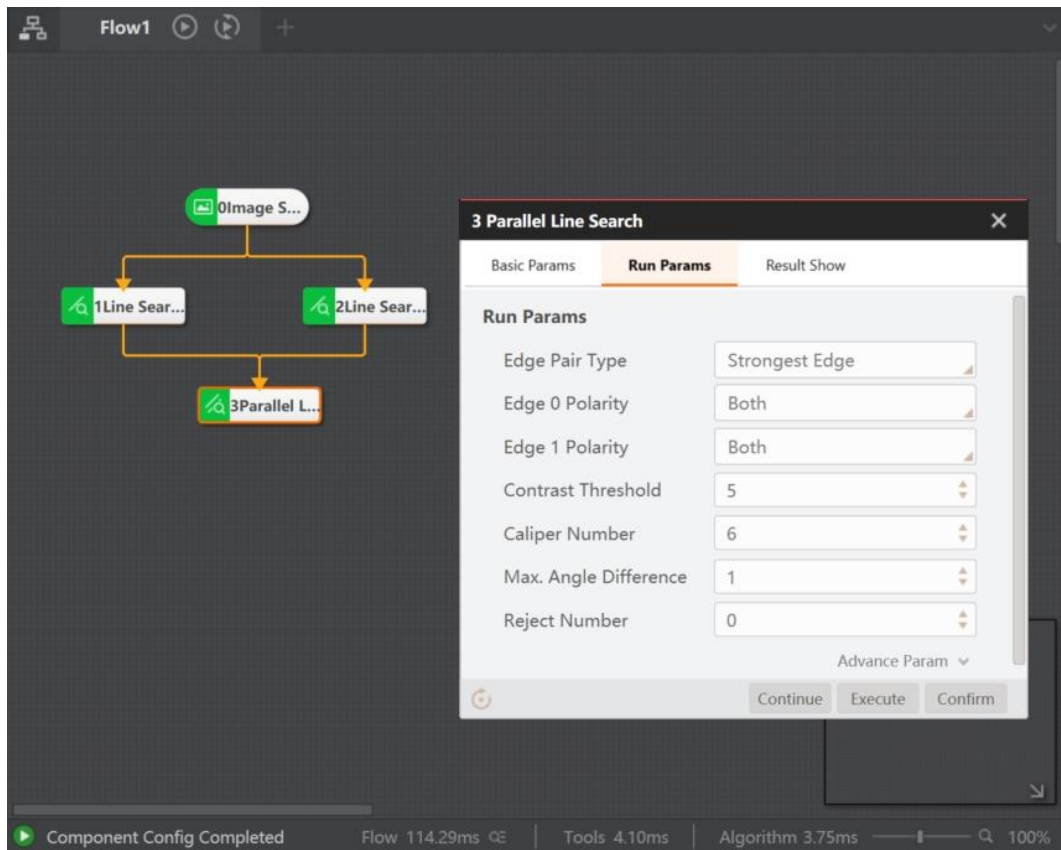
4.2.22 Find Vertical Line

The find vertical line module can find the point-crossing vertical line or perpendicular bisector.

Prerequisite:

Drag the Find Vertical Line module to the process editing area. Complete the connection with other modules and ensure that other relevant modules have been connected with the module before, such as Line Search.

Steps:

1. Double-click **Find Vertical Lines** module to enter parameter edit window.

2. Select the image data source in the **Input Source**.

3. Select the method of finding vertical lines in **VerticalLine Type** according to the actual situation. There are two methods.

- **Point Perpendicular:** Obtain the vertical line of the selected line based on the selected point.

- **Perpendicular Bisector:** Find perpendicular bisector of the selected line based on the selected line.

4. When selecting **Point Perpendicular** in VerticalLine Type, you need to subscribe the data source of point input and line input as shown in the figure below.
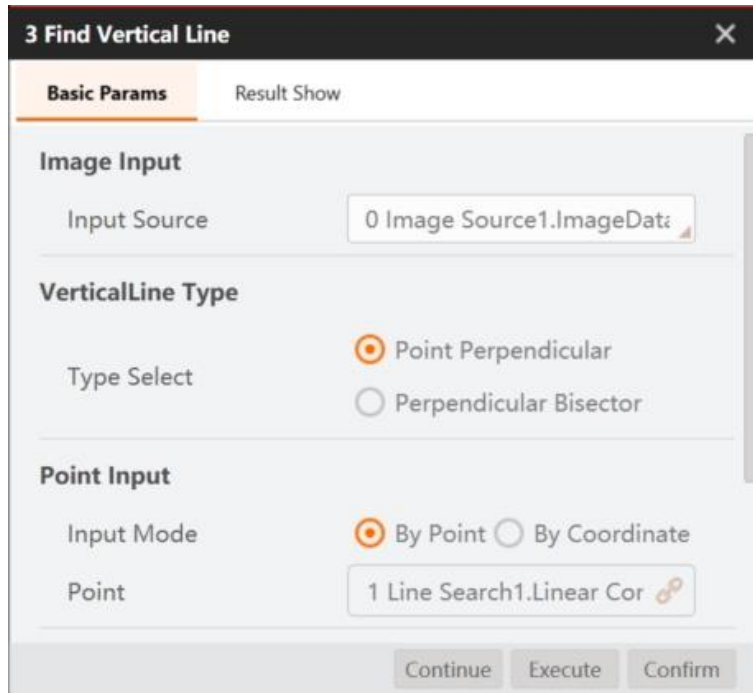
5. When selecting **Perpendicular Bisector** in Verticalline Type, you need to subscribe the data sources of line input only.

📖NOTE

- The subscription method of lines and points is similar to that of the find angle bisector module. See Find Angle Bisector for details.

6. Switch to Result Display and set the specific module, color and transparency of the image.

7. Click **Execute** or **Continue** to view the operation results as shown below. The following figure shows the operation results when perpendicular bisector is selected.
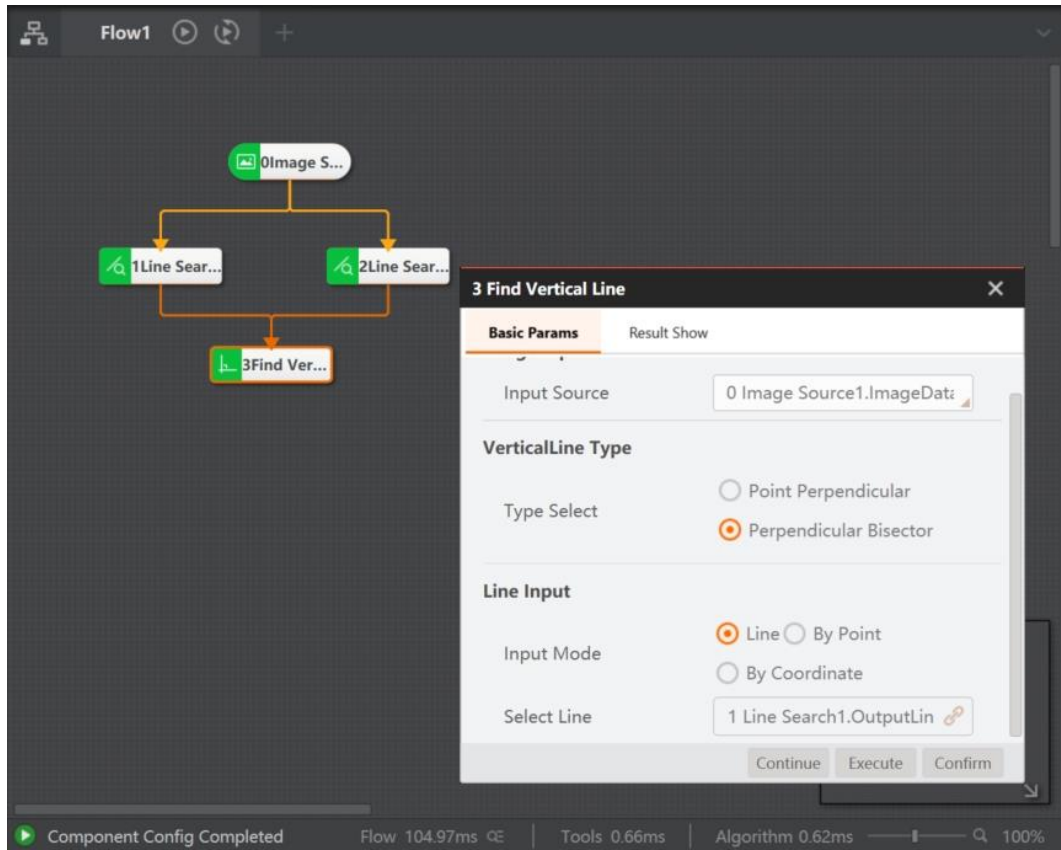
4.3 Measurement

4.3.1 L2C Measure

The tool of L2C measurement returns the vertical distance and the intersection coordinate of the line and the circle in the image. This tool finds the line and the circle in the image of the object to be measured first, as shown below.

When you select subscription mode, the specific data input is described as follows.
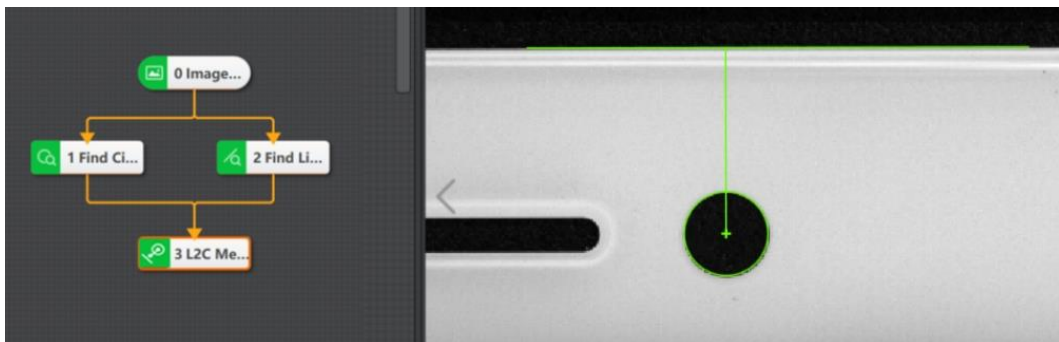
The specific steps of line circle measure are described as follows:

Steps:

1. Solution Creation: select the image source in the operation area, drag the algorithm module of finding line, finding circle and line2C measurement into the operation area, use the operation line

to connect the above-mentioned modules successively, and click Run Once to complete the solution creation, as shown above.

2. After finding the target circle and line respectively, and set line input and circle input. There are several ways to input line and circle, as shown below.

- By line or circle: select the result of finding line and circle for input source.

- By point: you can customize or link the start point, end point and angle of the line.

- By coordinate: you can customize or link the X/Y coordinate of the line's start point, and end point.

- By parameter: you can customize or link the coordinate of circle center and radius length.

3. Input Result: angle between line circle connecting line and horizontal line, the vertical distance between the line and circle, intersection point coordinate of the line and the circle, and projection coordinate of circle center.

When subscription mode is selected for data input, the operation parameters of line circle measurement module are invalid and do not need to be configured.

The data input of drawing method is shown in the figure:
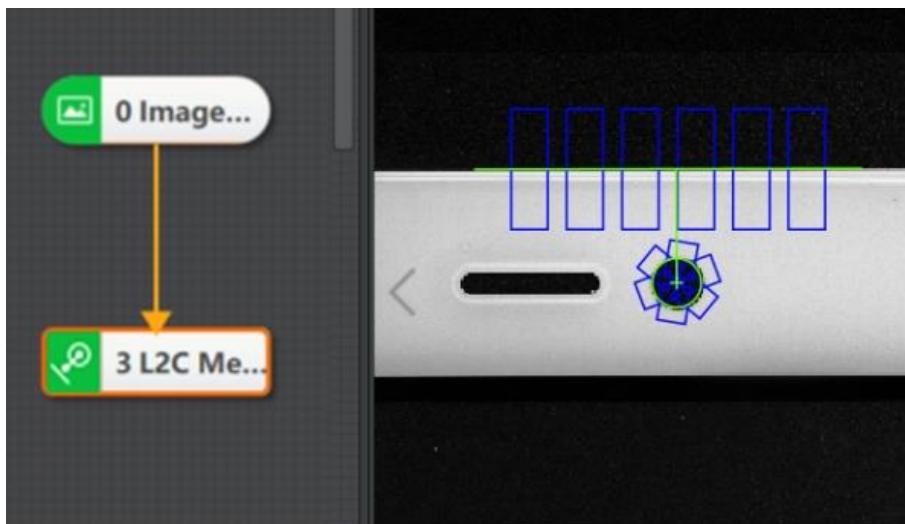
The specific steps of line circle measure are described as follows:

Steps:

1. Solution Creation: select the image source in the operation area, drag the line circle measurement module into the operation area, use the operation line to connect the modules, double-click the line circle measurement module, select Draw in the data input mode, and draw the ROI. Click Run to complete the solution construction, as shown in the above figure.

2. Data Source:

- Draw Method: It does not need to cooperate with line search and circle search, but only needs the image source and line circle measurement module. This method is to draw the ROI of searching line and circle in the input image.

3. Draw Input: Click Draw and draw ROI in the input image.

4. Output Result:angle between line circle connecting line and horizontal line, the vertical distance between the line and circle, intersection point coordinate of the line and the circle, and projection coordinate of circle center.

5. Running Parameter: the running parameters are valid only when the data source selects the drawing input mode, invalid when the subscription input mode is selected .

6. Select Type: Select an object, line or circle, to configure parameters.

Select Line for Type

- **Edge Type**:

  - Strongest Edge: only the edge point set with the largest gradient in the scanning range is detected and fitted into a line.

  - First Edge: the first line satisfying the condition.

  - Last Edge: the last line satisfying the condition.

- **Edge Polarity:**

  - Dark to light: it means that the transition from the area with a low gray value to the edge of the area with a high gray value.

  - Light to dark: it means the transition from the area with a high gray value to the edge of the area with a low gray value.

  - Any means both edges are detected.

- **Edge Threshold:** When the select type is line, the default value is 5. The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Reject Number**: It means that the number of minimum points that have high error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with the parameter of distance to remove.

- **Distance to Remove**: It means that the maximum pixel distance from the outlier to the fit line. The smaller the value, the more points are excluded.

- **Initial Fit**: It has two types, including global and partial fit.

  - Partial:Local optimization is to fit the line according to the local feature points. If the local feature more accurately reflects the position of the line, the local optimization is adopted, otherwise the global optimization is adopted.

 - Global: line fit with the found global feature points

- **Fit Mode**: It has three types, including least squares, huber and tukey. The three fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, the least squares, Huber and Tukey can be used step by step.

Select Circle for Type

- **Edge Type**:
  - Strongest Edge: only the edge point set with the largest gradient in the scanning range is detected and fitted into a circle.
  - Last Edge: only the edge point set with the largest distance from the center of the circle within the scanning range is detected and fitted into a circle.
  - First Edge: only the set of edge points with the smallest distance from the center of the circle within the scanning range is detected and fitted into a circle.

- **Edge Polarity:**
  - Dark to light: it means that the transition from the area with a low gray value to the edge of the area with a high gray value.
  - Light to dark: it means the transition from the area with a high gray value to the edge of the area with a low gray value.
  - Any means both edges are detected.

- **Edge Threshold:** When the select type is line, the default value is 5. The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Reject Number**: It means that the number of minimum points that have high error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with the parameter of distance to remove.

- **Initial Locating**: If it is enabled, combined with the circular location sensitivity and subsampling coefficient settings, this parameter can roughly determine that the center of the area closer to the circle in the ROI area used as the initial circle center, which is convenient for subsequent fine circle search. If the initial location is disabled, the ROI center is the initial circle center by default. Under normal circumstances, the previous module of finding circle is position correction, it is recommended to disable this parameter.

- **Subsampling Coefficient:** it is also called downsampling, which means that the number of sampling points is decreased. For an image of N*M, if the subsampling coefficient is K, then one dot is taken every K points of each row and column in the original image to create an image. Therefore, the larger the subsampling coefficient, the more sparse the contour points will be, and the less detailed contour will be. It is recommended that the value should not be set too large.

- **Circle Locating Sensitivity:** it is used to eliminate the interference points. The larger the value, the stronger the ability to eliminate noise interference, but it is also easy to cause the initial location of circle failure.

- **Distance to Remove**: It means that the maximum pixel distance from the outlier to the fit circle. The smaller the value, the more points are excluded.

- **Initial Fit**: It has two types, including global and partial fit.

  - Partial:Local optimization is to fit the circle according to the local feature points. If the local feature more accurately reflects the position of the circle, the local optimization is adopted, otherwise the global optimization is adopted.

  - Global: line fit with the found global feature points

- **Fit Mode**: It has three types, including least squares, huber and tukey. The three fitting methods only have some differences in the calculation of weight. With the increase of the number of outliers and the distance of outliers, the least squares, Huber and Tukey can be used step by step.

📖NOTE

- When you select Draw in the data input mode, the caliper box and the figure to be found must intersect.

4.3.2 **L2L, C2C Measure**

In general, two lines are not absolutely parallel, thus line to line distance measurement is calculated by the average distance from four end points of the line to another line. Distance of line to line measurement is absolute distance, as shown below. The input mode and output results are described here. The selecting method of data source of circle to circle measurement is the same as that of line to line measurement.
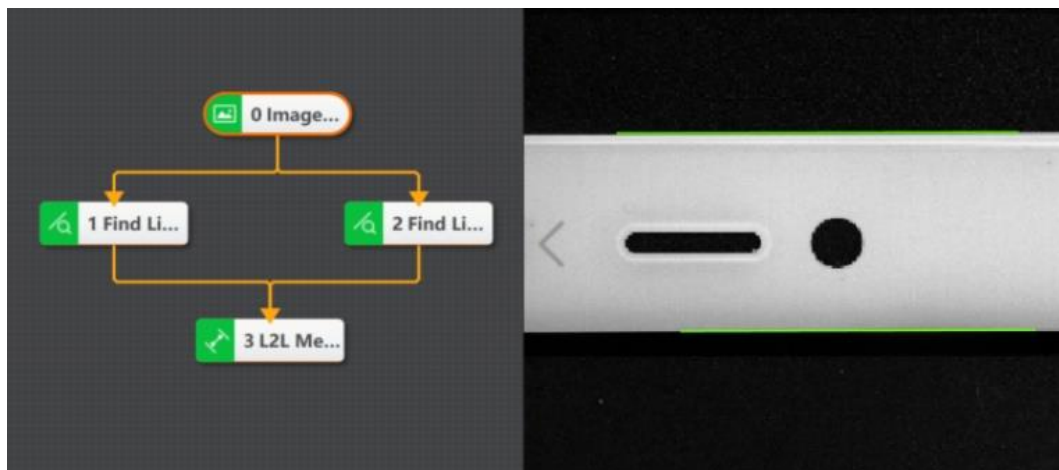
L2L Measure Parameters

- **Source Selection**: select the source of data, including subscription and drawing. See L2C Measurement for details.

- **By Line:** inputting source is the result of finding line.

- **By Point:** you can customize or link the start point, end point and angle of the line.

- **By Coordinate:** you can customize or link the X/Y coordinate of the line's start point, and end point.

- **Running Operation:** see L2C Measure for details.

L2L Measure Results

- **By Angle:** the angle difference between two lines.

- **Distance:** the average distance from four end points of the line to another line.

- **Absolute Distance:** the absolute value of distance.

- **Intersection Point X/Y:** the intersection point X/Y coordinate of extension lines of two lines.

4.3.3 P2C, P2L, P2P Measure

For P2C, P2L and P2P measurement, please refer to L2C Measure. You can set the output of corresponding tools according to your demands.

4.3.4 Intensity Measure

The tool of intensity measurement is used to measure grayscale average value and standard deviation of all pixels within the ROI of the measured image. Select the image source in the operating area first, drag the intensity measurement algorithm module into the operating area, and connect the module in turn using the operating line. You can use ROI tool to select area and narrow the search range. Click **Run** to see the result, as shown below.
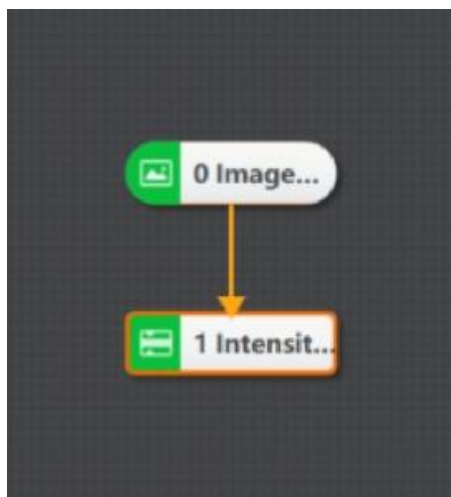
Output Results

- **Min./Max. Value**: Min./Max. grayscale value

- **Average Value:** grayscale average value

- **Standard Deviation:** The standard deviation is the arithmetic square root of the variance. The standard deviation can reflect the dispersion of a data set.

- **Contrast:** Contrast is a relative value. For a picture, it reflects the ratio of the brightest part to the darkest part of the picture.

4.3.5   Pixel Count

Count the number of pixels that meet the high and low threshold grayscale setting in the ROI area, as shown below.
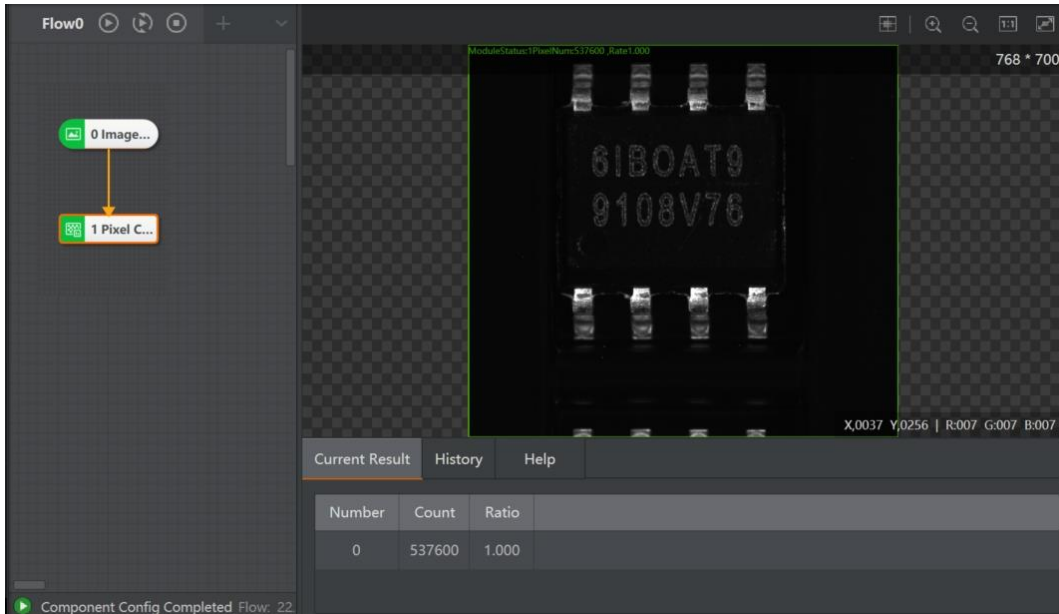
Parameters and Results:

- **Low Threshold:** the grayscale value in the area that needs count should be larger than low threshold value.

- **High Threshold:** the grayscale value in the area that needs count should be smaller than high threshold value.

- **Rate:** pixel point rate in this area.

⚠️ NOTICE

- If low threshold is larger than high threshold, the value of pixel should be between [0, high threshold] and [low threshold, 255]. If low threshold is smaller than high threshold, the value of pixel should be between [low threshold, high threshold].

4.3.6   Edge Distance

This tool is used to detect the distance between two feature edges. First, find the edge that meets the conditions, and then measure the distance, as shown in the following figure. As some parameters have been explained in previous sections, this section mainly describes part of the parameters.
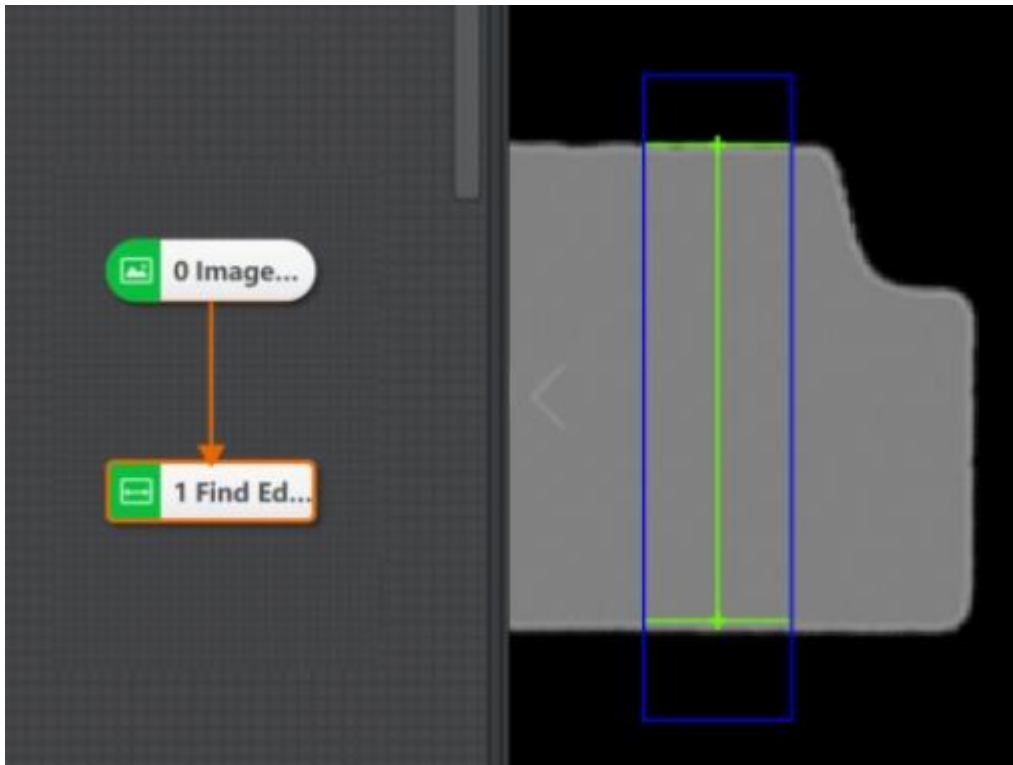
Running Parameter

- **Filter Size:** it is used to enhance the edge and suppress noise, and its minimum value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This value needs to be set based on the actual situation.

- **Edge Threshold:** The edge threshold is the gradient threshold, ranging from 0 to 255. Only edge points whose edge gradient threshold is greater than this value are detected. The larger the value is, the stronger the anti noise ability is, the less the number of edges is, and even the target edge points are screened out.

- **Edge Polarity:** it has three modes, including dark to light, light to dark and any.

- **Widest:** represents the edge pair with the largest spacing within the detection range.

- **Narrowest**: represents the edge pair with the smallest spacing within the detection range.

- **Strongest**: represents the edge pair with the largest average gradient within the detection range.

- **Weakest**: represents the edge pair with the smallest average gradient within the detection range.

- **First Pair**: represents the edge pair whose center of the edge pair within the detection range is closest to the starting point of the search.

- **Last Pair**: represents the edge pair whose center of the edge pair within the detection range is furthest to the starting point of the search.

- **Closest**: represents the set of edge pairs closest to the ideal width within the detection scanning range.

- **Not Closest**: represents the set of edge pairs not closest to the ideal width within the detection scanning range.

- **All**: represents all edge pairs within the detection scanning range.

- **Find Direction**: it includes top to bottom and left to right.

- **Min. Edge Score**: find the minimum score of the edge. The edge with a score lower than the minimum score will be filtered out.

- **Max. Result Number**: maximum number of searching

- **Ideal Spacing**: The closer the spacing between edge pairs is to this value, the better, which is used to filter the sorting results

- **Sort Method**: score ascending, score descending, direction forward and direction reverse. The results are sorted according to the selected type.

Output Result

- **Measured Width**: pixel width of spacing detection

- **Edge Point Coordinates X/Y**: start and end coordinates of edges

- **Score**: The score calculation method in spacing detection is completely consistent with caliper tool. However, the "scoring function curve" is set internally and is not open to the outside world.

- **Edge Polarity**: 1 means from black to white, 2 means from white to black.

- **Edge Status**: 0 means not locating to edge, 1 means located.

4.3.7 Histogram

The tool of histogram is used to count pixel quantity, average value, min. value, max. value, peak value, standard deviation and contrast of gray in a target area. It also generates a gray histogram, which clearly shows the distribution of pixel points under each gray value, as shown below.
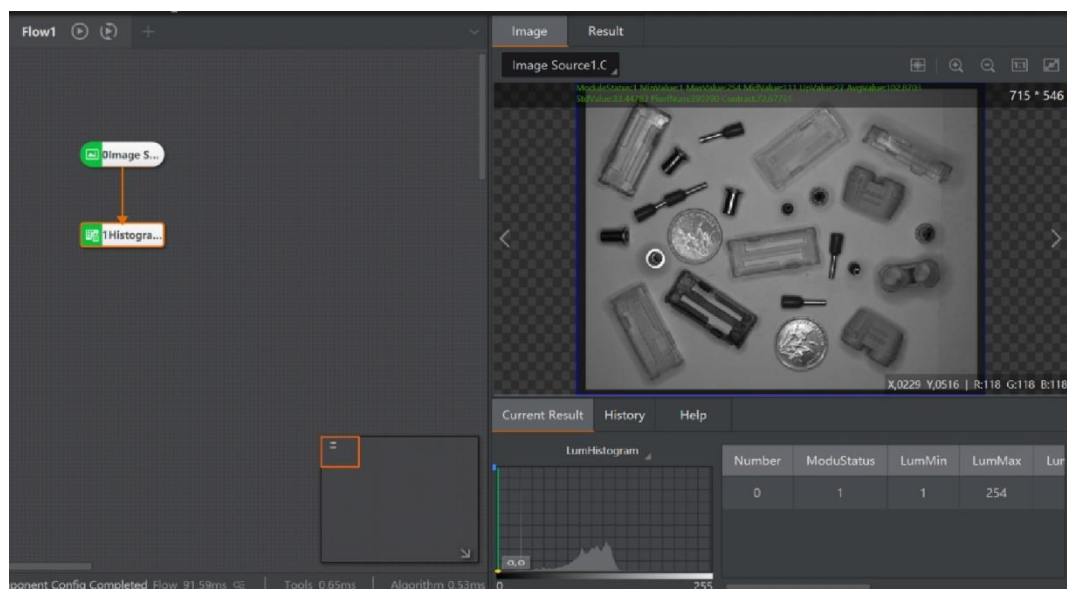
Results:

- **Min./Max. Value**: Min./Max. grayscale value

- **Mid-value, Peak Value, Average Value:** Mid-value, Peak Value, Average Value of grayscale

- **Standard Deviation**: The standard deviation is the arithmetic square root of the variance. The standard deviation can reflect the dispersion of a data set.

- **Pixel Quantity**: count pixel quantity in the image

- **Contrast:** Contrast is a relative value. For a picture, it reflects the ratio of the brightest part to the darkest part of the picture.

4.4 Image Generation

4.4.1 Circle Fit and Line Fit

This tool fits circle on the basis of three points or above, as shown below. Detect the intersection to form a point set firstly, and then fit into a circle.
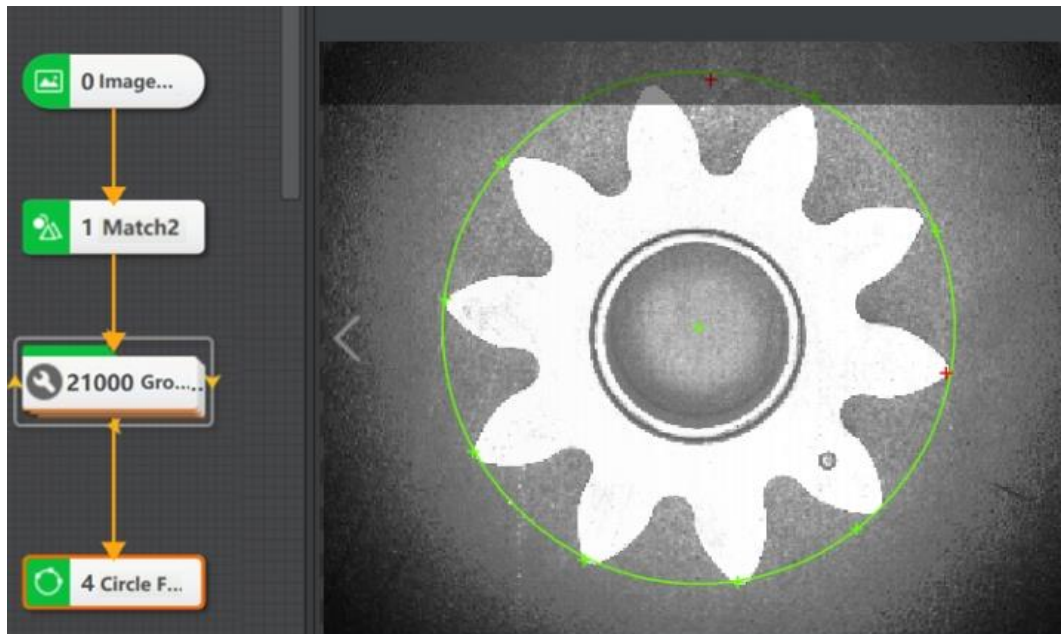
Basic Parameters of Circle Fit	
Image Input	select collected images
Fit point	select collected point in the flow as fitting source

Running Parameters of Circle Fit	
Reject Number	It means that the number of minimum points that have large error to be excluded from fitting. In general, if there is a great number of points excluded from fitting, its value should be set higher. For better results, it is recommended to use it in combination with Distance to Remove.

Distance to Remove	It means the maximum pixel distance from the outlier to the fit circle. The smaller the value is, the more points are excluded.
Initial Type	It includes global optimum and local optimum
Weighting Function	It has three types, including least squares, huber function and tukey function. These three fitting modes are different in way of calculating the weight only. As the number of outliers and the distance from the group increases, it is recommended to use least squares, huber, and tukey successively.
Max Iteration Times	max. execution times for fitting algorithm

Line fitting needs two fitting points, and its principle is similar to circle fitting. For specific parameters, refer to circle fitting mentioned above. Take a solution demonstration as an example here. The circle is used as the model for feature matching, and then the matching points are used to fit the line.
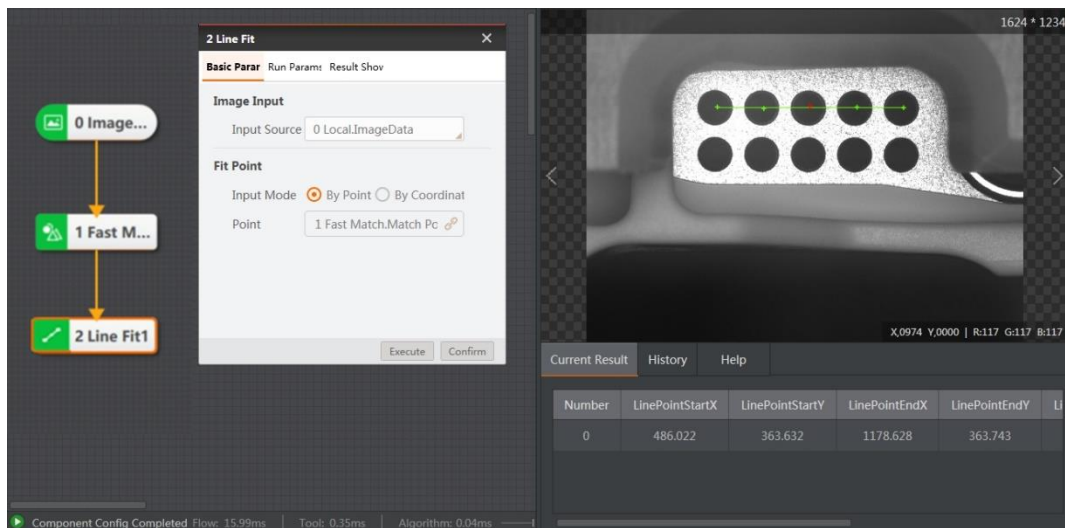
4.4.2 Geometry Generation

The tool of geometry generation is used to freely create multiple auxiliary graphics, including rectangles, points, line segments and circles. When some graphics are difficult to locate, you can move the mouse or modify the X and Y coordinates to change the position of the generated graphics, as shown below. The white circle contour that is difficult to locate can be created by yourself.
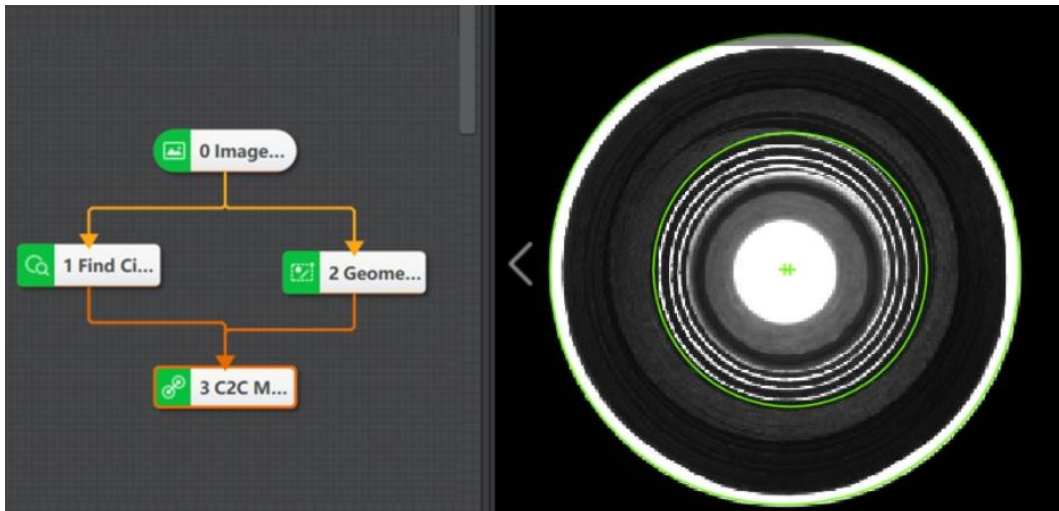
Geometry Creation	
Create Rectangle	Drag the mouse to draw on the image, and move or modify the X, Y coordinates, width, height, and angle of the center point. This tool can be used with position correction tool
Create Point	Click on the image with the mouse to create point, and then move or modify the X and Y coordinates, which can be used in conjunction with position correction
Create Line	Drag the mouse on the image to create a line. Drag the end point of the line or modify the X/Y coordinate of the end point, which can be used in conjunction with position correction
Create Circle	Drag the mouse on the image to create a circle. Move the end point of the circle or modify the X/Y coordinate of circle center and the radius, which can be used in conjunction with position correction

4.5 Recognition

Select the recognition tool from the drop-down menu. The tool of recognition includes 2D BCR recognition, BCR recognition and OCR recognition.

4.5.1 **2D BCR Recognition**

The tool of 2D BCR recognition is used to identify the 2D code in the target image, and output 2D code information in the form of characters. It can efficiently and accurately identify multiple 2D codes at a time. Currently, only QR code and DataMatrix code are supported, as shown below.

Recognition Parameters:

- **QR Code and DM Code:** after enabling, the software can recognize QR code and DataMatrix code in the image. When you do not sure about the code type, it is recommended to enable both of them.

- **2D Code Number:** the max quantity of 2D codes that are expected to be searched and output. If the quantity of actually found is smaller than this parameter, the actual quantity of 2D codes is output. Sometimes the quantity of 2D codes in the scene is variable. To identify all the 2D

codes that appear, you should set this parameter as the max. quantity of 2D codes in the scene. In some applications, the background texture is complicated, and the current parameters can be appropriately larger than the quantity of 2D codes to be recognized, which will reduce efficiency.

- **Polarity:** it has three types, including dark on white, white on dark and any. you can select them according to your demands.

- **Edge Type:** it has three types, including continuous, discrete and compatible type, as shown below. The left one means continuous type, right one means discrete type, and compatible type can be compatible with continuous and discrete type.

- **Subsampling Ratio:** it is the image subsampling coefficient. The larger the value,and the higher the efficiency of the algorithm will be. But the recognition rate of the 2D code is reduced.

- **Code Width Range:** the pixel width that 2D codes occupy, and it includes the pixel width of the largest and smallest code.

- **Mirror Mode:** it means the X direction mirror of image, including mirrored and non-mirrored mode.

- Mirror mode enable switch, which refers to image X-direction mirroring, including "mirror" and "non-mirrored" modes. This parameter should be enabled when the mage is collected from reflected mirror. Otherwise, this parameter should not be enabled.

- **QR Distortion**: this parameter needs to be enabled when the 2D code to be identified is printed on the bottle or bags of logistics industry.

- **Timeout-Period to Exit:** if the running time of the algorithm exceeds this parameter value, it will exit directly and unit is ms. When this parameter is set as 0, and the timeout exit time will be disabled.

- **Application Mode:** the normal mode is adopted in the normal scene. The expert mode is reserved for the 2D codes that are difficult to identify. When the application scene is simple, the code is clear, and area is large and clean, the fast speed mode can be adopted.

- **DM Code Type:** it has three types, including square, rectangle and compatibility mode.

Recognition Results:

- **Center X/Y:** center X and Y coordinates of 2D BCR

- **Code Angle:** the angular offset of the 2D BCR from the horizontal position

- **PPM:** pixels quantity occupied by the side length of a module in the 2D BCR

4.5.2   BCR Recognition

The tool of BCR recognition is used to locate and identify the bar code in the specified area, and tolerate the target barcode to rotate at any angle and tilt at a certain angle. It supports CODE39 code, CODE128 code, Codabar code, EAN code, alternating 25 code and CODE93 code. The specific operation is shown below.
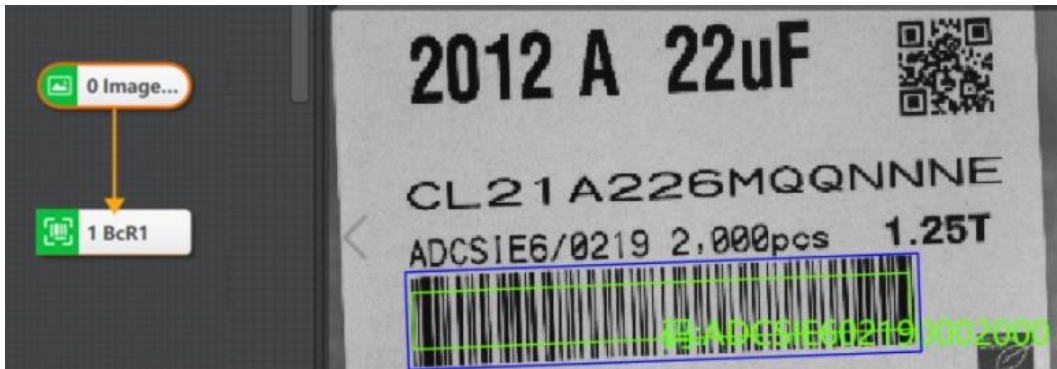
Recognition Parameters:

- **Code Enabling:** it supports CODE39 code, CODE128 code, Codabar code, EAN code, alternating 25 code and CODE93 code. Enable according code type.

- **Bar Code Number:** the max. quantity of bar codes that are expected to be found and output. If the quantity of actually found is smaller than this parameter, the actual quantity of bar codes is output.

- **Subsampling coefficient:** it is also called downsampling, which means that the number of sampling points is decreased. For an image of N*M, if the subsampling coefficient is K, then one dot is taken every K points of each row and column in the original image to create an image. Therefore, the larger the subsampling coefficient, the more sparse the contour points will be, and the less detailed contour will be. It is recommended that the value should not be set too large.

- **Detection Window Size:** it is the size of bar code area location window size. The default value is 4, and when the blank space in the bar code is relatively large, you can set it larger, for example 8. But you have to make sure that the bar code height is greater than 6 times of that of the window size, and the value range is from 4 to 65.

- **Quite Zone Width:** it refers to the width of the blank area on the left and right sides of the bar code. The default value is 30. If the blank area is sparse, you can set the value as 50.

- **Bar Code Height Range:** the minimum bar code height and the maximum bar code height that algorithm is able to recognize. The default value is from 30 to 200.

- **Dfk Filter Size**: the minimum bar code height and the maximum bar code height that algorithm is able to recognize. The default value is from 30 to 2400.

- **Timeout-Period to Exit:** if the running time of the algorithm exceeds this parameter value, it will exit directly and unit is ms. When this parameter is set as 0, the actual time that algorithm costs should prevail, and the unit is ms.

4.5.3   OCR Recognition

The tool of OCR recognition is used to read the character text on the label. This tool requires character training. The specific steps are shown below.

1. Drag the character recognition module in to the flow editing area and set relevant parameters after double-click.

2. Set parameters before character training.

Running Parameters:

- **Character Polarity:** it has two types, including dark on light and light on dark.

- **Character Width Range:** it is used to set the min. width and max. width of character, and the range is [1, 512].

- **Width Type:** it has two types, including changeable type and equal-width type. When the character width is the same, it is recommended to select equal-width type. Otherwise, select changeable type.

- **Character Height Range:** it sets the min. height and max. height of the character, and the range is [1, 512].

- **Binary Ratio:** it is the parameter of binaryzation threshold, and the range is [0, 100].

- **Area of Fragment:** the area range of single character, and the range is [0, 100000].

- **Accept Threshold:** it refers to the min. score of a character that can be recognized.

Advanced Parameters:

- **Distance Threshold:** the distance from the Blob to the text baseline. If the actual value is greater than this parameter, it will be deleted.

- **Ignore Borders:** whether to delete the blob that is in touch with the ROI boundary.

- **Main Direction Range:** the search range of text tilt angle, and the range is [0, 45].

- **Tilt Range:** the max. range that allows characters to be tilted, and the range is [0, 45].

- **Min. Gap of Characters:** the min. transverse gap between two characters.

- **Min. Gap of Lines:** the min. gap between multi line characters.

- **Max Width and Height Ratio:** the largest width and height ratio range of a single character circumscribed rectangle is [1, 1000].

- **Classification Method:** it has three methods, including the nearest distance, the highest weight and the fastest rate.

- **Stroke Width Filter Enable:** Whether to enable stroke width filter or not.

- **Stroke Width Range:** the width range of a single stroke, and it can only take effect after the width filter is enabled, and the max. range is [1, 64].

- **Similarity Type:** it supports euclidean distance and cosine distance. Different types will affect recognition rate.

3. Double-click fonts training.

- Select the target character area.

- Click Draw Character and it will show characters that are divided by red box.
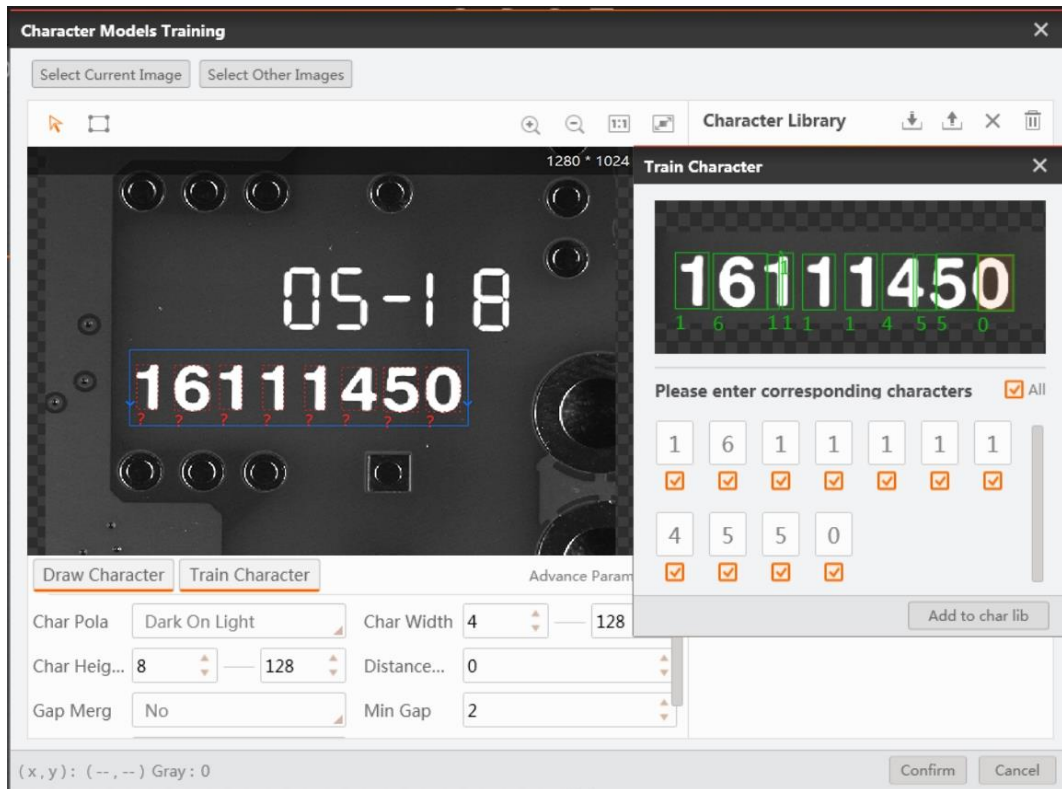
- Click **Train Characters**. Complete the training by inputting the true values of the corresponding characters and adding them to the character library. If the recognition is inaccurate,

you can repeat the training. Select a single character in the character library and click to expand the training of a single character, as shown in the figure below.
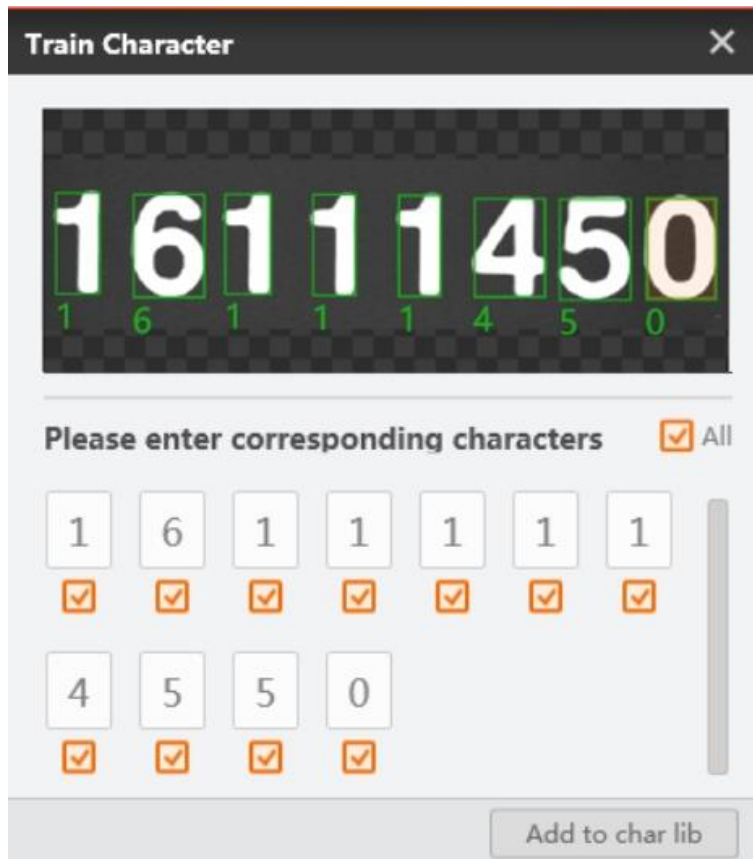
4. In order to improve the accuracy of recognition, you can enable character filtering. Now only the character types you set are recognized in the corresponding positions, as shown in the following figure.
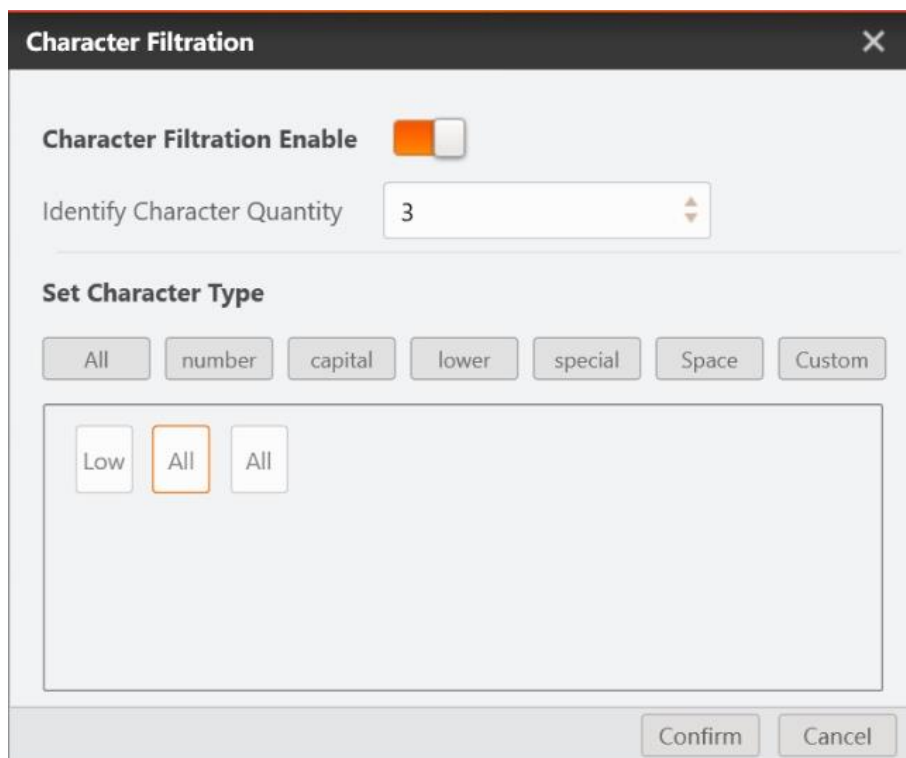
When character filtering is enabled, you can customize the number of recognized characters and the type of each character, including all, numbers, uppercase letters, lowercase letters, special characters, spaces, customization, etc. You can define characters that are easy to be misunderstood through **Customize**, but only if the customized characters exist in the character library.

5. Click **Run** to output the target character in the image. The first possible recognition result and candidate recognition result will be output. The first possible result is read by default, as shown in the following figure.
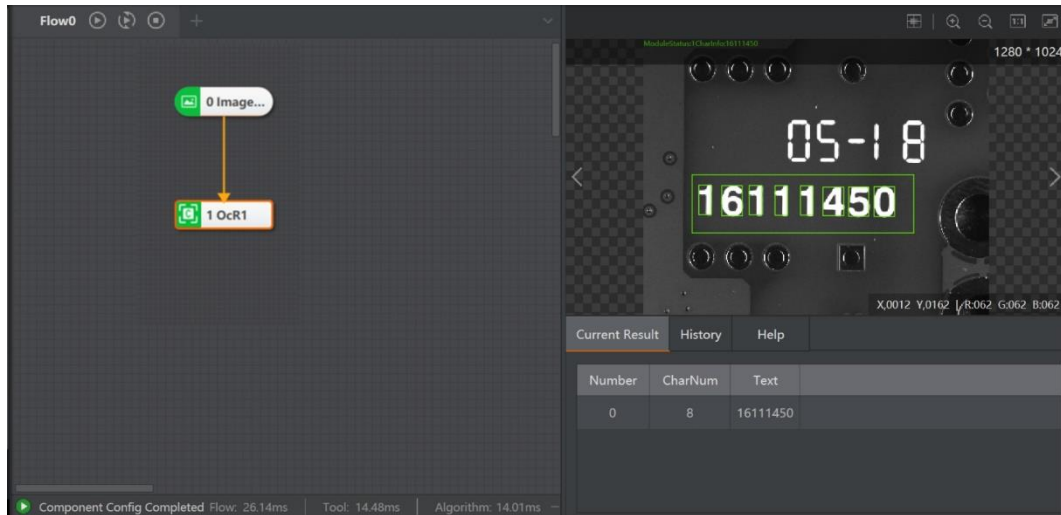
4.5.4   **DL Character Recognition**

Character recognition is a process of converting image information into symbols that can be represented and processed by the PC. Essentially, character recognition task can be considered as a special translation process: translating image signals into natural language. This is similar to speech recognition and machine translation: from a mathematical point of view, they convert a set of input sequences containing a large amount of noise into a set of output sequences of a given label through the model obtained by automatic learning.

With features of low rejection rate, low error rate, fast recognition speed, high stability, friendly user interface, etc., DL character recognition is widely applied to dot and matrix character recognition, IC chip character recognition, inkjet printing character recognition, bank card character recognition, etc. Character training is required before character recognition, and it is recommended to use character recognition tool together with character location tool.
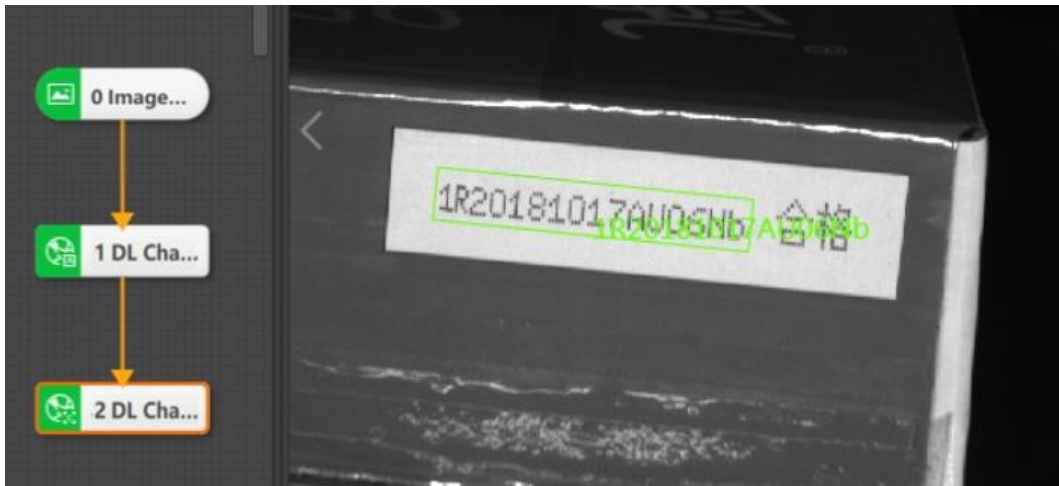
- **Basic Parameters**: In this setting, the ROI area where the target character is located must be selected. When the graphic position changes, it is best to use it in conjunction with character positioning.

- **Running Parameters**: The settings are as following:
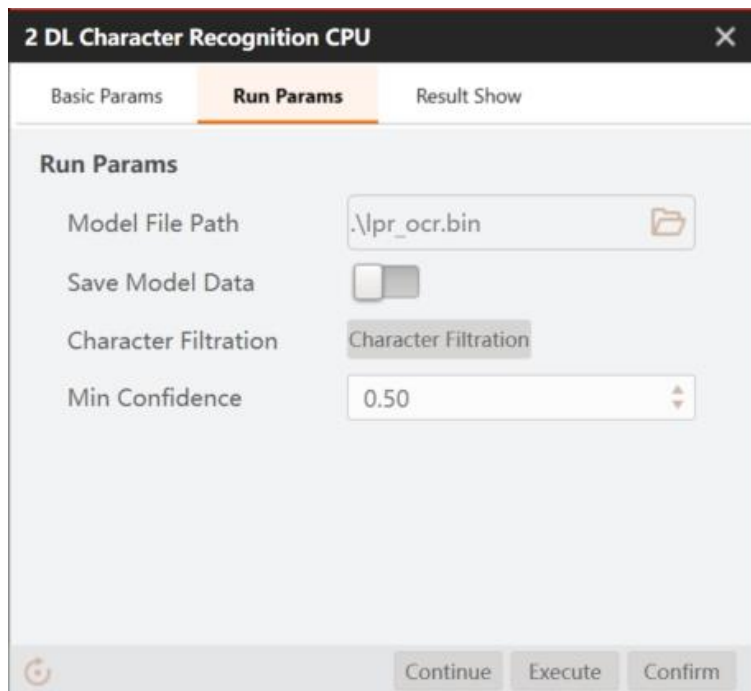
- **Model File Path**: The model file provides a default model, and you can also load the model file created by the previous character training.

- **Saving Model in Solution**: After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.

- **Character Filtration**: Each ROI supports setting character filtration independently
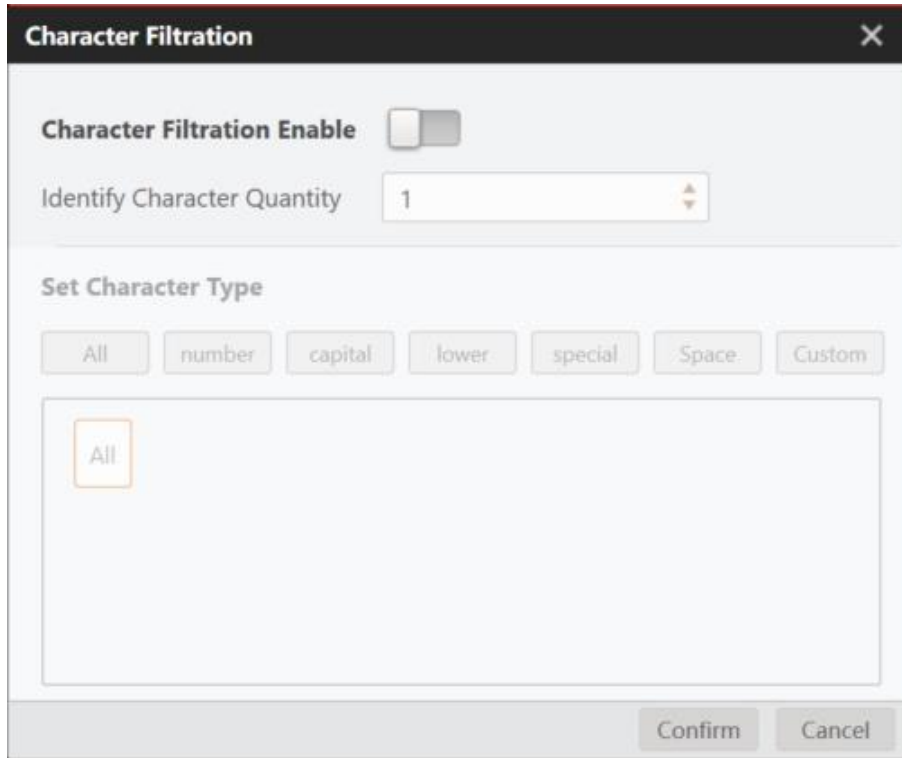
When character filtering is enabled, you can customize the number of recognized characters and the type of each character, including all, numbers, uppercase letters, lowercase letters, special characters, spaces, customization, etc. You can define characters that are easy to be misunderstood through **Customize**, but only if the customized characters exist in the character library.

- **Min. Confidence**: It refers to the min. score for recognizing characters.

4.5.5   DL Code Reading

The tool of DL code reading can read the 2D BCR and BCR in the specific area. It supports CODE39 code, CODE128 code, Codabar code, EAN code, alternating 25 code and CODE93 code for BCR, supports QR code and DataMatrix code for 2D BCR. The specific solutions are as following.

DL code reading module is divided into DL code reading C and DL code reading G. They need different operating environments but have the same parameters and functions. Therefore, you can select according to your own computer configuration.

Level Running Parameters of 2D BCR:

- **ISO Standard**: ISO15415 and ISO29158, select according to demands.

- **Mirror Mode**: mirror image refers to the image in X-direction mirror image. Three modes can be selected:

  - Mirror Image: select this mode if the collected image is a reflection image in the mirror.

  - Non-Mirror Image: select this mode if the collected image is not a reflection image in the mirror.

  - Any: default mode includes mirror image and non-mirror image.

- **Rating Processing Type**: processing 1 and processing 2 can be selected.

  - Processing 1: supports HIK rating mode.

  - Processing 1: supports ISO rating mode.

- **Aperture Size**: it is filter size, it is more obvious to increase the filter effect, and the default value is recommended.

- **Rating Mode**: HIk and ISO can be selected.

- **Polarity:** it has three types, including dark on white, white on dark and any. you can select them according to your demands.

- **Number of 2D BCR Rows and Columns:** The 'row' and 'column' of the smallest 'square' or 'circle' constituting the 2D BCR are one row or one column. It indicates the number of rows and columns contained in the actual 2D BCR. It is recommended to use the default value. In case of abnormality, the number of rows and columns of 2D BCR can be filled in according to the actual situation.

- **Edge Type:** Continuous and discrete type can be selected.

Level Running Parameters of 1D BCR:

- **Time-Period to Exit**: If the algorithm running time exceeds this value, it will exit directly, and the unit is ms. When it is set as 0, the timeout exit time will be closed and the algorithm will run for as long as the actual time required.

- **High Performance Mode**: DL code reading C module has unique parameters. After it is enabled, the recognition effect will be better, but the CPU usage will increase

- **Code Grade Flag**: If it is enabled, you can view an set more specific code parameter configurations.

- **Enable Button:** when enabling, it means the sub level of the index reckons in the total level, including decoding level, edge certainty, contrast, min. reflectivity rate, edge contrast, module uniformity, decode ability, defect degree and static area.

- **Indicator ABCD Threshold**: It refers to the interval when the score of the index is used to calculate the grade. The index includes decode ability, defect degree, minimum reflectivity rate, edge contrast, module uniformity and contrast.

- **Aperture Size**: it is filter size, it is more obvious to increase the filter effect, and the default value is recommended.

⚠ NOTICE

- There is no quantitative correlation between the timeout exit time and the algorithm time at the bottom of the interface. The timeout time represents the time when the algorithm locates and reads the code in the image.
- DL code reading library supports the upper limit of 7936 * 5888 pictures.
- The DL code reading module of this version only supports codes below 16 data areas of 2D BCR for the time being, and the limit of code reading character set is 256. If you need to expand the ability set, please contact our technicians.

4.5.6 DL Character Location

The tool of DL character location can accurately locate characters in images when the character background is complex and the location is not fixed. The specific process is shown in the figure below.

Running Parameters	
Model File Path	Select the model file created by the previous character training.
Save Model Data	After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.
Max. Number to Find	It refers to the max. character quantity to be searched, the default is 1 and the range is [1, 100].

| Min. Confidence	It refers to the min. score for the character location box. The default is 0.3 and the range is [0, 1].
Overlap Rate	It refers to the overlap rate of character location boxes, the default is 0.3 and the range is [0.01, 1]
Sort Object	It refers to the sorting order of characters, including by X/Y coordinate of center point, and by confidence.
Advanced Parameters	
Edge Filter Enable	After the function is enabled, the minimum edge score can be set. If the proportion of the part within the edge of the search target in the whole is less than the minimum edge score, the search target will be discarded.
Character Angle Enable	It sets the relative angle range tolerance for target characters. To search a target with rotation change, you need to set it accordingly, and angle range is from -180° to 180°.
Character Width Enable/Character Height Enable	If it is enabled, characters whose width/height are within this range can be detected.
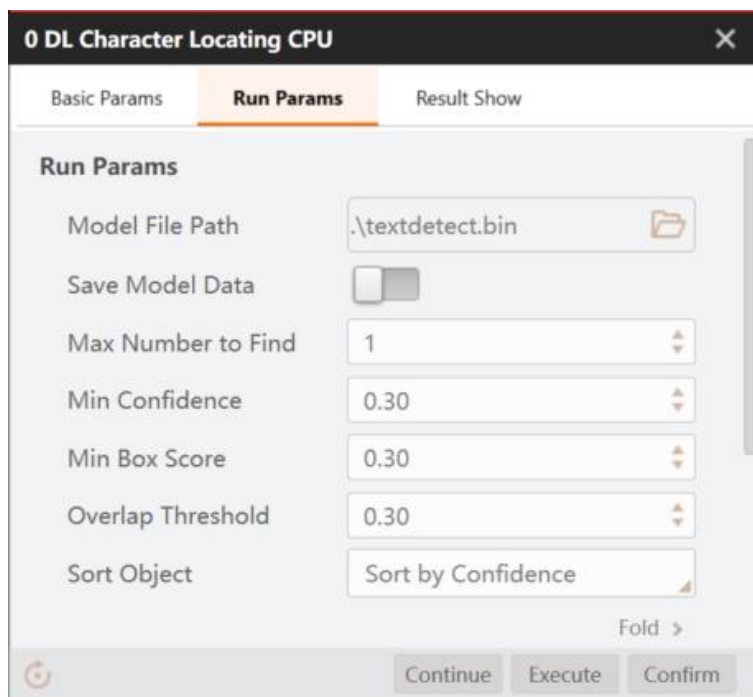
4.5.7 DL Single Character Recognition

When there are multiple lines of text in the image and the combination of positioning and recognition takes a long time, the single character recognition module can be considered, as shown in the figure below.
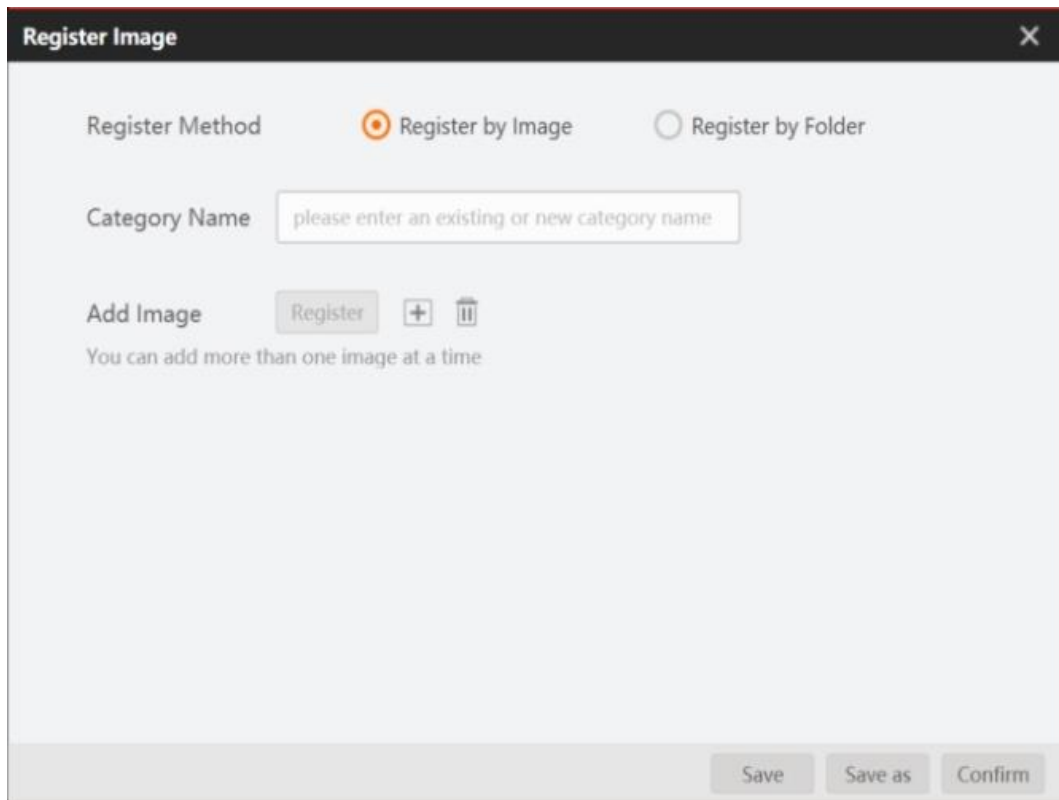
Running Parameters:

- **Model File Path**: Select the model file created by the previous character training.

- **Saving Model in Solution**: After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.

- **Character Filtration**: Each recognition frame can set customized character filter information. Refer to Character Recognition for details.

- **Max. Number to Find**: It refers to the max. quantity of objects to be searched.

- **Min. Confidence**: It refers to the min. score for target objects.

- **Overlap Rate**: It refers to the max. overlap rate of the target image.

- **Sort Object**: It refers to the character's sorting order, including X coordinate of center, Y coordinate of center and confidence.

Advanced Parameters:

- **Edge Filter Enable**: After enabling, the minimum edge score can be set. If the proportion of the part within the edge of the search target in the whole is less than the minimum edge score, the search target will be discarded.

- **Character Width Enable**: If it is enabled, target objects whose width are within this range can be detected.

- **Character Height Enable**: If it is enabled, target objects whose height are within this range can be detected.

📖NOTE

- When you copy module parameters, the character filtering data in the running parameters will not be copied. If you paste a parameter to another module of the same type, the character filtering content in the running parameter must be reset.

4.6 **Deep Learning**

Deep Learning is a machine learning algorithm, which is developed based on the traditional neural network. With a deep learning module, the machine can absorb, learn, understand and handle complex information in the real world as human beings.

Specifically speaking, machine with the deep leaning module, can execute and finish high-difficulty recognition tasks, such as character recognition, character positioning, image segmentation, image classification, object detection, image retrieval, anomaly detection and instance segmentation.

As deep learning is based on data, you need to collect a large amount of data sets before starting deep learning. The data sets participating in the training need to be labeled to ensure the diversity of data as much as possible and have low resolution requirements. Take character positioning as an example. At least 150 picture samples are required. You need to use VisionTrain for deep learning training.

📖NOTE

- The deep learning module has two versions: G and C. The suffix of module name of GPU version is G, the suffix of module name of CPU version is C, and the CPU version does not depend on the graphics card.

- DL character recognition, DL code reading, DL character location, and DL single character recognition belong to the recognition category.

- The function module has a high requirement for the PC configuration. See Operating Environment for details.

4.6.1 DL Image Segmentation

In image segmentation, you can configure parameters and detect foreground objects through self-trained model. Image segmentation can be divided into two-level classification mode and multi-level classification mode. The two classification mode is to only detect defects, as shown in the figure below.

- Two-level Classification Mode
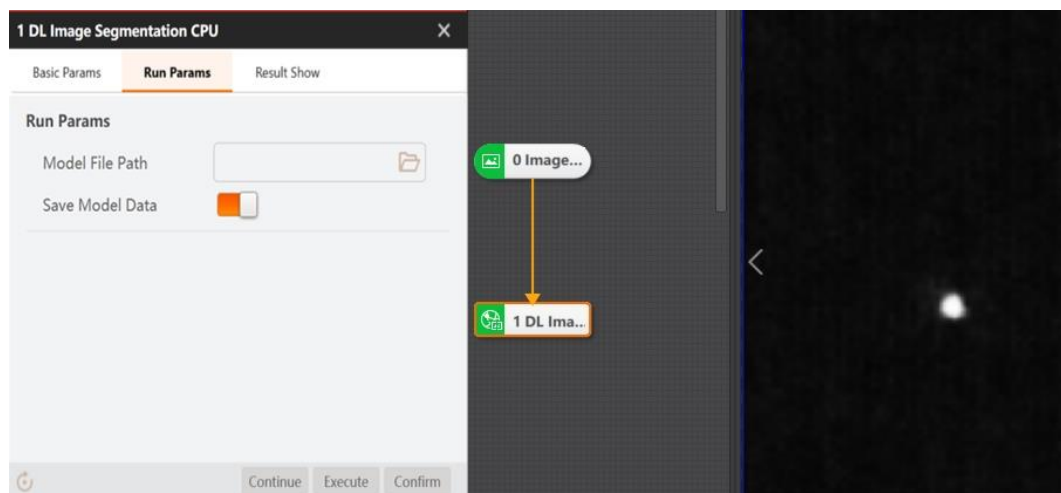
For defects, the pixel value is high, and most of the interference can be removed through subsequent processing or secondary training. The image on the right side of the above figure is the defect probability diagram of image segmentation.

- Multi-level Classification Mode
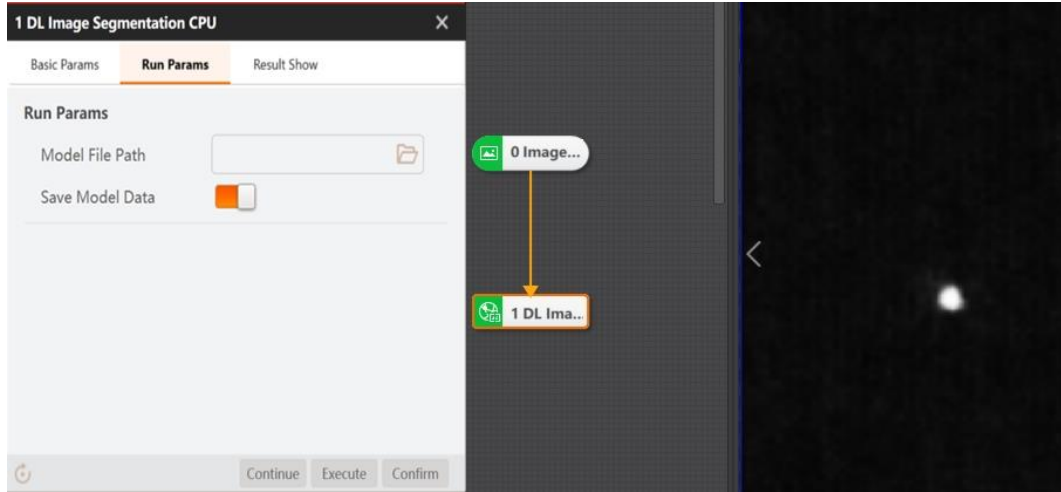
For defects, the pixel value is high, and most of the interference can be removed through subsequent processing or secondary training. Through subsequent processing, the image on the right side of the above figure is the defect probability diagram of image segmentation.

- Multi-level Classification Mode

The right side of the figure above is the category diagram of image segmentation, and its operation parameter settings are shown in the figure below.

Running Parameters of Defect Detection	
Model File Path	Select the model file generated by the previous image segmentation training.
Saving Model in Solution	After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.
Min. Score	It is classified as a certain type of probability.
Display Probability Diagram	You can select defect probability diagram displayed on the display interface.
Output Type	You can select the defect probability diagram that can be subscribed by subsequent modules.

📖NOTE

- The DL image segmentation module supports the multi classification function of defects. When marking defects with the deep learning training tool, if it is necessary to classify defects, mark the defect type at the same time, and only the large/small model of single image segmentation and the self-learning template mode in image comparison support the multi classification function.

4.6.2 **DL Classification**

Deep learning classification is an image processing method for distinguishing the targets of different types according to different features reflected in image information. It uses the PC to analyze images,

and classifies each pixel or area in an image into several categories so as to replace human beings' visual judgment. It has been widely applied into object recognition and sorting. The specific processes are as follow.

Running Parameters	
Model File Path	Select the model file created by the previous character training.
Saving Model in Solution	After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.
Top-K Categories	It outputs the index number and corresponding confidence of the highest confidence score of K categories.

4.6.3 DL Object Detection

Object detection is an image segmentation based on target geometric and statistical features. It combines target segmentation and recognition. DL object detection has two ways: G and C. The suffix of module name of GPU version is G, and the suffix of module name of CPU version is C. The CPU version does not depend on the graphics card.

Running Parameters:

- **Model File Path**: Select the model file created by the previous character training.

- **Saving Model in Solution**: After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.

- **Max. Number to Find**: It refers to the max. quantity of objects to be searched.

- **Min. Confidence**: It refers to the min. score for target objects.

- **Overlap Rate**: It refers to the max. overlap rate of two target objects.

- **Sort Object**: It refers to the character's sorting order, including X coordinate of center, Y coordinate of center and confidence.

Advanced Parameters:

- **Edge Filter Enable**: After enabling, the minimum edge score can be set. If the proportion of the part within the edge of the search target in the whole is less than the minimum edge score, the search target will be discarded.

- **Angle Enable**: It sets the relative angle range tolerance for target objects. To search an object with rotation change, you need to set it accordingly, and angle range is from -180° to 180°.

Width/Height Enable: If it is enabled, target objects whose/height width are within this range can be detected.

4.6.4 DL Image Retrieval

DL image retrieval is mainly used to search for the desired type of target image among various types of images. The DL image retrieval module supports color images and black-and-white images. The specific solution is shown in the figure below.

- Select the image to be trained, use the VisionTrain to train the image marking, and divide the image types in the image set. See the user manual of VisionTrain for specific training methods.

- Import the model trained by VisionTrain into the running parameter model file path of DL module, as shown in the following figure.
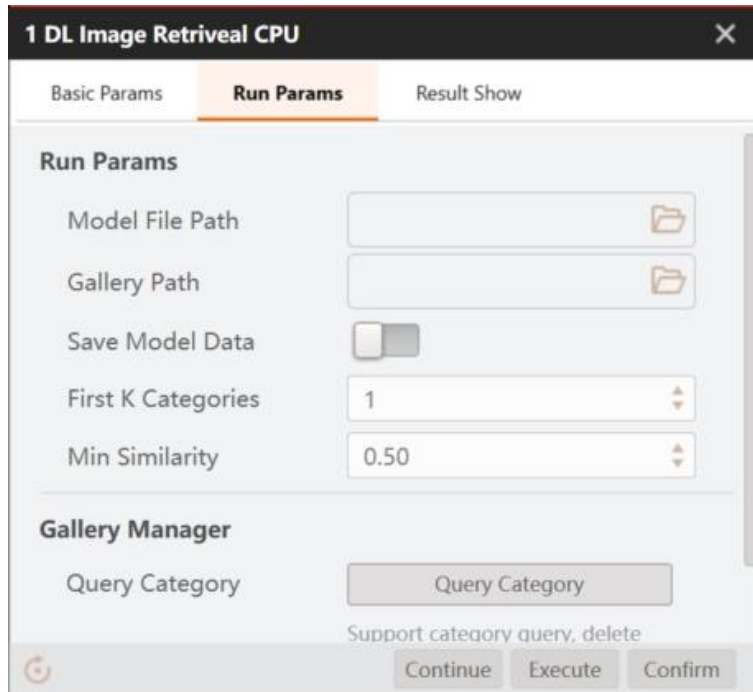
- Import the Gallery model file obtained during training into the Gallery path, as shown in the following table:

- After adding the Gallery path and model file path, click Execute to configure the parameters.

Running Parameters:

- **Model File Path:** Select the model file created by the previous character training.

- **Saving Model in Solution:** After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.

- **Gallery Path:** It is generated together with the training model during training, and the path of the gallery file is VisionTrain1.2.0\Applications\DeepLearningModel.

- **Top-K Category:** The number of categories displayed in the result, with a value range of 1 to 10.

- **Min. Similarity:** You can filter results whose search results are less than this value.

Gallery Management:

- **Search Category:** You can search and delete categories in the gallery.

- **Register Image:** You can create Gallery files manually.

If Gallery file is not found in this folder, DL image retrieval supports self creation of files. The specific methods are as follows

- Click Register to enter the following interface:

Register Image ✕

Register Method ⦿ Register by Image ○ Register by Folder

Category Name [please enter an existing or new category name]

Add Image Register ⊞ 🗑
You can add more than one image at a time

Save Save as Confirm

- Select Register by Image to register a type. Fill in the category name and click + to add image and click Register. You can only register one type using the method.

- Select Register by Folder to register multiple types, as shown in the following figure:
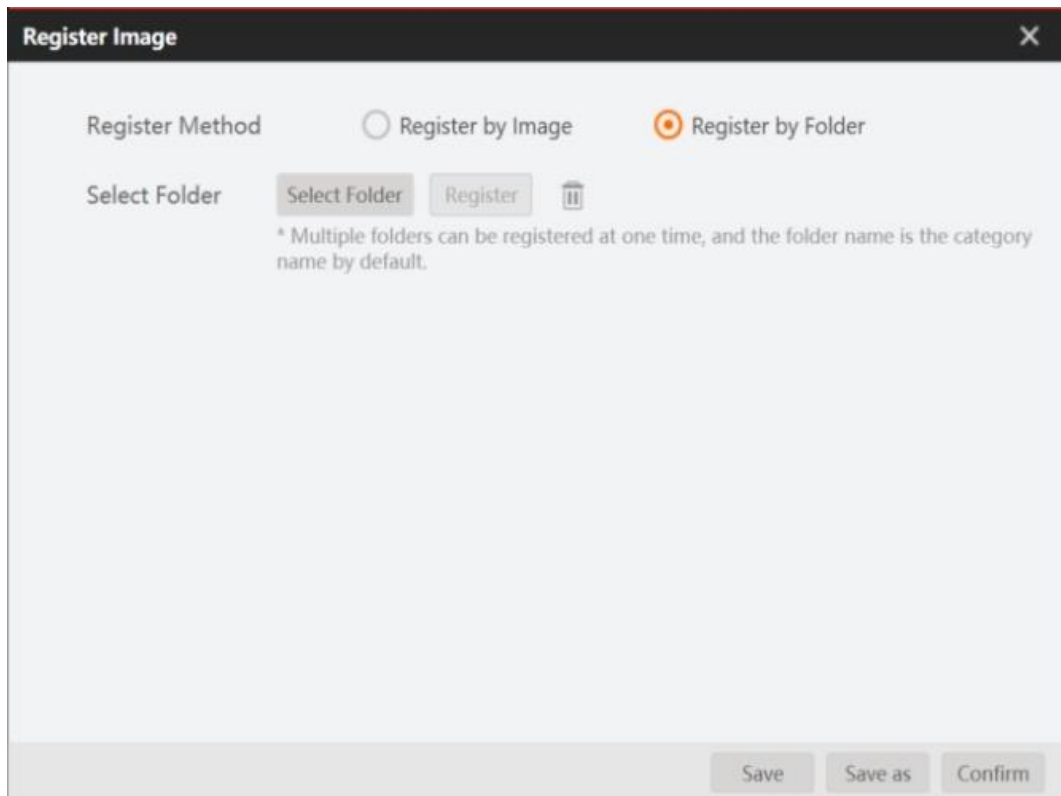
- Click to select a folder and then click Register. Place Images of the same category in the folder and name it as the category name.

4.6.5 DL Anomaly Detection

DL anomaly detection is to detect exceptional pictures by learning from a few OK samples. It can be used to the scenario that there are a large number of OK samples, but no NG samples or few types of NG samples and the defect type is uncertain.

The image with obvious detects is shown in the figure below.

After registering training model, run the results as shown below.

Basic Parameters:

In this setting, you need to draw the ROI area where the defect is located.

Running Parameters:
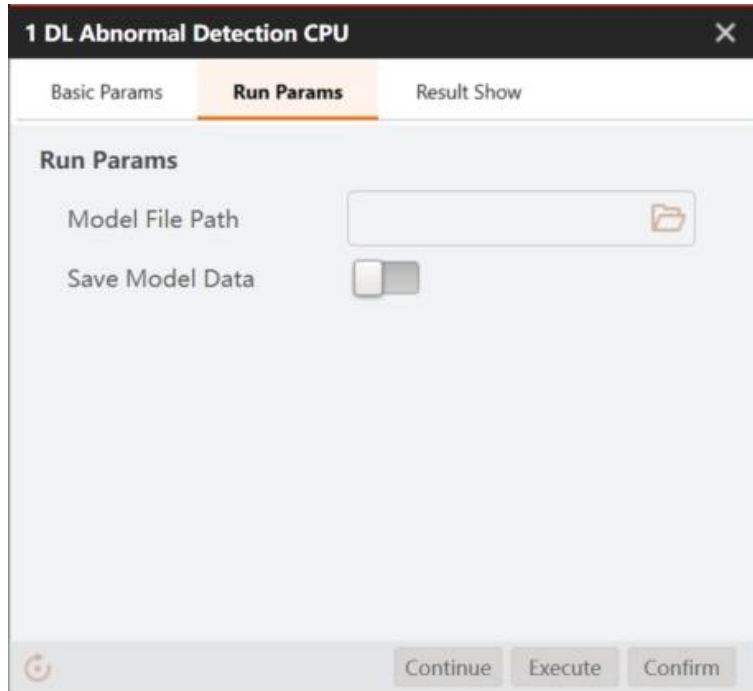
- **Model File Path**: Load the model file created by the previous training.

- **Saving Model in Solution**: After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.

4.6.6 DL Instance Segmentation

Instance Segmentation has the characteristics of Semantic Segmentation, which needs to be classified at the pixel level. It also has part of the characteristics of Object Detection, which needs to locate different instances, even if they are of the same kind. The effect of DL instance segmentation module is shown below.

Running parameters	
Model File Path	Select the model file created by the previous training.
Save Model Data	After enabling, save the model data to the solution file or process file. When loading a solution across machines, you do not need to enter the model file path.
Max. Number to Find	It refers to the max. quantity of targets for target detection.
Min. Confidence	It refers to the min. score for the position box.
Overlap Threshold	The max. proportion allowed for overlaying in the target image.
Mask Threshold	The min. value for the mask. If the actual value is smaller than this value, the software will not output.
Max. Overlap Threshold	The maximum overlap of the two mask areas. If the actual value is higher than this value, the mask area with lower confidence will be filtered.
Advanced parameters	
Edge Filter Enable	After enabling it, you can enter min. edge score. If the proportion of the searched target in the edge to the whole image is less than the minimum edge score, the search target will be discarded.
Render Mask Image	After the function is enabled, the target detected in the image after running will be presented in the form of mask.

4.7 Calibration

4.7.1 Camera Mapping

The camera mapping module calibrates the conversion relations between the two camera coordinate systems via the corresponding pixel pair of the two cameras, and outputs the calibration file, calibration status, and calibration error, as shown below.
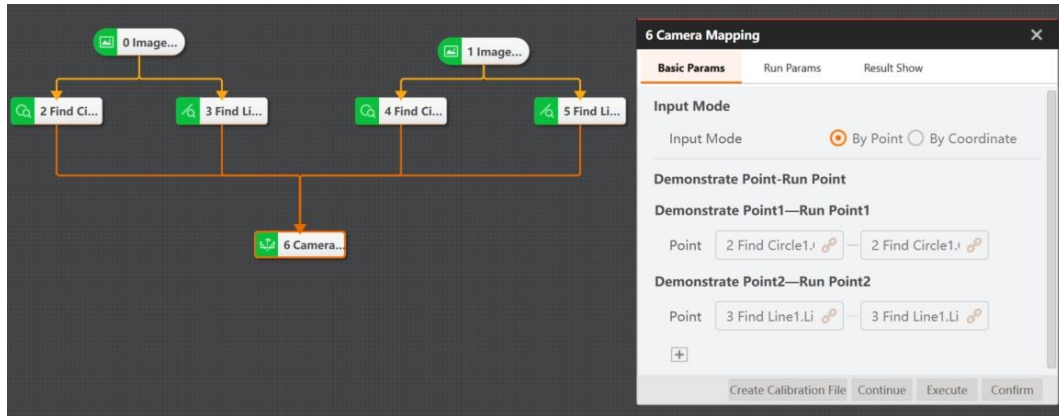
Basic Parameters of Camera Mapping	
Input Mode	It includes by point or by coordinate.
Demonstrate Point-Run Point	Select demonstration point and run point. You need to select 2 pairs at least and 8 pairs at most.
Create Calibration File	Output calibration file

Running Parameters of Camera Mapping	
DOF	It includes three types: scaling, rotation, aspect ratio, tilt, translation and transmission; scaling, rotation, aspect ratio, tilt and translation; scaling, rotation and translation. The three parameter Settings correspond to perspective transformation, affine transformation and similarity transformation respectively.
Weighting Function	You can choose least square method, Huber or Tukey algorithm function. You are advised to use the default parameters
Weighting Coefficient	Set this parameter when you select Tukey or Huber. The weight coefficient is the clipping factor of the corresponding method. You are advised to use the default value

Output Results	
Scale X/Y	It refers to X/Y coordinate ratio of the conversion matrix from the coordinate system where the running point is located to the coordinate system where the demonstration point is located.
Translate X/Y	It uses the calculated calibration matrix to map the origin of the coordinate system where the demonstration point is located to the coordinate X/Y obtained by the coordinate system where the running point is located.

Rotate	The rotation angle (in radians) of the coordinate system where the demonstration point is located relative to the coordinate system where the running point is located. When the rotation θ is a positive value, after the X axis of the coordinate system where the demonstration point is located rotates θ counterclockwise, its X axis is consistent with the X axis of the coordinate system where the running point is located. When the rotation θ is a negative value, the demonstration point is located. After the X axis of the coordinate system rotates clockwise by -θ, its X axis is consistent with the X axis direction of the coordinate system where the operating point is located.
Scale	The unit length in the coordinate system where the demonstration point is located corresponds to the number of pixels in the coordinate system where the running point is located.
Skew	The difference between the Y-axis rotation angle and the X-axis rotation angle of the coordinate system where the demonstration point is located (in radians).
Aspect	The ratio of the Y-axis zoom amount to the X-axis zoom amount of the coordinate system where the demonstration point is located.

4.7.2 CalibBoard Calibration

The calibration board calibration is divided into four types, including checkerboard, circle grid board, Hikrobot I, and Hikrobot II.

Take the checkerboard as an example. After Inputting the checkerboard grayscale image and its dimension parameters, the software will calculate the mapping matrix, calibration error, and calibration status between the image coordinate system and the checkerboard physical coordinate system. This tool can generate one calibration file to be used by the calibration conversion. By clicking **Creating Calibration File**, you can select the path for saving created calibration file, as shown below.
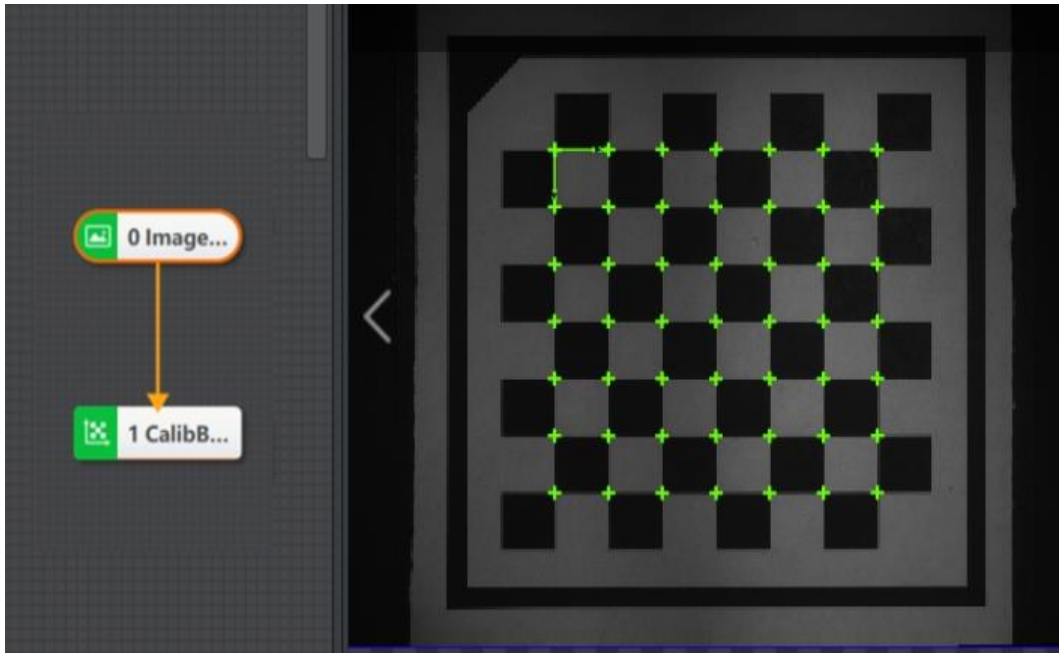
- **Create Calibration File:** select the creating calibration file storage path.

- **Calibration File Path:** the absolute path of the calibrate file. If the file exists in this path, it will be loaded. If it does not exist, it will fail to load and an error will be reported when running.

- **Update File:** After a round of calibration is completed, if the update file control is enabled, the new round of calibration will update the calibration results to the calibration file.

- **Origin (X) and Origin (Y):** this origin point is the origin point of the physical coordinates. The coordinates of origin point can be set, that is, origin location of X-axis and Y-axis in the image.

- **Rotation Angle:** the physical coordinate system direction can be adjusted by adjusting the rotation angle. it refers to the rotation angle of calibration board.

- **Coordinate System Mode:** select the left-hand coordinate system or the right-hand coordinate system.

- **Physical Size:** the side length of each black and white grid of the checkerboard or the center distance of two adjacent centers of the circular plate, and the unit is mm.

- **Calibration Board Type:** it is divided into checkerboard, circle calibration board, Hikrobot calibration board type I and Hikrobot calibration board type II. Type I is a self-developed code occupying four checkerboard positions, and type II is a self-developed code placed in the white grid of the calibration board.

    - Hikrobot Calibration Board: You can generate tool in the calibration board of Tool which customized the calibration board to be generated. After definition, the calibration board image will be generated in the... \ vm4.1.0 \ visionmaster4.1.0 \ applications \ tools path.

Running Parameters:

- **DOF:** you can select according to your demands, including scale, rotation, aspect ratio, tilt, translation and transmission, and scale, rotation, aspect ratio, tilt and translation, scale, rotation and

translation. The three parameters correspond to perspective transformation, affine transformation and similarity transformation respectively.

- **Grayscale Contrast:** it refers to the min. value of contrast between adjacent black-and-white squares in a checkerboard image, it is recommended to use default value.

- **Subpixel Window:** this parameter indicates whether to adaptively calculate the window size of corner sub-pixel accuracy. When each checkerboard grid accounts for more pixels, this value can be increased appropriately. It is recommended to use the default value.

- **Set Window Size:** it refers to the size of subpixel window that user sets. The width of each checkerboard pixel of the calibration board can be adjusted as /10.

- **Weighting Function:** you can select least squares, Huber, and Tukey algorithm functions. It is recommended to use default parameter.

- **Weighting Coefficient:** it is the parameter setting item when Tukey or Huber weight function is selected. It is the clipping factor of the corresponding method and recommended to use the default value.

Output Results:

- **Calibration Error**: it is the calibration parameters by calculation. The physical coordinates of the extracted calibration board feature points (such as checkerboard corner points or circle center of circle calibration board) are mapped back to the image coordinates system, which is the average value of the distance from the actual image coordinates.

- **Scale**: the unit length in the world coordinate system corresponds to the number of pixels in the image coordinate system.

- **Pixel Accuracy:** the size in the physical coordinate system corresponding to a single pixel.

- **Calibration Point Quantity**: number of extracted calibration plate feature points.

- **Translation X/Y**: it is the calibration parameters by calculation. The origin of the world coordinate system is mapped to image coordinates system, and obtain the coordinate X/Y.

- **Rotation**: the rotation angle (unit: radians) of the world coordinate system relative to the image coordinate system. When rotating θ is positive, and after the X-axis of the world coordinate system rotates counterclockwise θ, its X-axis is consistent with the X-axis direction of the image coordinate system θ. When it is negative, and after the X-axis of the world coordinate system rotates clockwise θ, its X-axis is consistent with the X-axis direction of the image coordinate system.

- **Chamfer**: difference between Y-axis rotation angle and X-axis rotation angle of world coordinate system (unit: radians).

- **Aspect Ratio:** the ratio of Y-axis scaling to X-axis scaling in the world coordinate system.

⚠ NOTICE

When failing to use the calibration tool, you need to adjust the parameters. The common debugging steps are as follows:

- Check whether the input image is a calibration board image.

- Check whether the calibration type in the basic parameters is set correctly.

- Check whether the parameter setting is reasonable. For checkerboard calibration, check whether the gray contrast is high. If so, you can change the sub-pixel window from adaptive to the set value, and set the window size to about checkerboard pixel width/10.

- For the round dot matrix calibration board, check whether the round dot type is set correctly, whether the dot roundness threshold is too high, and whether the edge extraction threshold is unreasonable.

4.7.3 N-Point Calibration

The calibration is mainly used to determine the conversion relations between the camera coordinate system and the robot arm coordinate system. The N-point calibration realizes the conversion between the camera coordinate system and the executing structure coordinate system and generates calibration file via N-point pixel coordinate and physical coordinate. The N needs to be larger than or equal to 4.

In the actual situation, there are mainly two calibration methods, including upper camera capture and lower camera alignment, as shown below.

Workpiece   Upper Camera Capture   Lower Camera Alignment
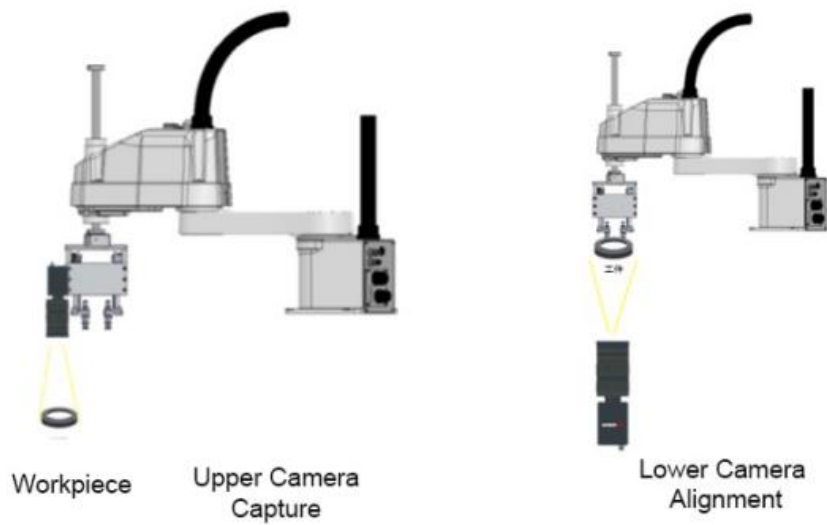
The recommended calibration solution is shown below. The branch module is used to determine whether feature matching is successful or not. If it is successful, the flow enters N-point calibration. Otherwise, format a specific character and sent it out to feed back the matching results.
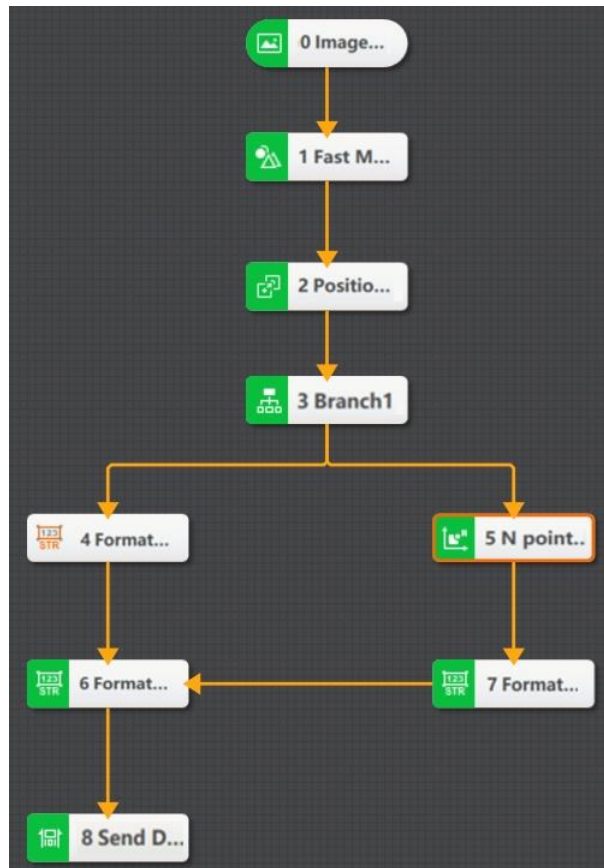
Taking lower camera alignment as an example, N-point calibration is executed by the camera that is driven by the mechanical arm to move in the direction set by the parameter. Each movement will trigger the camera to capture a picture. At this time, the calibration module in the solution is synchronously calibrated. At last, the calibration file is created. The specific parameter settings are shown below.
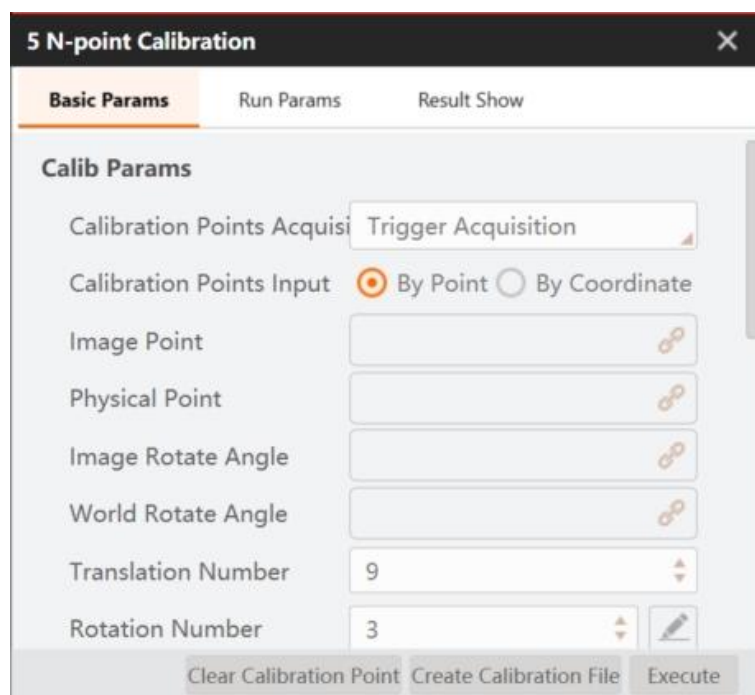
Basic Parameters:

- **Calibration Points Acquisition:** Select trigger acquisition or manual input.

- **Calibration Points Input:** Select by point or by coordinate.

- **Image Point:** The calibration point of N-point, and points of other modules can be subscribed.

- **Physical Point:** Coordinate point of the robot arm. An image point on the VM image corresponds to a physical point of the robot arm. (It is recommended not to subscribe, but to generate automatically.) You can select one from physical angle and physical coordinate.

- **Image Rotate Angle**: The angle of other modules can be subscribed, and the rotation consistency and left and right hand coordinate system can be obtained through related calculations.

- **World Rotate Angle**: The angle of the current pose manipulator is generally obtained from an external device, and the rotation consistency and left-handed coordinate system can be obtained through related calculations. You can select one from physical angle and physical coordinate.

- **Translation Number:** The times for obtaining calibration by moving. It is related with X/Y movement only, and it is set as 9 by default.

- **Rotation Number:** The number of rotations is required when the rotation axis is not coaxial with the center of the image, and it is recommended to set as 3. The rotation happens at the 5th location.

- **Update File:** After a round of calibration is completed, if the update file control is enabled, the new round of calibration will update the calibration results to the calibration file.

- **Set Calibration File Path:** The absolute path of the calibrate file. If the file exists in this path, it will be loaded. If it does not exist, it will fail to load and an error will be reported when running.

- **Demonstration**: After enabling it, the software can identify whether the external signals are demonstration signal or not, and you need to set external input character and external triggered character.

- **External Input Character**: You can subscribe signals of external devices.

- **External Triggered Character**: It judges whether the external input signal is the basis of the demonstration signal. When the external input character is consistent with the external trigger character, the signal is a demonstration signal.

- **Fiducial Point X and Fiducial Point Y:** Physical coordinate of calibration original point, it sets as (0, 0), and the unit is mm.

- **Offset X and Offset Y:** Physical offset in X or Y direction of each movement of the robot arm, which can be positive or negative, and the unit is mm.

- **Movement First:** Sets the movement direction of the mechanical.

- **Commutation Times:** The times of robot arm changes direction after moving.

- **Angle Offset:** The initial rotation angle and rotation angle at each time. If it rotates 3 times, and rotation angle is from -10 degrees to 0 degree, and then to +10 degrees. The fiducial angle is -10 degrees and offset angle is 10 degrees.
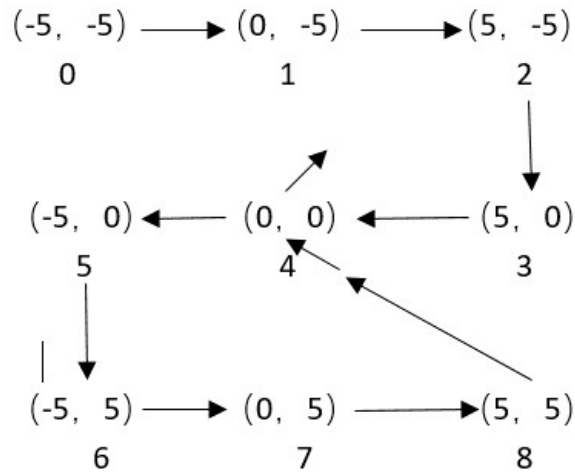
In the image above, movement is made towards X or Y direction for 9 times, and rotation is made towards other direction for 3 times, offset is 5. It is X axis movement first and the times of changing direction movement is 3.

- **Use Relative Coordinates**: The default state is off. After enabling, the calibration original point size can be configured.

- **Calibration Origin**: It is generally set to 4, because it is counted from 0, so it is the middle point.

Running Parameters:

- **Camera Mode:** it has three types, including static camera upper position or static camera lower position, and dynamic camera.

  - static camera upper position: the camera is fixed and above the shooting work piece.

  - static camera lower position: the camera is fixed and below the shooting work piece.

  - dynamic camera: camera moves with robot arm.

- **DOF:** you can select according to your demands, including scale, rotation, aspect ratio, tilt, translation and transmission, and scale, rotation, aspect ratio, tilt and translation, scale, rotation and translation. The three parameters correspond to perspective transformation, affined transformation and similarity transformation respectively.

- **Weighting Function:** you can select least squares, Huber, Tukey, and Ransac algorithm functions. It is recommended to use default parameter.

- **Weighting Coefficient:** it is the parameter setting item when Tukey or Huber weight function is selected. It is the clipping factor of the corresponding method and recommended to use the default value.

- **Distance Threshold:** it is the parameter setting item when Ransac weight function is selected, which means that the distance threshold for eliminating the error point. The smaller the

value, the stricter the point set selection will be. When the point group's accuracy is not high, this threshold can be appropriately increased. It is recommended to use the default value.

- **Sampling Rate:** it is the parameter setting item when Ransac weight function is selected. When the point group's accuracy is not high, the sampling rate can be appropriately reduced. It is recommended to use the default value.

Output Results:

- **Calibration Status**: 1 represents calibrated, 0 means failed calibration.

- **Evaluate Calibration Error Status:** Evaluate whether the calibration error is OK, 0 indicates that the error is within the normal range, and 1 indicates abnormal calibration results.

When the calibration error is large, the accuracy of image point and physical point information can be checked in the calibration parameters, and can also be analyzed from the moving track of N-point calibration processing results.

Firstly, check the motion trajectory of image points. Generally, the motion trajectory in the same direction is parallel, and the motion trajectory in different directions is vertical, which indicates that the selected image points have high quality, otherwise it will lead to large fitting error, as shown in the figure below.
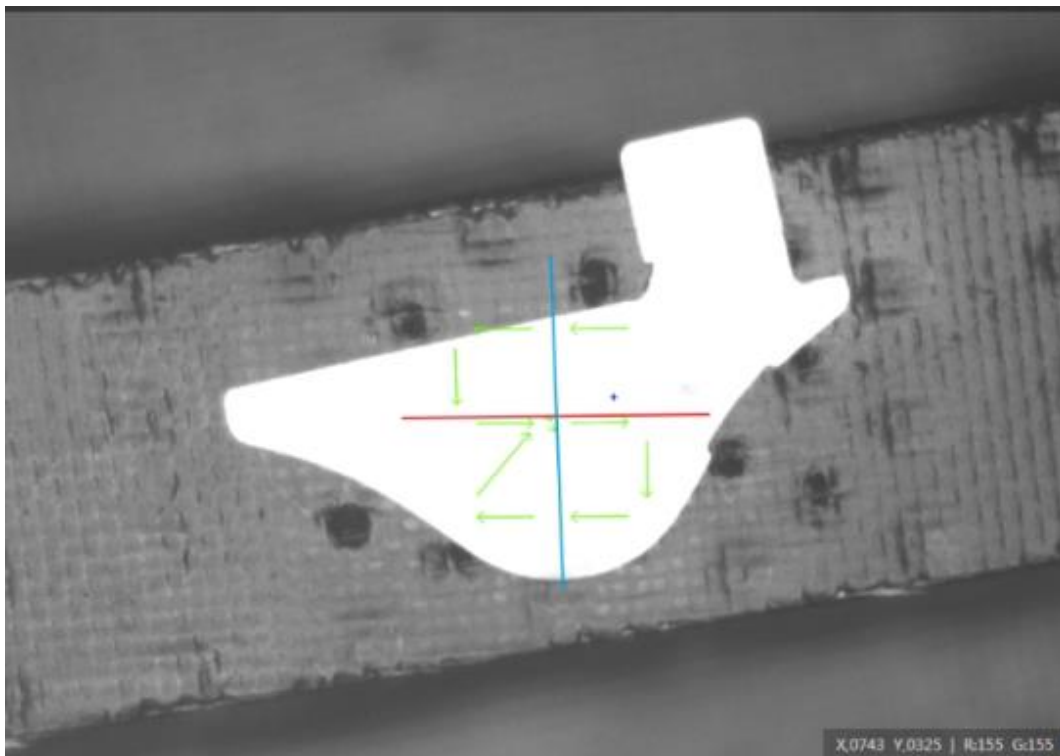
If the rotation error is large, it is necessary to check the rotation image point and input angle. If the over rotation error is small, but it is much different from the rotation position of the real image, check the input angle and camera mode.

From the motion trajectory analysis, assuming that the structure motion is X first and then Y, the coordinate system in the image is shown in the figure below.
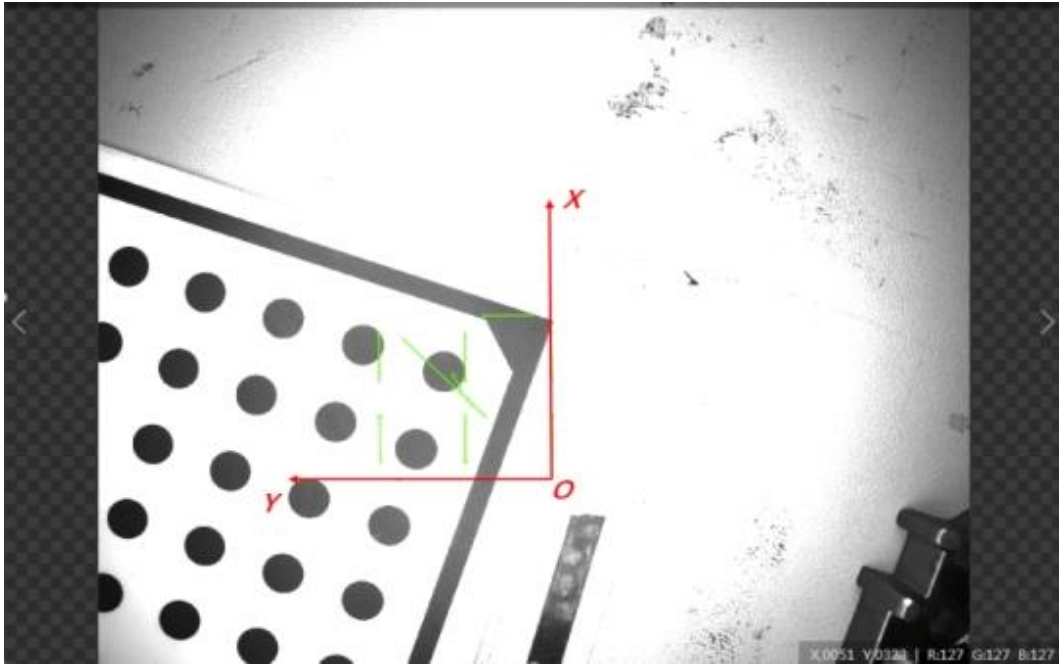
In the coordinate system, the rotation angle from the X positive direction to the Y positive direction is positive, and vice versa, as shown in the following figure.
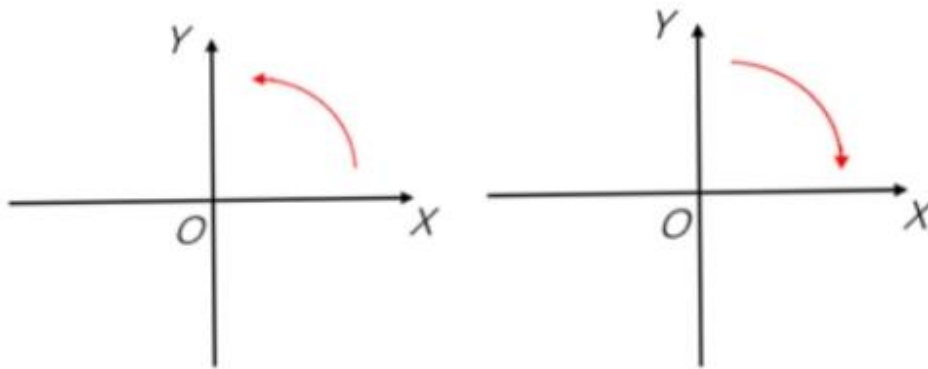
4.7.4　Distortion Calibration

The tool of distortion calibration is used to calibrate calibration board images that have distortion by inputting gray scale calibration template image. It generates calibration file, outputs calibration error and calibration status, as shown below.
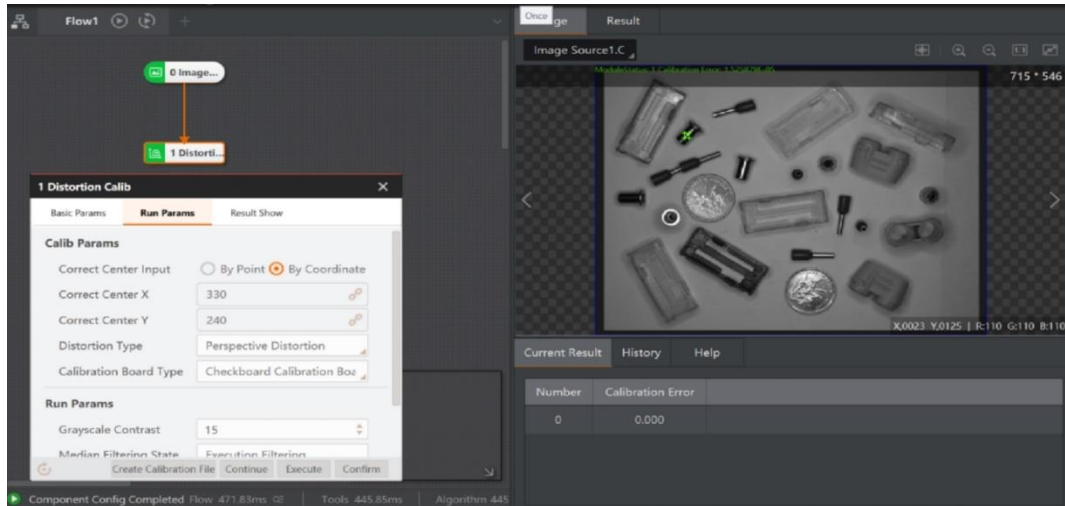
Parameters:

- **Correction Point Input**: it includes By Point and By Coordinates.

- **Correction Center Point**: It refers to center point coordinate of perspective distortion correction. When "Input by Point" is selected, you can link the data of the previous module. When "by coordinate" is selected, the X and Y coordinates of the correction center need to be customized.

- **Distortion Type:** it has three types, including perspective distortion, radial distortion and radial perspective distortion.

- **Calibration Board Type:** select checkerboard calibration board, or circle calibration board.

- **Dot Circularity:** it is the threshold of circle detection. The larger the value, the much rounder circle will be detected.

- **Edge Low Threshold:** it is used to extract the low threshold of the edge.

- **Edge High Threshold:** it is used to extract the high threshold of the edge. Only the edge point whose edge gradient threshold is between edge low threshold and edge high threshold can be detected.

- **Round Dot Type:** black circle on white and white circle on black can be selected

- **Grayscale Contrast:** it refers to the min. value of contrast between adjacent black-and-white squares in a checkerboard image, it is recommended to use default value.

- **Median Filter Status:** Whether to perform median filtering before corner point extraction. There are two modes: "Perform Filtering" and "No Filtering". It is recommended to use the default value.

- **Subpixel Window:** this parameter indicates whether to adaptively calculate the window size of corner sub-pixel accuracy. When each checkerboard grid accounts for more pixels, this value can be increased appropriately. It is recommended to use the default value.

- **Set Window Size:** adjust window size manually.

- **Weighting Function:** you can select least squares, Huber, and Tukey algorithm functions. It is recommended to use default parameter.

- **Weighting Coefficient:** it is the parameter setting item when Tukey or Huber weight function is selected. It is the clipping factor of the corresponding method and recommended to use the default value.

4.7.5 Mapping Calibration

With the tool of mapping calibration, you can convert coordinates of different coordinate systems. Only the self-developed calibration board is supported. See CalibBoard Calibration for the generation method of the calibration board. Input two self-developed calibration board images or calibration files corresponding to the self-developed calibration board images. Calculate the mapping relations between image 1 and image 2, and then generate a new calibration file for calibration conversion.
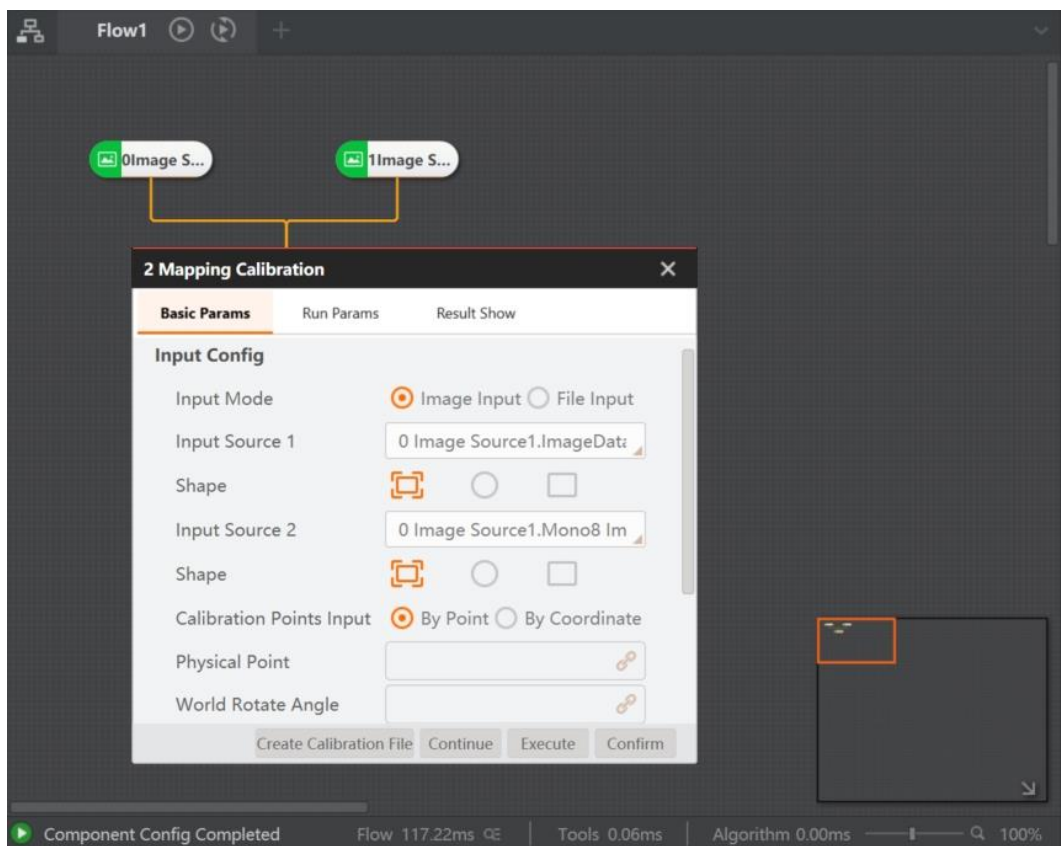
Basic Parameters	
Calibration Points Input	It selects by point or by coordinate.
Physical Point	Coordinate point of the robot arm. An image point on the VM image corresponds to a physical point of the robot arm. (It is recommended not to subscribe, but to generate automatically.) You can select one from physical angle and physical coordinate.

World Rotate Angle	The angle of the current pose manipulator is generally obtained from an external device, and the rotation consistency and left-handed coordinate system can be obtained through related calculations. You can select one from physical angle and physical coordinate.
Demonstration	After enabling it, the software can identify whether the external signals are demonstration signal or not.
External Input Character	It can subscribe signals of external devices.
External Trigger Character	It identifies whether the external input signal is the basis of the demonstration signal. When the external input character is consistent with the external trigger character, the signal is a teaching signal
Set Calibration File Path	The absolute path of the calibrate file. If the file exists in this path, it will be loaded. If it does not exist, it will fail to load and an error will be reported when running.
Update File	After a round of calibration is completed, if the update file control is enabled, the new round of calibration will update the calibration results to the calibration file.
Physical X and Physical Y	It refers to the physical coordinate X and Y.
Running Parameters	
Calibration Board Type	It selects by point or by coordinate.
DOF	Coordinate point of the robot arm. An image point on the VM image corresponds to a physical point of the robot arm. (It is recommended not to subscribe, but to generate automatically.) You can select one from physical angle and physical coordinate.
Weighting Function	The angle of the current pose manipulator is generally obtained from an external device, and the rotation consistency and left-handed coordinate system can be obtained through related calculations. You can select one from physical angle and physical coordinate.
Weighting Coefficient	After enabling it, the software can identify whether the external signals are demonstration signal or not.
Grayscale Contrast	It refers to the min. value of contrast between adjacent black-and-white squares in a checkerboard image, it is recommended to use default value.
Median Filtering State	Whether to perform median filtering before corner point extraction. There are two modes: "Perform Filtering" and "No Filtering". It is recommended to use the default value.
Subpixel Window	This parameter indicates whether to adaptively calculate the window size of corner sub-pixel accuracy. When each checkerboard grid accounts for more pixels, this value can be increased appropriately. It is recommended to use the default value.
Set Window Size	It refers to the size of subpixel window that user sets. The width of each checkerboard pixel of the calibration board can be adjusted as /10.
Output Results	

Current Angle Point Quantity	Input the number of corner points extracted in image 1.
Target Angle Point Quantity:	Input the number of corner points extracted in image 2.
Mapping Angle Point Quantity	The number of corner points extracted from image 1 that can be mapped to image 2.

4.7.6　**N-Image Calibration**

N-image calibration tends to create image points and physical points, and calculate the mapping relationship between the image coordinate system and the physical coordinate system.

Generally, the camera is installed above the self-developed calibration board. Make sure the camera can capture enough angle points and self-developed codes. The min. value for image translation is 3. When the value is larger than or equal to 4, the direction of movement is changed every 3 images. At present, translation calibration, rotation calibration and translation rotation calibration can be supported, as shown in the figure below.
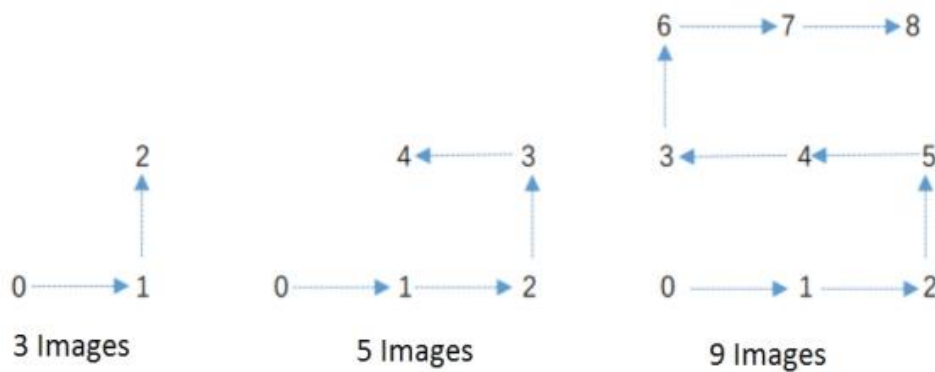
When translating coordinates only, the original point of the physical coordinate system is the start point of the first calibration board. When rotating coordinates, the original point of the physical coordinate system is the physical point of the rotation center of the image.
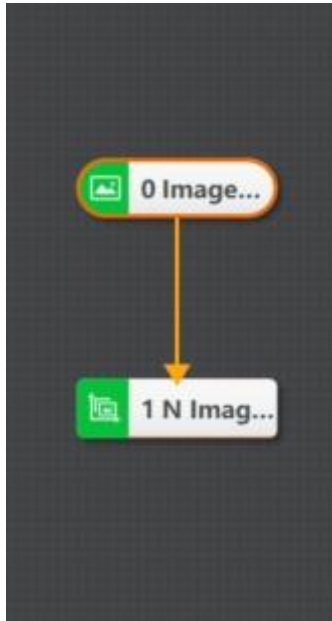
Basic Parameter Description

- **Update File:** After a round of calibration is completed, if the update file control is enabled, the new round of calibration will update the calibration results to the calibration file.

- **Calibration File Path:** the absolute path of the calibrate file. If the file exists in this path, it will be loaded. If it does not exist, it will fail to load and an error will be reported when running.

- **Calibration Points Input:** select by point or by coordinate.

- **Physical Point:** the coordinate point of the robot arm. An image point on the VM image corresponds to a physical point of the robot arm.

- **Rotation Angle**: the physical coordinate system direction can be adjusted by adjusting the rotation angle.

- **Translation Times:** Image quantity for translation.

- **Rotation Times:** Image quantity for rotation.

- **Fiducial Point X and Fiducial Point Y:** physical coordinate of calibration original point, it sets as (0, 0).

- **Offset X and Offset Y:** physical offset in X or Y direction of each movement of the robot arm, which can be positive or negative.

- **Movement First:** set the priority offset direction for each operation of the robot arm, including X priority and Y priority.

- **Commutation Times:** the times of robot arm changes direction after moving.

- **Fiducial Angle/Angle Offset:** the initial rotation angle and rotation angle at each time. If it rotates 3 times, and rotation angle is from -10 degrees to 0 degree, and then to +10 degrees. The fiducial angle is -10 degrees and offset angle is 10 degrees.
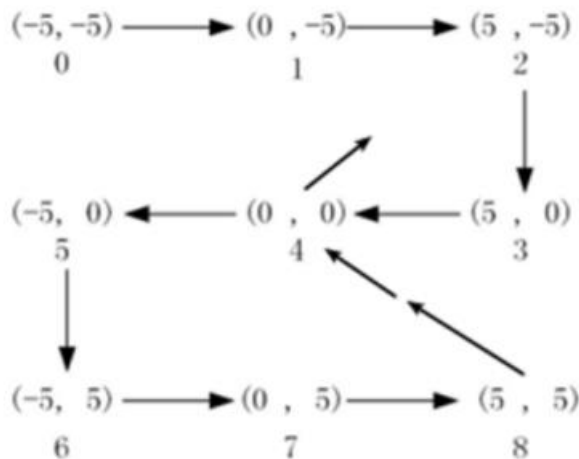
- **Matrix Correction Enable:** In the conversion relationship generated by N image calibration, only when moving the calibration horizontally, the coordinates of the upper left corner of the checkerboard corner of the first image in the image are the image origin by default. When there is rotation calibration, the default is that the image rotation center is the origin of the physical coordinate system. If this correspondence does not meet the requirements, the matrix correction enable can be enabled.

- **Input Mode:** it includes by point and by coordinate.

- **Image Point:** enable matrix correction, input image points, correct the position of the matrix, and transform this image point into a specified physical point.

- **Physical Point:** enable matrix correction, input physical points, correct the position of the matrix, and transform specific image point into the physical point.

Running Parameters:

- **Camera Movement:** If the camera has relative movement, you can enable this parameter.

- **Calibration Board Type:** Self-developed I type, and self-developed II type. Type I is a self-developed code occupying four checkerboard positions, and type II is a self-developed code placed in the white grid of the calibration board.

- **Grayscale Contrast:** it refers to the min. value of contrast between adjacent black-and-white squares in a checkerboard image, it is recommended to use default value.

- **Median Filter Status:** Whether to perform median filtering before corner point extraction. There are two modes: "Perform Filtering" and "No Filtering". It is recommended to use the default value.

- **Subpixel Window:** 2 modes: self-adaptive, and configured value.

Output Results:

- **Average Error of Pixel Translation:** according to the pixel estimation error when translation image calculates the matrix, the smaller the error, the more stable the movement of the mechanism and the more reliable the calibration result.

- **Translate Real Average Error:** The average error of translation pixel is the real error obtained by single pixel precision transformation, and the unit is mm.

- **Average Error of Pixel Rotation:** according to the pixel estimation error when the rotating image calculates the rotation center, the smaller the error, the more stable the rotation of the mechanism and the more reliable the rotation center.

- **Rotate Real Average Error:** The average error of rotation pixel is the real error obtained by single pixel precision transformation, and the unit is mm.

- **Rotation Center Coordinate X/Y:** rotation center image coordinates calculated by rotating image.

4.7.7 Load Calibration

The load calibration module can reload some calibration files generated by the calibration module when the subscribed refresh signal is not 0, and output relevant information. The supported calibration modules are N-point calibration, mapping calibration and N image calibration.

Prerequisite:

Drag the load calibration module to the process editing area, complete the connection with other modules and ensure that other relevant modules have been connected with the module before.

Steps:

1. Double-click Find Vertical Lines module to enter parameter edit window.

2. Click [folder icon] to open the selected calibration file in the Calibration File Path, and then the relative calibration information will be shown as below.
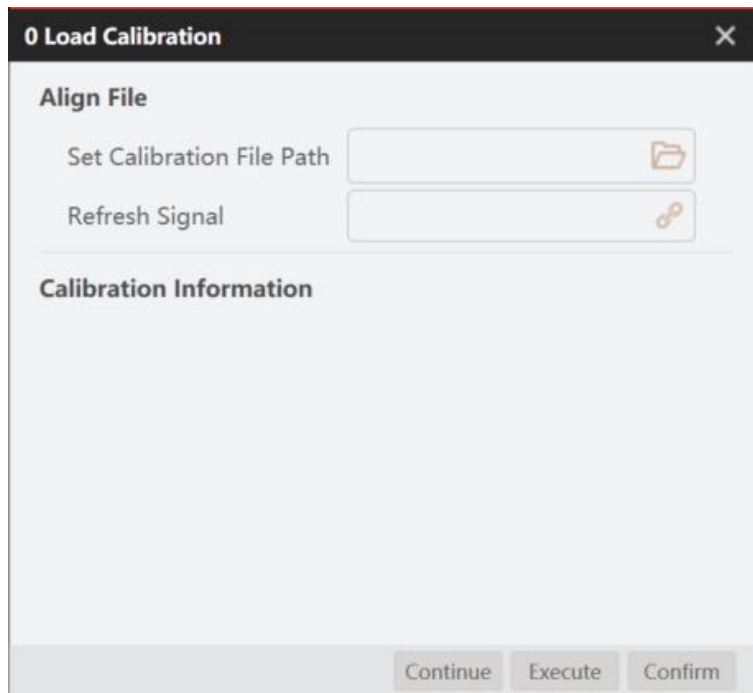
☐NOTE

• Calibration files can be generated through some calibration modules, and support XML format calibration files generated by N-point calibration, mapping calibration and N image calibration

3. Refresh the int data source of the preamble module at the signal. When the data source subscribed by the refresh signal is not 0, the module will automatically reload the selected calibration file.

4.8 **Calculation**

4.8.1 **Single Point Alignment**

According to the input target point position (X0, Y0) and the direction and the object point position (X1, Y1) and direction, the tool of single point alignment calculates the movement amount required from the object point to the target point, including the position movement amount and angle movement amount. The alignment module inputs the physical coordinates, so it needs to be used together with the calibration conversion, as shown below.
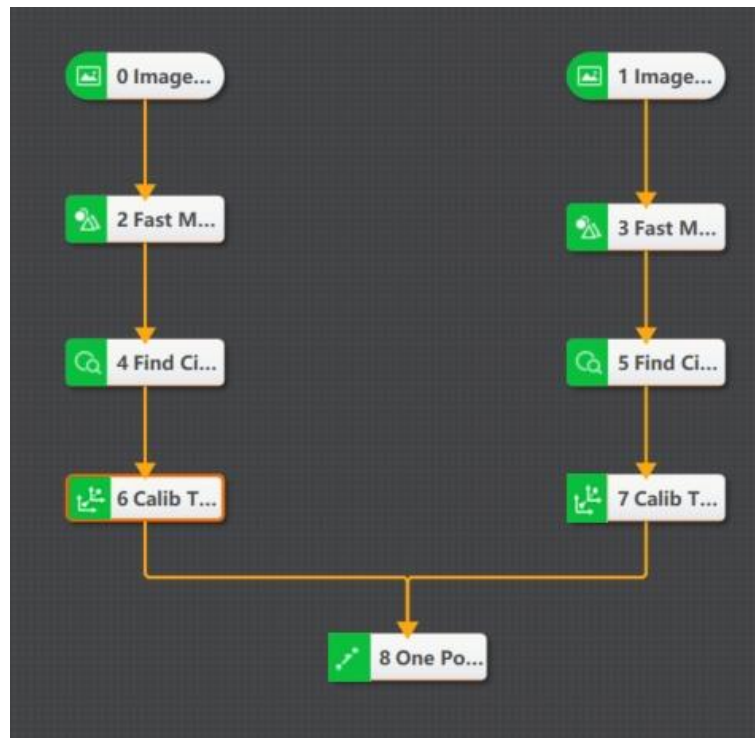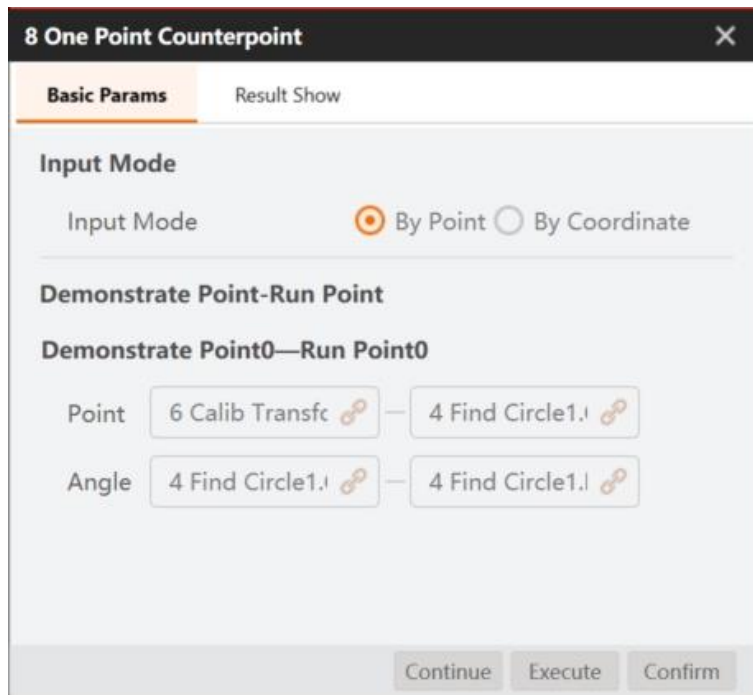
Basic Parameters of Single Point Alignment	
Input Mode	It includes By Point or By Coordinate.
Demonstrate Point-Run Point	Select demonstration point and run point. You need to select 8 pairs at most.

4.8.2 Calculate Rotation

The rotation calculation module can rotate the point or line counterclockwise or anticlockwise around the rotation center point according to the rotation angle, and obtain the relevant information of the point or line after rotation.

Prerequisite:

Drag the **Rotate Calculate** module to the process editing area. Complete the connection with other modules and ensure that other relevant modules have been connected with the module before, such as Find Angle Bisector.

Steps:

1. Double-click **Calculate Rotation** module to enter parameter edit window.

2. Select the image data source in the **Input Source**.

3. Select the data type to be rotated in **Input Type**: by Point or Line.

4. Select the data source of the point or line to be rotated in **Point Input**.

5. Subscribe the data source of rotation center in **Rotate CenterPoint**.

6. Subscribe the data source of rotated angle in **Rotate Angle** as shown below.
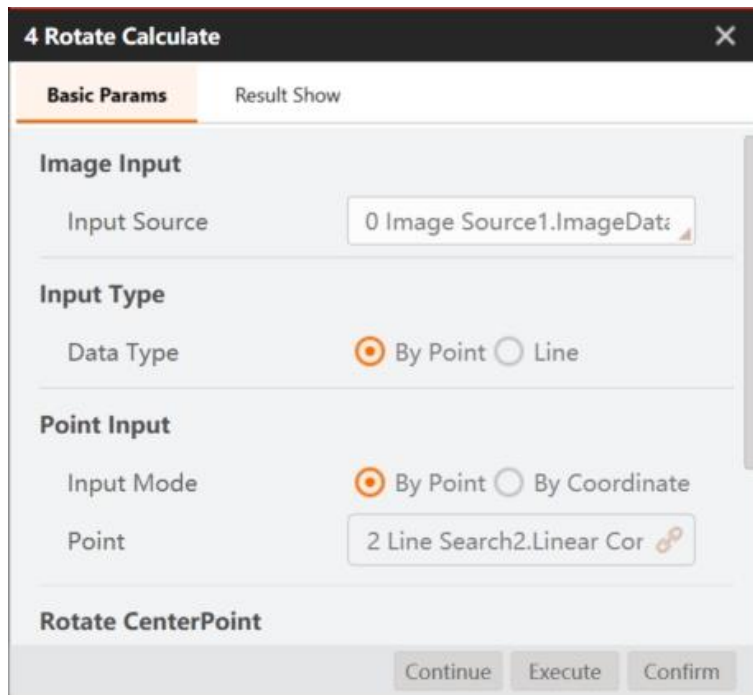
📖NOTE

- If the subscribed data source of rotation angle is positive, it is clockwise rotation; Otherwise, it rotates counterclockwise.

- The subscription method of lines and points is similar to that of the find angle bisector module. See the description of step 3 in Find Angle Bisector for details.

7. Switch to **Result Show** and set the specific module, color and transparency in Image Display, and set the text content and color in **Text Show**.

8. Click **Execute** or **Continue** to view the operation results as shown below. The following figure shows the operation results when line is selected in **Input Type**.
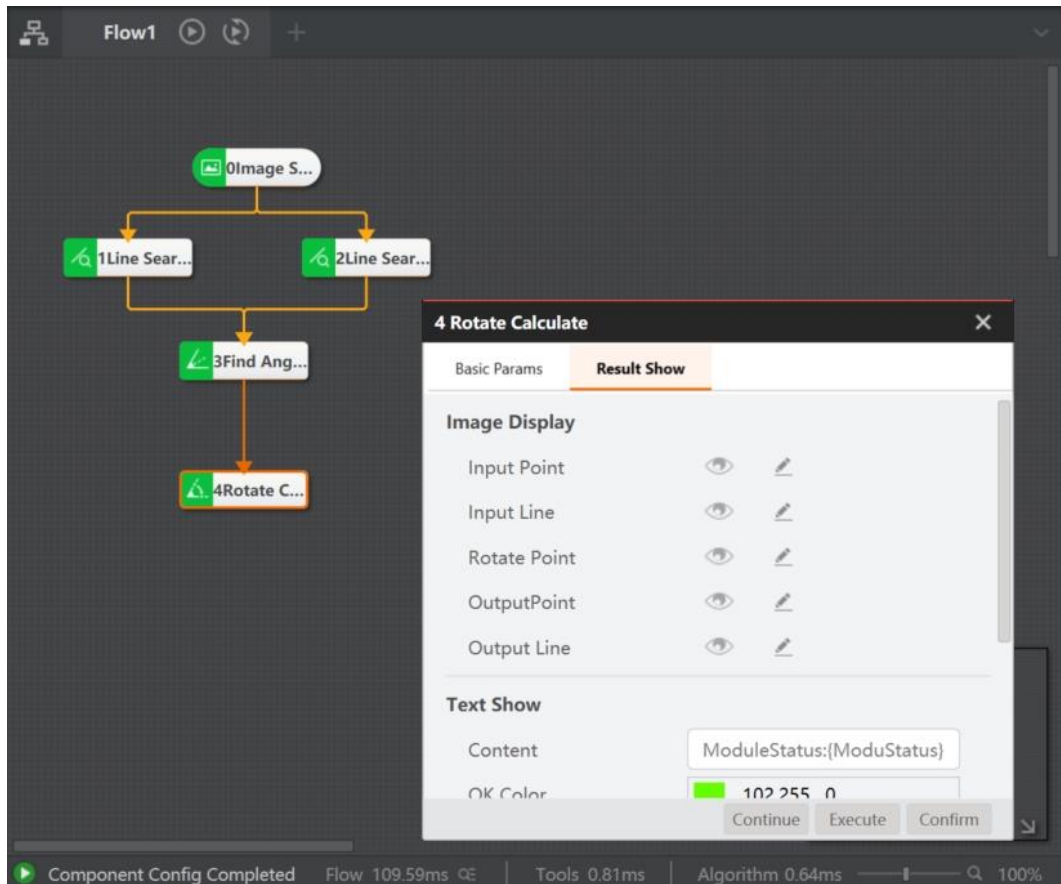
4.8.3 Point Set Alignment

According to the X array and Y array of input target points, and the X array and Y array of object points, the tool of point set alignment calculates the movement amount required from the points to the target point, including the position movement amount and angle movement amount. The alignment module inputs the physical coordinates, so it needs to be used together with the calibration conversion, as shown below.
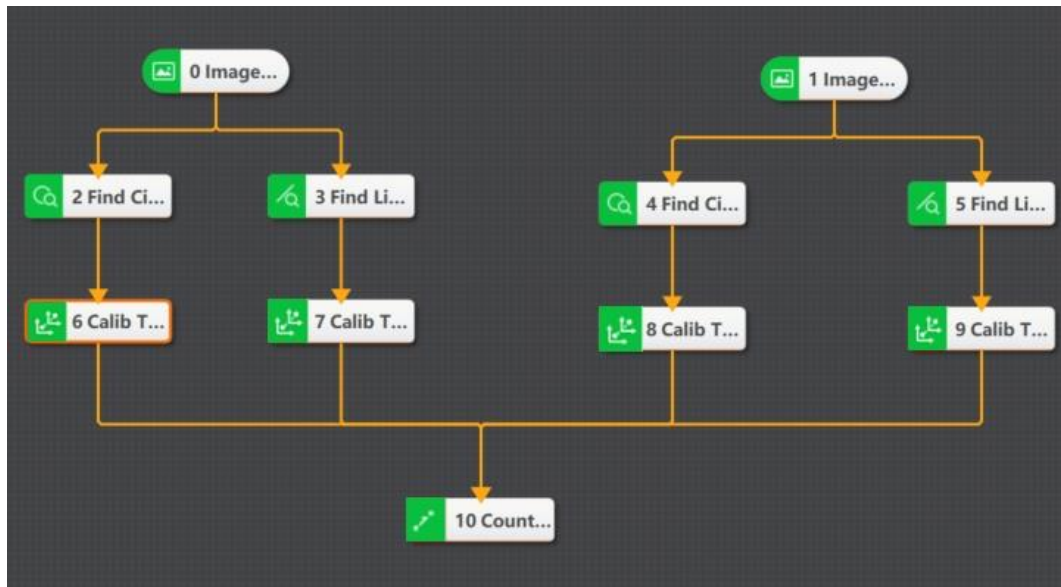
Basic Parameters of Point Set Alignment	
Input Mode	It includes by point or by coordinate.
Demonstrate Point-Run Point	Select demonstration point and run point. You need to select 2 pairs at least and 8 pairs at most.

4.8.4   Calibration Transformation

After the calibration is completed, the conversion between the camera coordinate system and the robot arm coordinate system can be realized by the calibration conversion module. Click **Load Calibration File Path** in Calibration Transformation interface, and select calibration file path. The flow is shown below.

Find the position of the work piece in the camera coordinate system via the feature matching template, load the saved calibration file, and click **Run** to complete the operation. The position of the work piece in the robot arm coordinate system after the calibration conversion is shown below.
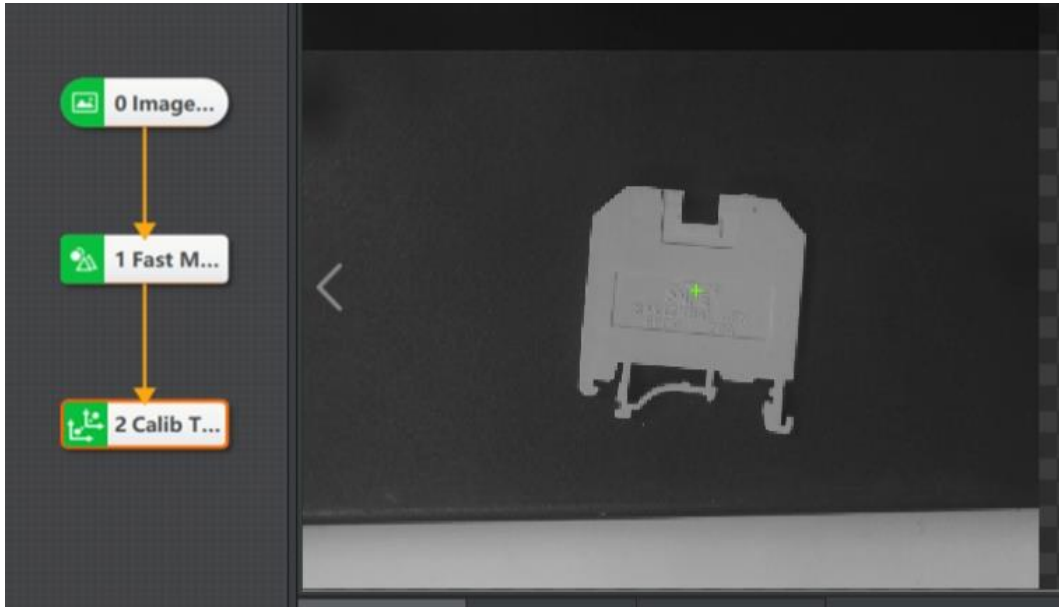
Through external communication, the camera is controlled to capture images. The pixel coordinate positioning of the work piece image is realized by using feature template function. The generated calibration file is loaded in the calibration conversion module, and the pixel coordinates are output as robot arm coordinate. Through formatting, the external communication tells the robot arm unit to complete the function of the control robot arm.

Calibration Transformation Parameters:

- **Image Coordinate Input:** select the input method by point or by coordinate, and the input source.

- **Angle:** the feature angle that needs physical transformation.

- **Coordinate Type:** image coordinates and physical coordinates can be selected. If the image coordinate is selected, it is the input image coordinate and the output physical coordinate; This is the same reason when selecting physical coordinates.

- **Load Calibration File**: the absolute path of the calibrate file. If the file exists in this path, it will be loaded. If it does not exist, it will fail to load and an error will be reported when running. It can load calibration files with iWcal and xml format.

- **Refresh Signal**: set to 0 not to update, set to non-zero to update. When it is set to non-zero, the file in the calibration file path will be automatically converted according to the updated calibration file.

Output Results:

- **Transform Coordinates X/Y**: coordinates obtained by calibration conversion / inverse conversion of input coordinates.

- **Transform Angle**: angles obtained by calibration conversion / inverse conversion of input angles.

- **Single Pixel Accuracy:** the size in the physical coordinate system corresponding to a single pixel.

- **Translation X/Y**: it is the calibration parameters by calculation. The origin of the world coordinate system is mapped to image coordinates system, and obtain the coordinate X/Y.

- **Rotation**: the rotation angle (unit: radians) of the world coordinate system relative to the image coordinate system. When rotating θ is positive, and after the X-axis of the world coordinate system rotates counterclockwise θ, its X-axis is consistent with the X-axis direction of the image coordinate system θ. When it is negative, and after the X-axis of the world coordinate system rotates clockwise θ, its X-axis is consistent with the X-axis direction of the image coordinate system.

- **Scale**: the unit length in the world coordinate system corresponds to the number of pixels in the image coordinate system.

- **Chamfer**: difference between Y-axis rotation angle and X-axis rotation angle of world coordinate system (unit: radians).

- **Aspect Ratio:** the ratio of Y-axis scaling to X-axis scaling in the world coordinate system.

4.8.5 Scale Transformation

The tool of scale transformation is used to convert pixel units like distance and width to physical units. For specific use, you only need to load the calibration file, set the distance to be converted, and subscribe refresh signal, as shown below.

Output Results	
Transform Results	Distance after the entered pixel interval is transformed through calibration file.
Single Pixel Accuracy	Size in the physical coordinate system corresponding to a single pixel.
Translation X/Y	It is the calibration parameters by calculation. The origin of the world coordinate system is mapped to image coordinates system, and obtain the coordinate X/Y.
Rotation	The rotation angle (unit: radians) of the world coordinate system relative to the image coordinate system. When the rotation angle θ is positive, after the X-axis of the world coordinate system rotates θ counterclockwise, its X-axis is consistent with the X-axis direction of the image coordinate system. When the rotation angle is negative, after the X-axis of the world coordinate system rotatesθ clockwise, its X-axis is consistent with the X-axis direction of the image coordinate system.
Scale	Number of pixels in the image coordinate system which the unit length in the world coordinate system corresponds to
Chamfer	Difference between Y-axis rotation angle and X-axis rotation angle of world coordinate system (unit: radians).
Aspect Ratio	Ratio of Y-axis scaling to X-axis scaling in the world coordinate system

4.8.6 Line Alignment

According to the input target lines and object lines that are both line arrays, the tool of line alignment calculates the movement amount required from the points to the target point, including the position movement amount and angle movement amount, as shown below.
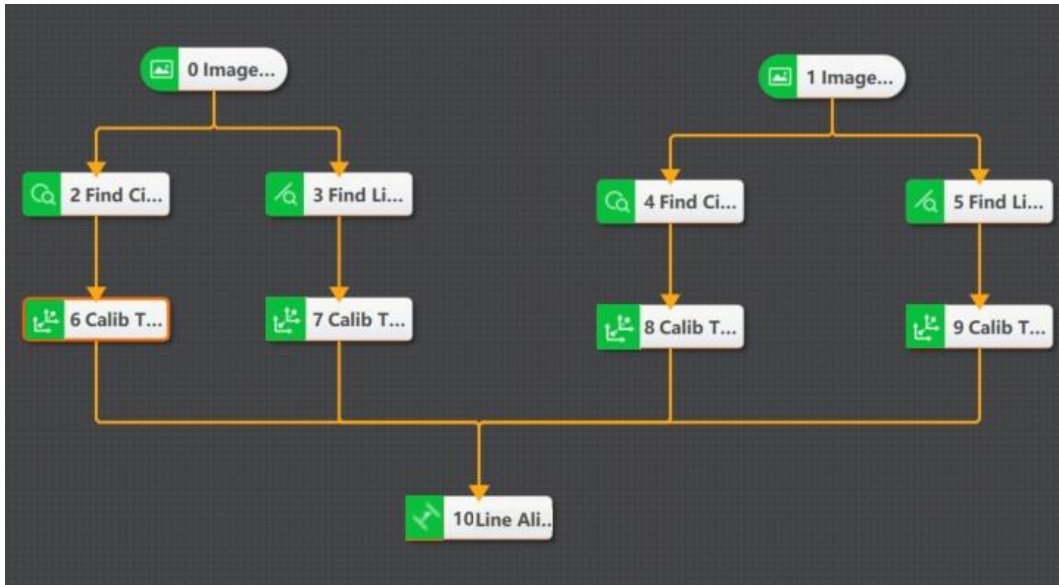
Basic Parameters of Camera Mapping	
Input Mode	It includes by point or by coordinate.
Demonstrate Point-Run Point	It selects demonstration point and run point. You need to select 2 pairs at least and 8 pairs at most.
Alignment Shape	According to the shape of lines, select opening or closing. If the shape of lines is closed, select closing.

4.8.7 Variable Calculation

This tool supports multiple input mixed calculations. You can customize parameters or select module data for calculation.
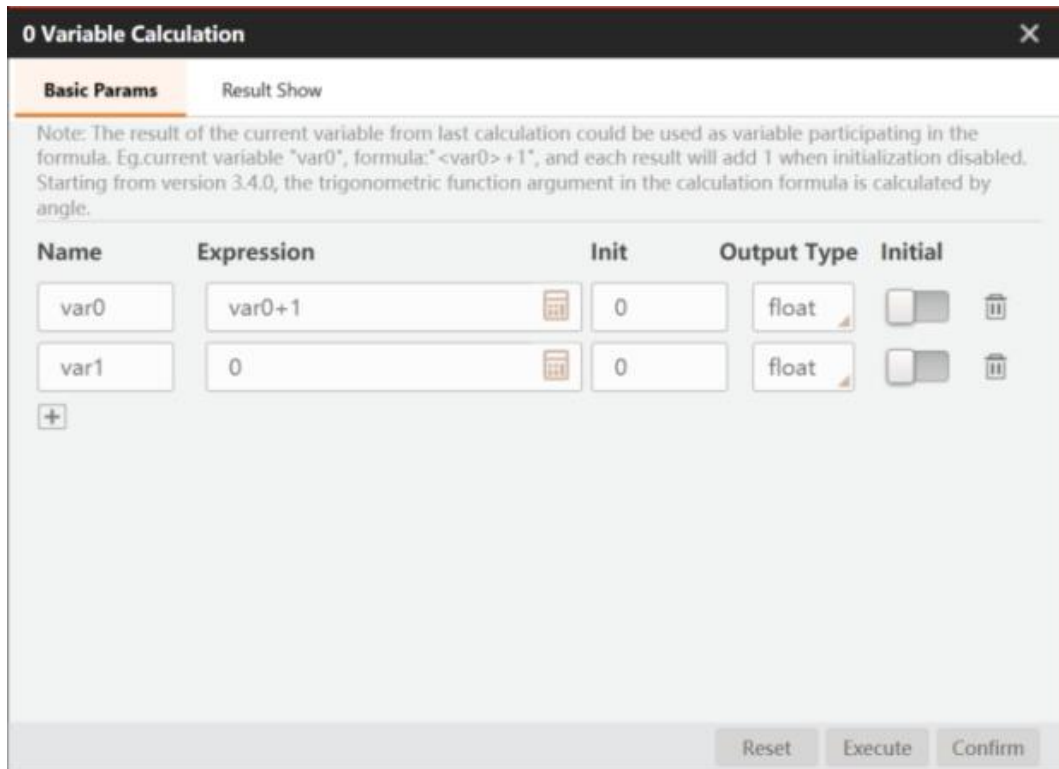
Calculator Parameters	
Reset	Click it to reset as initial value.
Execute	Click it to execute once.
Confirm	Click it to save and exit the tool.
Calculator Initial Value/ Calculator Initialization	The variable calculates the initial value. When enabling calculator Initialization, each time the process execution resets the variable to the initial value of the setting.
Expression	You can edit the expression here. After editing, you can click **Check** to verify its correctness.
Output Type	It has three types, including int, float and point. Note: The expression of point type supports plus, minus and multiplication only.

sin(x)	x is angle, the returned value is sine.	asin(x)	It is asin, -1≤x≤1, angle value is returned.
sinh(x)	x is angle, the returned value is sinh.	asinh(x)	It is asinh, angle value is returned.
cos(x)	x is angle, the returned value is cos.	acos(x)	It is acos, -1≤x≤1, angle value is returned.
cosh(x)	x is angle, the returned value is cosh.	acosh(x)	It is acosh, angle value is returned.

tan(x)	x is angle,the returned value is tan.	atan(x)	It is atan, angle value is returned.
tanh(x)	x is angle,the returned value is tanh.	atanh(x)	It is atanh, angle value is returned.
max(x,y)	Get the larger value from x and y.	min(x,y)	Get the smaller value from x and y.
round (decimal value)	Round all decimal places to ones place, and output after the decimal position is 0.	log(x)	Returns the natural logarithm of the specified number (base e).
pow(x,y)	x raised to the power of y.	abs(x)	Returns the absolute value of x.
ceil(x)	The smallest integer value of returned value is larger than or is equal to x.	log10(x)	Returns the logarithm of x to the base 10
floor(x)	The max. integer value of returned value is smaller than or is equal to x.	trunc(x)	Calculate the integer part of x, which is the nearest integer rounded towards zero.
sqrt(x)	The returned value is x's square root.	exp(x)	Returns e to the power of x.

4.9 Image Processing

The tool of image processing is used to process the target image. The sub-menu of image processing includes image combination, image morphology, image binarization, image filter, image enhancement, image math, image sharpness, image fixture, shade correction, affine transformation, polar unwrap, copy fill, frame mean, etc.
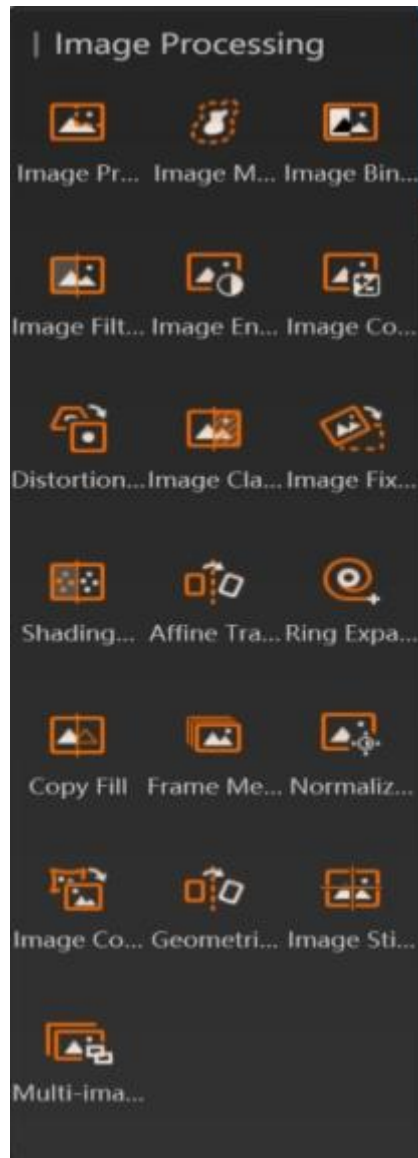
4.9.1 **Image Combination**

The image combination combines with five image processing modules, including morphological processing, image binarization, image filter, image enhancement and shade correction. Its operation process is shown below.
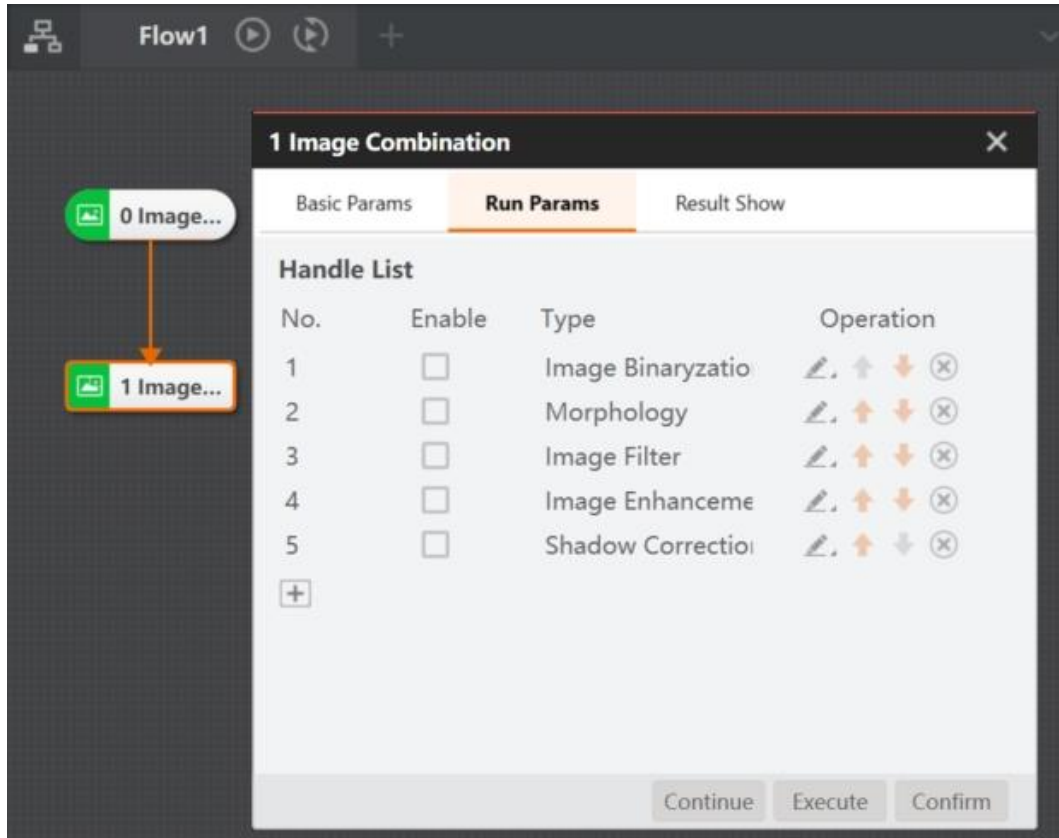
Steps:

1. Add different image processing modules to the processing list.

2. Check Enable to enable the corresponding module function.

3. Click ![pencil icon] of the corresponding module to set the running parameters.

4. Click ![up down arrows] and then output.

📖NOTE

- The order in which the corresponding modules operate can be adjusted.

4.9.2   **Image Morphology**

The tool of image morphology is used to extract image components that are meaningful to the expression and description of area shape, so that the subsequent recognition work can obtain the most essential shape features like edge and connected area of the target object. This tool copes with the white pixels in the image, and related parameters are shown below.

- **Morphology Type:** it supports dilation (expansion), erosion, opening and closing.

  - Dilation (expansion) is to separate independent image elements, and connect adjacent elements.

  - Erosion is a corresponding operation to dilation.

- Opening operation means erosion first and then dilation.

- Closing operation means dilation first and then erosion.

- **Structuring Element**: it is a common parameter, and it supports rect, ellipse and cross.

- **Iteration Times:** the max. running times of the morphological operation algorithm, and it only takes effect after setting dilation and erosion.

- **Element Width**: it is the width of adjacent elements.

- **Element Height**: it is the height of adjacent elements

Corrosion

Whenever a sub-image that is the same as the structural element is found in the target image, the pixel position corresponding to the origin of the structural element in the sub-image is marked as 1, and all such pixels marked on the target image are composed of is the result of the corrosion calculation.

Target Image   Structural Element   After Corrosion
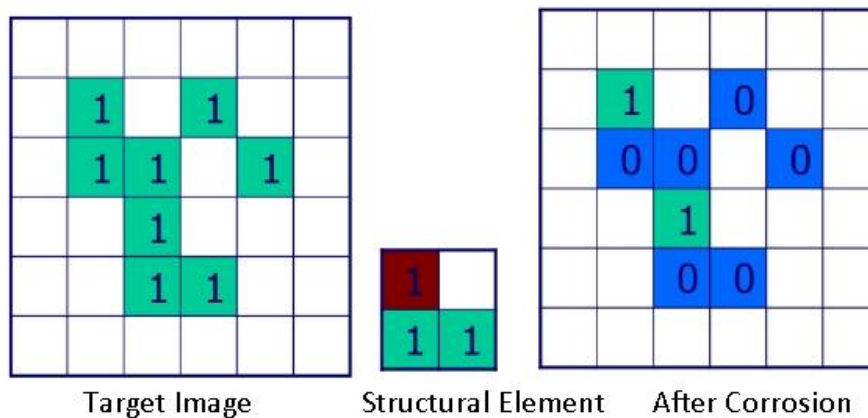
Expansion

Firstly, reflect the structure element about its origin to obtain the reflection set, and then translate the reflection set on the target image, then those reflection sets after translation and the target image have at least 1 non-zero common element when the corresponding reflection set's origin is intersected. This is the result of the expansion operation.

Target Image Structural Element After Expansion
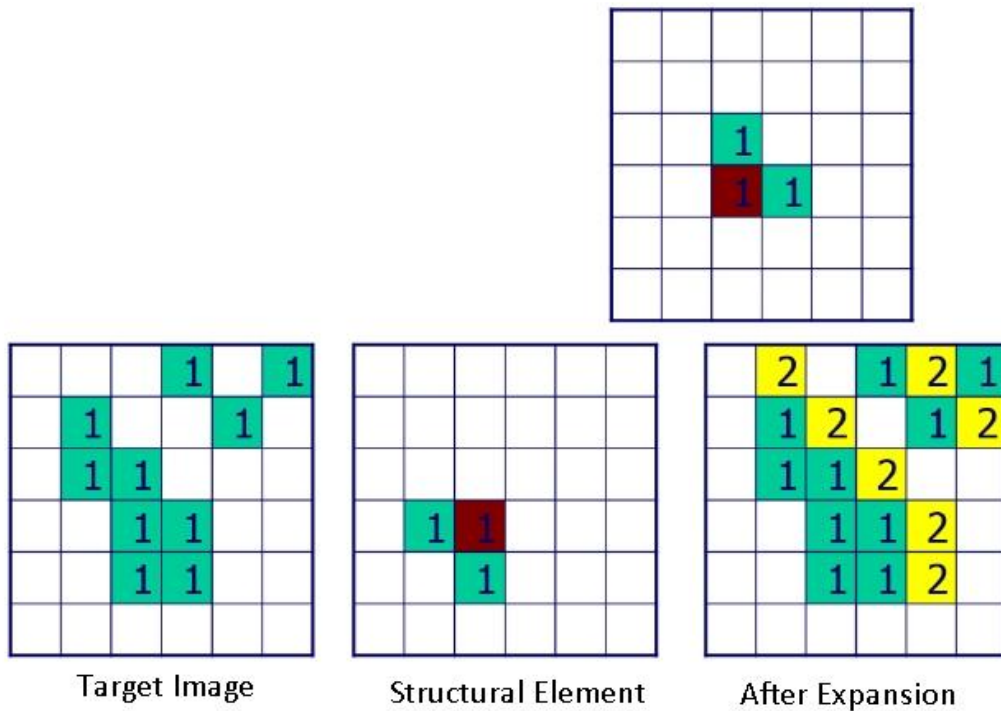
Open Operation

Using the same structural element to perform the corrosion operation on the target image first, and then using the expansion operation is called the open operation. The open operation has the effect of polishing the outer boundary of the image.

Close Operation

Using the same structural element to perform the expansion operation on the target image first, and then using the corrosion operation is called the close operation. The close operation has the effect of polishing the inner boundary of the image.

4.9.3 Image Binarization

The image binarization refers to the creation of binarized images that reflect the overall and local features of images from 256 grayscale images of the brightness level via appropriate threshold selection.

- **Binarization Type:** it refers to the segmentation method of binarization, including hard threshold binarization, mean binarization, Gaussian binarization, and auto binarization. When setting as hard threshold binarization, the grayscale is between low threshold and high threshold, and the respective binarization image pixel is white. Otherwise, it is black. When setting as auto binarization, you do not need to adjust other parameters, area with large grayscale in binarization is shown as white area, and area with small grayscale in binarization is shown as black area.

- **Hard Threshold Binarization:**
  - Low threshold: the min. threshold set by this threshold
  - High threshold: the max. threshold set by this threshold.

- **Mean Binarization Effect:**

  - Filter kernel width: the average value of filter kernel width. Increasing this value can make the average filtered image smoother.

  - Filter kernel height: the average value of filter kernel height. Increasing this value can make the average filtered image smoother.

  - Comparison type: it has four comparison types, including greater than or equal to, less than or equal to, equal to, and not equal to. If the condition is met, it will be displayed as a white area in the binarized image, otherwise it will be displayed as a black area.

  - Threshold offset: the compensation value added to the current pixel value during the mean binarization or Gaussian binarization, the compensated pixel value and the average image or Gaussian filter image.

- **Gaussian Binarization:**

  - Gaussian filter kernel: it refers to the size of the filter kernel. Increasing this value can make the image after Gaussian filter smoother.

  - Gaussian standard deviation: it refers to the level of Gaussian filter.

  - Comparison type: it has four comparison types, including greater than or equal to, less than or equal to, equal to, and not equal to. If the condition is met, it will be displayed as a white area in the binarized image, otherwise it will be displayed as a black area.

  - Threshold offset: the compensation value added to the current pixel value during the mean binarization or Gaussian binarization, the compensated pixel value and the average image or Gaussian filter image.

- **Auto Binarization:** The software will automatically perform image binarization.
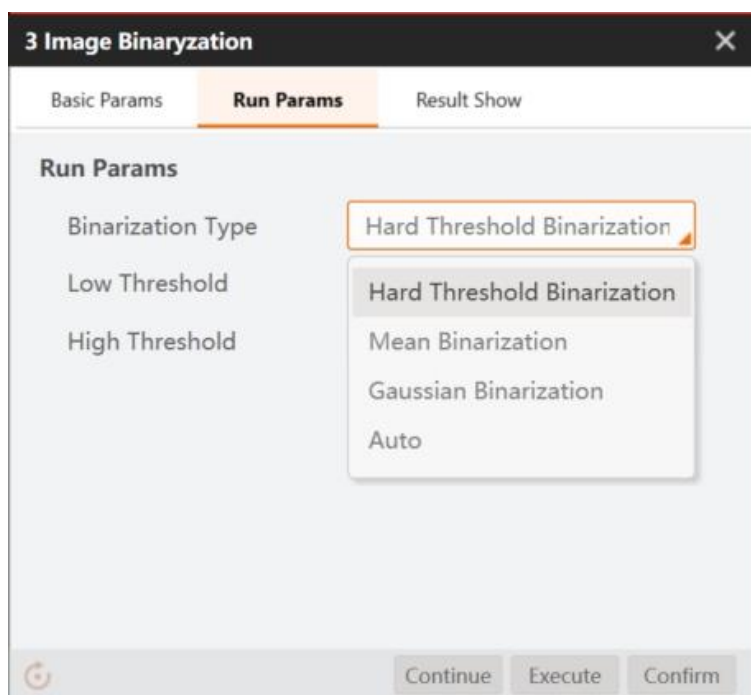
4.9.4　Image Filter

The tool of Image filter is used to suppress the noise of the target image while reserving the image detail features as much as possible.

Image Filter	
Gaussian Filter	Gaussian filtering is a linear smoothing filter, and Gaussian smoothing filter is very effective for suppressing noise that obeys a normal distribution.
Median Filter	Median filter is a non-linear smoothing filter, and it is used to eliminate salt and pepper noise in the image. It can eliminate the noise while protecting the edge of the signal so that it will not be blurred.
Mean Filter	Mean filter is a normalized filter, which has a good suppression effect on periodic interference noise.
Inverse Filter	It inverts the target image grayscale.
Edge Extraction	It binarizes the edge image whose gradient magnitude is within the edge threshold range to extract the edge.
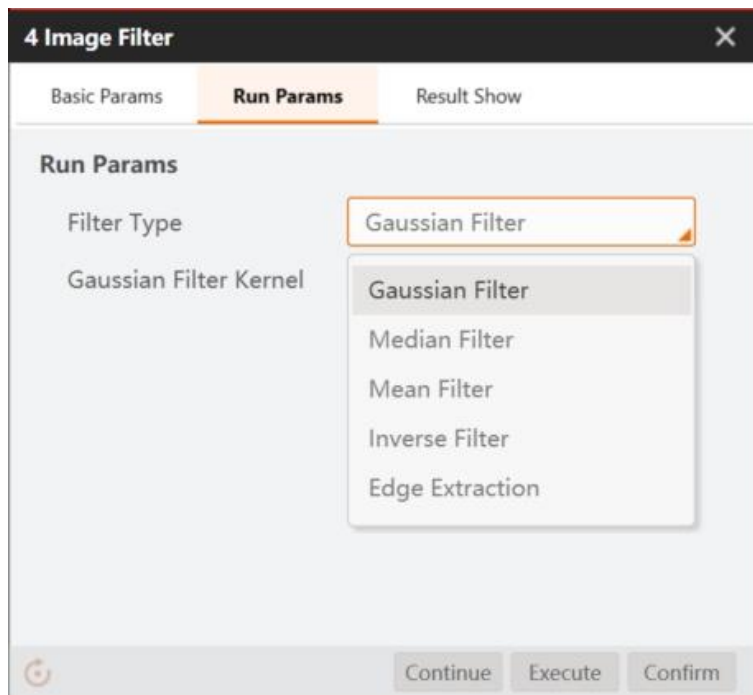
If you want to recognize the first line of characters in the figure below, but because the characters are composed of a dot matrix and the gray level difference is small, it is difficult to recognize. After image binarization, corrosion, and Gaussian filtering, the second line of characters can be obtained.

4.9.5 Image Enhancement

The tool of image enhancement includes sharpness, contrast adjustment, Gamma adjustment, and brightness adjustment.

Image Enhancement	
Sharpness	Image sharpening is to highlight the edges, contours, and features of some linear target elements on the image. This filtering method improves the contrast between the edge of the object and the surrounding pixels, so it is also called edge enhancement. It has two parameters, including **sharpen intensity** and **kernel size**. The larger value of sharpen intensity, and the sharper the image is. The range of kernel size is between 1 and 51.
Contrast	Image contrast is the perception of the difference in image color and brightness. The greater the contrast, the greater the difference between the object and the surroundings of the image, and vice versa. **Contrast coefficient**: it is a common parameter, and is used to control contrast coefficient. 100 stands for not adjustment, and the number is larger than 100, it means that contrast increases. Otherwise, it means that contrast reduces.
Gamma	it is a common parameter, and 1 refers to effect without adjustment. Gamma adjustment is used to edit the gamma curve of the image to achieve non-linear tone editing of the image. It can detect the dark portion and the light portion of the image signal, increase their ratio, thus improving Image contrast effect. But, the too large parameter will make the picture dark. If the Gamma is between 0 and 1, the dark area of the image will become bright. if the Gamma is between 1 and 4, the dark area of the image will become dark.

Brightness	An image is overexposed and appears very white, or insufficient light appears very dark. At this time, brightness correction and correction can be carried out. curdst[i]=offset+cursrc[i]*gain Among them, cursrc[i] represents the current gray value of the input image, curdst[i] represents the current gray value of the output image, gain represents the brightness correction gain, and offset represents the brightness correction compensation. In the above calculation formula, the calculation results of curdst[i] are all limited to the range of [0,255]. **Gain:** it is used to increase the overall pixel brightness of the image screen. The default value is 0 and the adjustment range is from 0 to 100. **Compensation:** it is used to add or subtract this value for overall pixel of the image. The default value is 0 and the adjustment range is from -255 to 255.

4.9.6   Image Computing

Image math needs to configure two images of the same size, and only supports full image operation. The principle of image math is to calculate the gray values of the pixels at the same coordinates in the two images and then obtain a new image, as shown below.
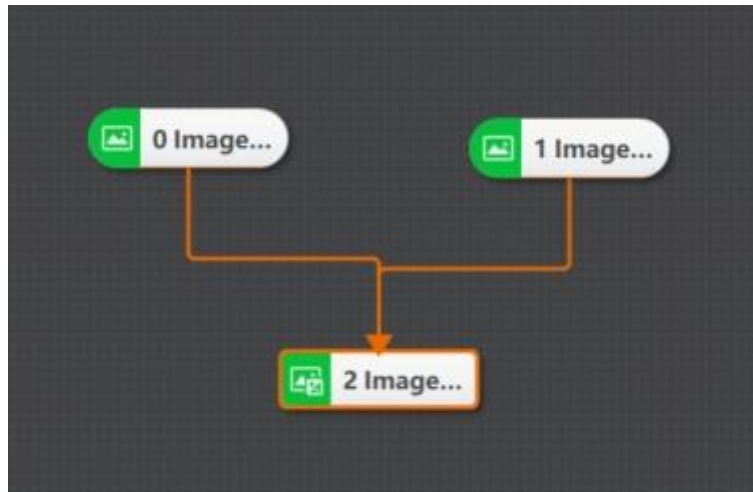
Refer to the figure below for the effect of image absolute difference calculation.

- **Image Input 1/2:** you can select the input source image including input source 1 and input source 2, and execute computing to these two images.

- **Image Weight 1/2**: it refers to the multiplication coefficient of input source 1/2 image gray value.

- **Calculation Type:** it includes addition, substraction, absolute difference, max. value, min. value, mean value, and, or, etc.

4.9.7   Distortion Correction

The tool of distortion correction is used to correct images by loading distortion calibration file, and outputs the corrected image. After loading distortion calibration file and setting parameters of calibration board, you can use click Run to operate. The image comparison between the original image and the corrected image is shown below.
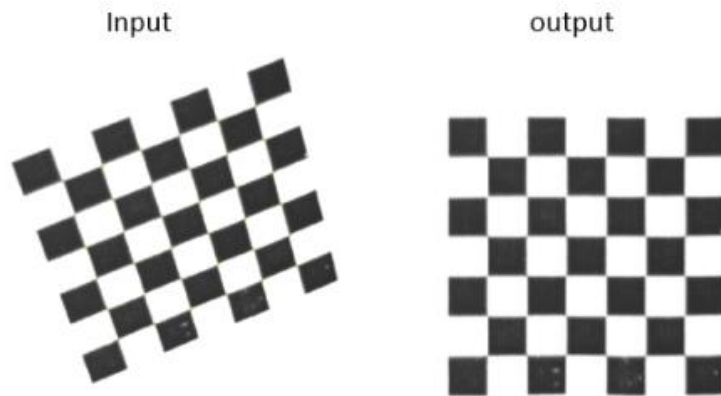
Correction Mode: it has three types, including perspective distortion correction, radial distortion correction and radial perspective distortion correction.

- Perspective distortion correction: it is used to solve the perspective transformation matrix of the image. It is applied to the tilted calibration board (which is not perpendicular to the camera optical axis), the lens distortion is relatively small, and you can obtain an image without perspective distortion.

- Radial distortion correction: it is used to solve the radial distortion parameters of the image. It is applied to estimate the radial distortion coefficient of the lens. If you do not need to remove the perspective distortion of the image, but need to remove the radial distortion, and you can select this mode.

- Radial perspective distortion correction: it is applied to general scenes, and it can solve both perspective distortion and radial distortion.

4.9.8 Image Clarity

The tool of image clarity is used to assess the sharpness of the image and output the image sharpness score via inputting an image. This tool can judge whether the camera is clearly focused, as shown below.
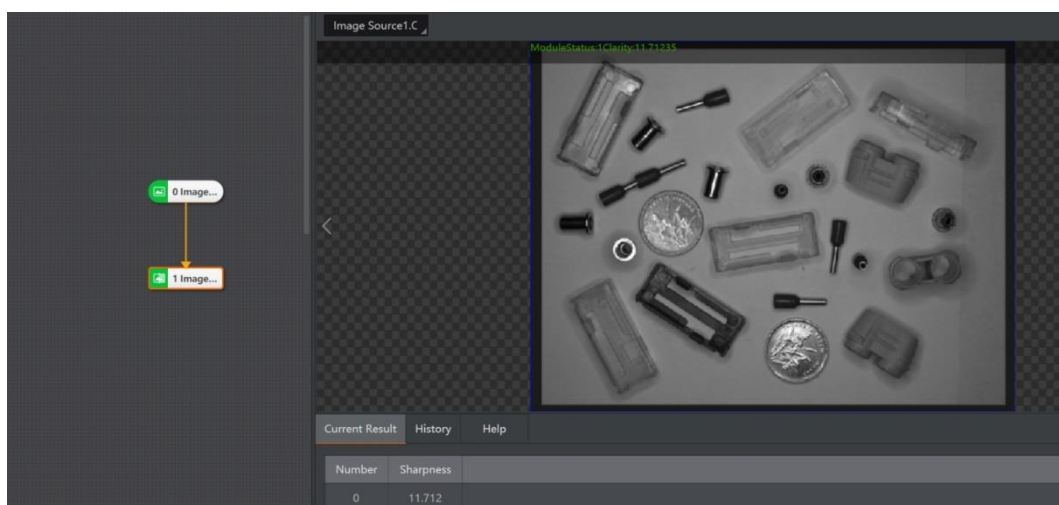
- **Assess Mode:** it has two modes, including auto correlation and gradient square. The auto correlation mode is applied to auto focus scene, and the gradient square mode is applied to the scene with rich image edge information.

- **Noise Level:** the default value is 0. When the image gray level difference is large, you can appropriately increase this parameter. It is valid in the auto correlation mode only.

4.9.9 Image Fixture

Image fixture is to perform image offset repair on the correction object by pre-setting the initial information of the reference point and the movement of the reference point (position and angle) detected during operation, so that the corrected image and the reference image have the same position. In the process, it is sometimes impossible to guarantee that the conveyed objects will not shift, as shown below.

When the position of the object is shifted in the field of view, the image needs to be corrected to ensure the accuracy of the positioning. The correction information in the image correction can be imported from the position correction. It is recommended to use a standard image to establish a template to ensure the accuracy of the correction information.

Image Fixture Parameters	
By Info	You can bind the correction information in the position correction directly.
By Point	You can bind the reference point, reference angle, operating point, and operating angle transmitted from the previous module.
By Coordinate	The coordinates of the reference point and the operating point can be customized. This method can be selected when the image needs to be rotated.

4.9.10 Shade Correction

Shadow correction performs mean filtering on the input image, and compares the mean filtered image with the original image to obtain the image residuals, and resets the pixels according to a certain rule. It is mainly used to perform illumination correction on the input image with uneven illumination.

The image before shade correction is shown below:

The image after shade correction is shown below:

The parameters of shade correction are shown below:

- **Filter Kernel Size:** it refers to the size of the filter kernel, and its range is from 1 to 50.

- **Gain:** it refers to the gain of signal amplification, and its range is from 0 t0 100.

- **Compensation:** it refers to the brightness compensation value, and its range is from 0 to 255.

- **Noise:** it is used to eliminate noise. If the signal is lower than this parameter value, it will be set as 0, and its range is from 0 to 255.

- **Direction:** it has three types of direction, including X, Y, XY, and all of them indicate the direction of filter kernel size.

4.9.11 Affine Transformation

The affine transformation has the function of cutting and zooming the image. Select the camera image on the right side of the image display source to frame the ROI. After frame selection, the ROI area will be cut out and displayed, as shown below.
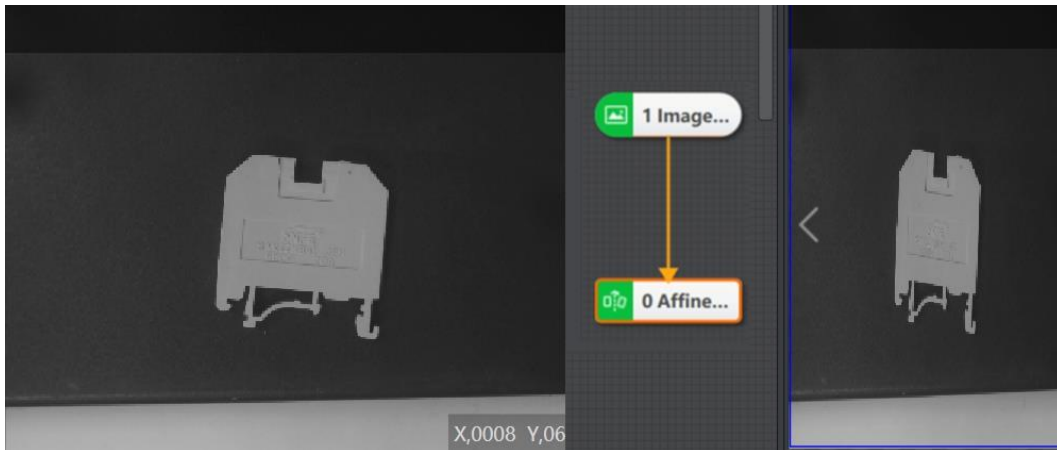
- **Scale:** it refers to the image's scale coefficient.
- **Aspect Ratio:** it refers to the ratio of width and height.
- **Interpolation:** it includes two types, including Nearest Neighbor and bilinear.
- **Fill Mode:** it includes two types, including constant and copy nearby.
- **Fill Value:** its range is from 0 to 255.
- **Width**: Dimension* image height.
- **Height**: Dimension* image width* aspect ratio

4.9.12 Ring Expansion

In the ring expansion interface, select the local image in the input source, otherwise the ROI cannot be selected. After that, in the specific rectangular area, ring expansion can be performed, as shown below.
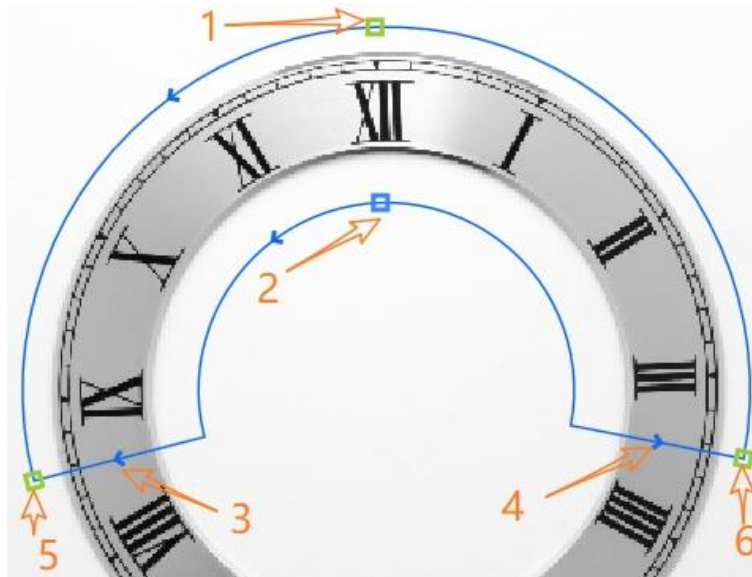
- Arrow 1: Adjust the radius of the outer circle and the inner ring will not change.

- Arrow 2: Adjust the curvature of the inner and outer rings at the same time.

- Arrow 3/4: Adjust the arc length of the inner and outer rings at the same time.

- Arrow 5/6: When selected one, the other is used as the fiduciary point for rotation and scaling.

- Direction of the circle: It has two directions, including counterclockwise and clockwise. The arrow direction is same of the inner and outer circles. The image above shows the counterclockwise direction, and you can adjust the direction of the circle by the arrow 3 or 4 direction.

- Radial direction: It has two directions, including from the inside to the outside and from the outside to the inside. You can adjust arrow direction via the location arrow 2.

4.9.13 Copy and Fill

The tool of copy and fill processes the ROI and ROI's min. circumscribed rectangle. The copy tool is to copy the image in the ROI and fill the area inside the min. circumscribed rectangle outside the ROI. The fill is to fill inside and outside the ROI, and the circumscribed rectangle.
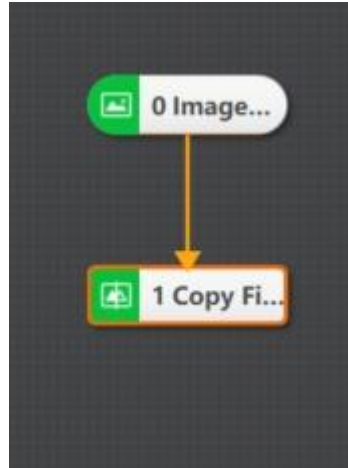
When you want to process a certain area separately in the whole picture, you can choose the copy mode shown in the figure below.

- **Process Type:** You can select fill or copy.

- **Fill Value outside the Region:** It refers to the filling outside ROI region, and its range is from 0 to 255. The fill effect can be seen in the result display only when the ROI is not a rectangle or the entire image.

- **Fill Vale inside the Region:** It refers to the filling inside ROI region, and its range is from 0 to 255. This parameter is valid only when the process type is fill.

4.9.14 **Frame Mean**

The tool of frame mean is used to calculate the average value of the pixels of ROI region with the same size set by the multi-frame images, and output the average image of the region.

Steps:

1. Select the ROI, and perform a frame mean operation on the ROI or on the full image.

2. Click Current Image Count to accumulate. Click Current Image Ignore, you can skip the frame mean operation of the current image, as shown below.
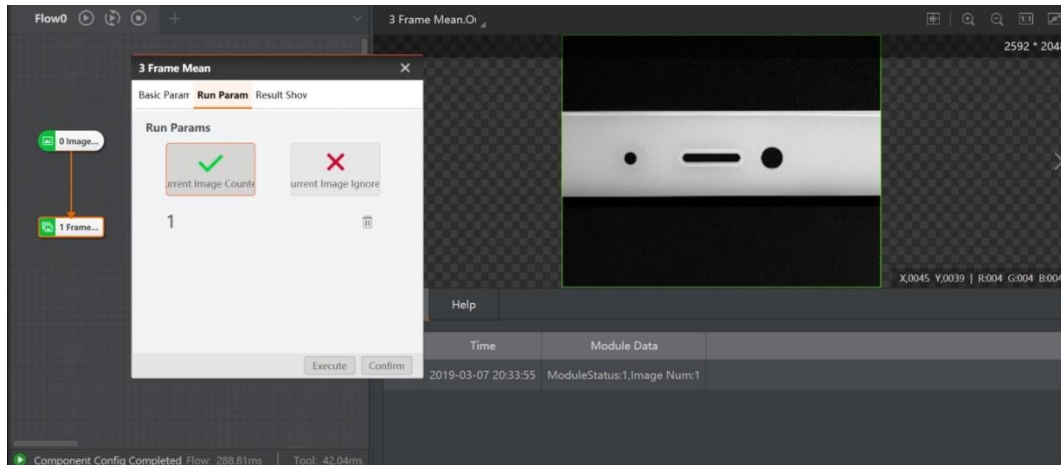
- **Accumulate:** It counts 100 input images at most, and output average images.

- **Ignore:** It skips the accumulated statistics for the current input image.

- **Clear Statistics Image:** It clears the average images obtained by the current statistics.

Before executing statistical operation for ROI region, you need to clear the statistics image.

4.9.15 Image Normalization

The tool of image normalization is used to perform gradation transformation for input images. The effects of this tool are shown below. These effects, from left to right, are the original image, histogram equalization effect, histogram normalization, and standard deviation normalization.

Normalization Type: It has three types, including histogram equalization, histogram normalization, and standard deviation normalization.

Image Normalization

Histogram Equalization	Equalization helps to extend the image histogram. After equalization, the gray level range of the image is wider, which effectively enhances the contrast of the image.
Histogram Normalization	It transforms histogram distribution of inputting image that is removed left and right-end ratios into the specified histogram distribution. Gray value range: The minimum value is the gray scale of the left end of the histogram, and the maximum value is the right end of the histogram.
Standard Deviation Normalization	It transforms the input image gray mean standard deviation to the standard deviation gray level. - Target mean value: it refers to the target mean value. - Target standard deviation: it refers to target standard deviation.

4.9.16 Image Correction

Lens radial distortion is the general term of the inherent perspective distortion of the optical lens. The image shape distortion that caused by optical lens inherent features (the convex lens merges light rays and the concave lens diverges light rays) is divided into barrel distortion and pincushion distortion. This function can correct these two kinds of distortions, as shown below
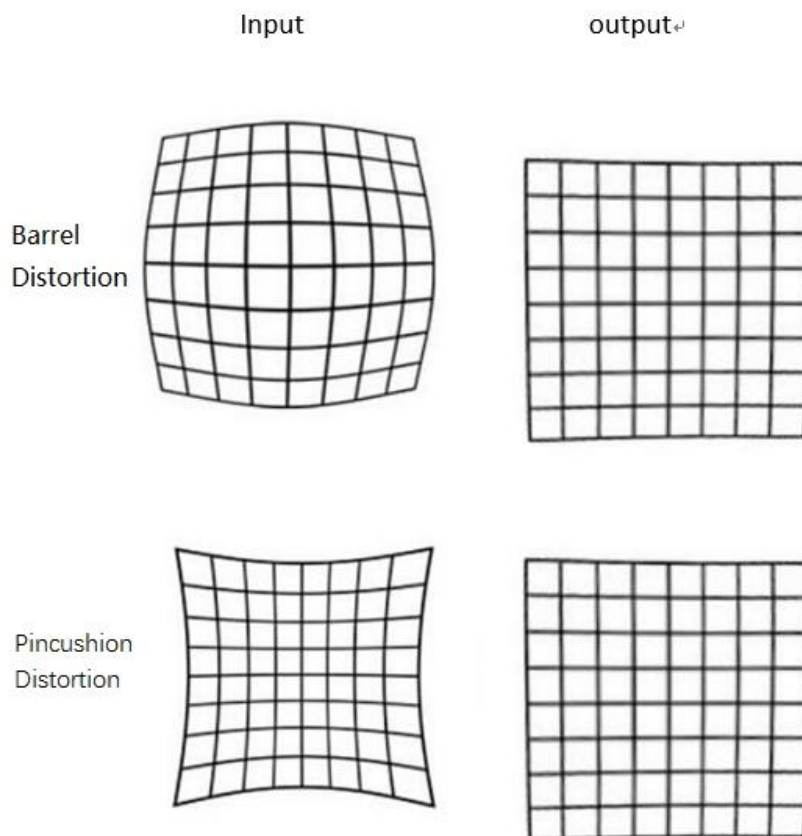
- **Image Correction Parameters**

- - **-Expansion Amount**: When the value is larger than 0, it will correct the barrel distortion. When the value is smaller than 0, it will correct the pincushion distortion.
  - **Scaling Amount**: Zoom out the whole image without changing its resolutions. Zoom in when the value is above 0 while zoom out when it is below 0.

4.9.17 Geometric Transformation

The geometric transformation can be used for horizontal, vertical, horizontal and vertical transformation of the image. At a certain angle, the entire image can be rotated after mirror image transformation. When "none" is selected as the mirror direction, setting a certain angle can directly rotate the image horizontally.

- Horizontal mirroring is to reverse the left and right parts of the image, with the vertical center axis of the image as the center.

- Vertical mirroring is to reverse the upper and lower parts of the image, with the horizontal central axis of the image as the center.

- Diagonal mirroring is to reverse the image by centering on the intersection of the horizontal central axis and the vertical central axis of the image. This is equivalent to mirroring the image horizontally and vertically in succession, as shown below.
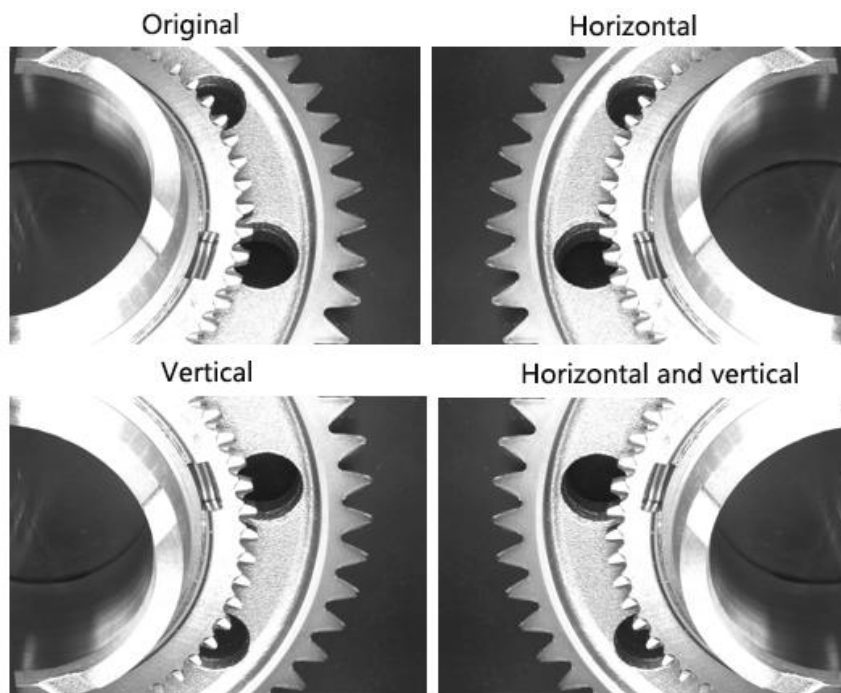
4.9.18 Image Stitch

Due to hardware limitations, the field of view of a single camera cannot cover the entire field of view. When the display of the entire object is required in the project, multiple parts of the object need to be stitched into a whole picture, as shown below.
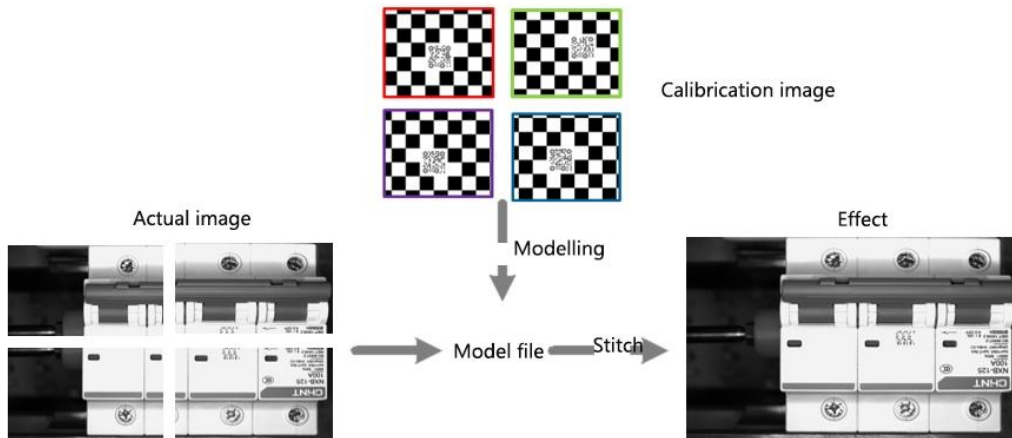
Image stitching only supports calibration with self-developed calibration board.

Take the stitching of 9 images as an example. Before stitching, you need to set up 9 cameras in sequence above the calibration board, or move a single camera to 9 fixed areas in a fixed way to shoot, and the finally 9 pictures need to cover the entire calibration board.

After inputting a series of calibration board images, you can get the relative position relationship between the images based on the checkerboard corner position information of different images.

The image stitch parameters can be set in the basic parameters, and the model can be used directly after the template configuration is completed based on the parameter settings, as shown below.

Image Stitch Basic Parameters	
Input Mode	There are two input methods, i.e., single source and multiple source.
	Single source: select one image source; single source corresponds to an application where a single camera moves multiple times.
	Multiple source: stitch several image sources; multiple source corresponds to an application where multiple cameras shoot at a fixed position.
Stitch Number	Customize the number of images that need to be stitched.

	Fill in the number of image sources in the box **Stitch Number** , and finish stitching by clicking **Execute**.
Stitch Method	A×B is the image of row A and column B, the value of which affects the image distribution in the stitch mode.

The modeling process is as follows:

1. First take a picture of the calibration board in 9 different areas, and select the images to load in sequence in the model settings, as shown below.
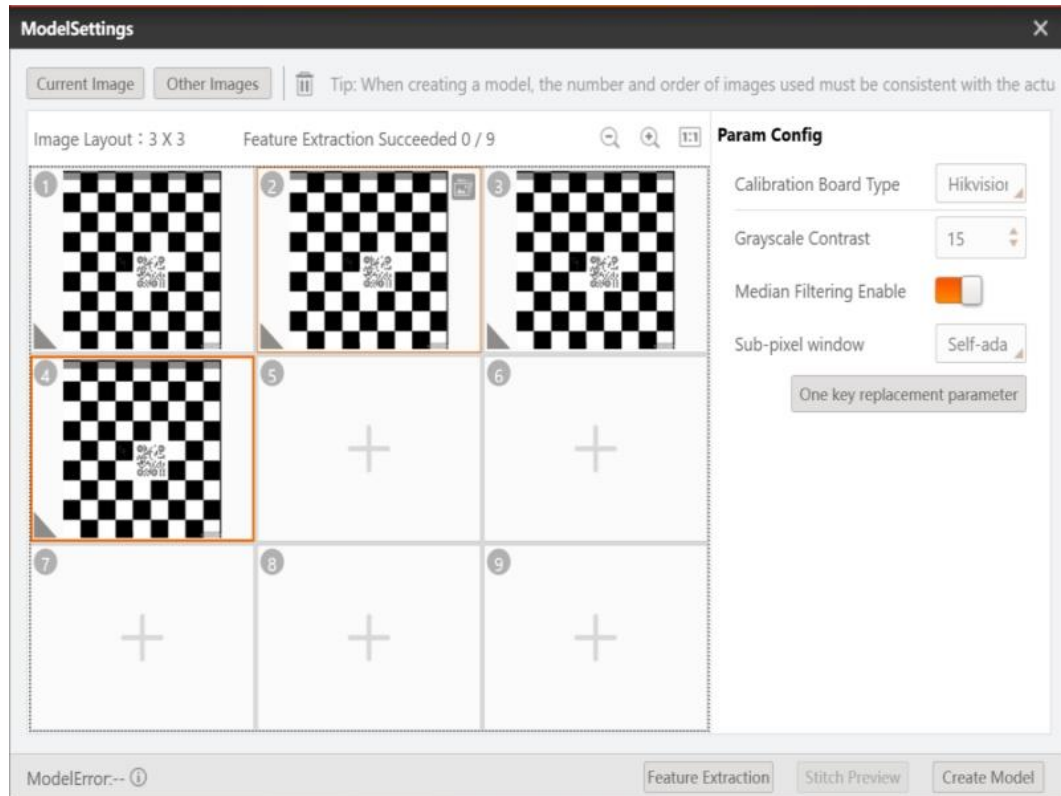
Parameter Configuration	
Calibration Board Type	Hikvision Type I and Hikvision Type II.
Grayscale Contrast	Grayscale contrast refers to the contrast of black and white grids. When the grayscale value of the black and white grids of the image is close, the grayscale contrast can be set lower,
Median Filtering Enable	Median Filtering is enabled after opening.
Subpixel Window	This parameter indicates whether to adapt the window size of the corner sub-pixel accuracy. When each square of the checkerboard occupies more pixels, the value can be increased appropriately. The default value is recommended.
One Key Replacement Parameter	Replace all calibration parameters of other images with current parameters.

2. After the image is loaded, click **Feature Extraction** to extract the feature. If the feature extraction is successful, the gray triangle in the lower left corner of the image will turn green, prompting the end of feature extraction.

3. After the feature extraction is completed, click **Create Model** to generate the model, and click **Stitch Preview** to preview the stitching effect picture.

After the setting is completed, the single camera takes pictures in a fixed order several (stitch number) times or the multiple cameras take pictures once to complete the stitching, as shown below.

Image Normalization	
Merge Type	It includes merge mean, merge min, merge max, and merge uncover. • Merge mean: It is the default method. After taking the average value of the repeated area and then complete the merger, usually the effect is better. • Merge max: Get the maximum value of the coincident image and add it to the stitched image. It can be used to stitch the bright and dark images in the middle. • Merge min: Take the minimum value in the coincident image area, and add the minimum value to the merger image. • Merge uncover: The stitched image will not be stitched repeatedly, and only the un-stitched area will be processed to solve the ghost phenomenon in stitching, but the gradation of the image connection is poor.
Cut Ratio	The range is between 0 and 25. The larger this parameter, the smaller the processing area and the less time the module runs. This parameter is mainly for the area where the image overlaps with a large amount.
Auto Clear	• If it is enabled, the input image will be deleted automatically after one stitching of the image is completed.

	• If it is disabled, after completing one image stitching, when another image is input, it will replace one of the 9 images that are stitched together previously.

4.9.19 **Multiple Images Fusion**

This tool needs to be used in conjunction with the multiple images collection. Use one camera and multi-angle and same-spectrum light sources (commonly used as four or eight angle light sources) to obtain the same number of images with the same light sources by turning on the light sources respectively.

This tool can obtain obvious shape images and texture images, which can be used in scenes such as distinguish, blemish/stain, character recognition (convex), "character recognition (concave), and so on. The interface and parameters of multiple images fusion are shown below.
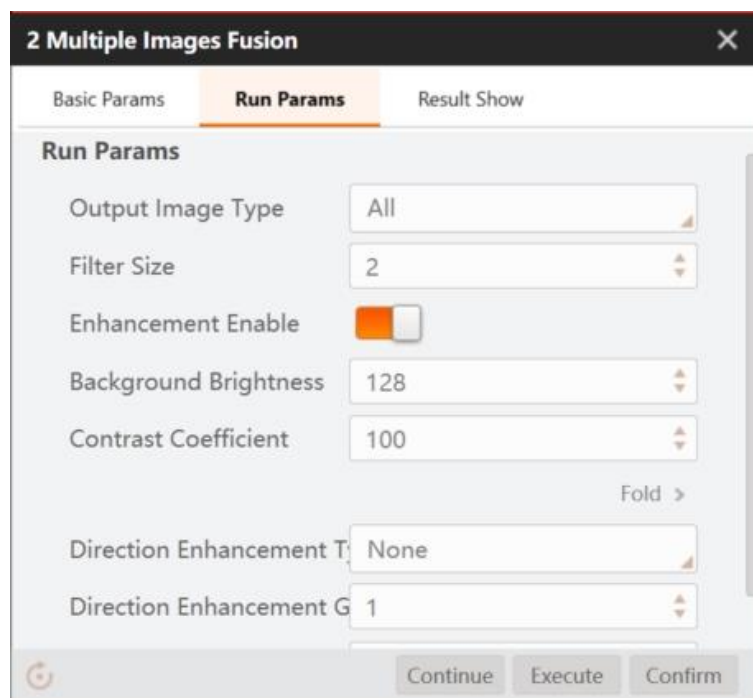
Text-Protocol Parse	
Output Image Type	It includes all, reflection and shadow.
Filter Size	The size of the filter kernel, and its range is from 1 and 50. Its function is to filter out the noise in the shadow image. The larger the value, the more blurred the shadow image, the stronger the ability to filter noise, but the impact on the target is also equal.
Enhancement Enable	• It it is enabled, you can set background brightness and contrast coefficient. • If it is disabled, the software will automatically give the shadow image.

Background Brightness	The larger the value, the darker the background of the shadow image, and the smaller the value, the whiter the background of the shadow image.
Contrast Coefficient	The larger the value, the more obvious the shadow of the shadow image, and the smaller the value, the less obvious the shadow.
Direction Enhancement Type	It includes none, x-direction and -direction.
Direction Enhancement Grade	It controls the intensity of the direction enhancement.
Halo Removal Grade	If 4 multi-angle light images are input, the value setting range should be 1 to 4. if 8 multi-angle light images are input, the value setting range should be 1 to 8. The larger the value, the greater the removal strength, and the darker the output reflection image. if the input is 4 images, it is recommended to configure it as 3, and if it is 8 images, it is recommended to configure it as 5.

📖NOTE

- This tool currently supports grayscale images only.

- Input at least 3 and 8 images collected by multi-angle and same-spectrum light sources.

4.10 Color Processing

4.10.1 Color Extraction

Color extraction is used to segment the target area from a color image and get a binary image containing only the target object. The color space of the color extraction tool can be RGB, HSV or HSI. The three-channel threshold can be generated automatically by modeling or manually set, as shown below.
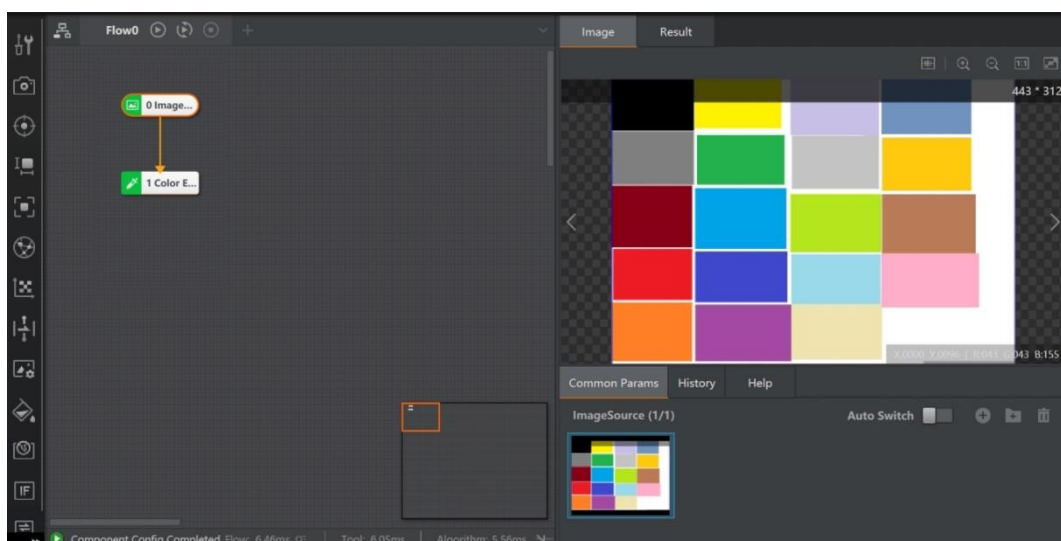
To extract the red area from the target map, you need to create a color extraction list first. First, measure the approximate values of the three channels, and manually set the three-channel extraction threshold, as shown below.
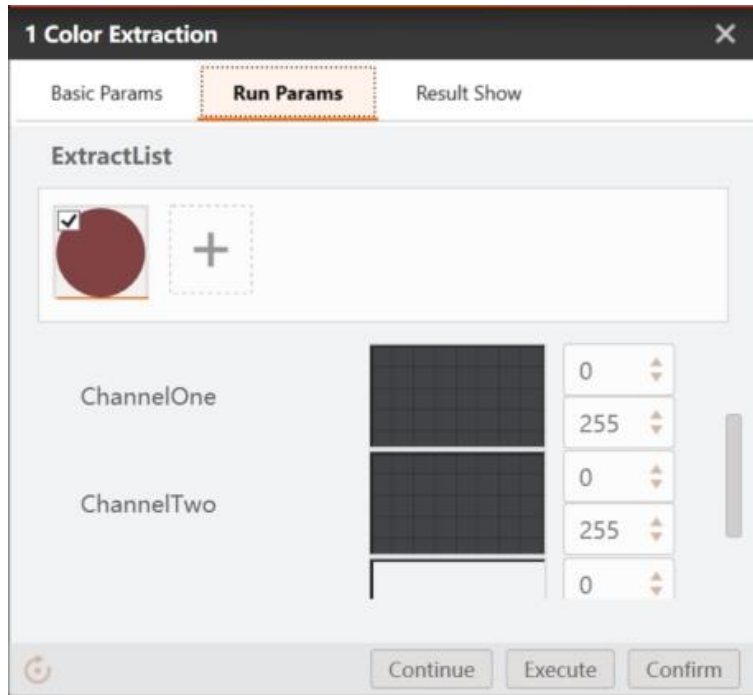
The extraction model can also be generated automatically through modeling, as shown below.

1. Select the color area. Click the rectangle tool to select the color you want to extract.
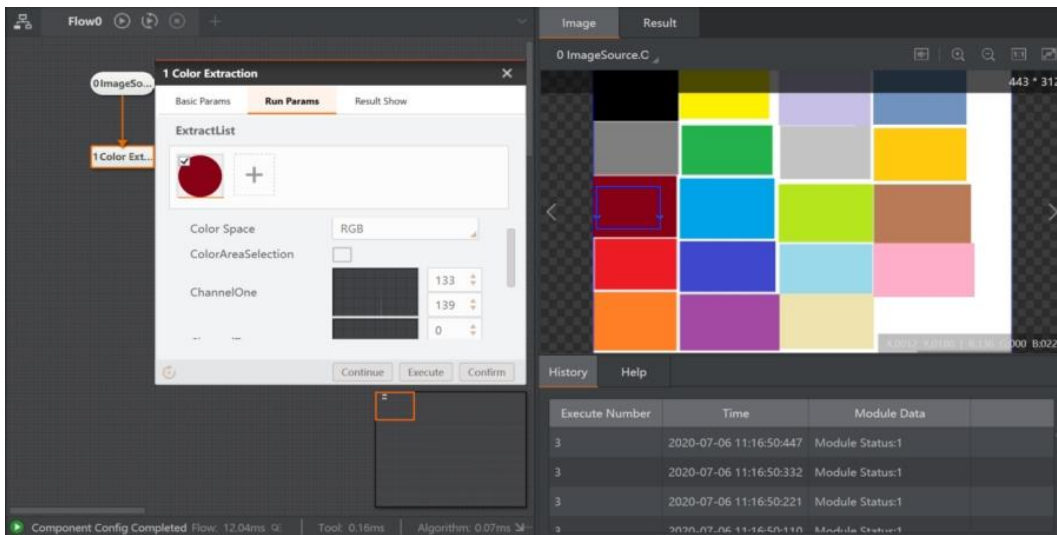
2. Draw the ROI in the target area where the image needs to be segmented.
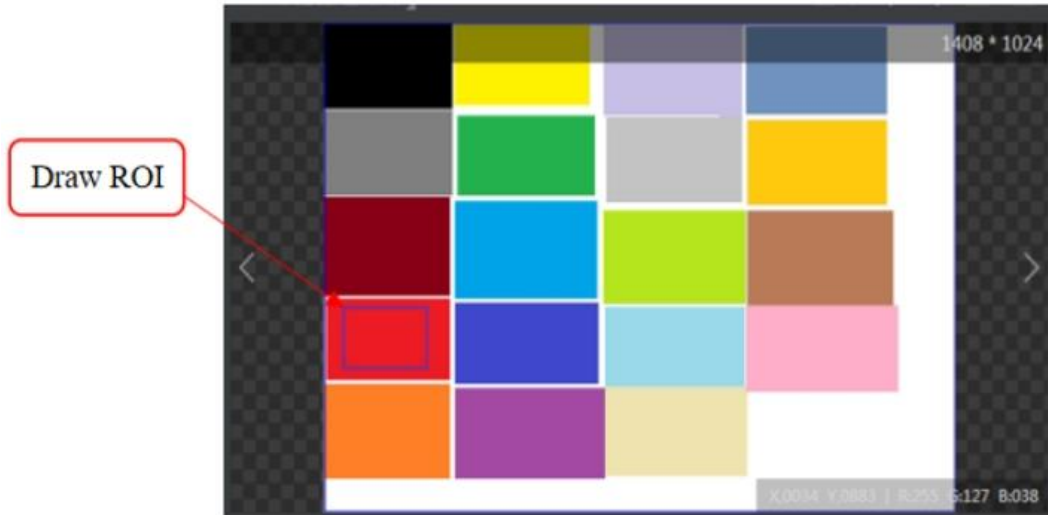
3. The three-channel extraction threshold is automatically generated. The threshold is the recommended value. If the segmentation result does not meet the requirements, you can make minor adjustments based on the three-channel histogram data.
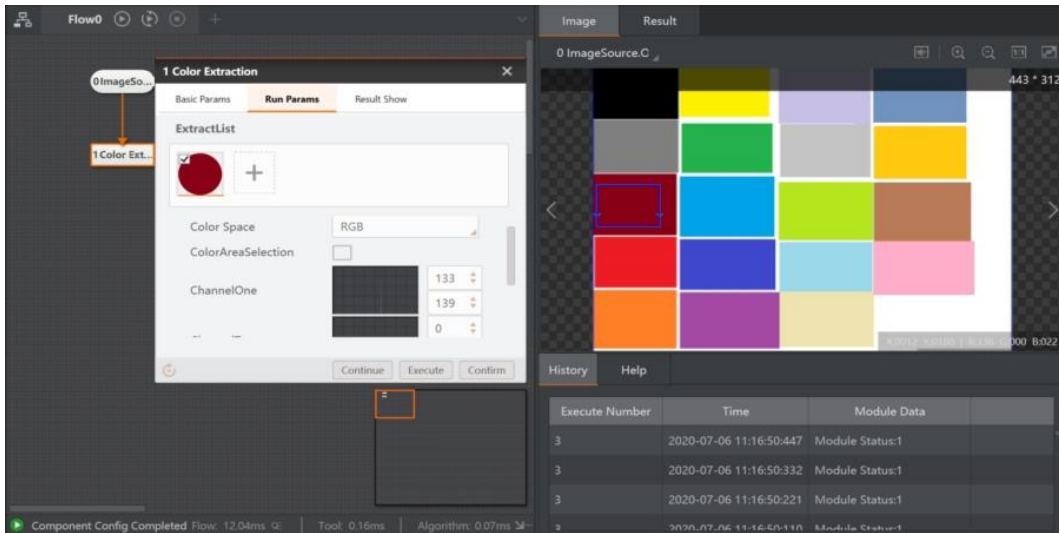
After the color extraction list is generated, the software will automatically extract the objects in the channel range and perform binaryzation, as shown below.
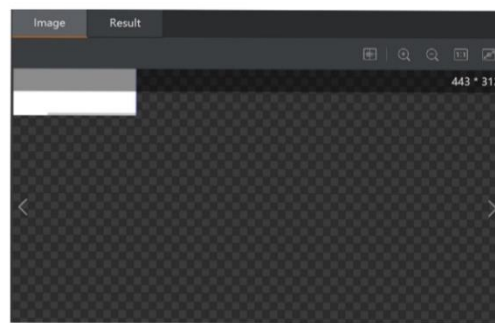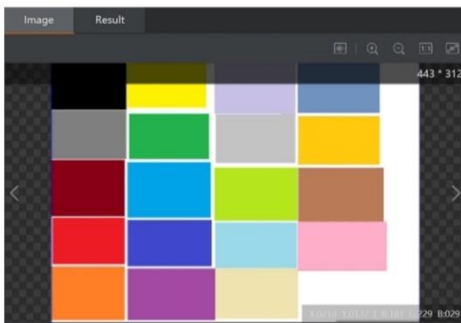
Click ⊞ and refer to the above modeling method to create multiple color extraction lists, as shown below.

Color Extraction	
Color Space	RGB, HSV and HSI.
Channel Lower Limit	The lower limit of the pixel values extracted by the image channel in the specified space.
Channel Upper Limit	The upper limit of the pixel values extracted by the image channel in the specified space.
Color Inversion	Color inversion after the binaryzation of image.
Note: Pixel values greater than or equal to the lower limit and less than or equal to the upper limit will be assigned a value of 255, and other pixel values will be assigned a value of 0.	

After you enable **Color Total Area Check** in **Result Show** page, the output results are filtered according to the output area.

The **Result Show** interface is shown below.
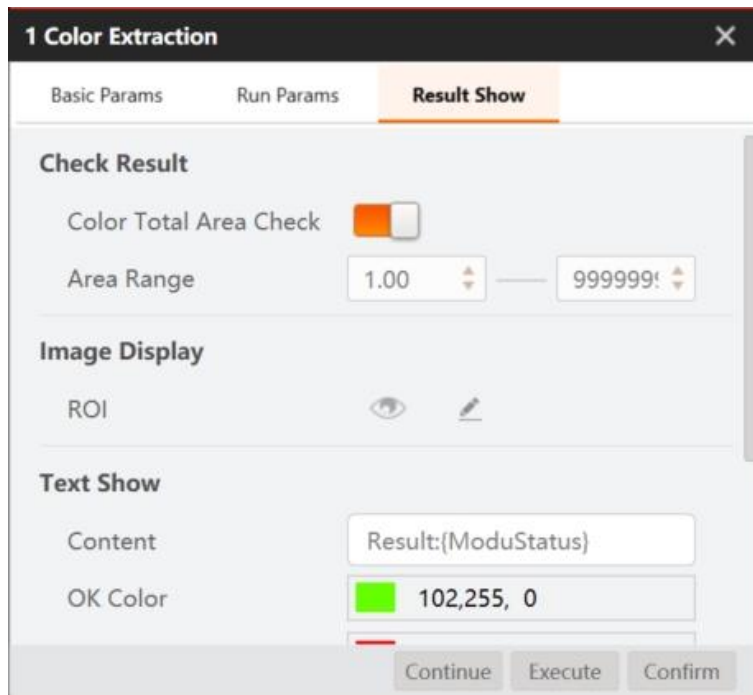
4.10.2 Color Measurement

The tool of color measure is used to measure the color information in the specified area of the color image, including the max. value, min. value, mean value, standard deviation and histogram of each channel, as shown below.
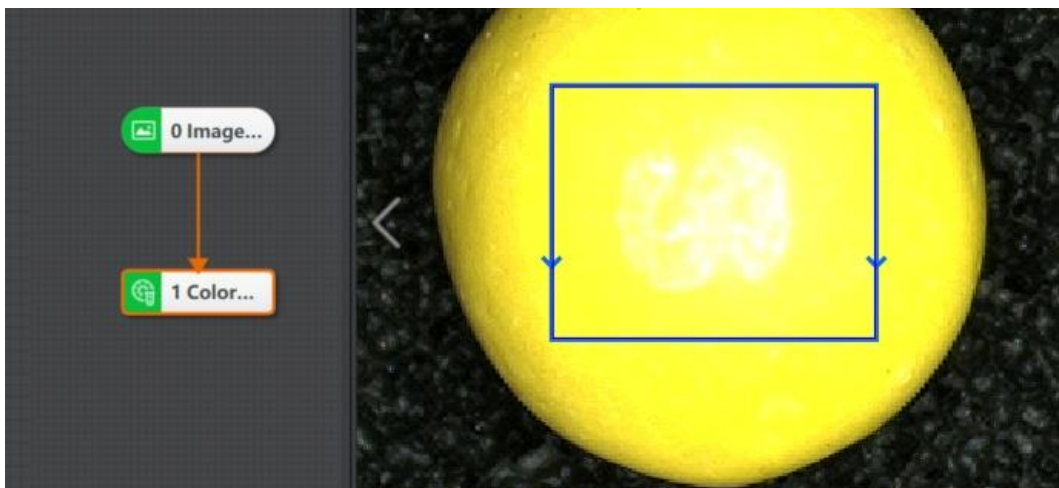
Color Measurement Parameters	
Color Space	RGB, HSV and HSI

The operation result is shown below.

	Number	C1Min	C1Max	C1Mean	C1Std	C2Min	C2Max	C2Mean	C2Std	C3Min
	0	0	255	106.486	34.056	0	255	103.684	35.078	0
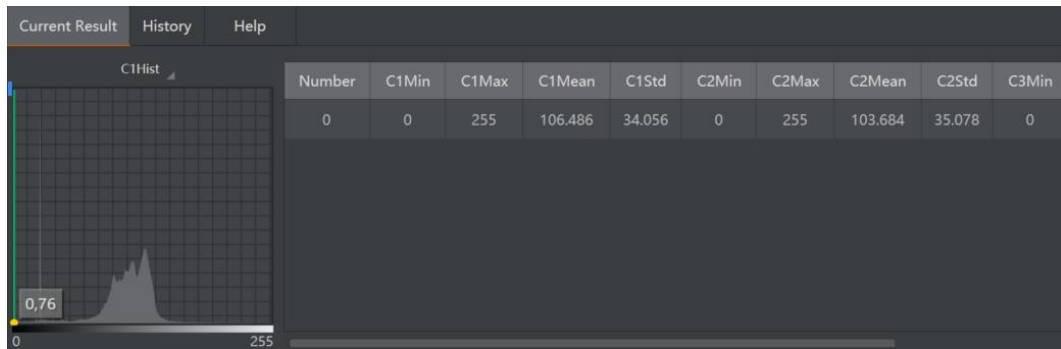
Color Measurement	
Channel Min.	It is the min. value of the corresponding color channel.
Channel Max.	It is the max. value of the corresponding color channel.
Channel Mean	It is the average value of the corresponding color channel.
Channel Standard	It is the standard deviation of the corresponding color channel.

4.10.3 Color Transformation

After inputting a colored image, you can choose transfer type, including RGB to grayscale, RGB to HSV, RGB to HSI, and RGB to YUV. The tool of color transformation transforms the color space in the specified area of the color image, and outputs the gray image of specific color channel after transformation in this area, as shown below.
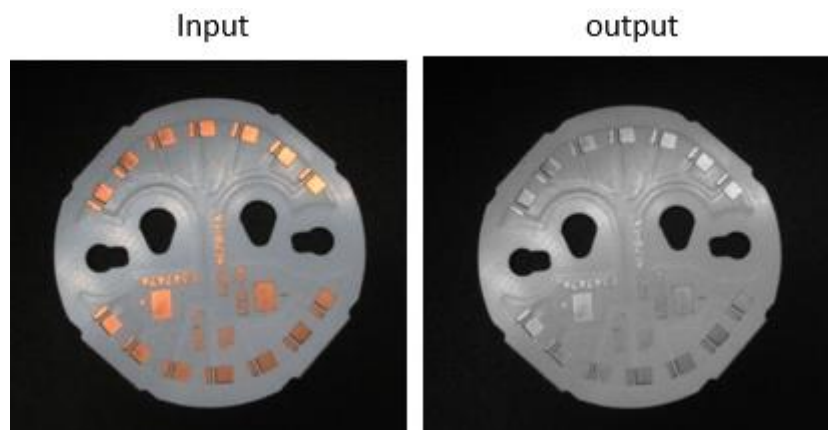
Color Transformation		
RGB to Grayscale	General transfer ratio	0.299r + 0.587g + 0.114b. r stands for the gray value of the R channel, g stands for the gray value of the G channel, and b stands for the gray value of the B channel.
	Average transfer ratio	(r + g + b) / 3
	Channel min. value	min (r, g, b)
	Channel max. value	max (r, g, b)
	User-defined transfer ratio	Self-defined coefficients

	Channel R	r + 0*g +0*b
	Channel B	0*r + 0*g +b
	Channel G	0*r + g +0*b
RGB to HSV, HSI and YUV	Channel 1	Transform according to channel 1.
	Channel 2	Transform according to channel 2.
	Channel 3	Transform according to channel 3.

4.10.4 **Color Recognition**

Color recognition relies on color as a template for classification. When different types of objects have obvious color differences, this tool can achieve accurate object classification and output related classification information. The template needs to be established before color recognition.
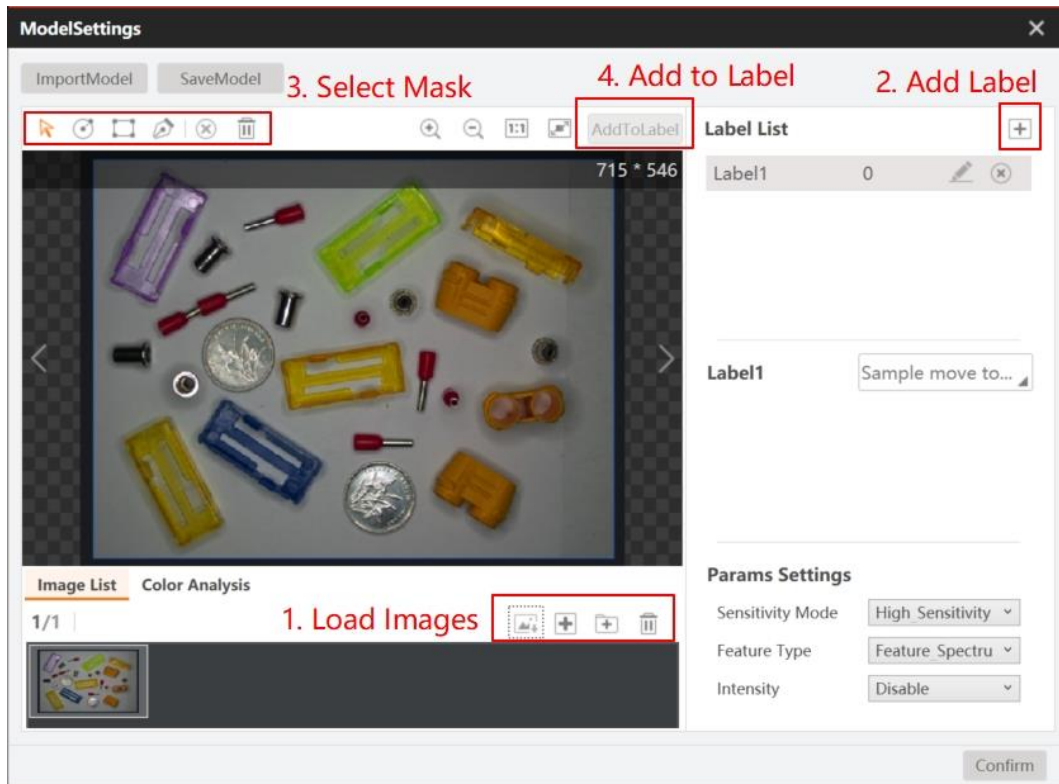
One type of object can be placed in a label, and the sample can be moved to the correct label list when the sample is incorrectly marked. After completing the modeling, you can adjust the template parameters, as shown below.

Template parameters	
Sensitivity Mode	This parameter has three modes, including low sensitivity mode, medium sensitivity mode, and high sensitivity mode. It is recommended to select high sensitivity mode when the image is sensitive to external environment.

Feature Type	This parameter includes feature spectrum and feature histogram, and feature histogram is more sensitive.
Intensity	Intensity reflects the effect of light on the image. If you need to keep the recognition result more stable under the change of light, it is recommended to disable this parameter. You can only enable or disable intensity when selecting feature histogram as feature type. Intensity is always enabled when the feature type is feature spectrum.

When you run the flow after creating the template, loading the image and setting the ROI, the software can output the recognition score for each category and the best recognition effect according to the K value, as shown below. On the right side of the output result, the hue, saturation and brightness contrast chart are displayed between model area and current area.
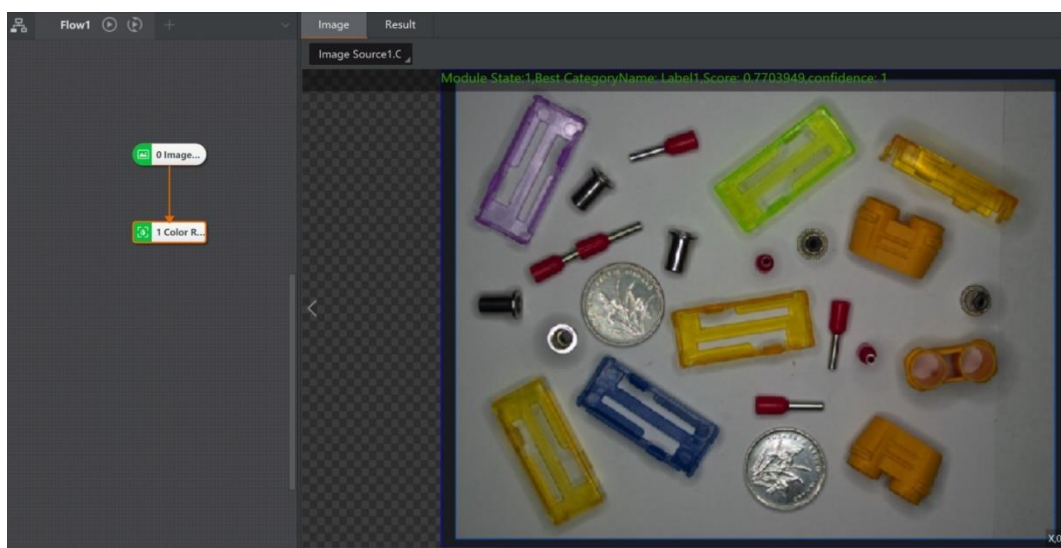
Running parameters of color recognition	
K Value	This parameter means that the class with the largest number in the first K samples is selected as the best recognition result.
KNN Distance	This parameter includes Euclidean distance, Manhattan distance and intersection distance. There are slight differences among various distances. You can select it according to actual conditions. Generally, you can select the default distance.

4.11 Defect Detection

4.11.1 OCV

The tool of OCV (Optical Character Verification) compares the target image with the standard image to detect whether printed characters and patterns have defects like characters missing and redundant. This tool is widely applied to packaging, printing, semiconductor and other manufacturing areas.

OCV is a process which compares the target image with the standard image, thus standard images need to be trained before defect detection.

Steps:

1. Select the OCV tool, and double click to open it.

2. Enter input source, ROI area, and rough match information in the basic parameter interface according to actual demands.

3. Click **Train Model** in the character model interface.

4. After opening the character training model, you can directly create model or inherit.
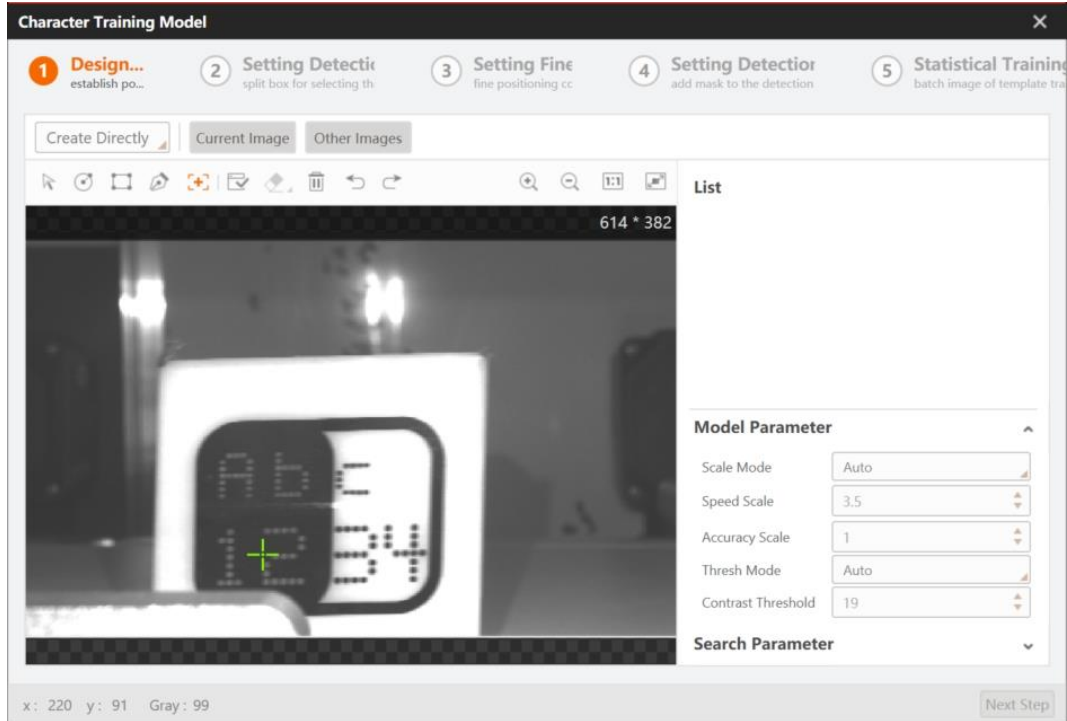
5. Click **Next Step** to enter the detection target interface, and use □ to draw detection area, and click **Draw Character** after setting related parameters.

Character Segmentation Parameters	Description
Min. Character Area	It sets the character area size.
Min. Character Width	It sets the character width.
Binarize Scale	It sets binarize scale.
Binarize Window Size	It sets binarize window size.
Binarize Threshold	It sets binarize threshold.
Binary Picture	After enabling, the software will display binary picture.
Character Polarity	It includes light on dark and dark on light.
Segment Mode	It includes segment by line, word and character.
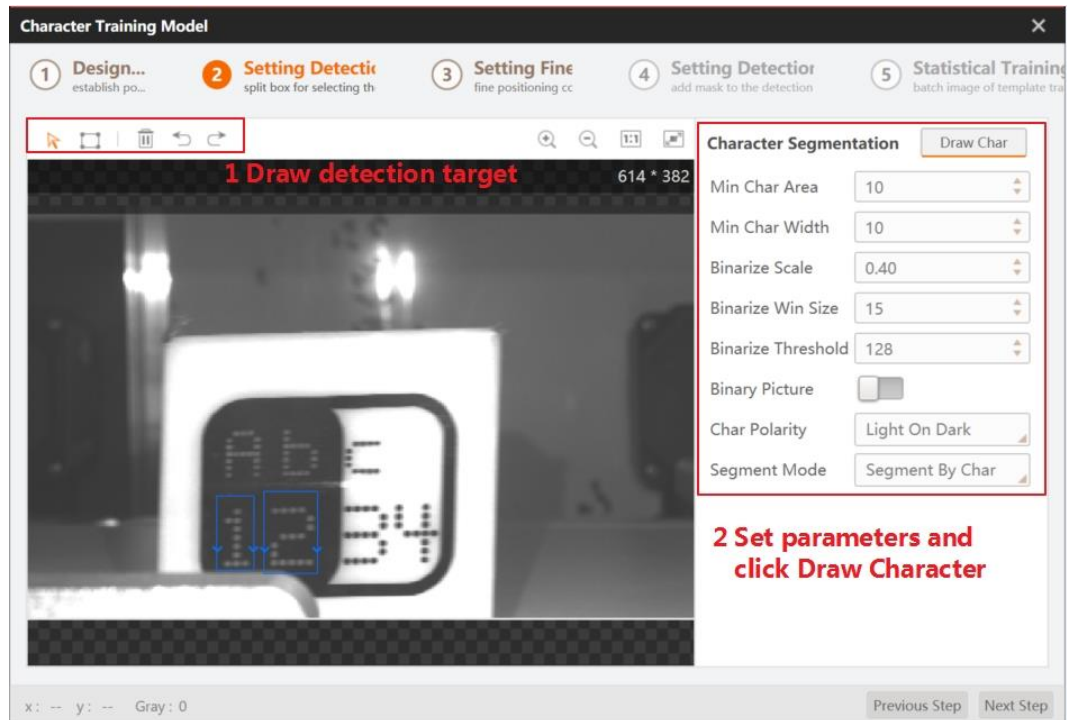
6. Click **Next Step** to enter fine positioning interface.

7. Draw the area that needs training, set training parameters and exact location parameters, and click **Model Training** at last.

Training Parameters	
Scale Mode	It includes auto and manual. It is recommended to use auto mode.
Precision Pyramid Scale	It indicates the fineness of extracting feature particles. When the fine scale is set to 1, the fineness is the largest, the number of edge points is the largest, and the precision is the highest.
Speed Pyramid Scale	It is the speed pyramid scale.
Threshold Mode	It includes auto and manual. • If auto mode is selected, the software will be self-adaptive according to the target characters. • If manual mode is selected, you need to set model low threshold, and the software will perform according to the user's configuration.
Model Low Threshold	It only takes effect when manual is selected as threshold mode.
Exact Location Parameters	
Min. Match Score	It refers to the degree of similarity between the feature template and the target in the search image, that is, the similarity threshold. The searched target will only be searched when the similarity reaches the threshold. The maximum is 1, indicating a complete fit, and the default is 0.5.

Angle Range	It Indicates the angle change range of the target to be matched relative to the created template. If you want to search for a target with a rotation change, you need to set it accordingly. The default range is between -180° and 180°.
Correct Flag	After enabling, the software will atomically correct the character position.
Threshold Type	It includes auto threshold, manual threshold, and model threshold.
Width Tolerance	The degree that the width direction is allowed to deviate from the template.
Height Tolerance	The degree that the height direction is allowed to deviate from the template.

8. Click **Next Step** to set detection area mask, and use ![eraser icon] to erase the area that do not need recognition.

9. Click **Next Step** to enter statistical training interface, and you can load up to 500 pieces of images to train.

  📖NOTE

- You can click green check mark to count image or click red cross to discard.
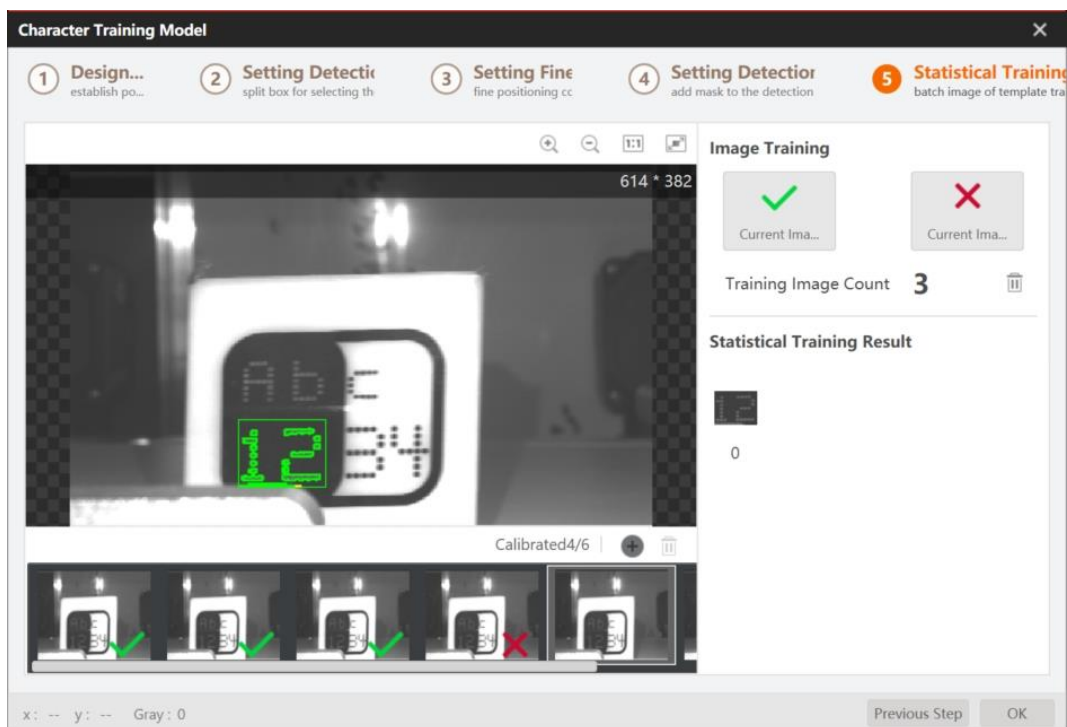
10. Click **OK** to finish training, and set running parameters.
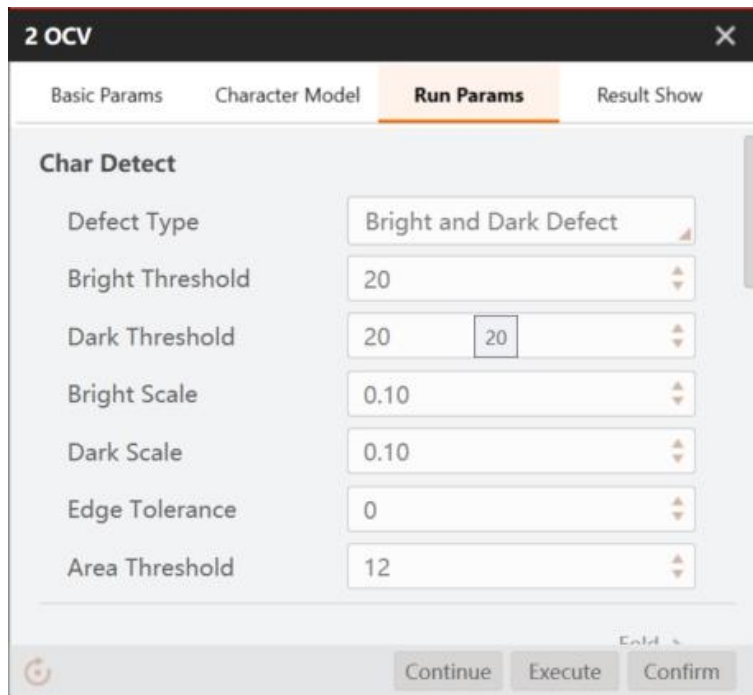
Running Parameters	
Character Detection	
Defect Type	**I**t has three types, including bright defect, dark defect, and bright and dark defect.
Bright Threshold	The min. grayscale of bright defect.
Dark Threshold	The min. grayscale of dark defect.
Bright Scale	The min. scale of bright defect.
Dark Scale	The min. scale of dark defect.
Edge Tolerance	The larger the value, and greater tolerance for defect.
Area Tolerance	The detection image is compared with the high and low threshold image to obtain a difference binary image, and the blob in the binary image larger than the area threshold image is regarded as a defect.
Character Exact Location	
Min. Match Score	It refers to the degree of similarity between the feature template and the target in the search image, that is, the similarity threshold. The searched target will only be searched when the similarity reaches the threshold. The maximum is 1, indicating a complete fit, and the default is 0.5.
Angle Range	It Indicates the angle change range of the target to be matched relative to the created template. If you want to search for a target with a rotation change, you need to set it accordingly. The default range is between -180° and 180°.
X Scale Range	It indicates the variation range of the consistency scale of the target to be matched relative to the created template. If you want to search for a target with a consistent scale change, you need to set the corresponding settings.

Y Scale Range	It indicates the variation range of the consistency scale of the target to be matched relative to the created template. If you want to search for a target with a consistent scale change, you need to set the corresponding settings.
Threshold Type	It includes auto threshold, manual threshold, and model threshold.
Speed Enable	After enabling it, you need to enter speed threshold.
Correct Flag	After enabling, the software will atomically correct the character position.
Width Tolerance	The degree that the width direction is allowed to deviate from the template.
Height Tolerance	The degree that the height direction is allowed to deviate from the template.
Character Rough Location	
Min. Match Score	It refers to the degree of similarity between the feature template and the target in the search image, that is, the similarity threshold. The searched target will only be searched when the similarity reaches the threshold. The maximum is 1, indicating a complete fit, and the default is 0.5.
Match Polarity	Polarity stands for the color transition from the feature pattern to the background. When the edge polarity of the search target is inconsistent with the polarity of the feature template, it is still necessary to ensure that the target is found. The matching polarity needs to be set to ignore the polarity. If necessary, it can be set to consider the polarity, which can shorten the search time.
Angle Range	It Indicates the angle change range of the target to be matched relative to the created template. If you want to search for a target with a rotation change, you need to set it accordingly. The default range is between -180° and 180°.
X Scale Range	It indicates the variation range of the consistency scale of the target to be matched relative to the created template. If you want to search for a target with a consistent scale change, you need to set the corresponding settings.
Y Scale Range	It indicates the variation range of the consistency scale of the target to be matched relative to the created template. If you want to search for a target with a consistent scale change, you need to set the corresponding settings.
Threshold Type	It includes auto threshold, manual threshold, and model threshold.
Speed Enable	After enabling it, you need to enter speed threshold.

11. Set in the result displaying in the image display interface, and click run once or run continuously to run the flow.

4.11.2 Arc Edge Defect Detection

The tool of Arc edge defect detection can detect pits, bumps and fracture defects on the edges of arcs. It can accurately recognize defective arcs and output defect information. The specific operation method is shown below. It is recommended to enable **Standard Input** when the arc edge is blurry.
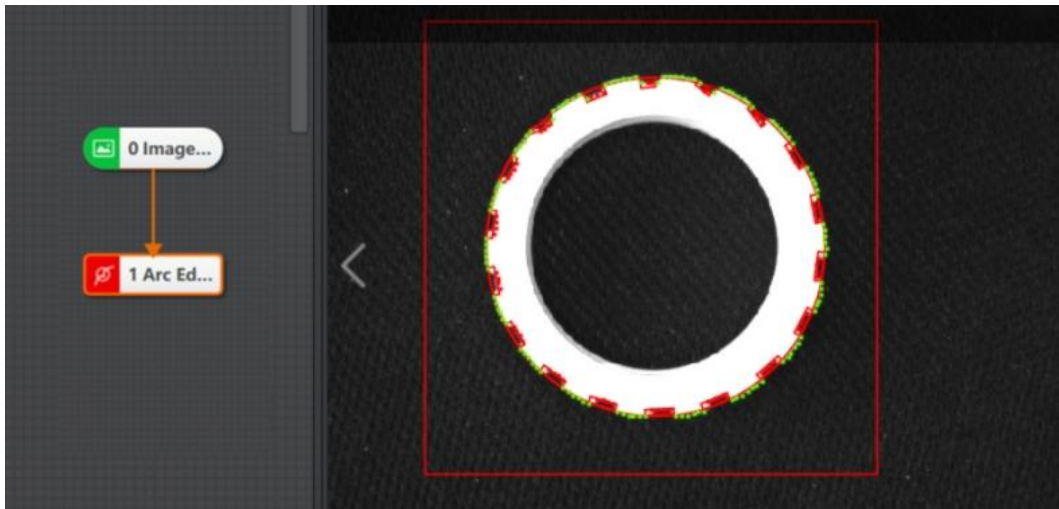
- **Input Mode**: You can select **By Circle** or **By Parameter**. When selecting **By Circle** as **Input Mode**, you need to link **Circle**, **Angle Start**, and **Angle Range**. When selecting **By Parameter** as **Input Mode**, you need to enter **Circle Center X**, **Circle Center Y**, **Radius**, **Angle Start** and **Angle Range**.

- **ROI Area**: You can select **Draw** or **Inherit**.

- **Edge Type**: It includes **Strongest Edge**, **First Edge** and **Last Edge**.

- **Edge Polarity**: It includes **Dark to Light**, **Light to Dark** and **Both**.

- **Filter Kernel Size**: It is used to enhance the edge and suppress noise, and its min. value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This parameter value needs to be set based on the actual situation.

- **Contrast Threshold**: It is also called gradient threshold, and its range is from 0 to 255. The edge point whose gradient threshold is larger than this value can be detected. The larger the value, the stronger noise resistibility, the smaller the number of edges obtained, and even the target edge points are filtered out.

- **Caliper Height**: It refers to the height of caliper.

- **Caliper Length**: It refers to the length of caliper.

- **Caliper Spacing**: It refers to the spacing of caliper.

- **Defect Polarity**: It includes **Trajectory Left Defect**, **Trajectory Right Defect**, and **Trajectory Both Defect**.

- **Rough Min Distance**: The distance between the edge point and the fitted straight line. If the distance is greater than the threshold, it is determined as the defect point to be filtered. If the **Defect Size Enable** or **Defect Area Enable** is enabled, you need to further filter according to the corresponding threshold.

- **Defect Size Enable**: If enabled, you need to enter **Rough Min Size**.

- **Defect Area Enable**: If enabled, you need to enter **Rough Min Area**.

4.11.3 **Linear Edge Defect Detection**

The tool of linear edge defect detection is used to detect defects and bumps on the linear edge. It outputs the position information of the defect bounding box and defect size. The specific operation method is shown below. It is recommended to enable **Standard Input** when the linear edge is blurry.
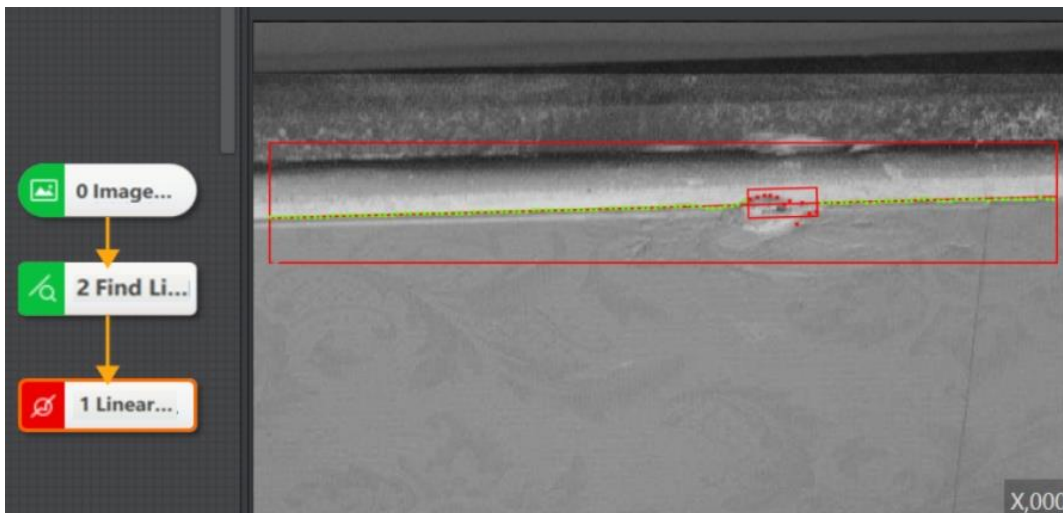
- **Input Mode**: You can select **Line**, **By Point**, or **By Coordinate**. When selecting **Line** as **Input Mode**, you need to link line. When selecting **By Point** as **Input Mode**, you need to enter **Start point**, **Endpoint**, and **Angle**. When selecting **By Coordinate** as **Input Mode**, you need to enter **Start point X Coordinate**, **Start point Y Coordinate**, **Endpoint X Coordinate**, and **Endpoint Y Coordinate**.

- **ROI Area**: You can select **Draw** or **Inherit**.

- **Edge Type**: It includes **Strongest Edge**, **First Edge** and **Last Edge**.

- **Edge Polarity**: It includes **Dark to Light**, **Light to Dark** and **Both**.

- **Filter Kernel Size**: It is used to enhance the edge and suppress noise, and its min. value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This parameter value needs to be set based on the actual situation.

- **Contrast Threshold**: It is also called gradient threshold, and its range is from 0 to 255. The edge point whose gradient threshold is larger than this value can be detected. The larger the value, the stronger noise resistibility, the smaller the number of edges obtained, and even the target edge points are filtered out.

- **Caliper Height**: It refers to the height of caliper.

- **Caliper Length**: It refers to the length of caliper.

- **Caliper Spacing**: It refers to the spacing of caliper.

- **Defect Polarity**: It includes **Trajectory Left Defect**, **Trajectory Right Defect**, and **Trajectory Both Defect**.

- **Rough Min Distance**: The distance between the edge point and the fitted straight line. If the distance is greater than the threshold, it is determined as the defect point to be filtered. If the **Defect Size Enable** or **Defect Area Enable** is enabled, you need to further filter according to the corresponding threshold.
- **Defect Size Enable**: If enabled, you need to enter **Rough Min Size**.
- **Defect Area Enable**: If enabled, you need to enter **Rough Min Area**.

4.11.4 Arc-Pair Defect Detection

The tool of arc-pair defect detection is used to detect the concave-convex and fracture part of the arc pair. By setting the width eligibility range, defect size, and defect area, this tool searches the defect area between two arcs and outputs related information. The specific operation method is shown below. See Arc Edge Defect Detection for other parameters.
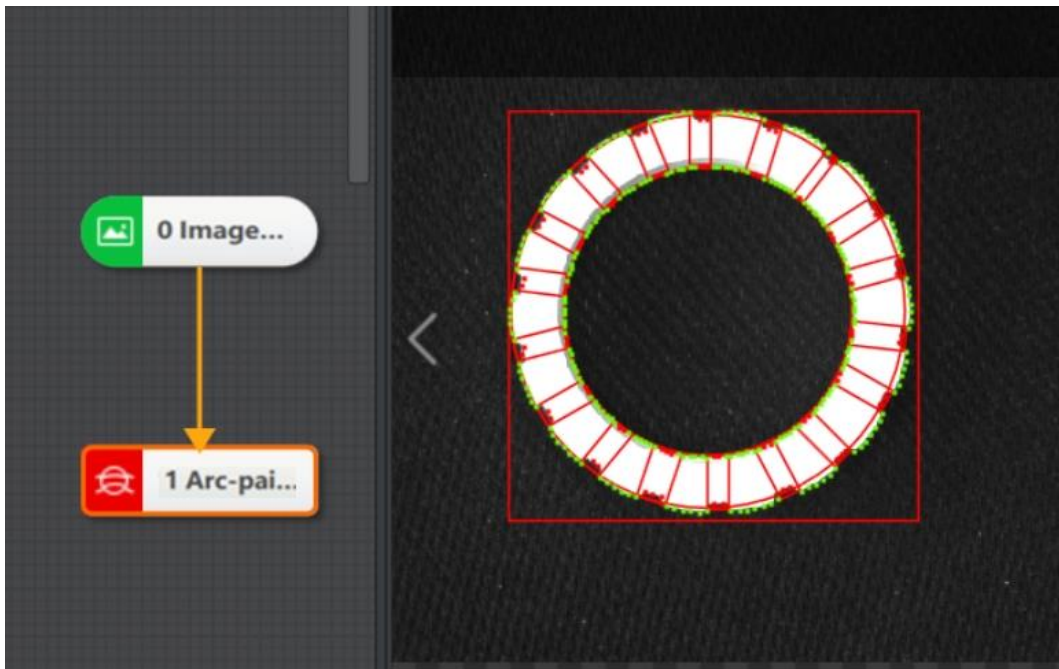
- **Edge Search Type**: It includes **Widest Edge Pair**, **Nearest Edge Pair**, and **Strongest & Nearest Edge Pair**.
- **Edge 0 Polarity:** It includes **Dark to Light**, **Light to Dark**, and **Both**.
- **Edge 1 Polarity:** It includes **Dark to Light**, **Light to Dark**, and **Both**.
- **Filter Kernel Size**: It is used to enhance the edge and suppress noise, and its min. value is 1. When the edge is blurred or there is noise interference, you can increase its value to make the detection result more stable. If the distance between the edge and the edge is smaller than the filter size, it will affect the accuracy of the edge location or even lose edge. This parameter value needs to be set based on the actual situation.
- **Contrast Threshold**: It is also called gradient threshold, and its range is from 0 to 255. The edge point whose gradient threshold is larger than this value can be detected. The larger the

value, the stronger noise resistibility, the smaller the number of edges obtained, and even the target edge points are filtered out.

- **Ideal Width**: It refers to the ideal distance between inner and outer arcs.

- **Caliper Height**: It refers to the height of caliper.

- **Caliper Length**: It refers to the length of caliper.

- **Caliper Spacing**: It refers to the spacing of caliper.

- **Width Eligibility Range**: This parameter is the main parameter for the detection of arc pair defects. Only the arc pair width within this parameter range is considered as a eligible.

- **Defect Size Enable**: If enabled, you need to enter **Rough Min Size**.

- **Defect Area Enable**: If enabled, you need to enter **Rough Min Area**.

- **Caliper Number**: It is used to scan the ROI area quantity in edge points.

- **Reject Number**: The minimum number of points whose error is too large to be excluded from fitting. In general, the more outliers, the larger the value should be set. In order to obtain a better search effect, it is recommended to use it in conjunction with the elimination distance

- **Threshold to Remove**: The maximum pixel distance between the outlier and the fitting circle is allowed. The smaller the value, the more points will be excluded.

- **Angle Tolerance**: The maximum angle is allowed.

- **Track Tolerance**: The maximum pixel offset is allowed by edge tracking.

4.11.5 Line-Pair Defect Detection

The tool of line-pair defect detection is used to detect defects between a pair of straight lines that are deformed or broken, and output the corresponding defect information. It can be used to detect the deformation and defects of the edges of rectangular work pieces, determine the regularity of the work piece edges, and search small burrs and dirt. The specific operation method is shown below. See Arc Edge Defect Detection for other parameters.
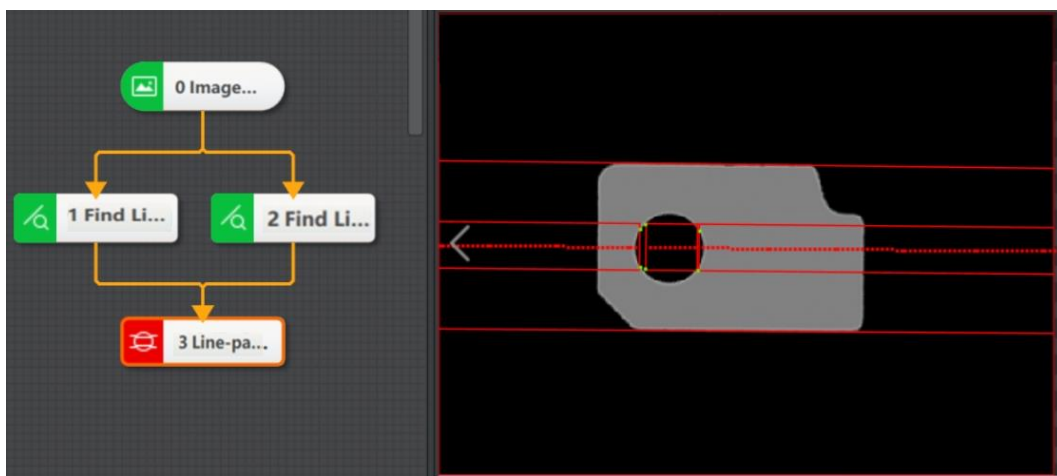
Line-Pair Defect Detection	
Edge Search Type	It includes Widest Edge Pair, Nearest Edge Pair, and Strongest & Nearest Edge Pair.

Edge 0/1 Polarity	Edge 0 and Edge 1 in order from top to bottom of ROI
Ideal Width	It refers to the ideal distance between inner and outer arcs.
Width Eligibility Range	This parameter is the main parameter for the detection of arc pair defects.

4.11.6 Edge Group Defect Detection

Edge group defect detection can combine up to 32 edge defect detecting tools, including linear edge detection and arc edge detection. You can configure basic parameters and running parameters of each tool in the parameter settings. For details, see Arc Edge Defect Detection and Linear Edge Defect Detection. The operation method is as follows.
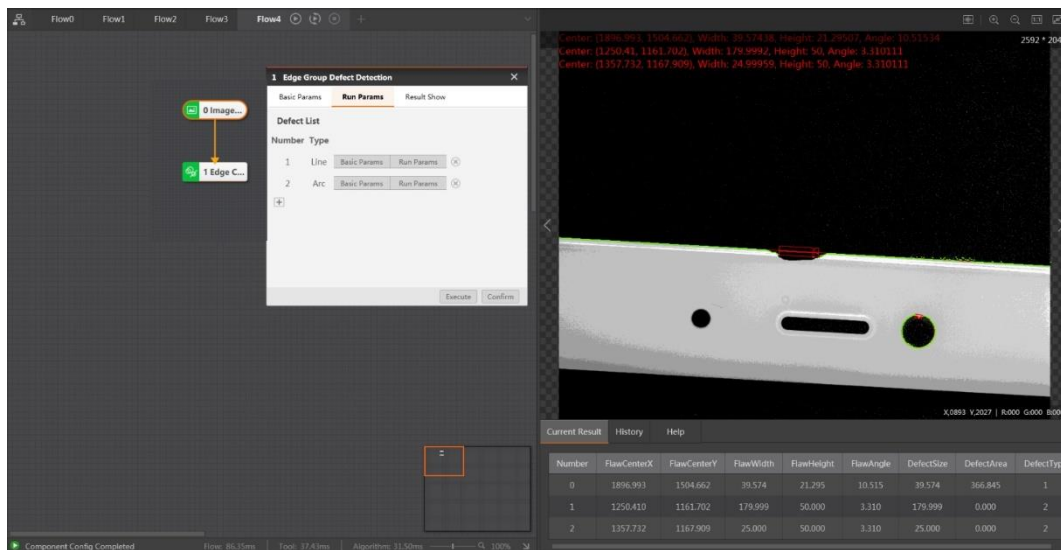
4.11.7 Edge Pair Group Defect Detection

Edge pair group defect detection can combine multiple edge-pair defect detecting tools, including line-pair edge detection and arc-pair edge detection. You can configure basic parameters and running parameters of each tool in the parameter settings. For details, see Arc Edge Defect Detection and Linear Edge Defect Detection. The operation method is as follows.
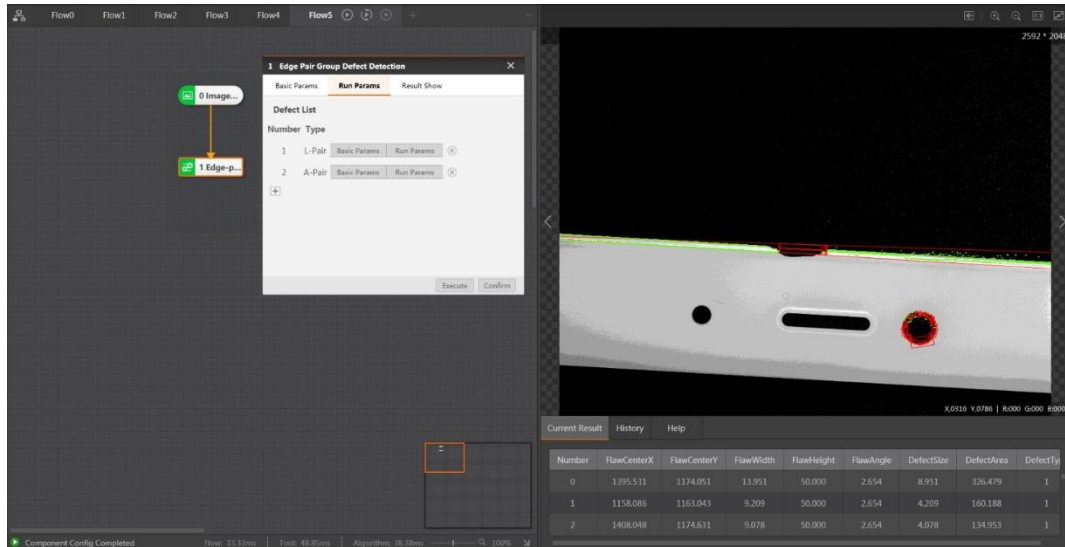
4.11.8 **Edge Model Defect Detection**

Edge model defect detection is used to compare with the standard model to output relative defect information, such as location deviation, fracture defect and hierarchical defect. You need to select a relatively completed model to execute model building before detecting. Load or train to generate models in **Edge Model**. The interface is shown below when you select train model.
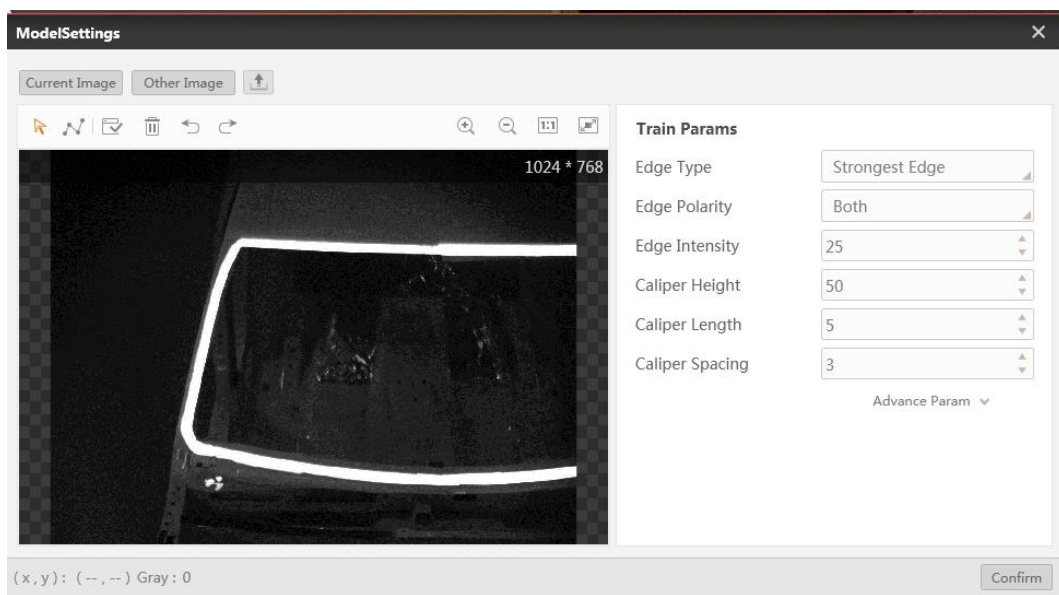
1. Click ⟋ to customize an edge model. Try to fit the edge template when you customize it. You can double click to stop customizing, as shown in the figure above.

2. Set proper train parameters. For unmentioned parameters, see Arc Edge Defect Detection.

Template Configuration Parameter

- **Edge Type**: It includes Strongest Edge, First Edge and Last Edge
- **Edge Polarity**: It includes Dark to Light and Light to Dark

- **Edge Intensity**: It is used for edge grayscale limiting. The larger the value is, the more filterable edge points are.

- **Edge Precision**: Generate a track automatically which fits the model trend, according to the model edge information.

- **Filter Kernel Size**: For strengthening edge and repressing noise, the minimal value is 1. Set this value according to the actual needs. If the edge is burry or it is intervened by noises, increase the value to make the detecting results more stable. However, it might impact the edge position precision or even cause edge loss, if the interval between edges is less than the filter kernel size.

3. Click **Confirm** to generate the edge model.

Configure corresponding running parameters. Relevant defect information will be output after running.

Edge Model Defect Detection Parameters

- **Location Deviation**: The comparison distance between the edge point of the detected image and the model building image. If this distance larger than the threshold, the point can be defined as a position defect point that to be selected.

- **Fracture Defect Enable**: enable it to detect the fracture defect

- **Hierarchical Defect**: For sawtooth-like defect detecting. This defect type's size and area are small as well as its deviation range.

  - **Hierarchical Deviation Height**: In the detected image, if the height difference between two adjacent edge points is larger than the threshold, the edge point can be defined as a hierarchical defect point that to be selected.

  - **Min. Hierarchical Length**: If the number of the adjacent hierarchical defects that to be selected exceeds this length, the defect can be defined as a hierarchical defect.

- **Grayscale Assisted Detect**: enable it to automatically define Filter Kernel Size.

- **Filter Kernel Size:** For strengthening edge and repressing noise, the minimal value is 1. Set this value according to the actual needs. If the edge is burry or it is intervened by noises, increase the value to make the detecting results more stable. However, it might impact the edge position precision or even cause edge loss, if the interval between edges is less than the filter kernel size.

4.11.9 Edge Pair Model Defect Detection

Edge pair model defect detection is used to compare with the standard model to output relative defect information, such as width, location deviation, fracture defect and hierarchical defect. You need to select a relative completed model to execute model building before detecting. Load or train to generate models in Edge Model. For model building details, see Edge Model Defect Detection.
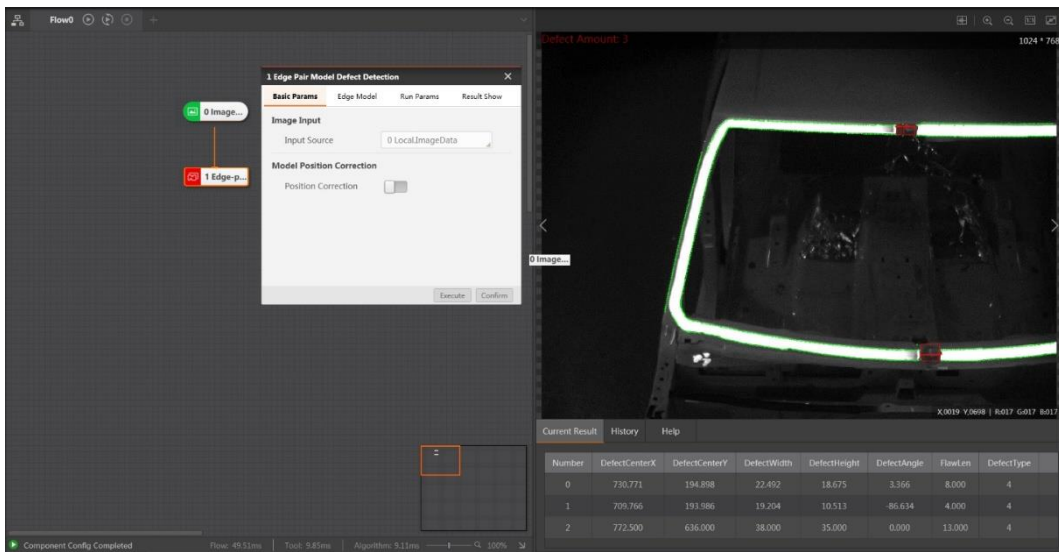
In model settings, you can click **Starting Range**, and click **Generate Trace** to create a trace.
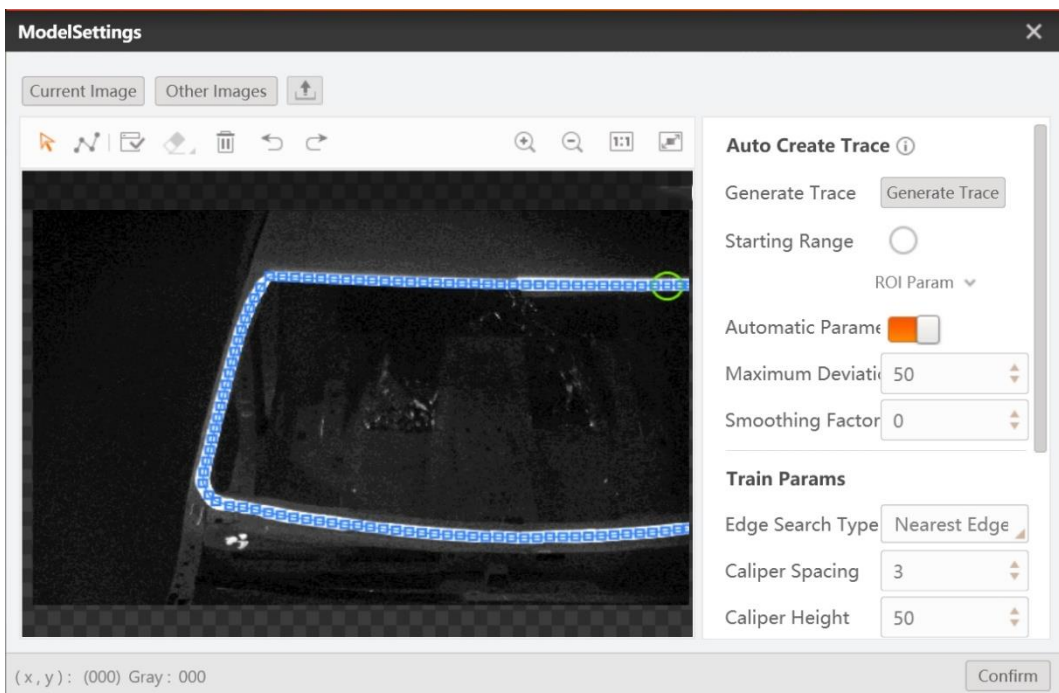
Bubble Defect Detection

- **Grayscale Acceptance**: Compare the average grayscale of the current caliper and the model-building caliper

- **Grayscale Change**: A defect can be defined as a change defect, if adjacent pixels grayscale difference value is larger than the grayscale change.

- **Bubble Defect Length**: Refers to the caliper number of the adjacent defects that defined as bubble defects.

- **Max. Num of Mutations**: There is a bubble defect in the current caliper, if the number of grayscale changes larger than the max. num of mutations.

⚠ NOTICE

This module is used with the position correction module. You should create the position correction reference point on an image. Run the process once first. Double-click the position correction module and manually click to create the reference point.

4.11.10 Defect Contrast

The defect contrast tool can train a defect contrast model to detect whether the target image is OK or NG.

Steps:

1. Double-click the defect contrast tool from the tool bar. Go to **Defect Model**, and click **New Model**.
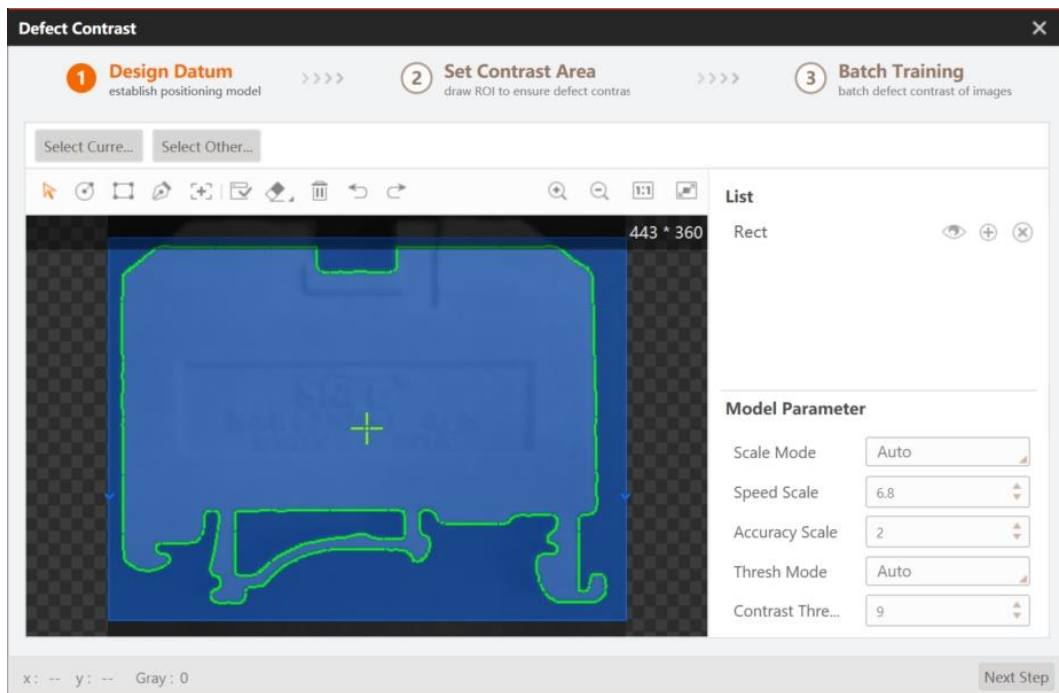
2. Set the contrast area, which can be the whole image or the ROI area according to the actual demands. The ROI area should contain the target area to be detected.

3. In the batch training window, click ⊕ to load images according to actual demands. Click **OK** or **NG** in **Register Model** according to actual conditions, and click **Train** to start training.

📖NOTE

- Up to 40 images can be added (20 OK images and 20 NG images) , including at least one OK image.
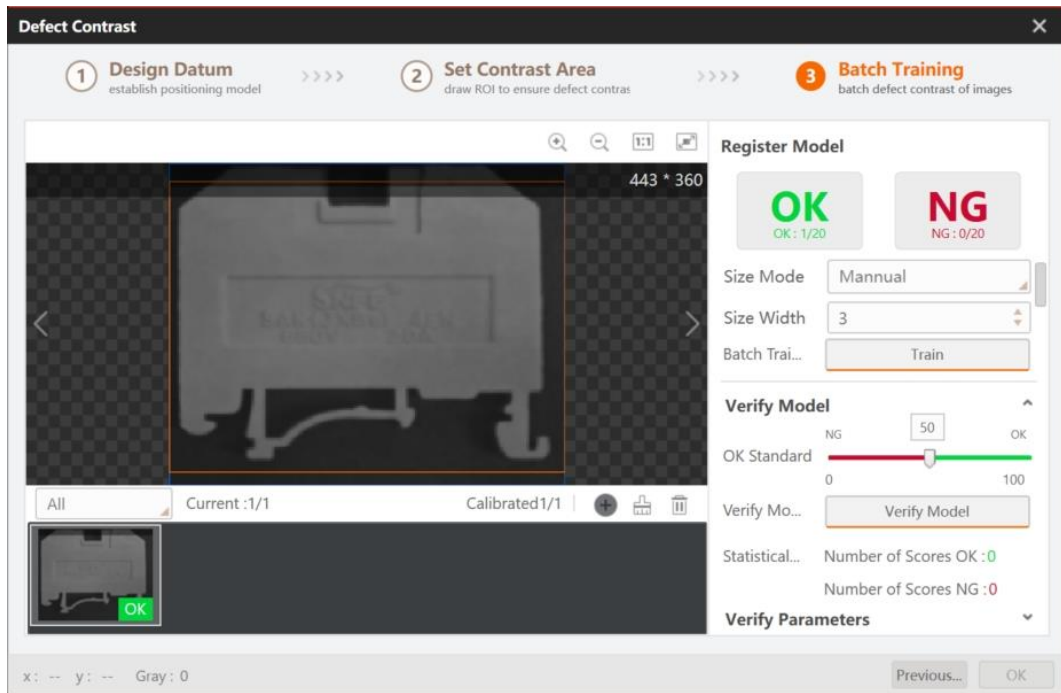
4. Import verified images, and click **Verify Model**.
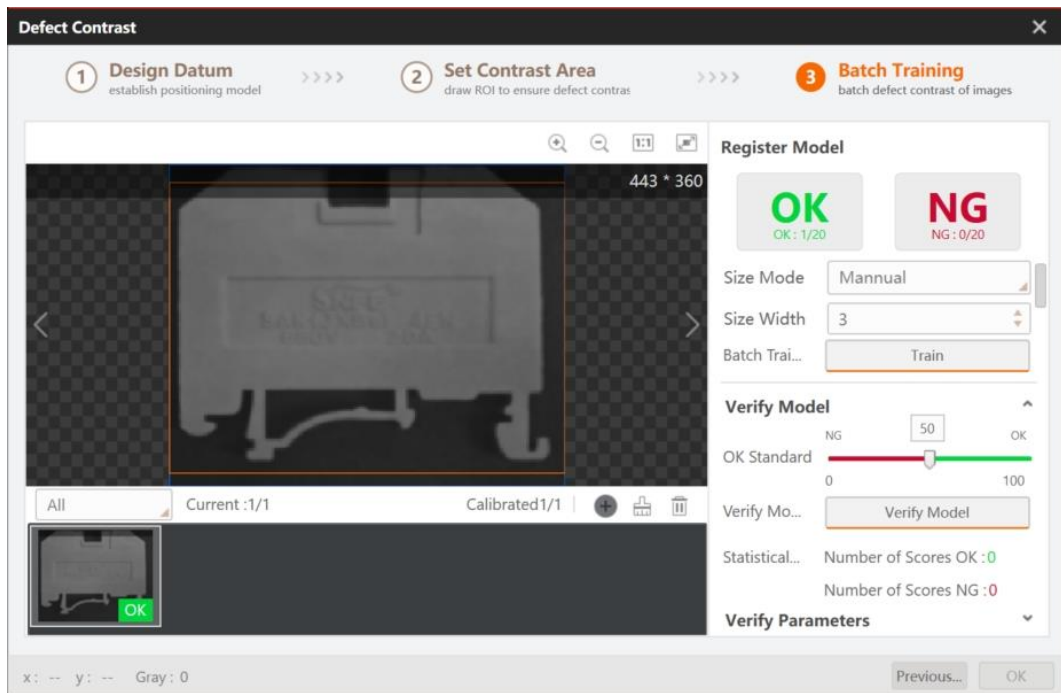
5. Run the operation models, as shown below.
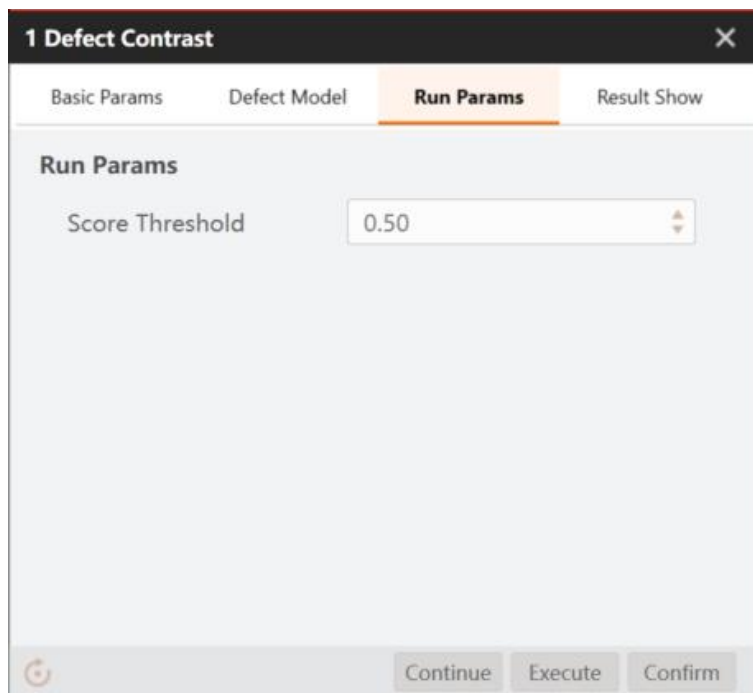
If the score of the target image is lower than the configured score threshold, the image will be labeled as NG.

6. Run the operation models. The NG image is shown below.

7. The OK image is shown below.

4.12 Logic Tools

4.12.1 Condition Detection

The condition detection determines whether the input data satisfies the condition. If it is satisfied, the operation interface displays OK character. Otherwise, it displays NG character, as shown below.
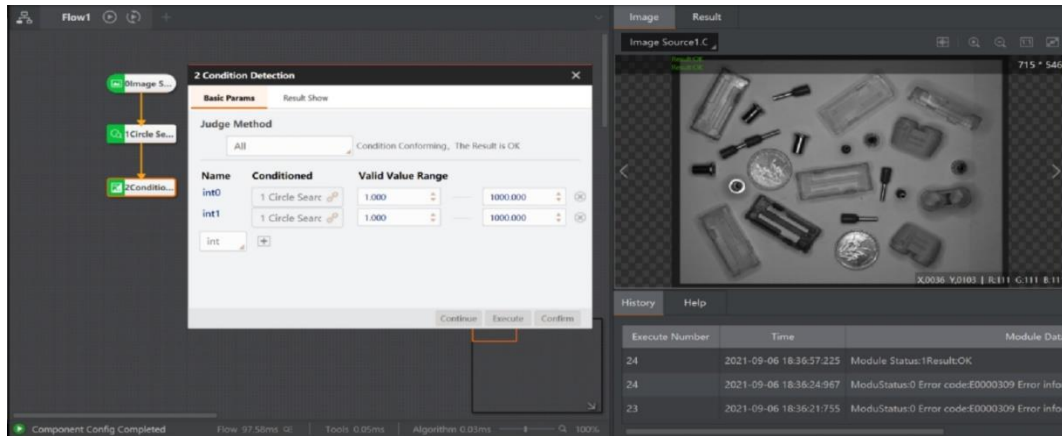
Condition detection	
Judge Method	It includes all and any. If the condition meets demands, the judge result is OK.
Condition Type	It includes int and float.
Condition	You need to link with previous module status, or other result outputs.
Valid Value Range	If the result selected meets the range from the min. value to the max. value, the result is OK, otherwise is NG.

📖NOTE

- The corresponding result of each added condition can be viewed in the history interface.

- The number of digits after the decimal point in the valid value range can be configured in the specified XML file. A maximum of 3 digits are supported.

- Take the default software installation path in a 64-bit system as an example. The file is under the installation path...\Module(sp)\x64\Logic\IfModule. The XML file is called ifModuleAlgorithmtab.xml, so change the value of DecimalDigits.

4.12.2 Branch

The branch tools can set the input conditions for different branch modules according to the actual requirements. When the input condition is this value, the corresponding branch module is executed.

The input value only supports integers and it does not support strings. If you need to enter string format, you need to use character branch, or use character recognition and branch modules. When you need to determine the subsequent branch work according to the template matching status, you can set the input condition as the template matching status, and set the condition value of the branch module, as shown below.

Branch Parameters		
Condition Input	It can bind the previous module or int data from external communications.	
Branch Parameters	Index by value	Index by value is to compare the condition input value with the set value after the module ID index. If these two values are the same, the branch will be executed. Otherwise, the branch will not be executed.
	Index by bit	Index by bit is to convert the condition input value into binary system, and the binary sequence corresponds to the bit sequence of the module ID. When the bit is 1, the branch is executed (multiple is available at a time). Otherwise, the branch is not executed.

4.12.3 Branch String

The branch string comparison module detects the input characters. If the detection passes, data transmission will be executed, as shown below.
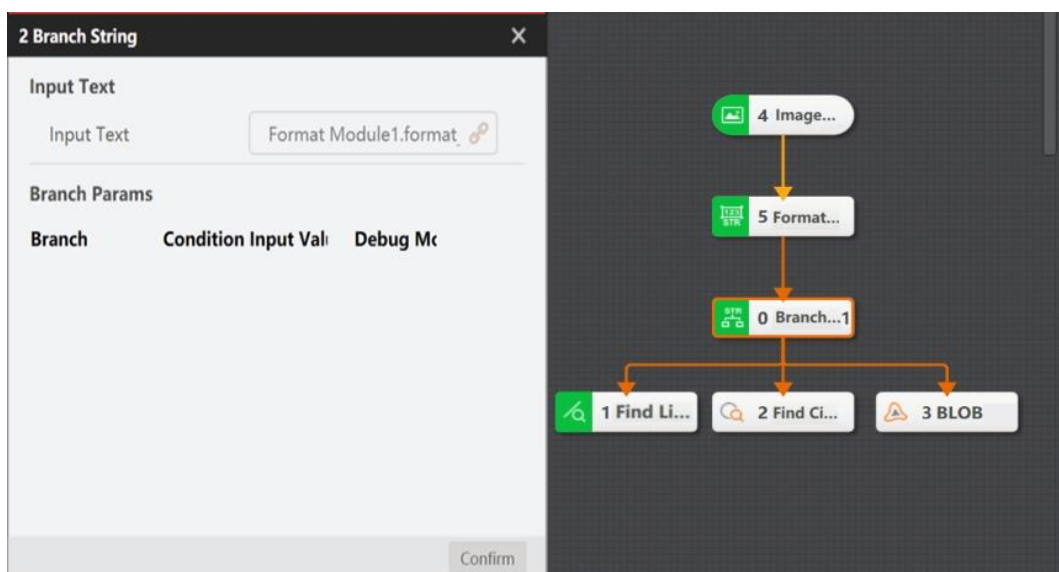
Branch String Parameters	
Input Text	Receive data from the external communication or from formatting.
Branch Parameters	Set the condition input value, and select branch module in accordance with the comparison of input text and condition input value.
Debug Mode	The branch will be always executed once being enabled.

4.12.4 Save Text

The tool of saving text is used to process complex data. It saves and loads the contents of the script that has been written. The upper limit length of script code is 4095 bytes. After the operation is started, the file is generated as a cache file, and text is generated only after the cache file reaches the set file size.

Save Text Parameters		
Data Source	TXT	Creates TXT format files.
	CSV	Creates CSV format files. It is recommended to use notepad to open the CSV files, and then save a new file and open it with excel. When choosing to create a CSV file, you need to perform data linking for each column of generated data.
Input Text	It selects input text.	
Save Trigger	It sets the limit condition when saving, and saves the file when the trigger variable reaches the saving condition	

Save Path	It customizes a saving path.
File Save Number	The max. file quantity can be stored.
Document Size	The Max. size of each file.
Save Mode	You can set the saving mode when the upper saving limit has been reached. Two save modes are available: stop saving and overwrite.
Timestamp Setting	The timestamp information may display front of the file name.
Generate Directory by Date	If it is enabled, you can create folder in accordance with date, and save images in it.
File Naming	It sets file name, and you can link with module data.
Real Time Save	After enabling it, data will be directly written into txt and csv files. If it is not enabled, data will be written into cache file first, and then into txt and csv files if file capacity is full.
Save Temporary File	Click it to cave cache files in txt or csv format.

4.12.5 **Logic**

The logic module includes calculation type and calculation data, as shown below.
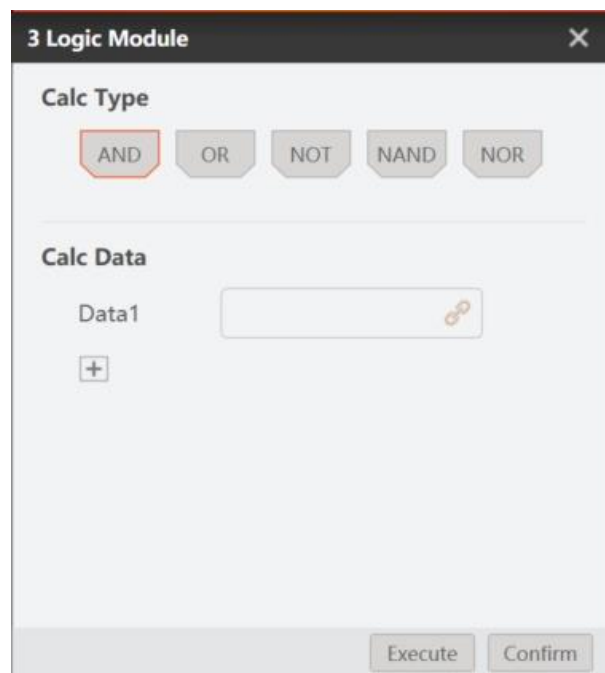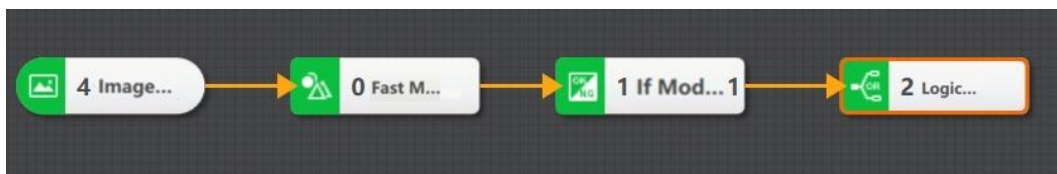
Logic Calculation	
Calculation Type	You can select and, or, not, nand and nor.
Calculation Data	you can select data source to execute logic calculation.

4.12.6 **Format**

The format tool can integrate and format the data into a string for output. It can link the result output of previous modules, and you can also directly enter characters in the box. This tool is usually used to organize the data before the data output via communications.
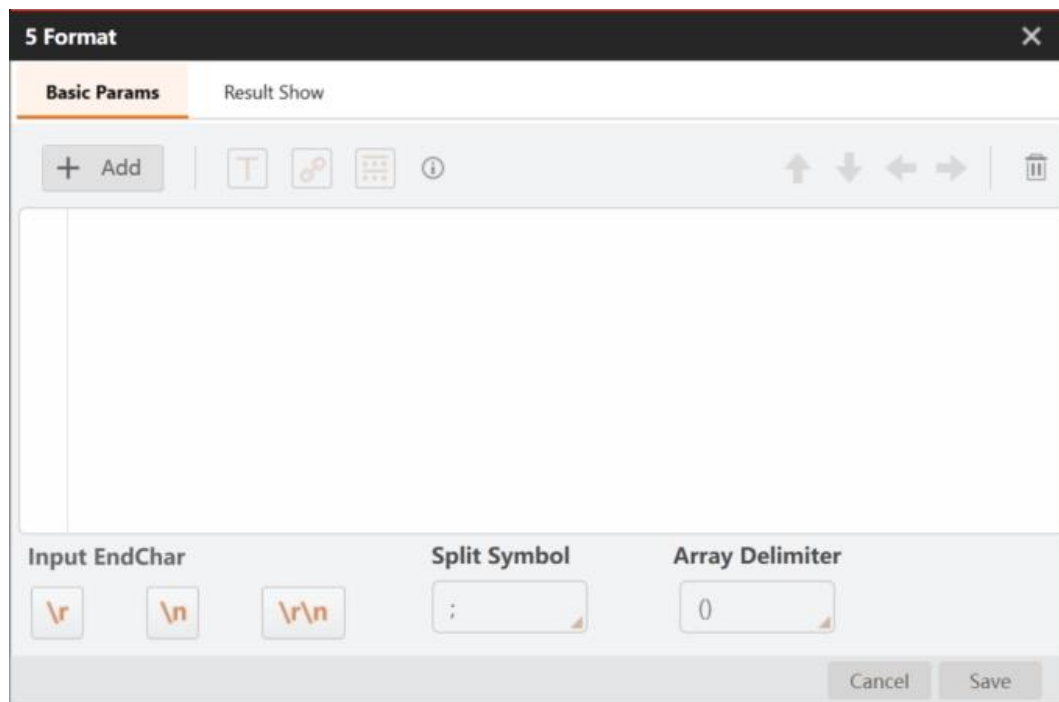
You can right click the added line and click **Delete** or **Clear Content** to delete or clear the content, as shown above.

Format Module	
+ Add	Click it to add the index of subscribed information.
🔗	Click it to link the output information of previous modules.
T	Click it to add customized texts.
▦	Click it to insert the array. • Split symbol is the delimiter between different elements, which can be revised. • Array subscript supports entering and subscribing.

	• Array list supports adding different array elements.
⬆ ⬇ ⬅ ➡	Click them to change the position of added information.
🗑	Click it to delete the currently configured contents.
Input End Character	\r: return; \n: new line; \r\n: return and new line.
Split Symbol	Split symbol is the delimiter between different elements.
Array Delimiter	It is used to separate multiple arrays.
Save	Click it to save format module.
Cancel	Click it to cancel format module.

4.12.7   String Comparison

The string comparison tool can compare the input character with the configured one. If they are the same, the software will output the corresponding index value. If they are different, the software will not output. The index value can be manually modified, and the quantity of index is up to 32. Generally, this tool is used in combination with branch tool, as shown below.
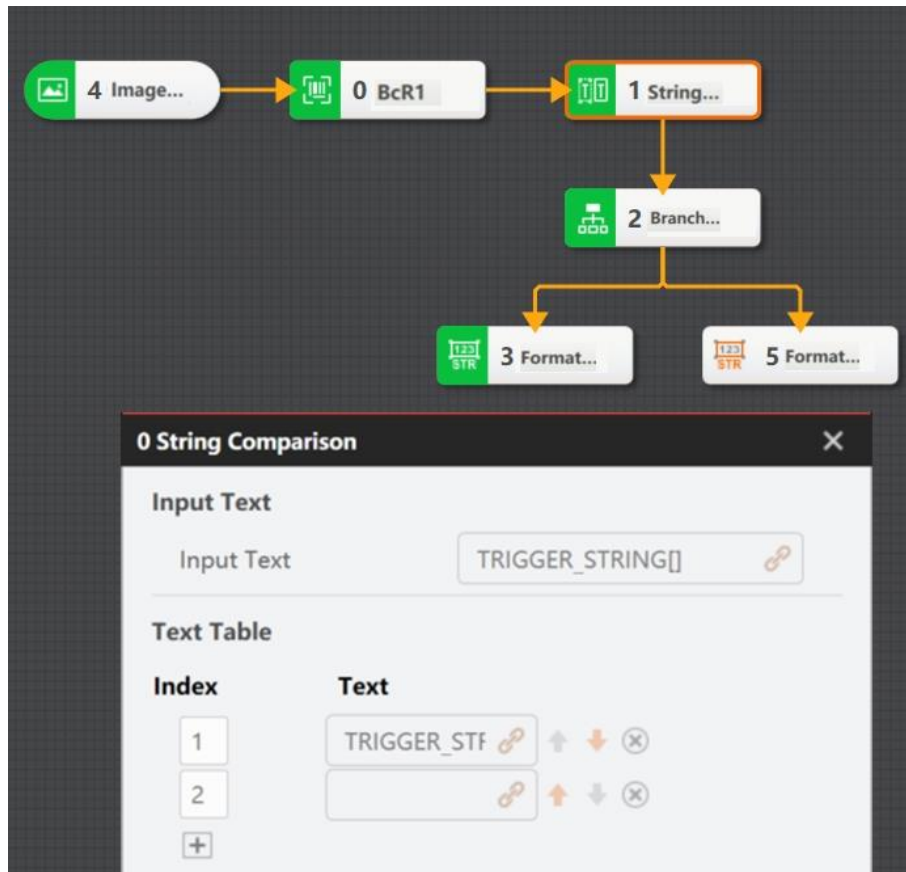
4.12.8 **Script**

The script tool is used to process complex data. It saves and loads the contents of the script that has been written, and the script file format is suffixed with cs. There is no limitation for the length of script code, and script code supports import and export. After the import is completed, the script tool will execute a compilation. If the compilation fails, the system will show exception. If the compilation is successful, the system will operate according to the new code. The parameter settings are shown below.
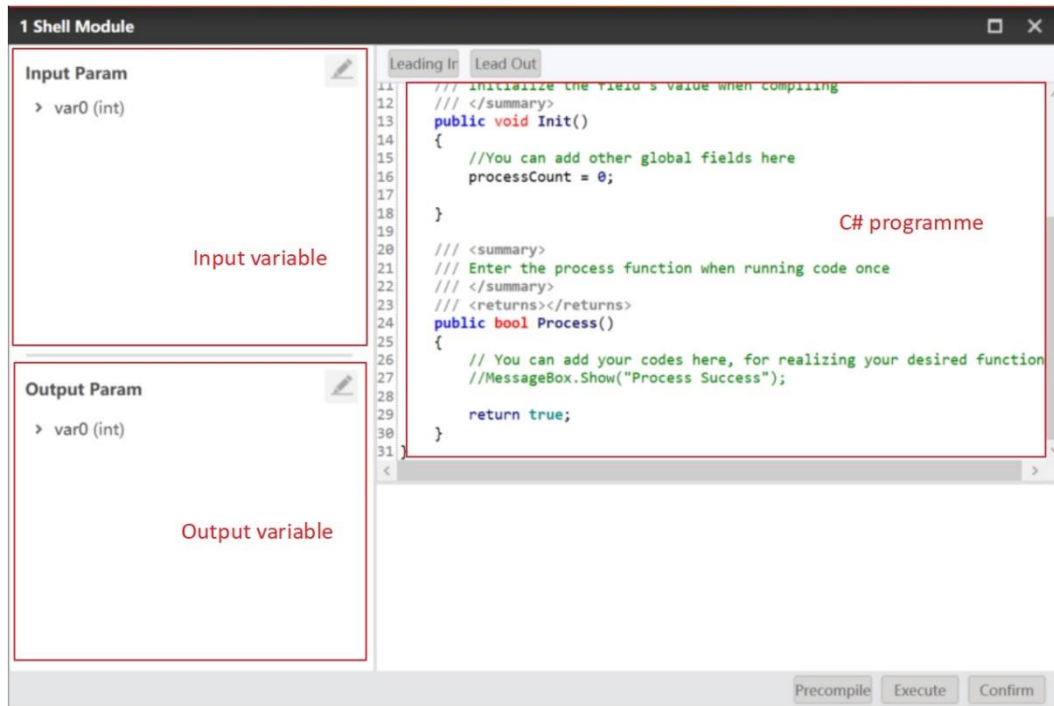
The function interfaces include data acquisition interface, data output interface, and debugging related interface.

Interface for setting/obtaining global variable

GlobalVariableModule.SetValue

Function Description	Set Global Variable		
Function Method	GlobalVariableModule.SetValue(string paramName,string paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	string	Variable Value
Return Value	Success: 0 Exception: error code rather than 0.		

GlobalVariableModule.GetValue

Function Description	Obtain Global Variable		
Function Method	object GlobalVariableModule.GetValue (string paramName)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Return Value	Success: specific result Exception: null		

Obtain result data of module

CurrentProcess.GetModule

Function Description	Obtain module result data

Function Method	CurrentProcess.GetModule(string paramModuleName).GetValue(string paramValueName)		
	Parameter Name	Data Type	Parameter Description
Input	paramModuleName	string	Variable Name
Input	paramValueName	string	Variable Value
Return Value	Success: specific result Exception: null		

Set running parameters of module

GetModule.SetValue

Function Description	Set module running parameters		
Function Method	CurrentProcess.GetModule(string paramModuleName).SetValue(string paramValueName，string paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramModuleName	string	Module Name
Input	paramValueName	string	Parameter Name
Input	paramValue	string	Parameter Value
Return Value	Success: 0 Exception: error code rather than 0.		

Interface for sending data

PLC, Modbus interface: SendData(string data,DataType dataType)

Function Description	PLC or Modbus sends int, float or string data		
Function Method	GlobalCommunicateModule.GetDevice(int deviceID).GetAddress(int addressID).SendData(string data,DataType dataType)		
	Parameter Name	Data Type	Parameter Description
Input	deviceID	Int	Device ID in communication management
Input	addressID	Int	Device address ID
Input	data	String	Data to be sent. If you send multiple data, use ";" to s
Input	dataType	DataType	Data type to be sent, including int, float and string
Return Value	Success: 0 Exception: error code rather than 0		

PLC, Modbus interface: SendData(byte[] bytedata,DataType.ByteType)

Function Description	PLC or Modbus sendshexadecimal data		
Function Method	GlobalCommunicateModule.GetDevice(int deviceID).GetAddress(int addressID).SendData(byte[] bytedata,DataType.ByteType)		
	Parameter Name	Data Type	Parameter Description
Input	deviceID	Int	Device ID in communication management
Input	addressID	Int	Device address ID

Input	bytedata	Byte	Hexadecimal data to be sent
Return Value	Success: 0 Exception: error code rather than 0.		

TCP, UDP, serial port interface: SendData(string data)

Function Description	Send String data		
Function Method	GlobalCommunicateModule.GetDevice(int deviceID).SendData(string data)		
	Parameter Name	Data Type	Parameter Description
Input	deviceID	Int	Device ID in communication management
Input	data	String	Data to be sent
Return Value	Success: 0 Exception: error code rather than 0		

TCP, UDP, serial port interface: SendData(byte[] bytedata)

Function Description	Send hexadecimal data		
Function Method	GlobalCommunicateModule.GetDevice(int deviceID).SendData(byte[] bytedata)		
	Parameter Name	Data Type	Parameter Description
Input	deviceID	Int	Device ID in communication management
Input	bytedata	Byte	Data to be sent
Return Value	Success: 0 Exception: error code rather than 0		

Data acquisition interface:

GetIntValue

Function Description	Obtain INT variable value		
Function Method	int GetIntValue(string paramName, ref int paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	int	Variable Value
Return Value	Success: 0 Exception: error code rather than 0		

GetFloatValue

Function Description	Obtain Flat variable value		
Function Method	int GetFloatValue (string paramName, ref float paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	Float	Variable Value
Return Value	Success: 0 Exception: error code rather than 0.		

GetStringValue

Function Description	Obtain String variable value		
Function Method	int GetStringValue (string paramName, ref string paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	string	Variable Value
Return Value	Success: 0 Exception: error code rather than 0.		

GetBytesValue

Function Description	Obtain Bytes variable value		
Function Method	int GetBytesValue (string paramName,ref byte[] paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	byte[]	Variable Value
Return Value	Success: 0 Exception: error code rather than 0.		

GetIMAGEValue

Function Description	Obtain image data		
Function Method	int GetIMAGEValue (string paramName, ref Image paramValue)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	Image	Variable Value
Return Value	Success: 0 Exception: error code rather than 0.		

GetIntArrayValue

Function Description	Obtain INT array variable		
Function Method	int GetIntArrayValue(string paramName, ref int[] paramValue, out int arrayCount)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	int[]	Variable Value
	arrayCount	int	Array Quantity
Return Value	Success: 0 Exception: error code rather than 0.		

GetFloatArrayValue

Function Description	Obtain float array variable

Function Method	int GetFloatArrayValue(string paramName, ref float[] paramValue , out int arrayCount)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	float[]	Variable Value
	arrayCount	int	Array Quantity
Return Value	Success: 0 Exception: error code rather than 0.		

GetStringArrayValue

Function Description	Obtain string array variable		
Function Method	int GetStringArrayValue(string paramName, ref string[] paramValue , out int arrrayCount)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
Output	paramValue	string[]	Variable Value
	arrayCount	int	Array Quantity
Return Value	Success: 0 Exception: error code rather than 0.		

Data output interface:

SetIntValue

Function Description	Set INT variable value		
Function Method	int SetIntValue(string key, int value)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	paramValue	int	Variable Value
Output			
Return Value	Success: 0 Exception: error code rather than 0.		

SetFloatValue

Function Description	Set float variable value		
Function Method	int SetFloatValue (string key, float value)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	paramValue	float	Variable Value
Output			
Return Value	Success: 0 Exception: error code rather than 0.		

SetStringValue

Function Description	Set string variable value		
Function Method	int SetFloatValue (string key, float value)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	paramValue	string	Variable Value
Output			
Return Value	Success: 0 Exception: error code rather than 0.		

SetBytesValue

Function Description	Set hexadecimal data		
Function Method	int SetBytesValue (string key, byte[] value)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	paramValue	byte[]	Variable Value
Output			
Return Value	Success: 0 Exception: error code rather than 0.		

SetImageValue

Function Description	Set image data		
Function Method	int SetImageValue (string key, Image value)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	paramValue	Image	Variable Value
Output			
Return Value	Success: 0 Exception: error code rather than 0		

SetStringValueByIndex

Function Description	Set string array		
Function Method	int SetStringValueByIndex(string key, string value, int index, int total)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	value	string	Variable Value
	index	int	Array index
	total	int	Array element quantity
Output			

Return Value	Success: 0
	Exception: error code rather than 0.

SetIntValueByIndex

Function Description	Set Int array		
Function Method	int SetStringValueByIndex(string key, string value, int index, int total)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	value	int	Variable Value
	index	int	Array index
	total	int	Array element quantity
Output			
Return Value	Success: 0		
	Exception: error code rather than 0.		

SetFloatValueByIndex

Function Description	Set Float array		
Function Method	int SetFloatValueByIndex (string key, int value, int index, int total)		
	Parameter Name	Data Type	Parameter Description
Input	paramName	string	Variable Name
	value	float	Variable Value
	index	int	Array index
	total	int	Array element quantity
Output			
Return Value	Success: 0		
	Exception: error code rather than 0.		

Debugging related Interface:

ConsoleWrite

Function Description	Print information into Debug View		
Function Method	void ConsoleWrite(string content)		
	Parameter Name	Data Type	Parameter Description
Input	Content	string	Print content
Output			
Return Value	None		

ShowMessageBox

Function Description	Print information into Debug View		
Function Method	void ShowMessageBox(string msg)		
	Parameter Name	Data Type	Parameter Description

Input	msg	string	Print content
Output			
Return Value	None		

The Init() function is the initialization function and the Process() is processing function. The initialization function runs only during the first time, as shown below.
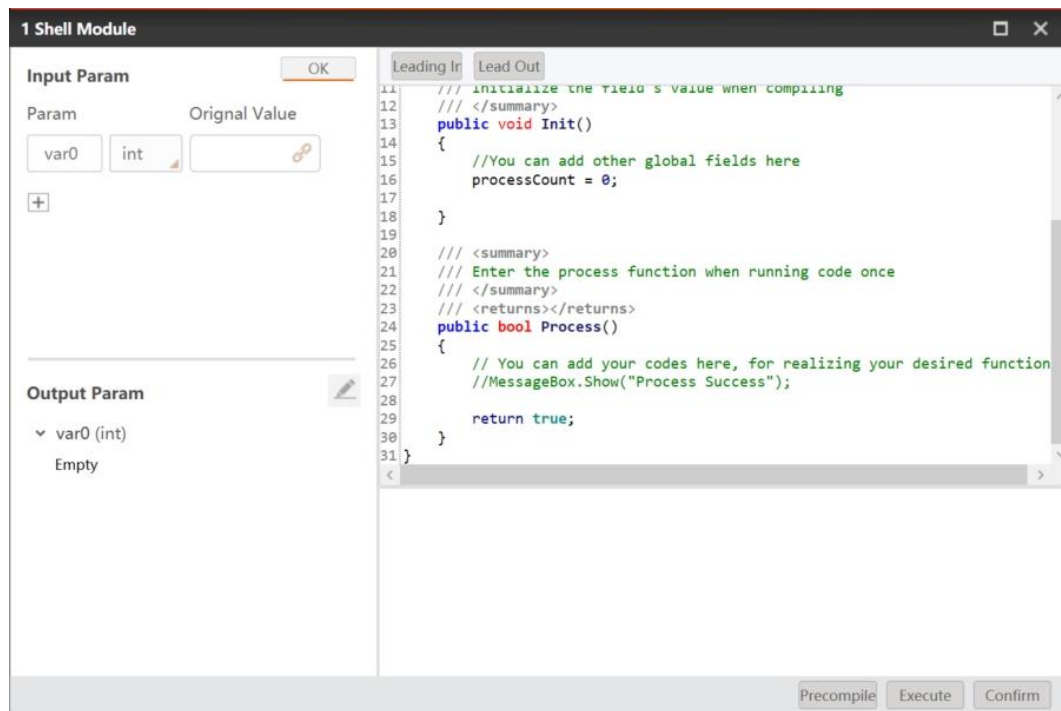
4.12.9 **Group**

In complex solution, too many modules may cause visual clutter. At this point, you can use Group tool to integrate different modules.

Double click **Group** and enter the Group sub-interface.

Click on the group tool to set related parameters.
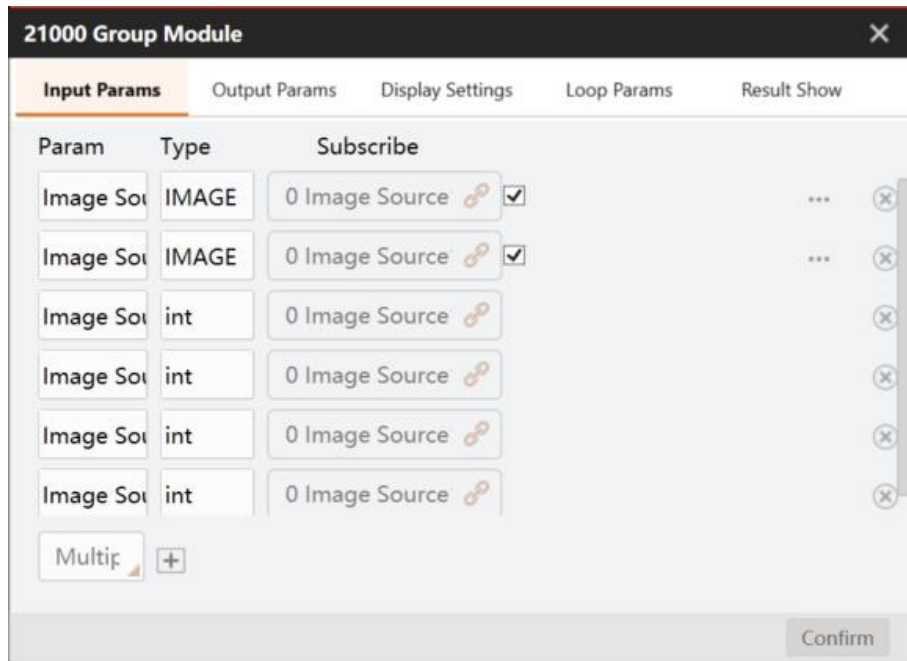
Input parameters and output parameters are used to bind and set input and output data, and they support multiple selections. Data outside the group needs to be set as input data before being passed to the Group, otherwise the relevant data cannot be bound within the Group. After the internal processing of the Group is completed, if the corresponding data is to be transmitted to the outside, the data also needs to be set as output data.

The result of the Group shows that the module status 1 will be output only when the output configuration is completed. If the output is not configured completely, even if the running status of the modules in the Group is 1, the Group will display the module status as 0. At the same time, the history module only displays the data type that is configured as output, and the unconfigured data type will not be output. The specific parameter settings are shown below.

Group Parameters	
Parameter	You can customize variable name.
Type	Input and output data include int (integer type), float (floating point type), string (string), IMAGE (image), ROIBOX (target area), POINT (point), LINE (straight line), CIRCLE (circle), FIXTURE (correction information), and ANNULUS (circular ring), ROIANNULUS (ROI arc)
Initial value	You should link with other modules.

The interface of **Display Settings** is shown below.
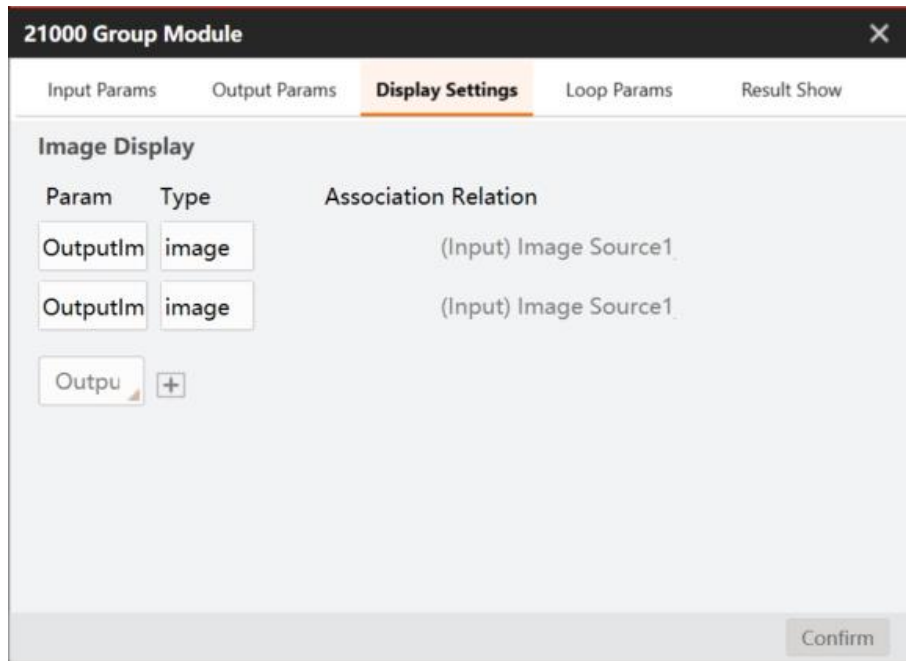
You can set loop execution of modules in Group. Before executing loop function, you should set up internal functions of the Group, and complete the input and output settings. The main parameters are shown below:
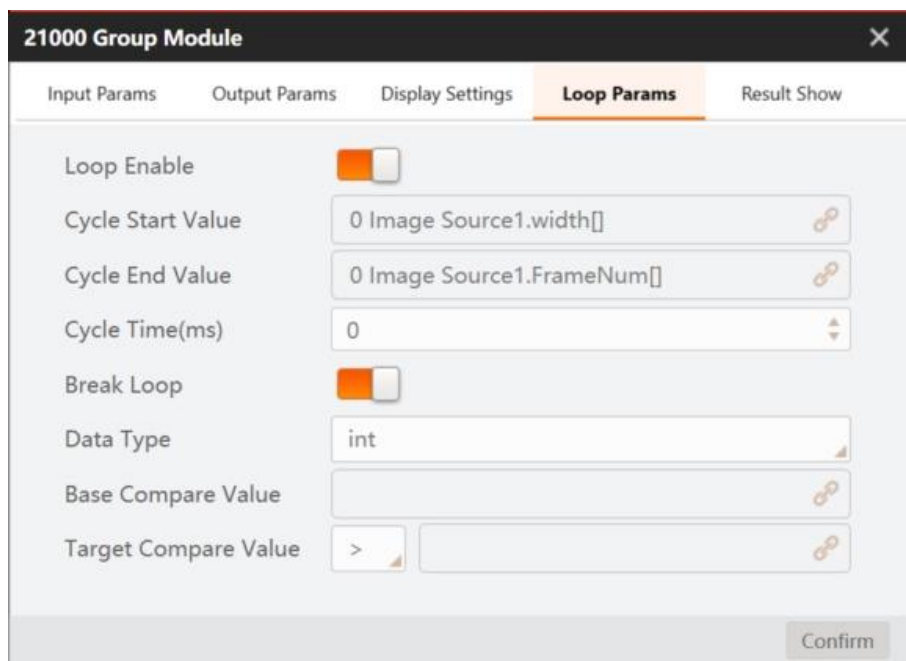
Loop Parameters	
Loop Enable	After enabling, you can set loop related parameters.
Cycle Start Value	It refers to the start value of the loop. It is recommended to set as 0.
Cycle End Value	It refers to the end value of the loop.
Cycle Time	It refers to the interval of a single loop.

Break Loop	After enabling, you can set conditions to stop loop.
Data Type	It sets the data type of the base comparison value.
Base Compare Value	You can set customized value or link the base comparison value according to actual demands.
Target Compare Value	It compares the base comparison value and target comparison value. If specific condition is meet, the interrupt will be executed.

You can set the content, font color, font size, position, etc. of the displayed result in **Result Show**. It also supports multi-layer group display and module copy, paste, import, and export. When the Group module performs these operations, the module can automatically update the subscribed ID according to the relative relation of the subscribed modules, and the operation results of the internal modules of the Group can be displayed outside the Group.

4.12.10 Point Set

The tool of point set is used to combine the related data of other modules into points sets with max. 16 point sets to facilitate subsequent operation. This tool supports point or coordinate input, and it can be dragged into loop control module to assemble points after **Loop Enable** is opened.

- **Point Input:** You can input the data of other modules by selecting By Point or By Coordinate.
- **Loop Enable:** It makes points sets in loop. Point sets obtained from each loop are added to output point sets.
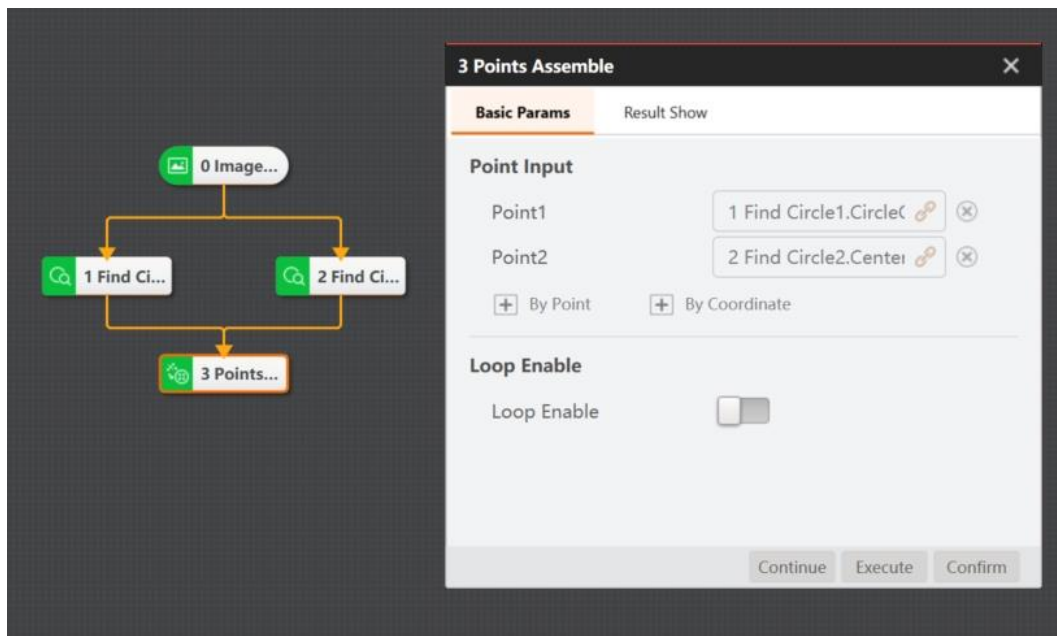
4.12.11 Time Consuming

The tool of time consuming is used to calculate the time from entering the start module to leaving the end module. The end time should be set later than the start time in **Basic Params** interface.

Otherwise, this tool cannot calculate the time consuming. Parameter settings and operation results are shown below.
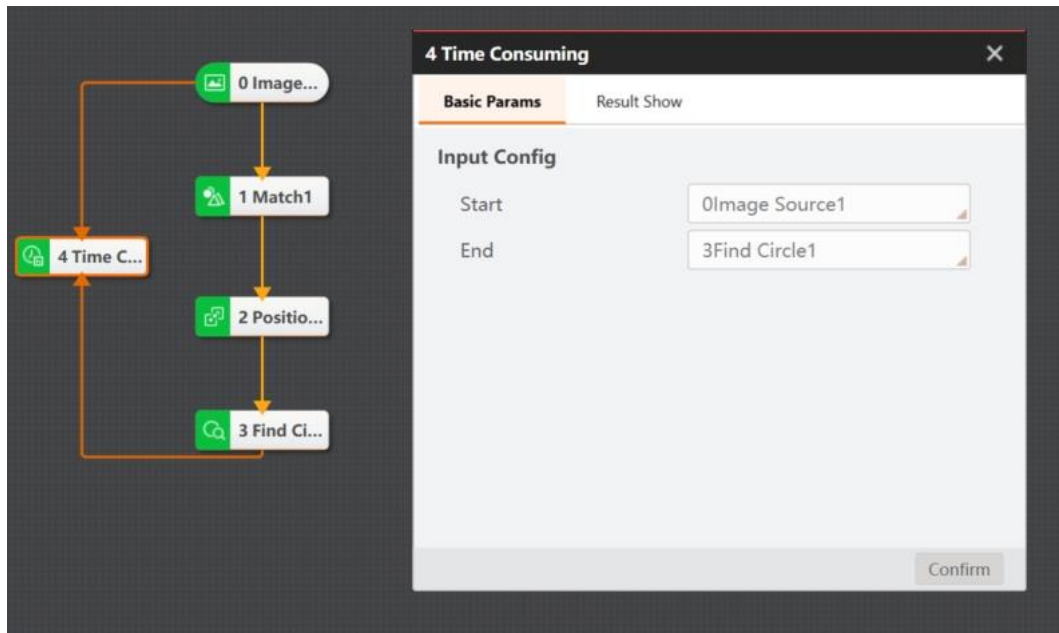
4.12.12 Data Set

Enter **Group** module to execute the internal loop and generate multiple result data, which can be integrated and output through the data set. All loop results or the result of the last loop can be output by setting the clear signal.

When executing the fast match tool within loop for multiple times, you can bind the data set tool with matching points of the fast match tool, and set Clear Signal as 0 or null, as shown below.
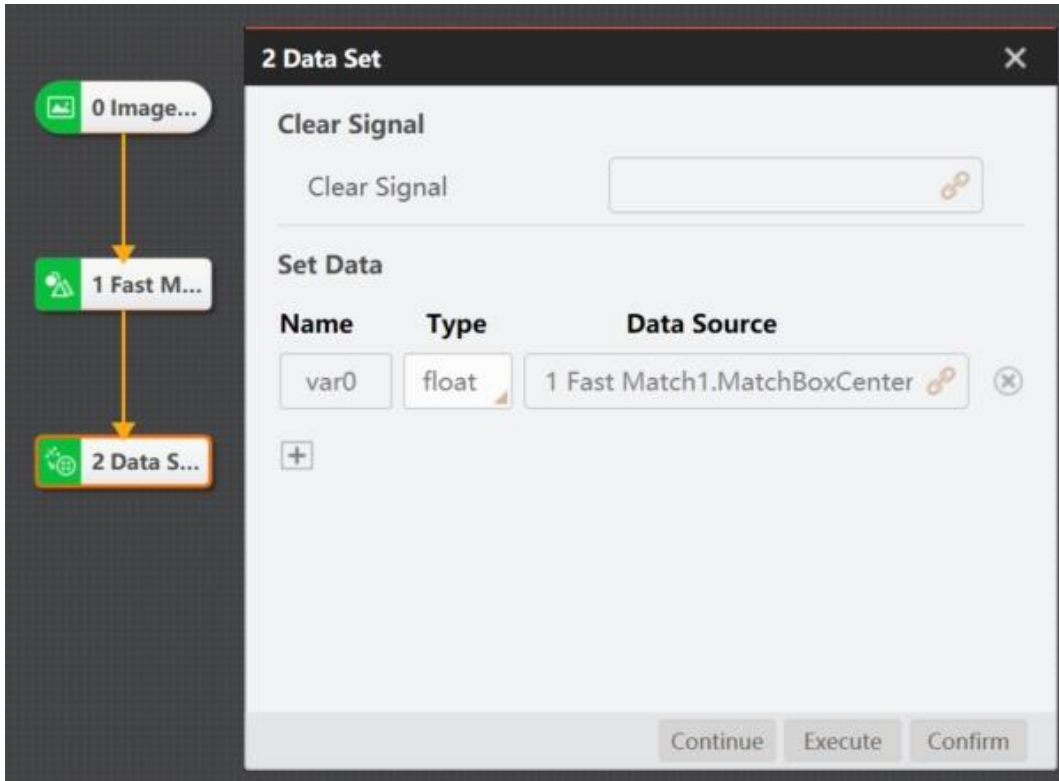
You can also use the format tool to bind the contents output by the Group tool, as shown below.
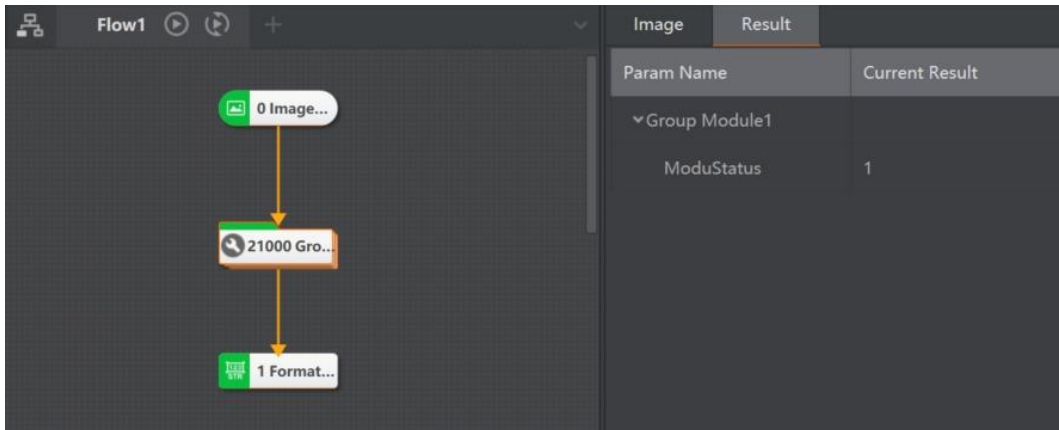
When the clear signal is set and not 0, the data generated in the last cycle can be output. The specific parameters are shown below.

Data Set Parameters		
Parameter	Empty	Completely output the cycle data, and clear the data before the start of the next cycle.
	0	Completely output the cycle data, but do not clear the data before the start of the next cycle.
	Not empty or 0	Output data of the last cycle.
Name	Customize the data name. Data shall be configured as output data in Group output configuration before the outputting.	
Type	The types of the data to be integrated, including int, float, and string.	

Data Source	Bind pre-module data that need to be integrated.

4.13 Communication

4.13.1 Receive Data

The **Receive Data** module can get data from data queue, communication devices and global variable. Here takes global variable as data source as an example.
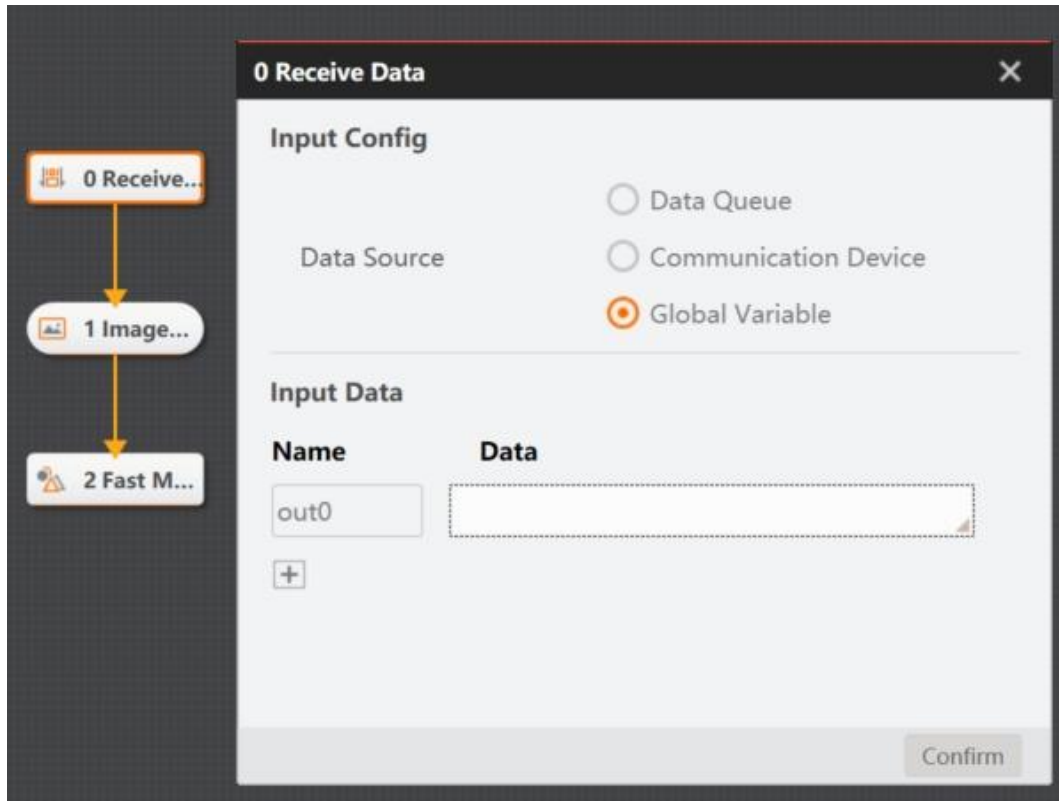
Add the data name to the input data and subscribe the data source. As the figure above, the receiving data module gets the data sent by flow 1 to the global variable.

4.13.2 Send Data

The tool for sending data can send data to data queue, communication devices, global variable, vision controller, and send event. Take sending data to the global variable as an example.
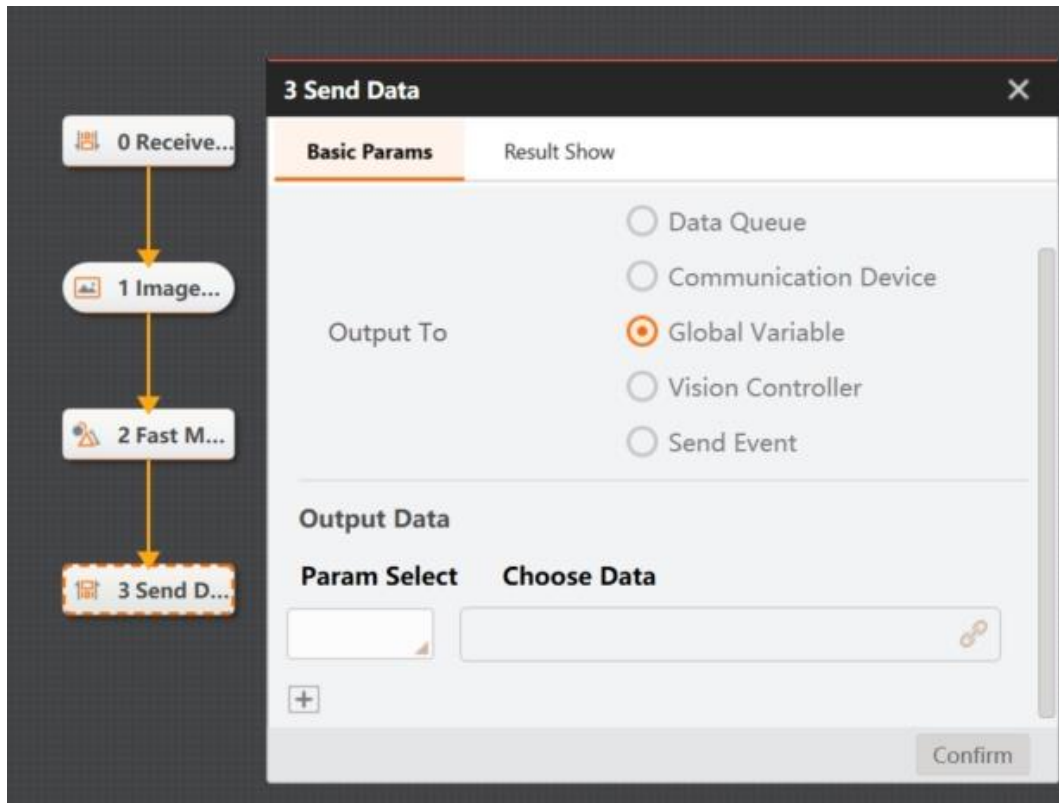
Select the global variable as the output option, and select the target global variable in the output data. You need to subscribe the data that needs to be sent to the global variable in the selected data. After sending data to the global variable, you can use the tool for receiving data to subscribe the data in the global variable, so as to get the sent data.

4.13.3 **Camera IO Communication**

Camera IO communication includes common camera communication and smart camera IO communication. Smart camera IO communication is generally used in the case of built-in algorithm platform of smart camera. Generally, the camera IO communication tool is used in combination with a certain result of the flow.
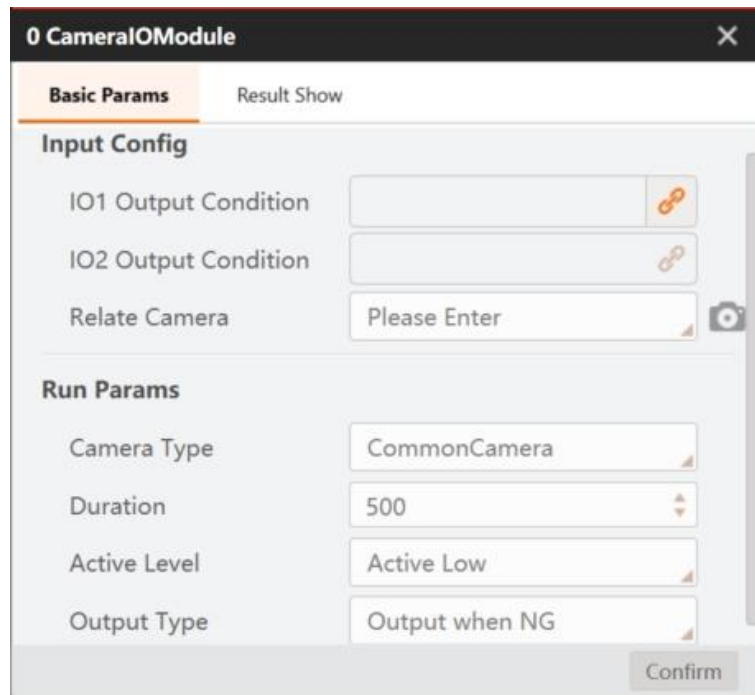
Camera IO Communication Parameters	
IO Output Condition	When the output condition is consistent with the event set by the output type, the corresponding IO port output signal.
Related Camera	You need to select the global camera.
Camera Type	It includes common camera, smart camera and dalsa camera. The common camera has 2 IO ports, smart camera has 3 IO ports, and dalsa camera has 4 IO ports.
Duration	Duration to output the active level, and the unit is ms.
Output Type	It has 2 types, including Output when NG and Output when OK. When the event meets condition, output active level. The default value is not output.

4.13.4 Protocol Parsing

There are three types of protocol parsing: text parsing, script parsing, and byte parsing.

When the character string sent by external communication contains special characters or line breaks, the text content can be parsed into multiple readable variables through text. For example, 1; 123; 234 can be parsed into 1, 123 and 234 by setting the split symbol as ";". The settings are shown as below.
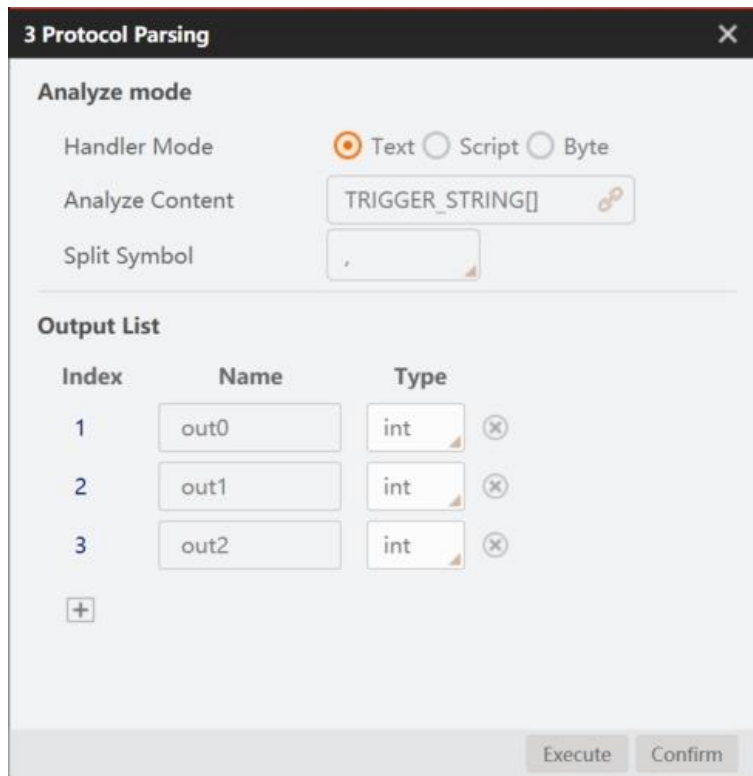
The result output is shown as below.

You can also customize the logic through python script, compile the script and save it as a file with the py. suffix.

There is a sample example under the installation path...\Module(sp)\x64\Communication\

DataAnalysisModule, as shown below.

```python
import struct
def getOutputParam():




    params = {}
    params['outPut1'] = 'int'
    params['outPut2'] = 'float'
    params['outPut3'] = 'string'
    return params


def handleMessage(info):






    info = bytearray.fromhex(info)
    params = {}
    outData = struct.unpack('>ii',info)
    params['outPut1'] = outData[0]
    params['outPut2'] = outData[1]
    return params
```

After editing the script, you can parse the text by loading the script file in the protocol analysis module.

For example, the formatted result "0000006400000005" can be parsed into decimal data 100 and 5 via script, as shown below.

📖NOTE

- The name, type and number of output variables must be defined in the script.

Param Name	Current Result	Global Variable
ModuStatus	1	🔗
outPut1	100	🔗
outPut2	5	🔗

4.13.5 Protocol Assembly

Protocol assembly is the reverse process of protocol analysis. Text assembly can assemble multiple data and separate the data with a custom delimiter, as shown below.
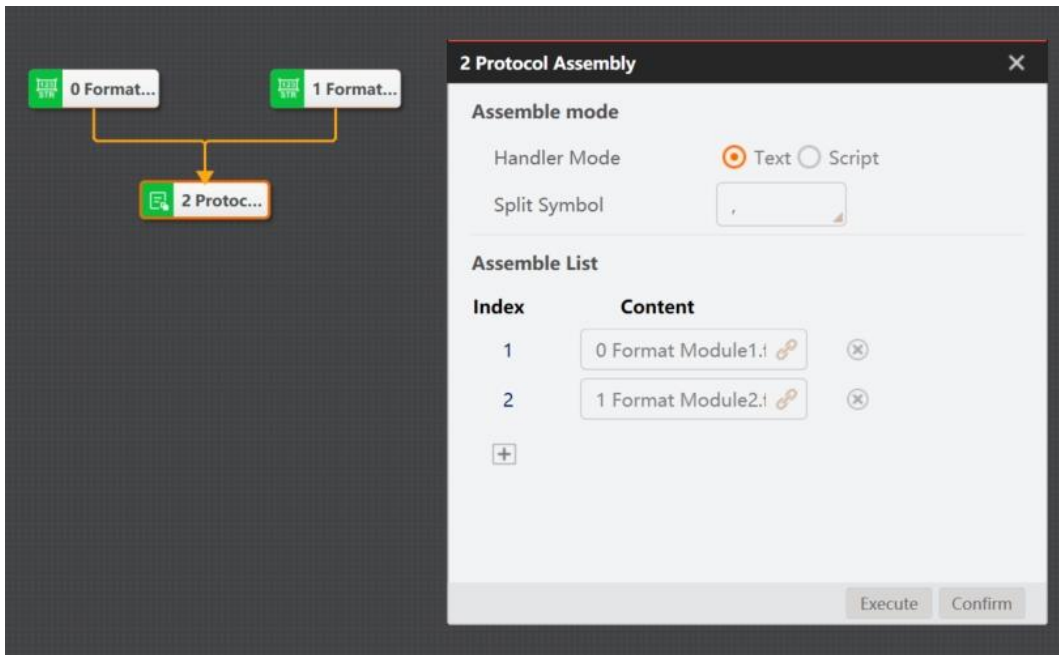
The script assembly can customize or bind the assembly content, and at the same time, customize the conversion logic and load the script file in the python script. Finally, data assembly can be realized according to the logic set by scripts after running, as shown below.
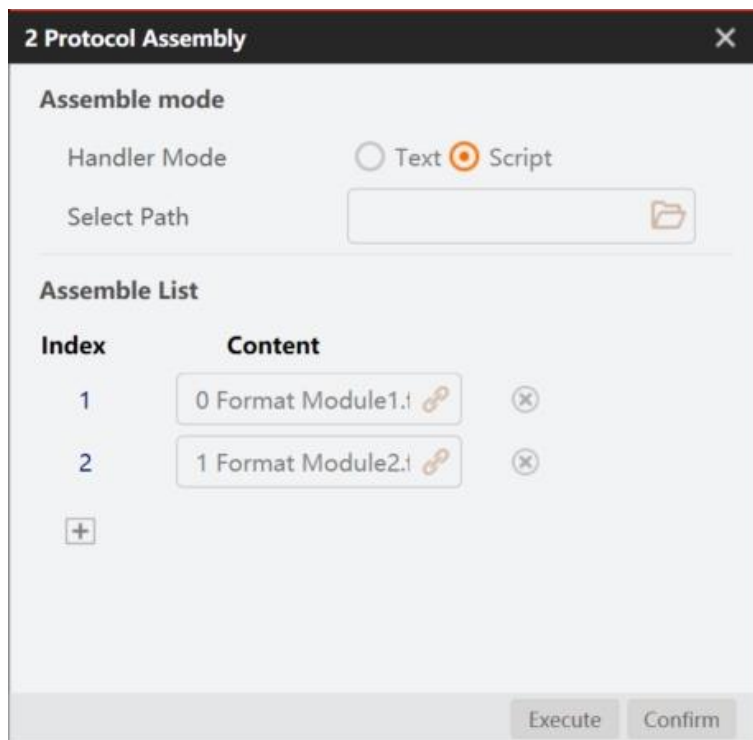
4.14 Dobot Magician Tools

4.14.1 Moving to a Point

Moving to a point means that Dobot Magician moves to a specified point according to the set motion mode. You can select motion mode based on site requirements, as shown below.
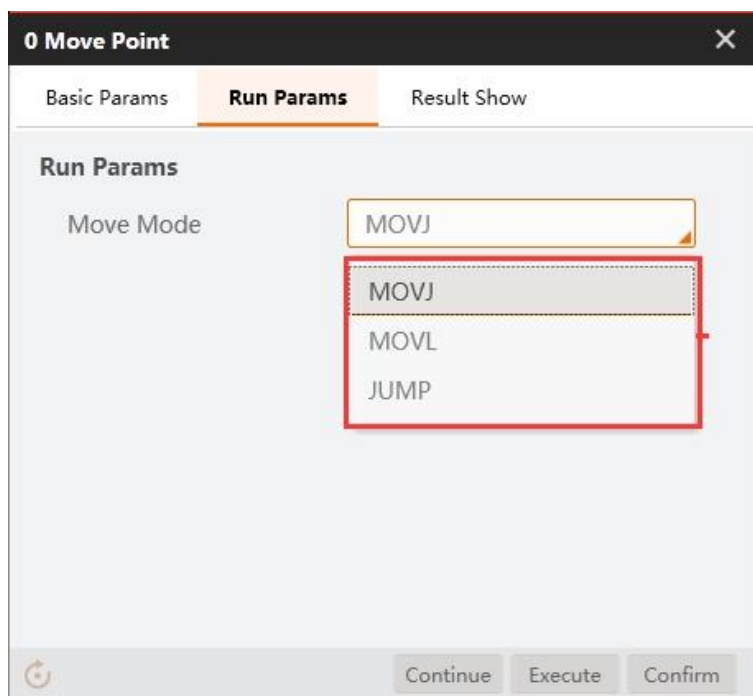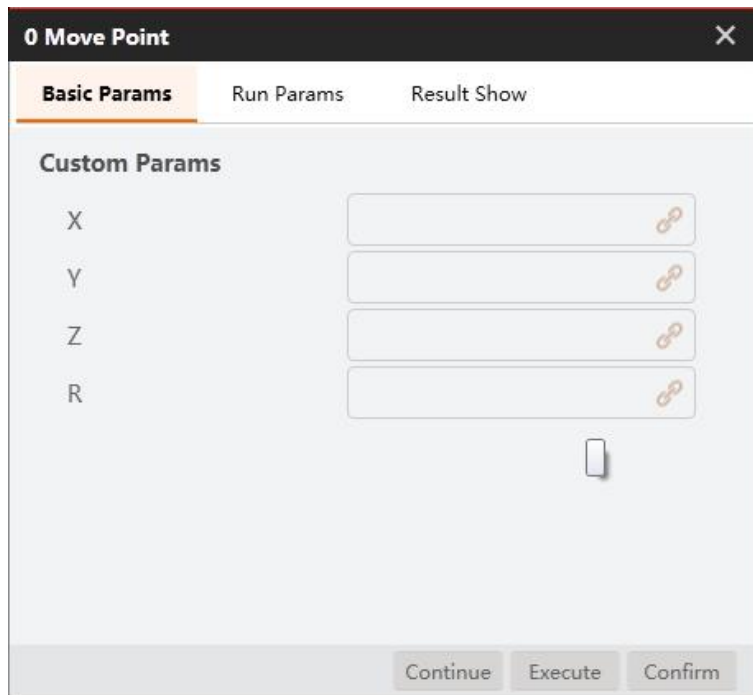
- Motion mode: the motion mode of the robot arm when it moves to the target position. The value range is MOVJ, MOVL, JUMP.
    - MOVJ: joint movement, from point A to point B. Each joint moves from the joint angle corresponding to point A to the joint angle corresponding to point B. During the joint movement, the running time of each joint axis should be consistent and the joint axis reaches the end point at the same time, as shown in the figure below.
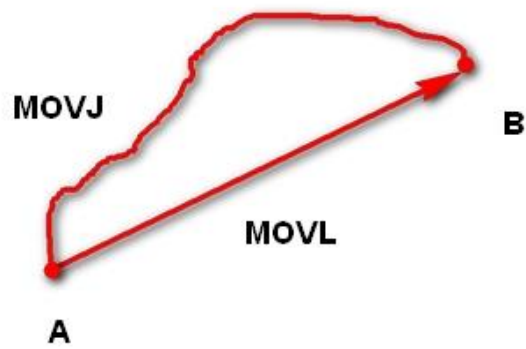
- MOVL: straight line movement, path S from point A to point B.

- JUMP: door-shaped trajectory, moving from point A to point B in MOVJ mode, as shown in the figure below.

    1. Rise to a certain Height in MOVJ mode.

    2. Transition to maximum lifting height (Limit) in MOVJ mode.

    3. Move to the height above point B in MOVJ mode.

    4. Transition to the height of point B plus Height in MOVJ mode.

    5. Descend to point B in MOVJ mode.
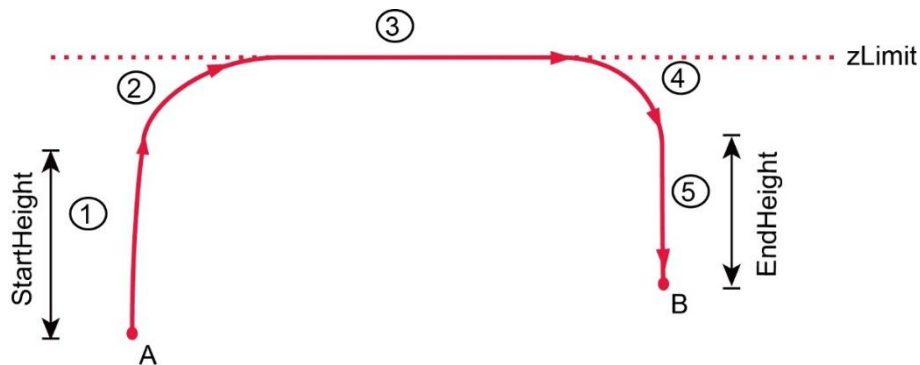
- X: Value of coordinate X
- Y: Value of coordinate Y
- Z: Value of coordinate Z
- R: Value of coordinate R

4.14.2 Speed Ratio

You can set the speed ratio of Dobot Magician to control the Dobot Magician' s speed. As shown below, the Dobot Magician will move at the 60% speed ratio.
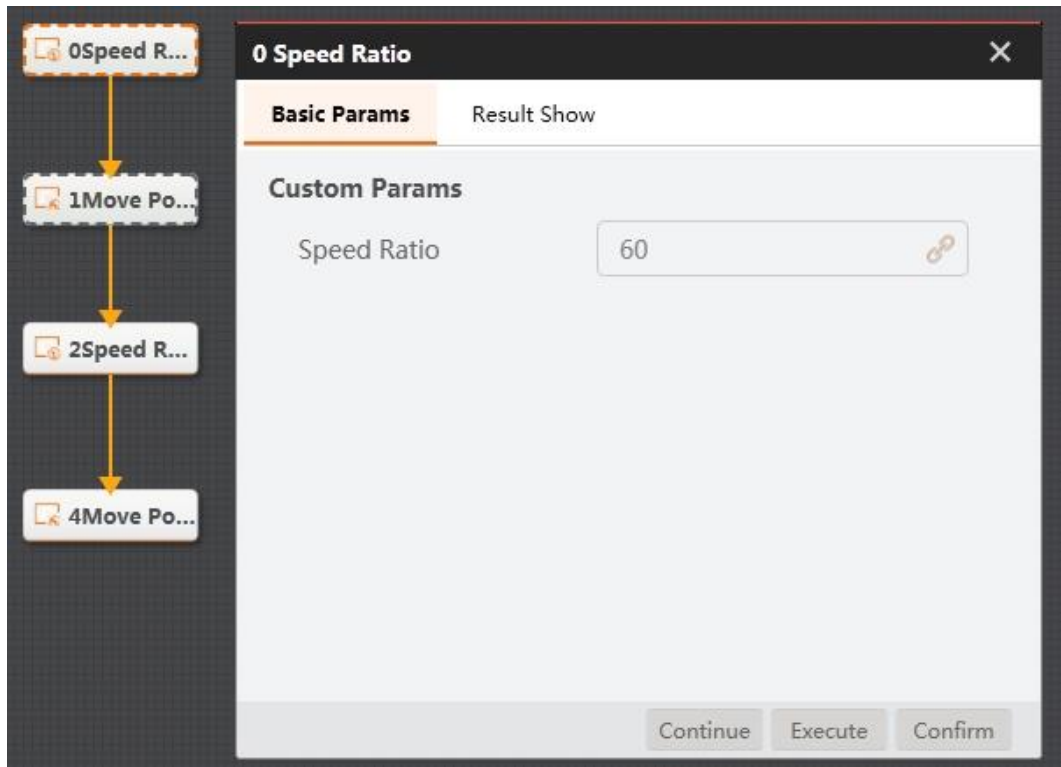
4.14.3 **Home Calibration**

If Dobot Magician loses step during working or encounters crash, you need to execute homing operation to improve its accuracy. The calibration tool is shown below.
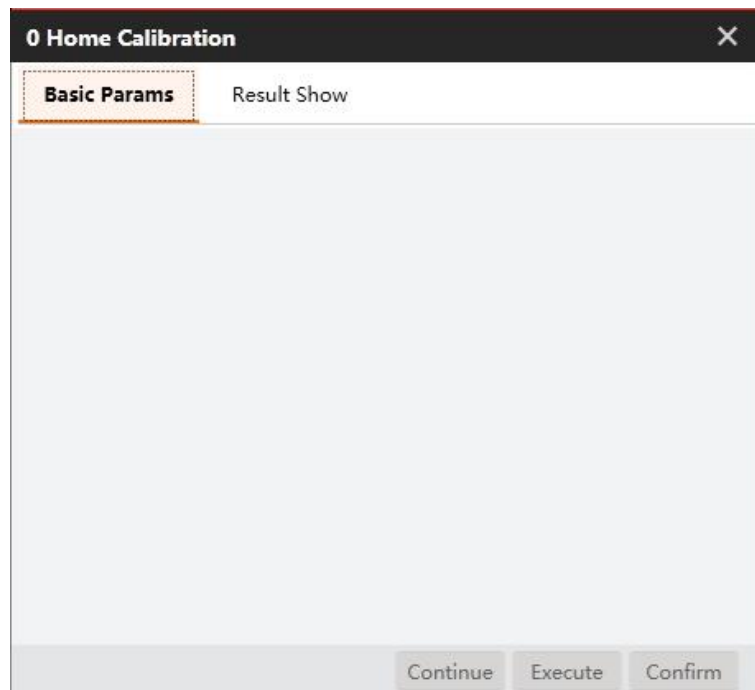
4.14.4 **Suction Cup Switch**

Suction cup is used to suck up or release object. After connecting suction cup to Dobot Magician, you can make it suck up or release object by controlling the switch, as shown below.

ON/CLOSE: Control the intake and outtake of air pump. Value range: **On** means intake, and **Close** means outtake.
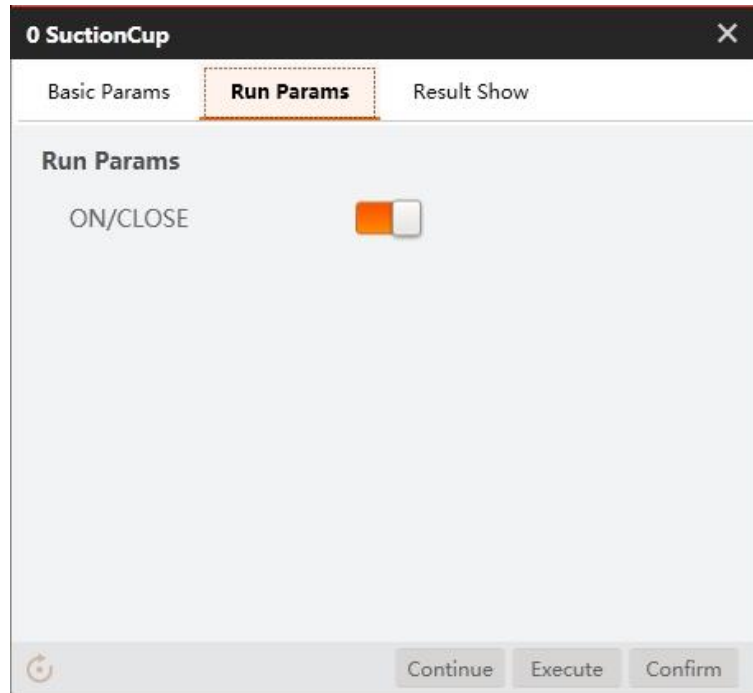
4.14.5 **Gripper Switch**

Gripper is used to grab or release objects. After connecting gripper to Dobot Magician, you can make it grab or release object by controlling the switch, as shown below.

ON/CLOSE: Set gripper to grab or release objects. Value range: **On** means grab, and **Close** means release.
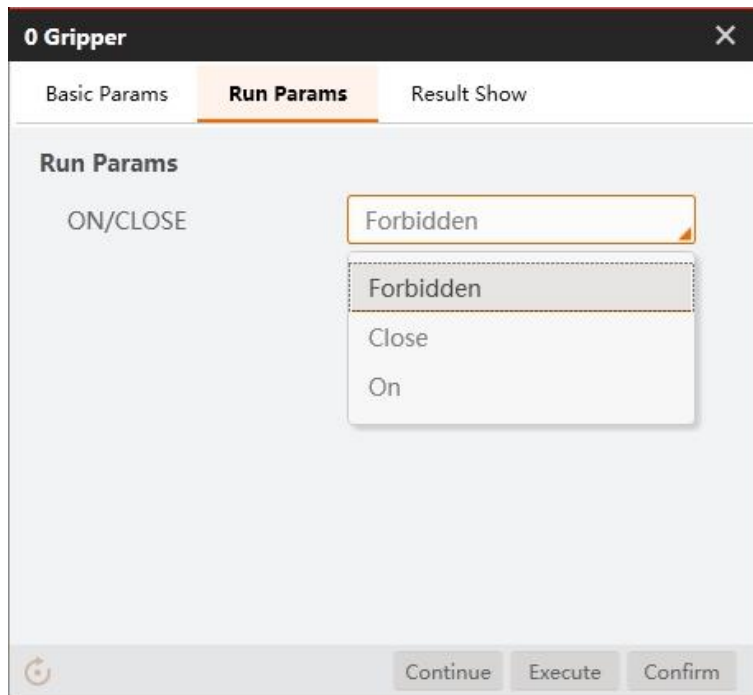
4.14.6 Laser Switch

Laser switch is used for laser engraving. After connecting laser engraving kit to Dobot Magician, you can make it work by controlling the switch, as shown below.

Laser: Click to open or close laser. Value range: **On** and **Off**.
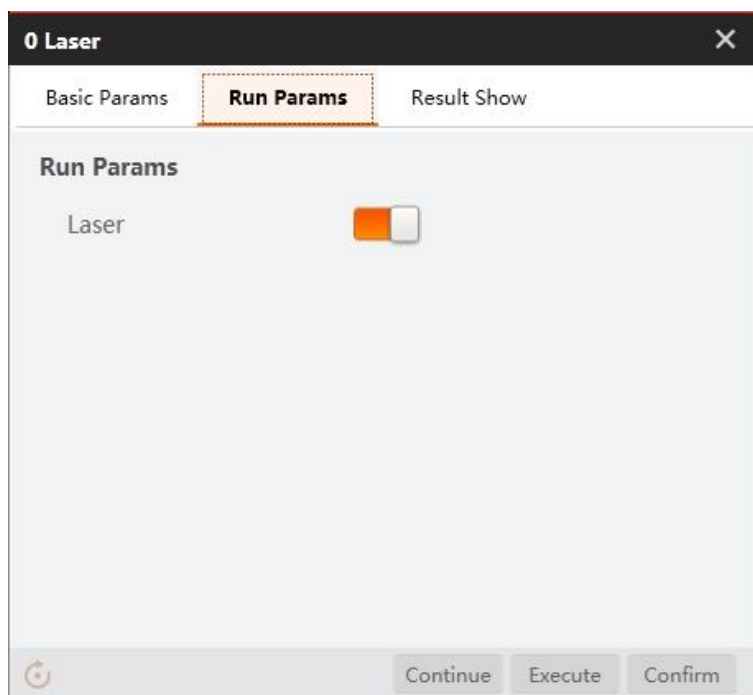
4.14.7 I/O Multiplexing

The laser switch is used for laser engraving. After connecting the laser engraving kit to Dobot Magician, you can set the laser switch tool for laser engraving, as shown in Laser Switch.

In the Dobot controller, all extended I/O is uniformly addressed. Based on the current situation, I/O functions include the following:

- High and low level output;

- PWM output;

- Read the input level (high and low);

- Read the input analog-to-digital conversion value.

Some I/O may have all of these functions. You need to configure I/O multiplexing before using different functions. For details, see *Dobot Magician User Guide*.

You can set the status of a specified I/O output interface using the I/O output tool. The figure below shows the I/O output tool.
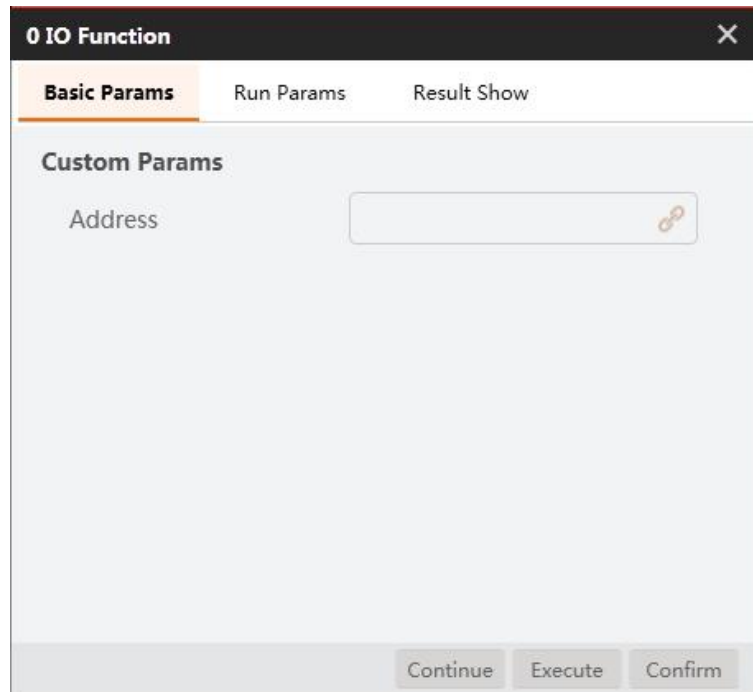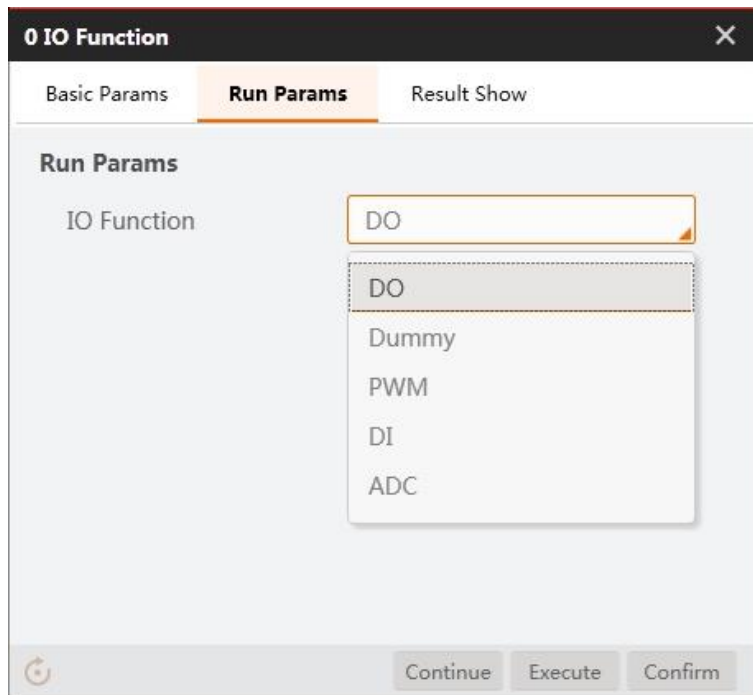
- Address: Set the address of the output interface. See the definition of Dobot Magician I/O Interface in Dobot Magician User Guide.

- DO: IO output;

- PWM: PWM output;

- Dummy: No function is configured.

- DI: IO input.

- ADC: AD input.

4.14.8 **I/O Output**

The addresses of the I/O interfaces in Dobot Magician are unified. You can set specified output status by I/O output tool, as shown below.
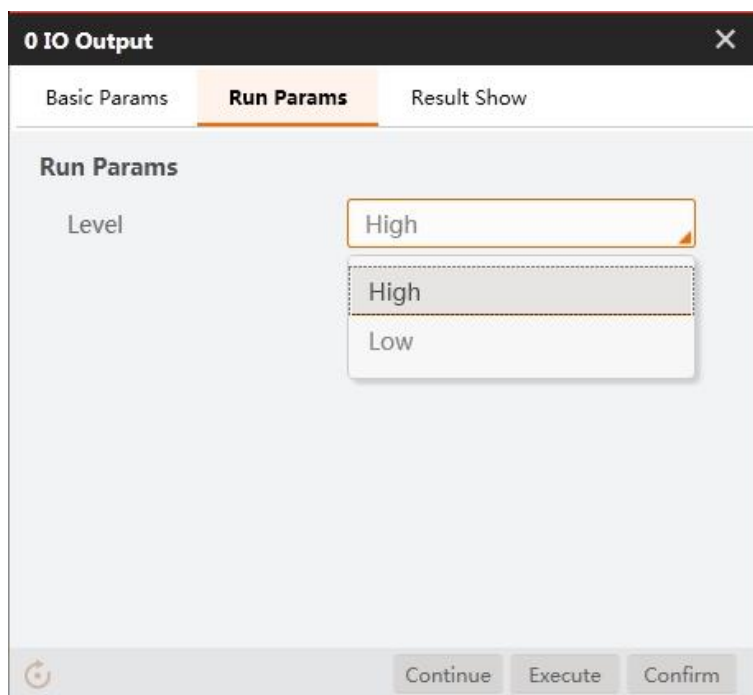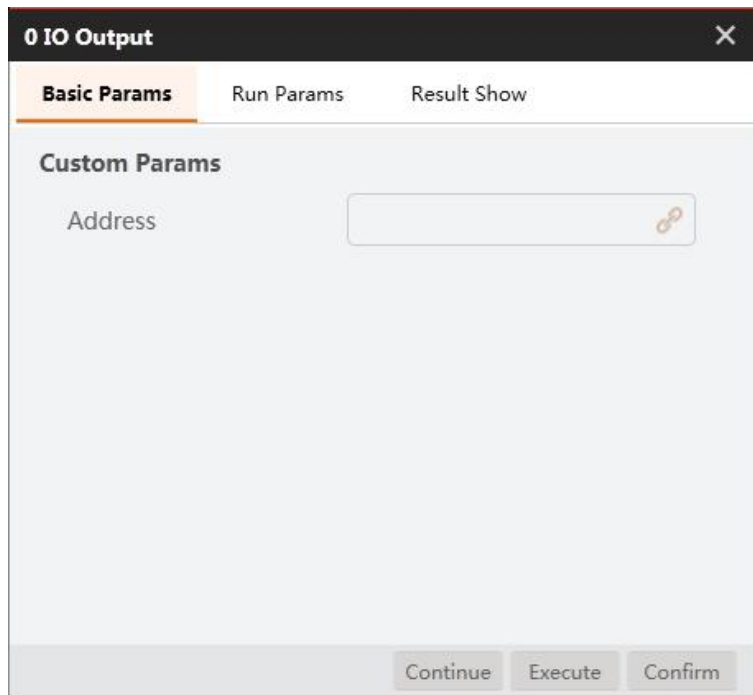
- Address: Set the address of output interface. For the definition of I/O interface, please refer to *Dobot Magician User Guide*.

- Level: Set I/O output status. Value range: **High** means high level, and **Low** means low level.

4.14.9 **I/O Input**

The addresses of the I/O interfaces in Dobot Magician are unified. You can get specified input status by I/O input tools, as shown below.
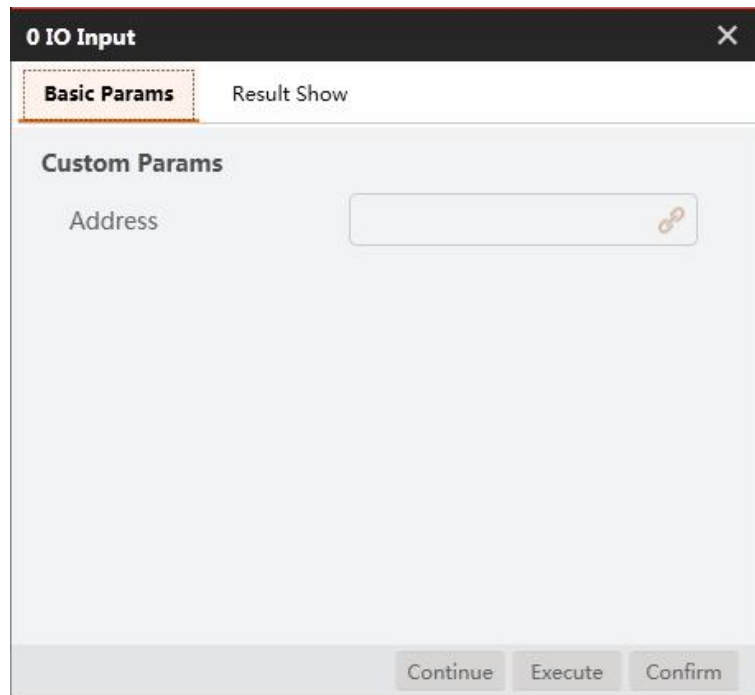
Address: Set the address of input interface. For the definition of I/O interface, please refer to ***Dobot Magician User Guide.***

5. **Cases**

5.1 **Location for USB Hole**

In this example, measure the position information of the CNC USB interface, and determine the center point position, as shown below.

Steps:

1. Solution establishment idea:

    • Find the position of the USB interface in the image by matching template.

    • Find the four lines of the trapezoidal interface, including upper line, left line, lower line, right line. l

    • Measure the intersection of two adjacent lines: the intersection point on the upper left line, the intersection point on the upper right line, the intersection point on the lower left line, and the intersection point on the lower right line.

    • Measure the distance between two diagonal points: the distance between the upper left line intersection point and the lower right line intersection point, and the distance between the upper right line intersection point and the lower left line intersection point.

The overall solution flow is shown below.
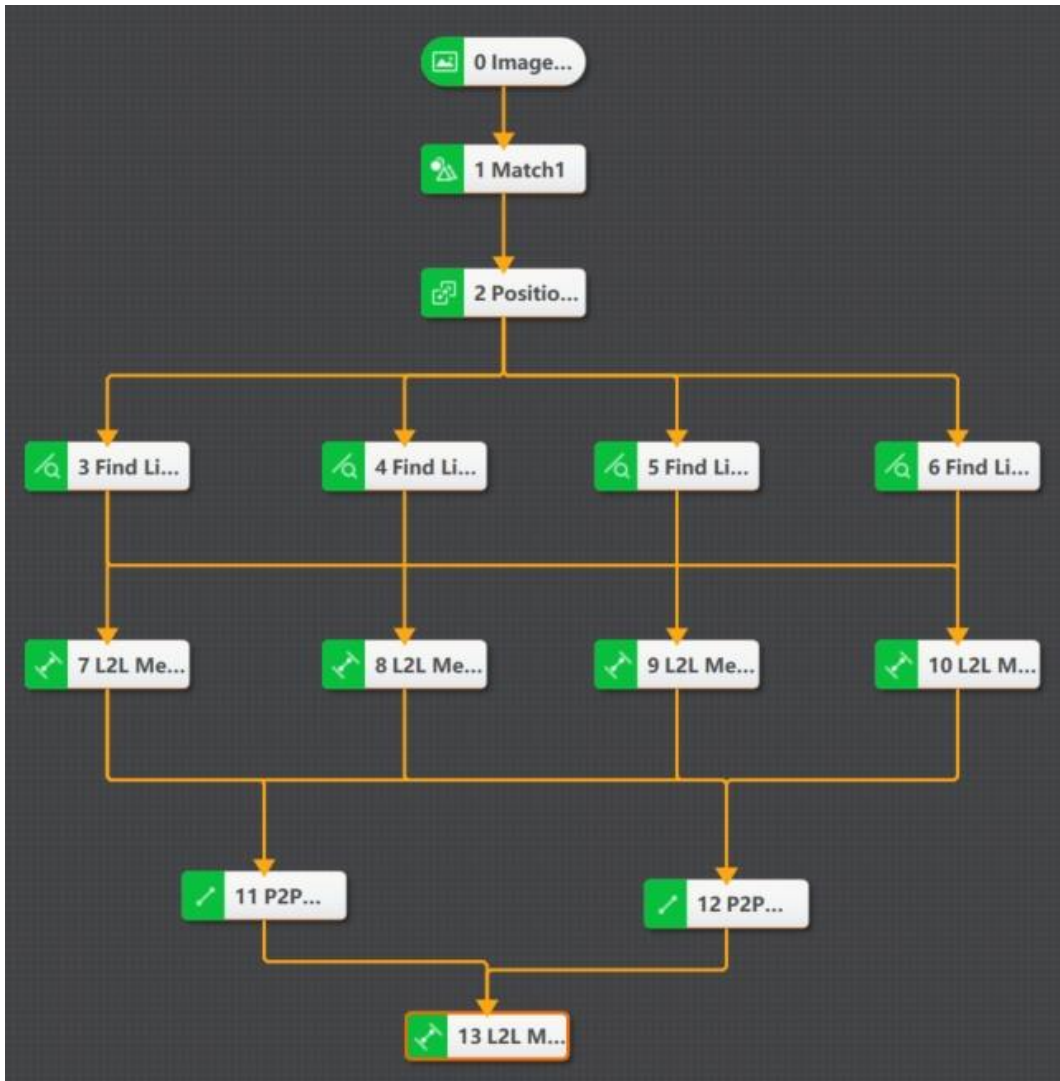
2. Save the solution.

3. Load solution.

4. Train model, as shown below.
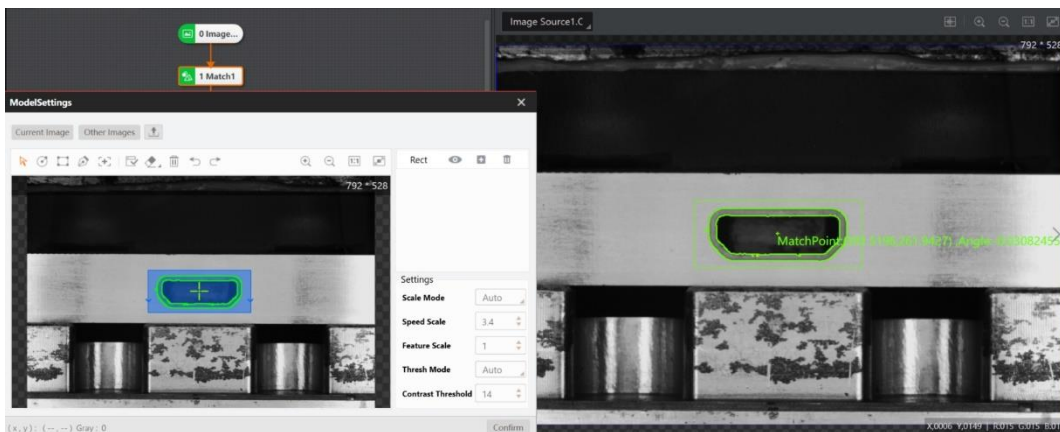
Locate the trapezoidal interface by matching template, as shown below.

5. Find lines. Select ROI according to actual features of lines in the image, and set parameters.

- Edge Polarity: it includes dark to light, light to dark and any.

- Search Mode: it includes best line, first line and last line.

- Search Direction: it includes top to bottom and lift to right.

In this example, find the upper line of the trapezoidal interface is shown below.
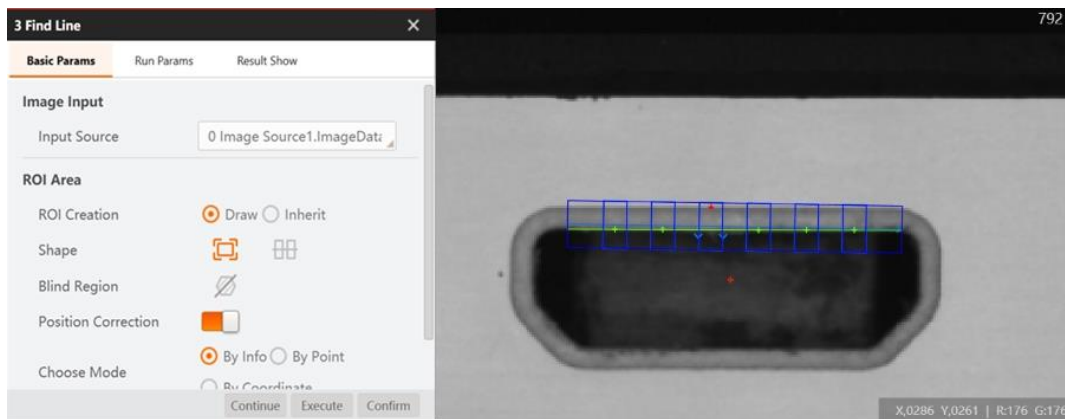
In this example, find the lower line of the trapezoidal interface is shown below.
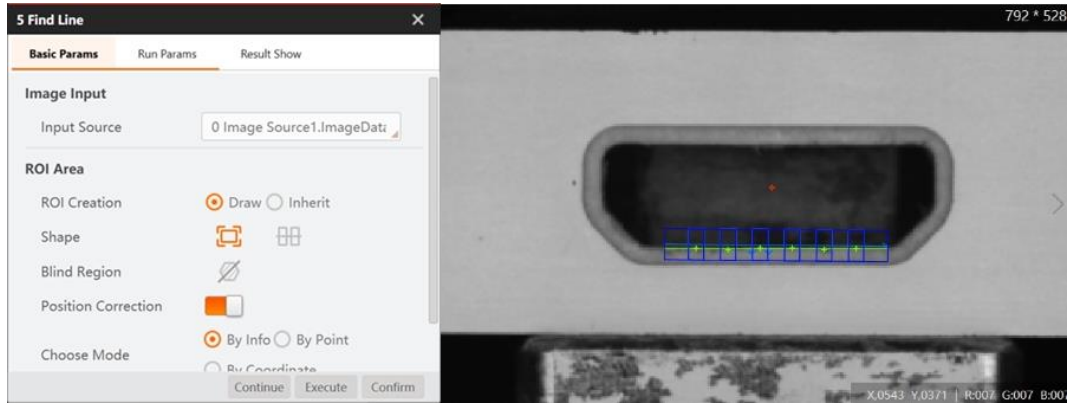
In this example, find the left line of the trapezoidal interface is shown below.
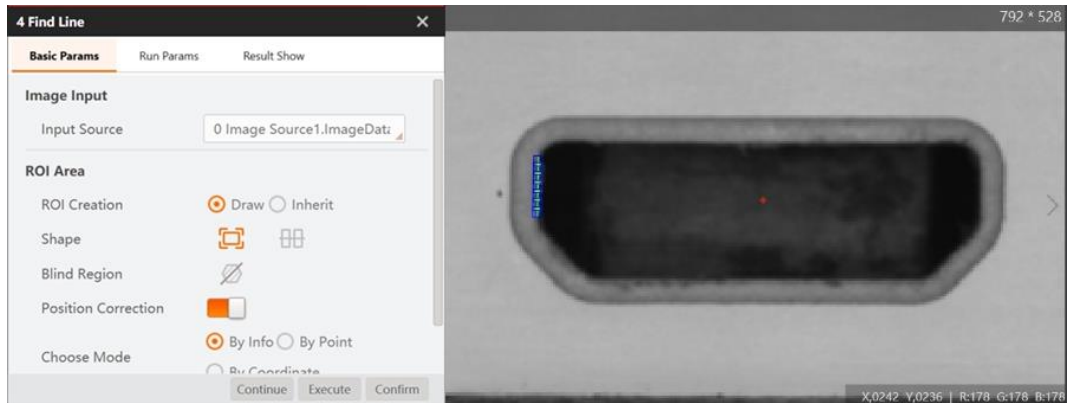
In this example, find the right line of the trapezoidal interface is shown below.
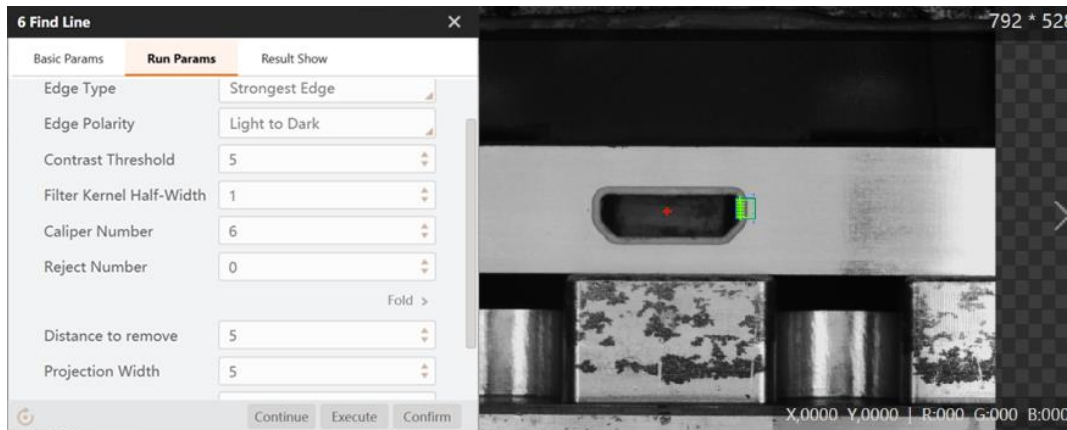
6.   Determine the left and upper intersection point of lines, as shown below.
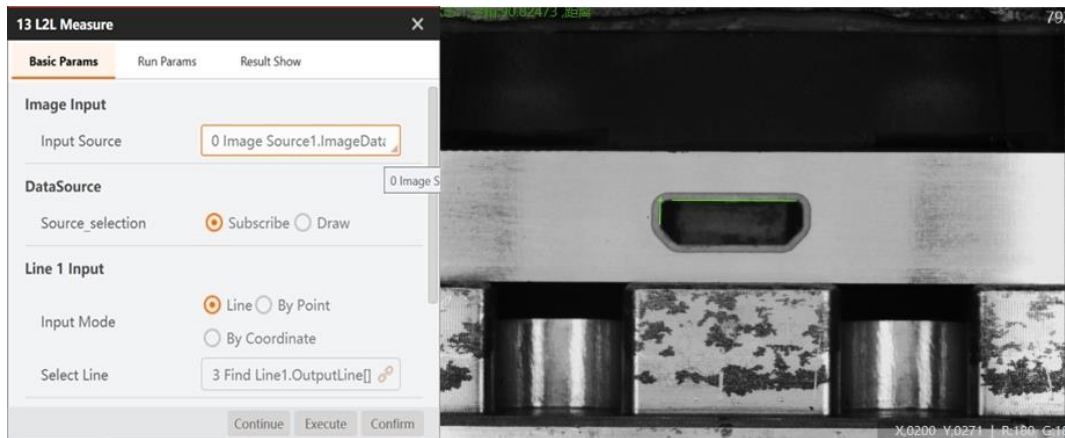
7.   After obtaining the four intersection points, execute point to point (P2P) measurement.

5.2   Detection for Detective Metal

In this example, it detects whether there is a metal cover and its position is right, and the sample image is shown below.
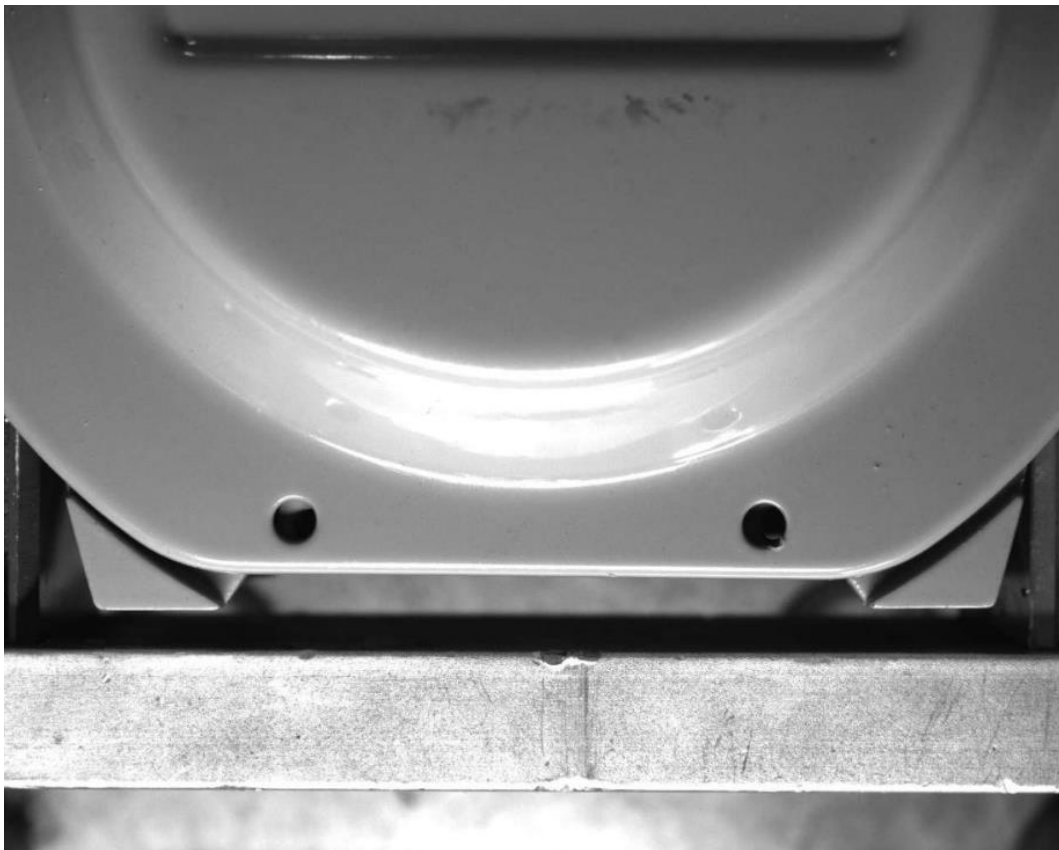
Steps:

1.   Solution establishment idea:

   •   The surface of the metal cover is reflective, and whether there is a metal cover can be detected by intensity analysis. l

   •   The bottom triangle can determine the installation position of the metal cover. Through

feature matching tool, you can set the center of the base as a matching point by the training template. l

- Find the center of the installation hole on the metal cover by the tool of finding circle.

- Measure the distance between the matching point and the center of the circle by the tool of point-to-point measurement (P2P measure).

- Determine whether the metal cover is installed correctly by the center distance and the tool of if module.

2. The overall solution flow is shown below.
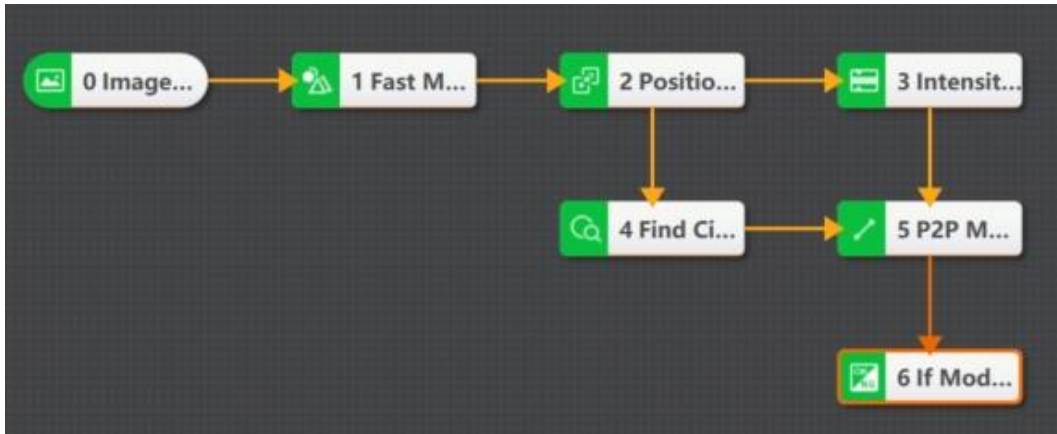
3. Train model, as shown below.
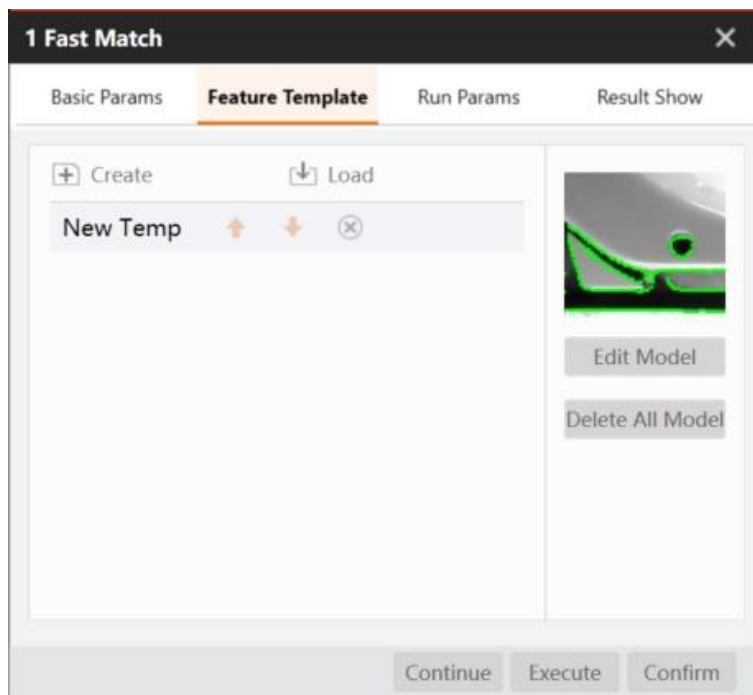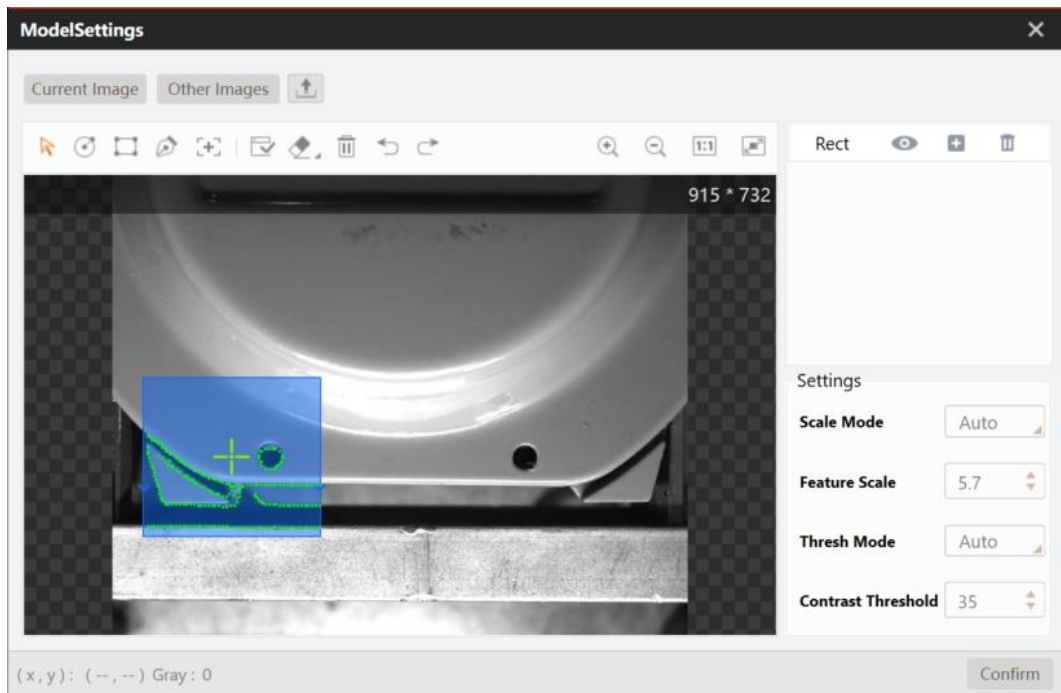
4. Find circle. Select the search range of circle, and determine the the location of metal cover, as shown below.
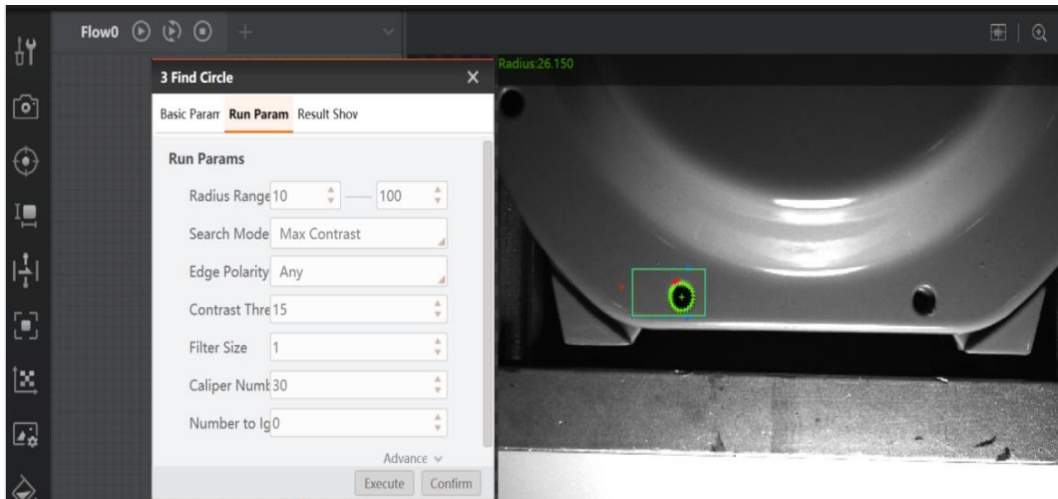
5. Measure. The distance between circle center and the matching point is shown below.
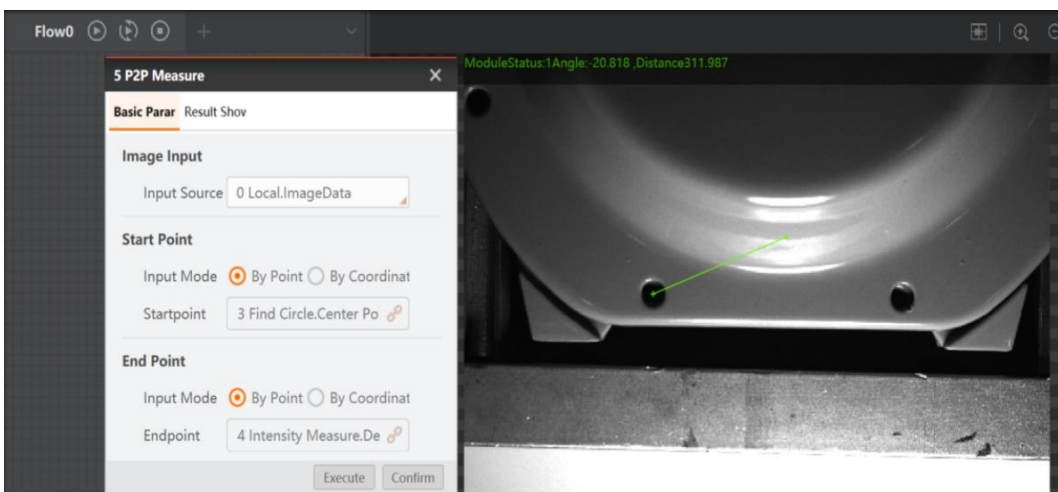
According to valid value range to determine whether the installation position is right or not.
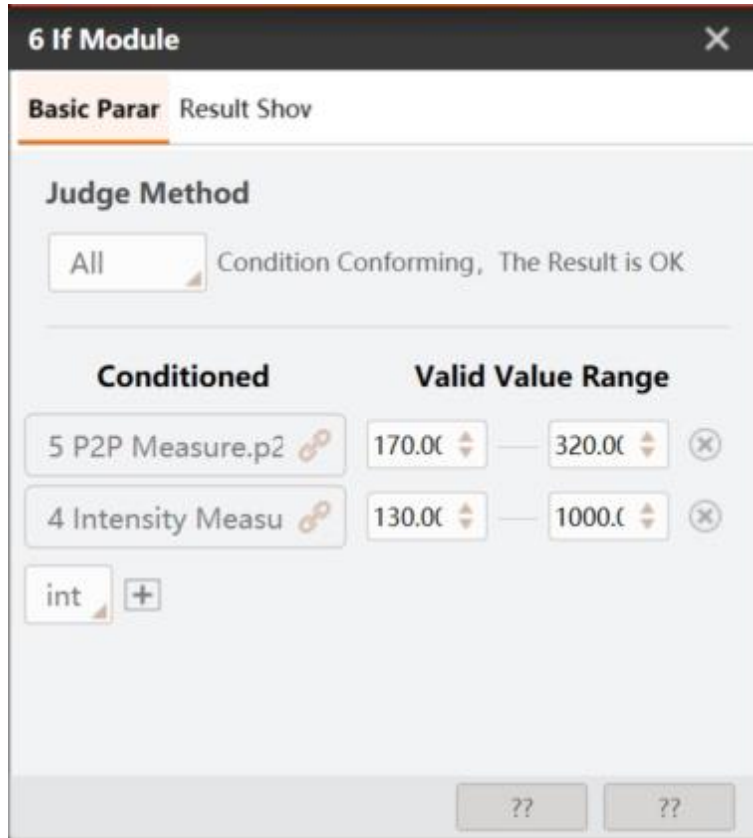
6. Intensity measurement analysis. Determine whether there is a metal cover by intensity measure and if module, as shown below.
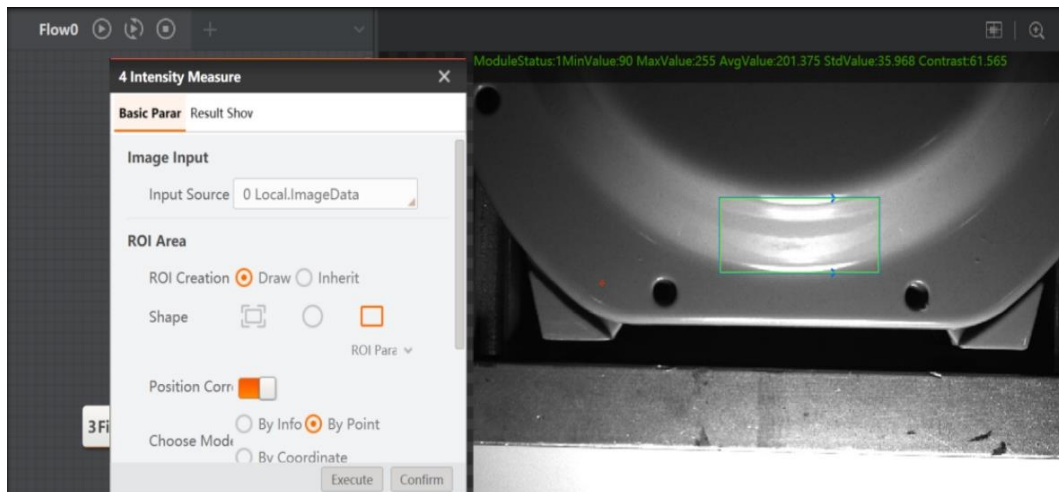
7. Detection result is shown below.
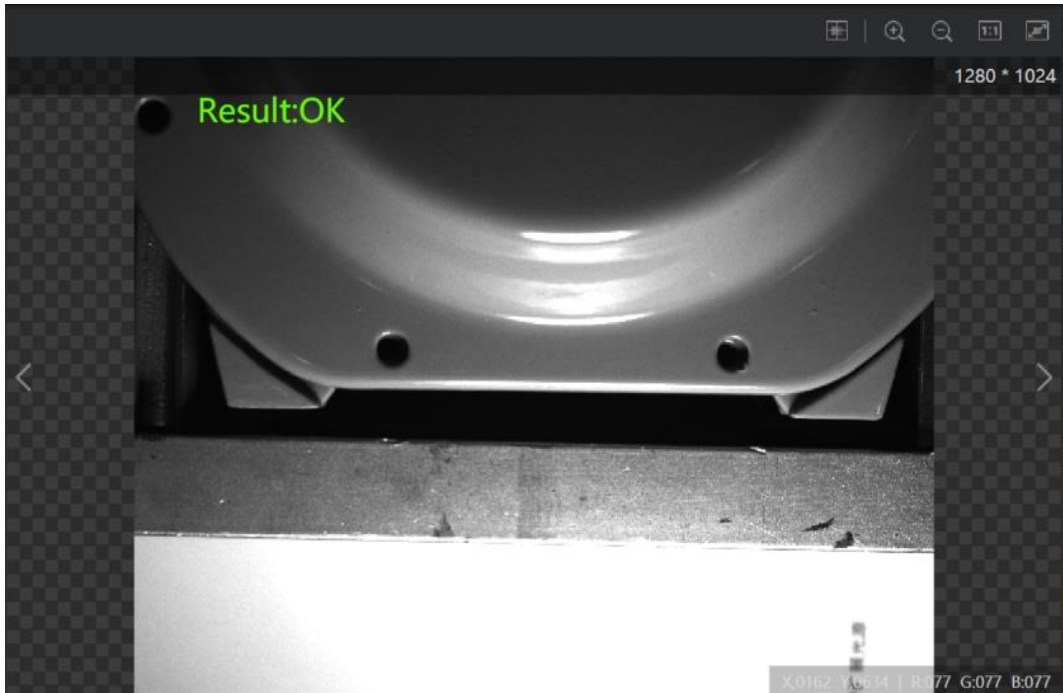
5.3 **Distance Detection**

In this example, detect the distance between the far left and far right circle holes on the electronics, as shown below.
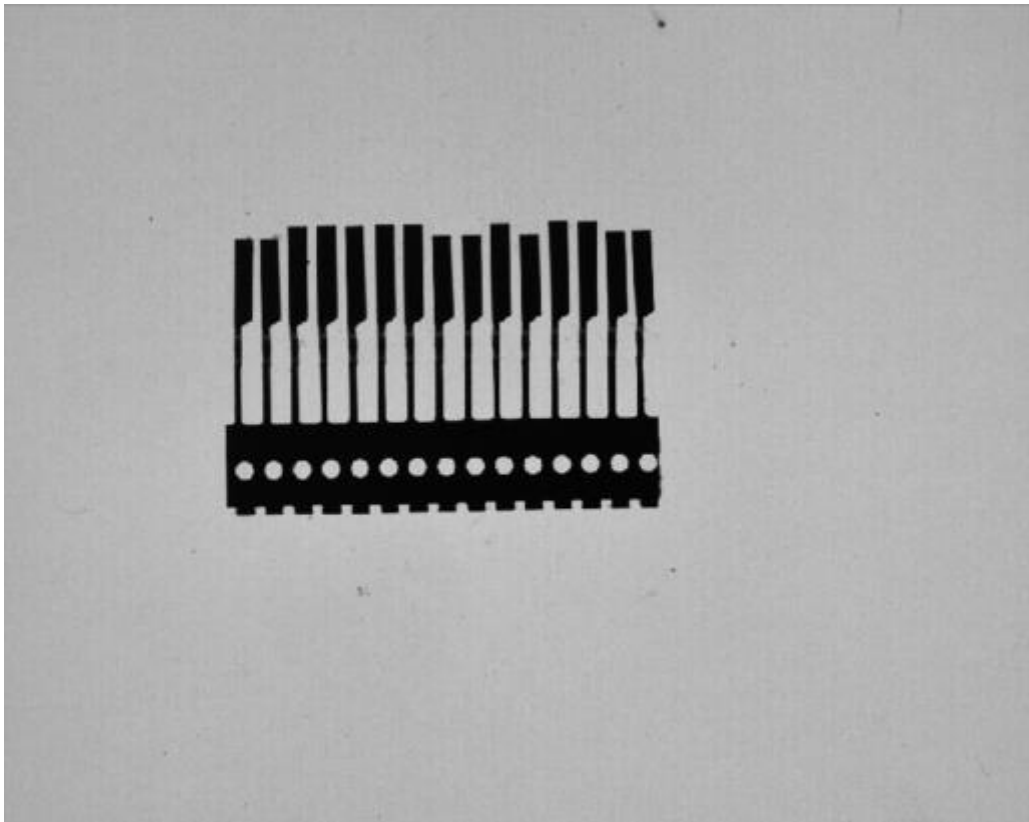
Steps:

1. Solution establishment idea:

- Calibration can be calibrated by checkerboard.

- There are a lot of interference for many circles among far left and far right circles. Thus, template matching and location is needed for capture the circle accurately.

- Transform the two circle centers to the post-calibration coordinates via calibration transformation.

- Measure the circle center distance by using point to point measure (P2P measure).

2. The overall solution flow is shown below.
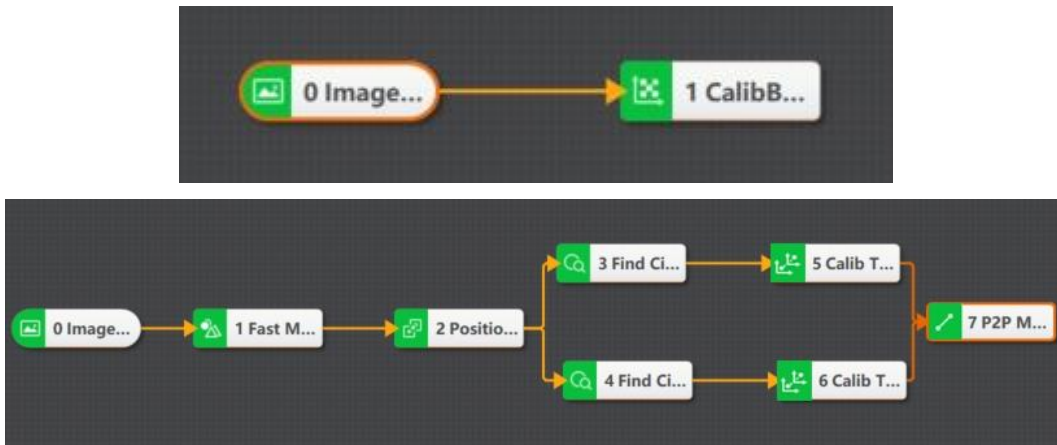
3. Calibration.

Load the calibration image into local image, connect calibration tool, set parameters of calibration tool, and select save path.

4. Find circle.

Select the ROI area of circle, and find the circle centers of two circles, as shown below.
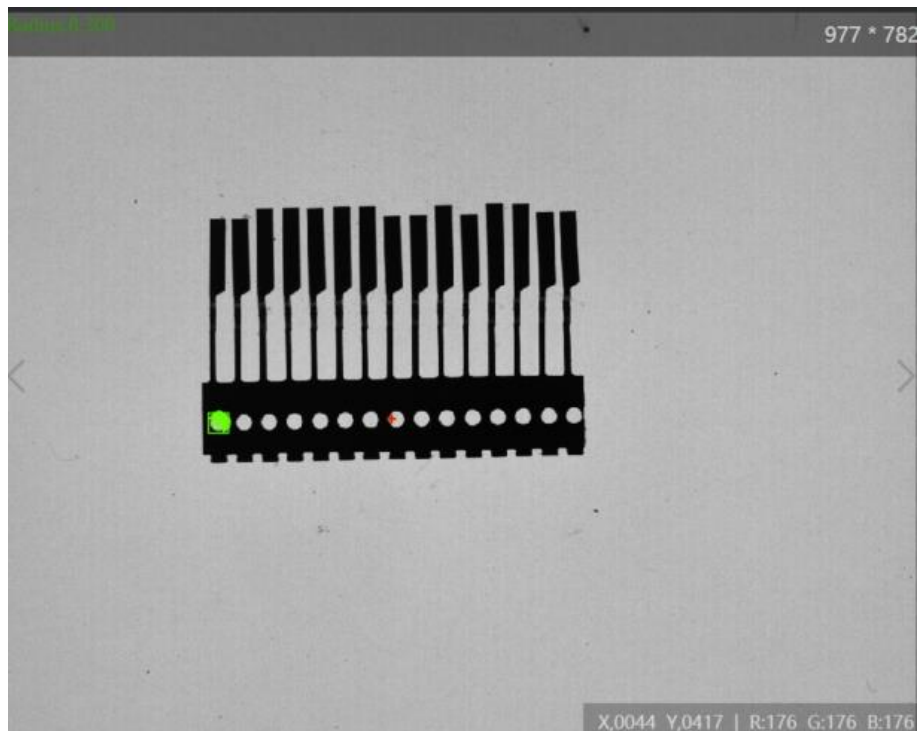
5. Calibration transformation

Transform the two circle centers to the post-calibration coordinates via calibration transformation.
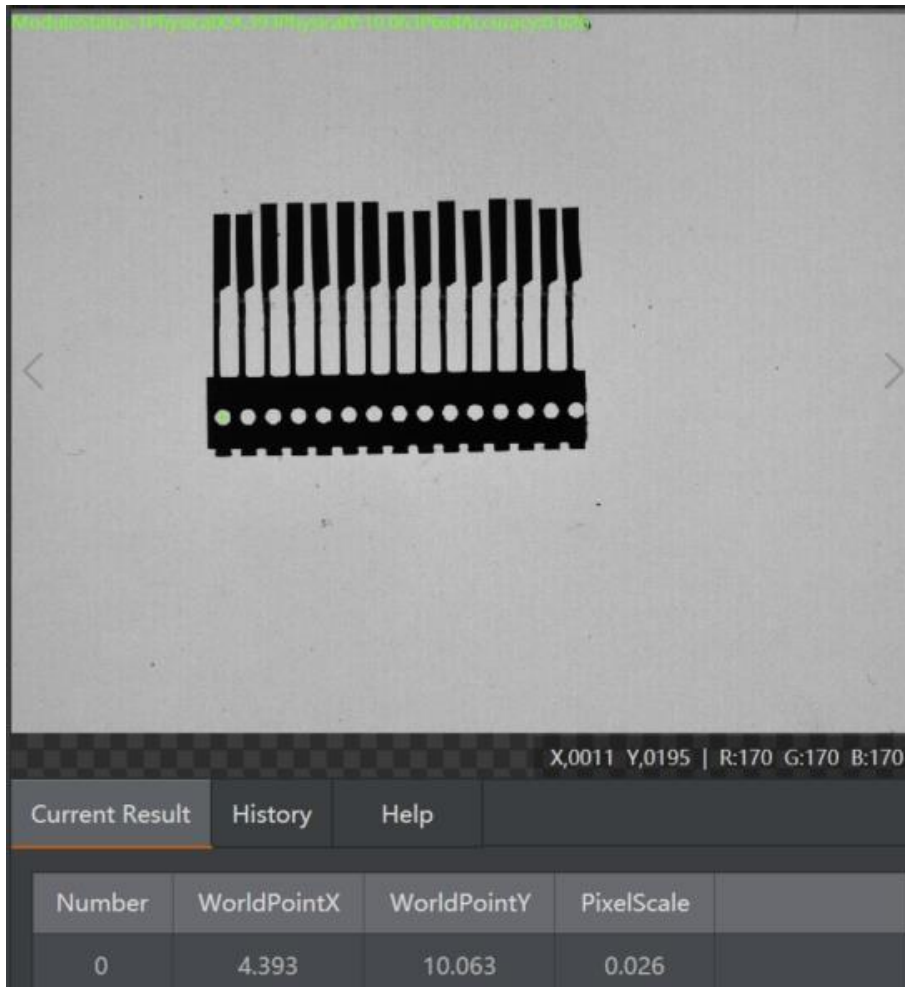
6.   P2P measure

In the basic parameter interface of P2P measure, enter the coordinates of two circle centers as start point and end point. The result is shown below after running the solution.
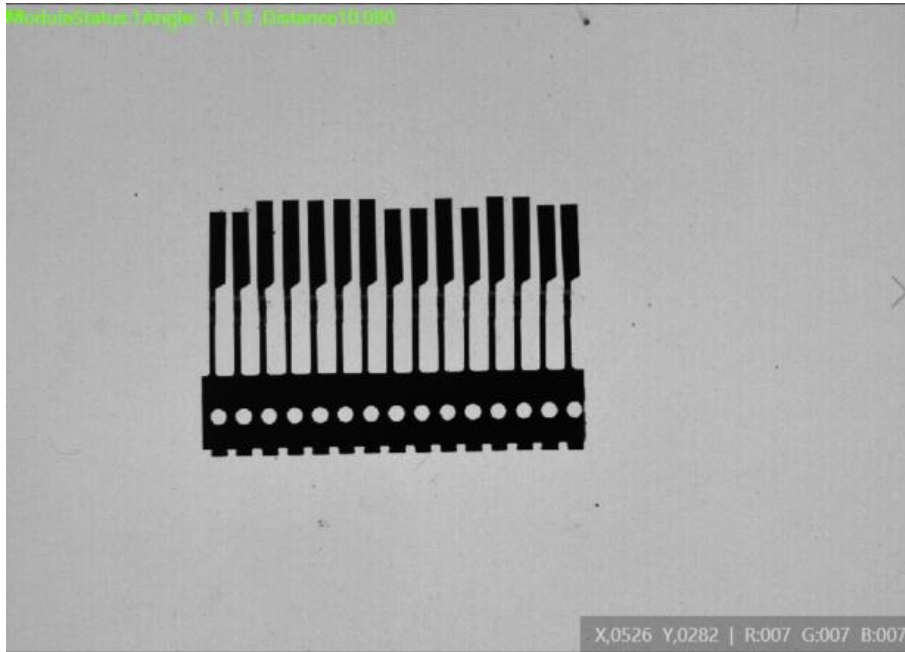
5.4 Loop Function

Steps:

1. Set up solution flow.

The overall solution flow is shown below.
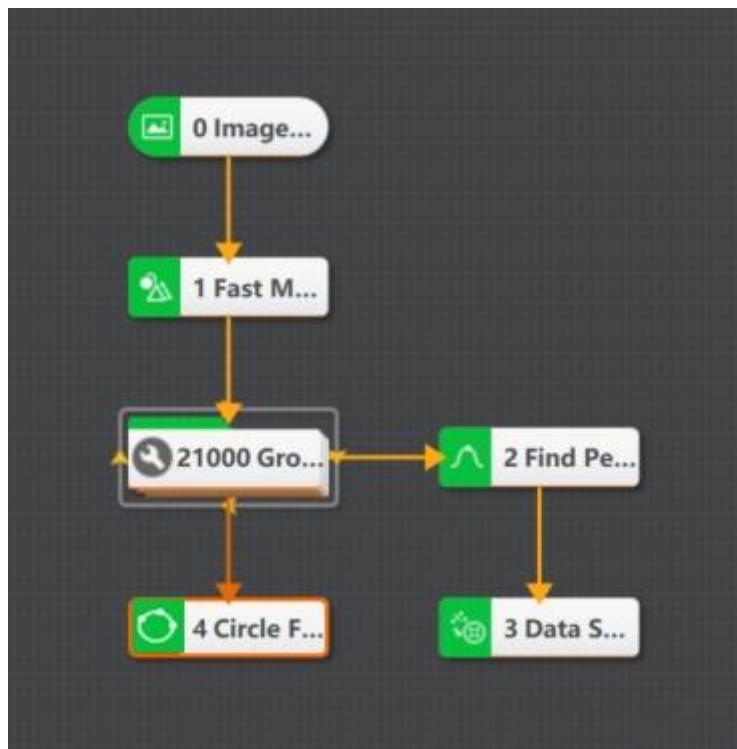
2. Set loop parameters.

The settings of loop parameters must have circle start value and circle end value, as shown below.
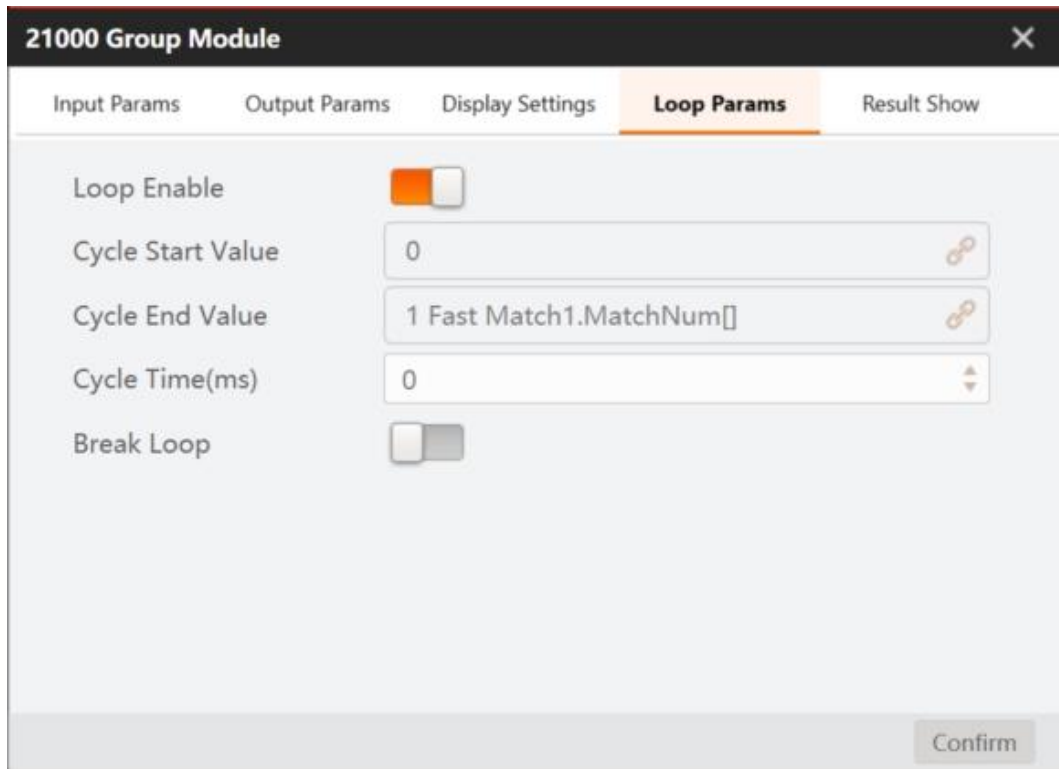
3.   Set the parameters of finding peak.

The tool of finding peak should set up standards according to loop times, as shown below.
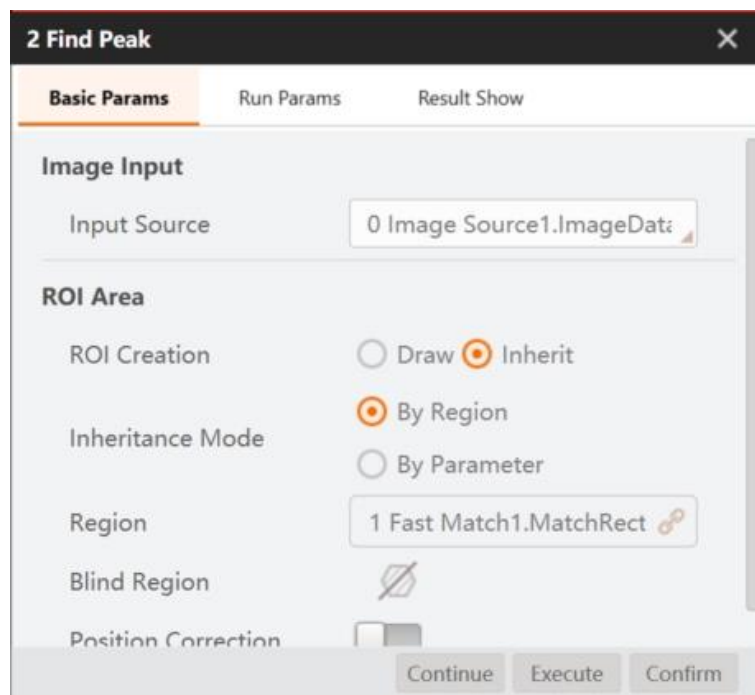
4.   Display result.

The result is shown below after running the loop control tool.
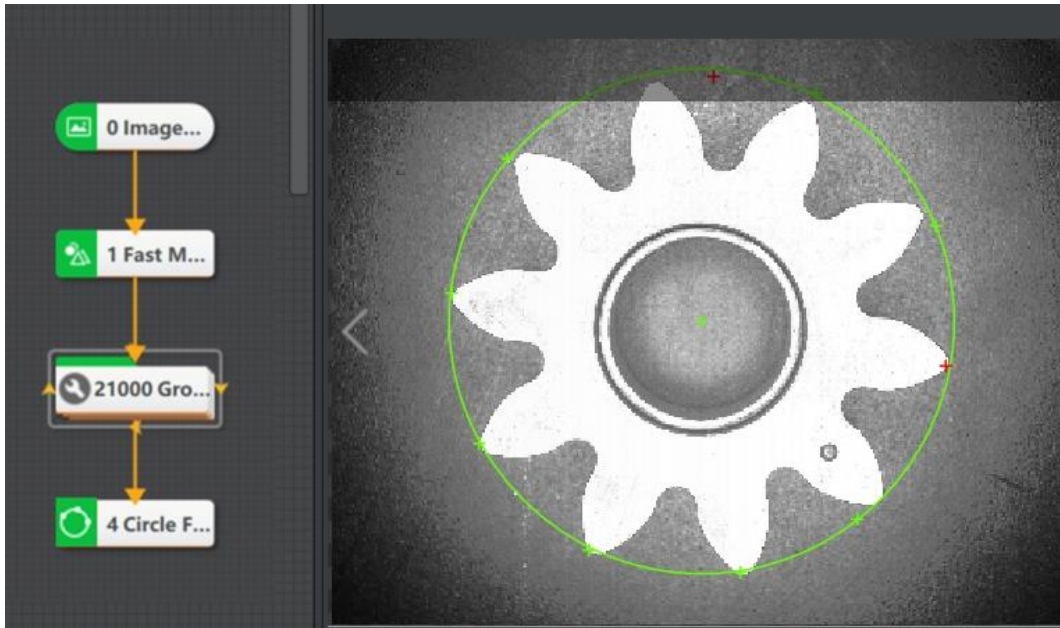
5.5 Script Function

The script function provides input interface, and it transmits to output via C# programme process.

Steps:

1.   Set up solution flow.

Find circle output diameter by template matching, as shown below.

2. Edit script.

Double-click the script module and enter editing page, as shown below.
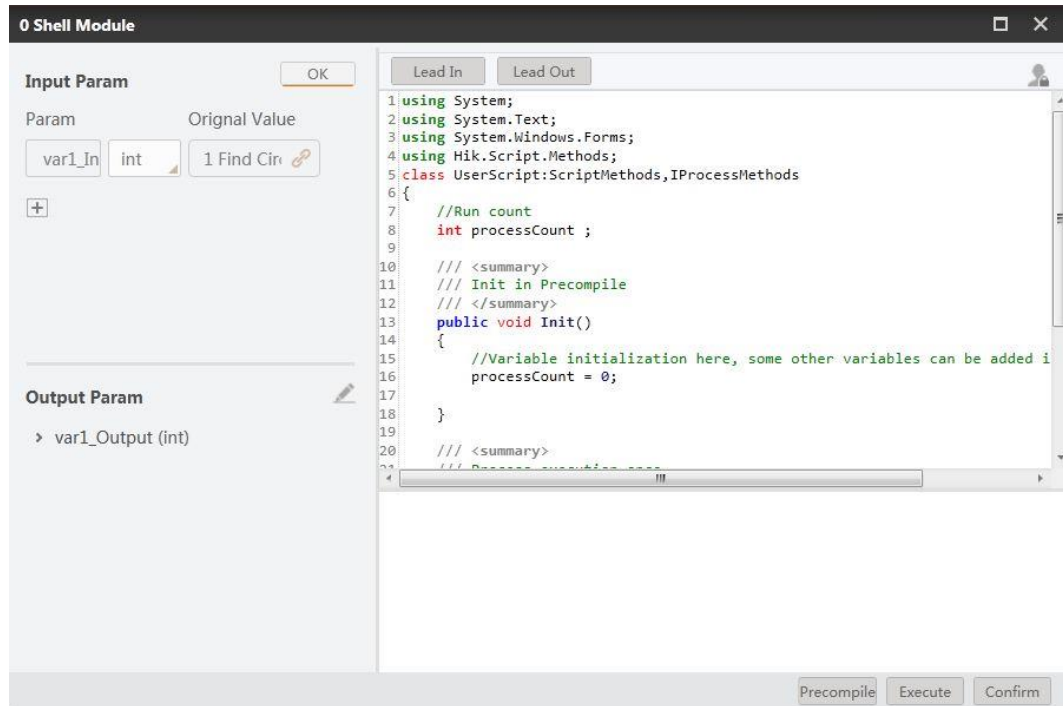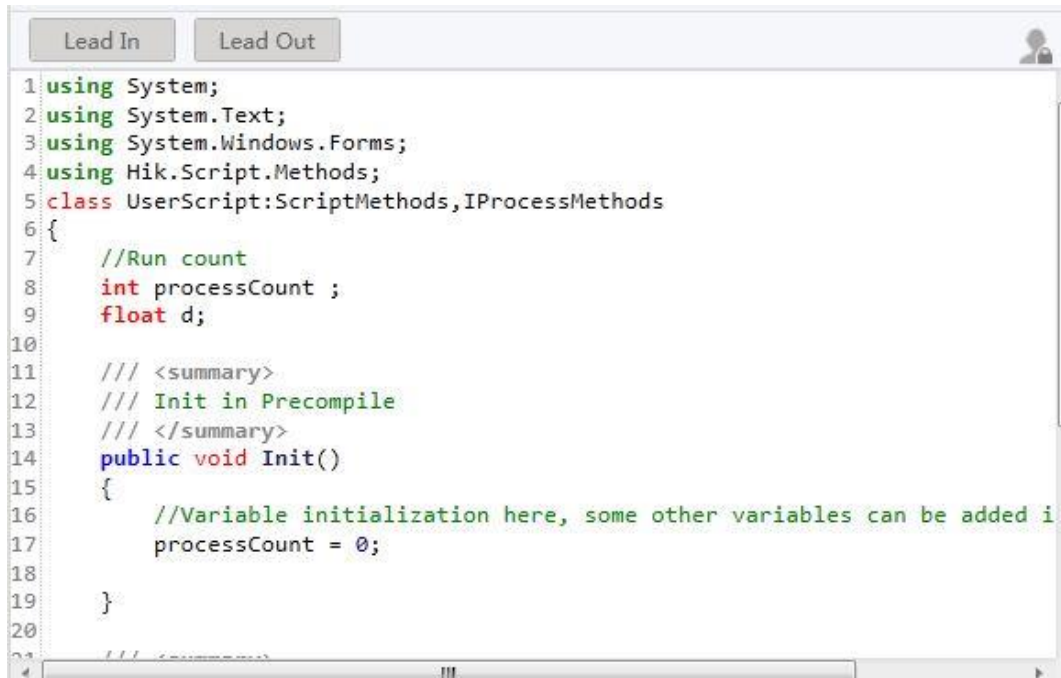
You can add new variable by clicking +. The variable has two types, including int and float. You can set value in original value, as shown below.
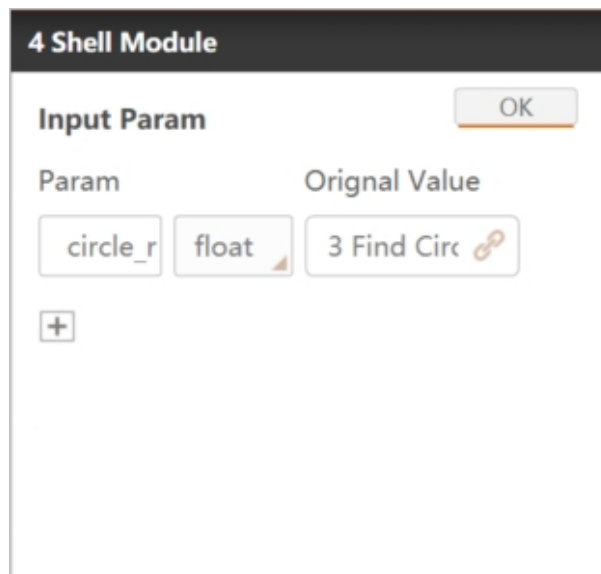
The main body of the script is divided into three parts, as shown below.

- The first part defines the global variable, and it only runs during first time. This solution should define an integer variable and a diameter variable, as shown below.
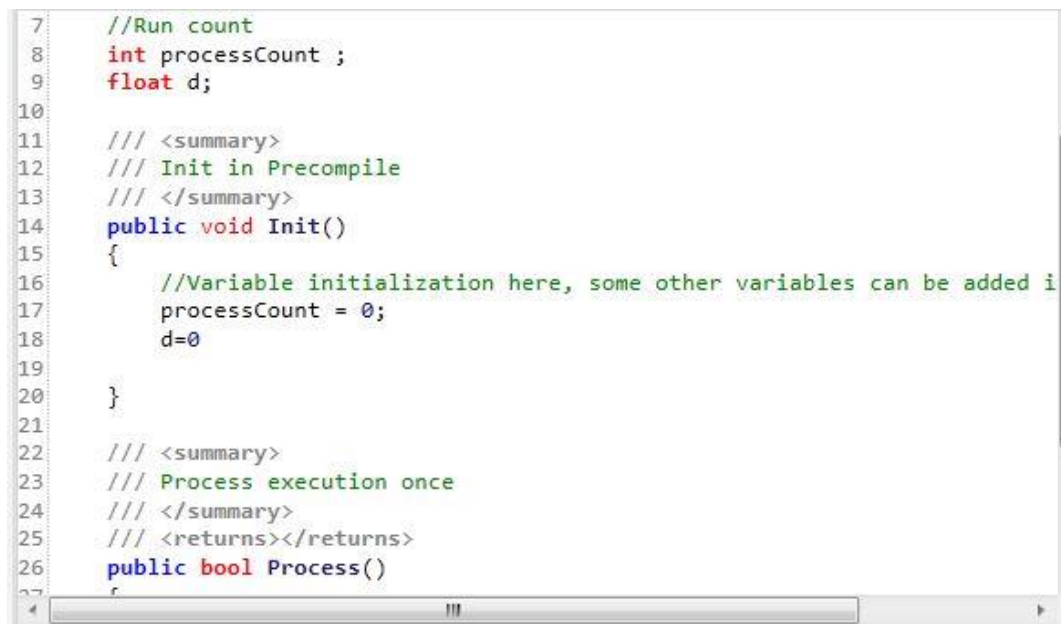
- The second part defines the initial variable, and it only runs during first time. This solution should define an initial integer variable and a diameter variable, as shown below.

- The third part defines the main function area, and user can edit according to its demands. The detailed code of this solution is shown below.

```
GetFloatValue("circle_r",ref circle_r);
circle_d = circle_r*2;

//Gained the diameter
SetFloatValue("circle_d",circle_d);

  return true;
}
```

5.6 Medicine Bottle Detection

Functional Requirement

A customer needs to conduct multiple tests on medicine bottles on site, as shown below.
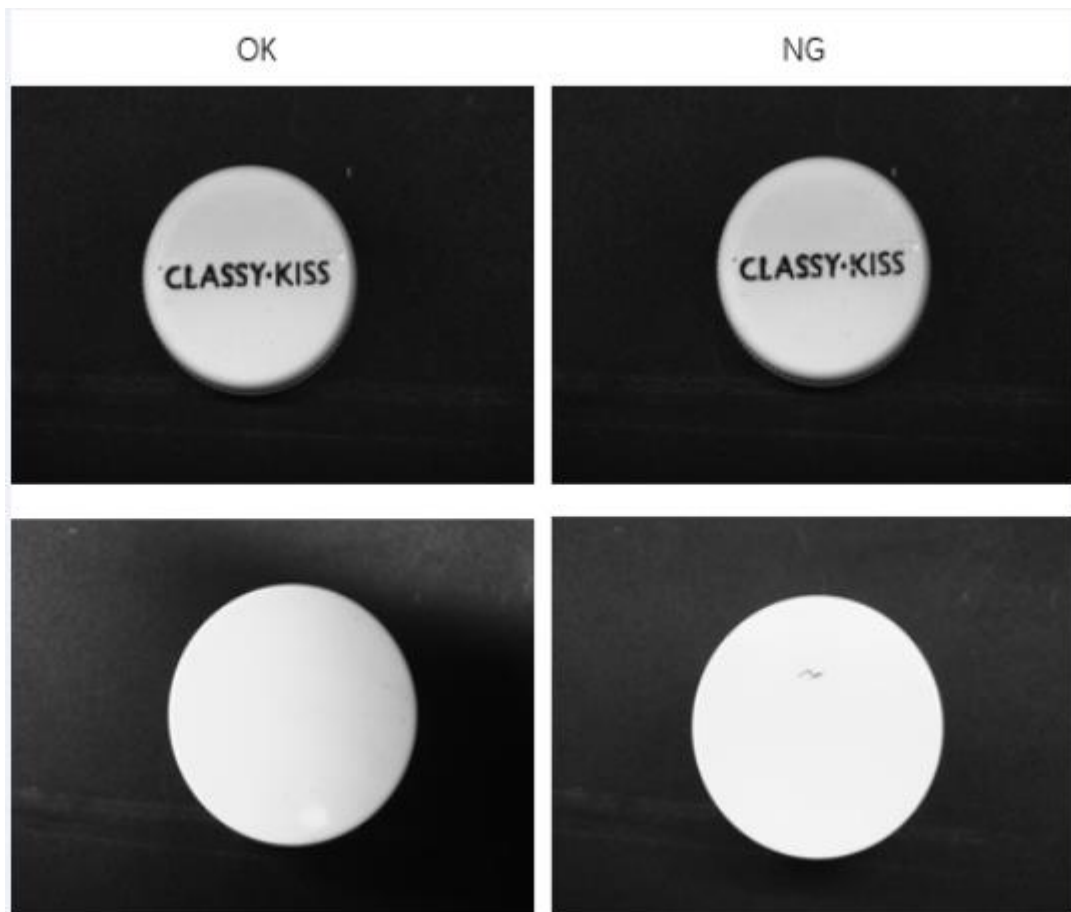
- Recognize the production date, expiration date, and product batch number printed on the bottle body.
- Check if the font on the bottle cap is defective, distorted, and the printing is qualified or not.
- Recognize the black stains and deformation at the bottom of the bottle.
- When the font on the bottle cap is unqualified or there is a stain on the bottom of the bottle, the IO signal will be output, and the unqualified products will be filtered.

Solution Design

- The information on the bottle body can be recognized by the tool of character recognition, and data can be integrated by formatting. But due to medicine bottles conveyed on site may be inclined, you can use feature matching and fixture tools to solve it.

- Regarding the problem of defective fonts on bottle cap, you can use defect detection tool.

- For stains on the bottle bottom, you can use image processing tool to deepen stains first, and then use the Blob tool to accurately locate them.

- The recognized information can be transmitted to the client's computer via network communication, and the unqualified medicine bottles can be converted into level signals via IO communication, and control external machines to remove unqualified bottles.

Bottle Body Detection

You can refer to following solutions to recognize the production date, expiration date, and product batch number printed on the bottle body.
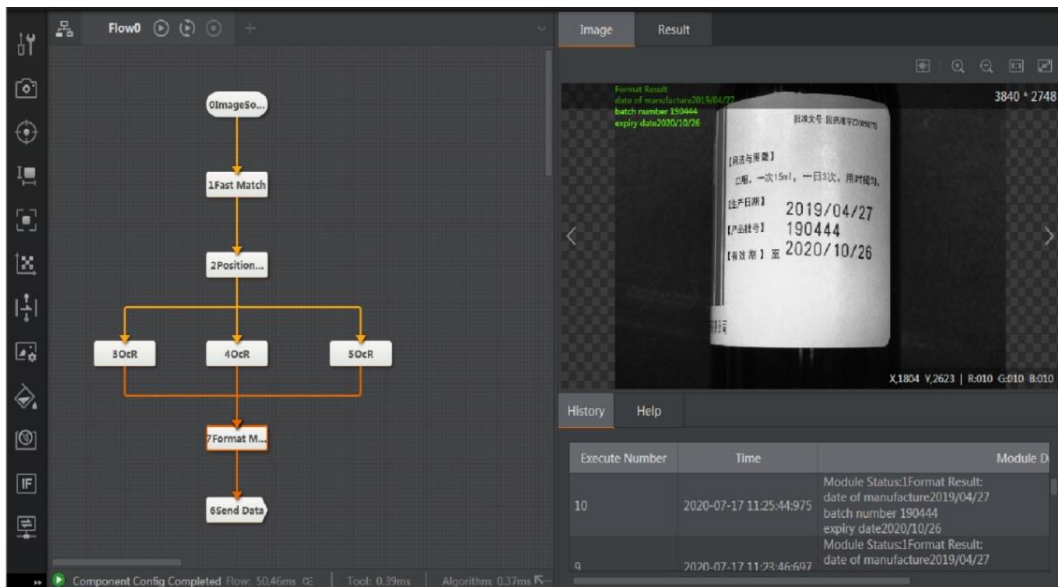
- Feature Matching + Fixture

It is used to assist imagedeviation. Generally, you need to set ROI first. But deviation may occur during the conveying process of bottles. Thus, you need to use both the feature matching tool and fixture tool. Refer to section Feature Matching and Position Correction for details.

- Character Recognition

One character recognition can only recognize one line of characters. For 3 recognition areas, you need use 3 character recognition flows. Refer to section OCR for details.

- Formatting

Before communication, you need to use formatting tool to integrate the output data and convert it to string type. Refer to section Format Module for details.
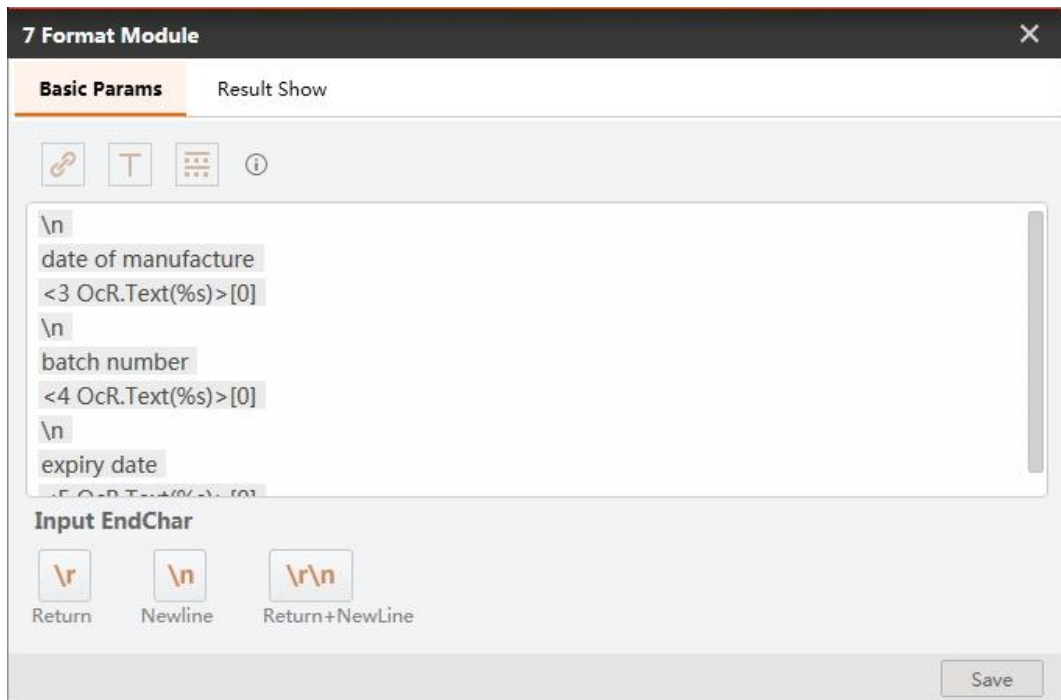
- Send Data

The role of sending data aims to send processed data to external device for statistics.

Bottle Cap Detection

You can refer to following solutions to check if the font on the bottle cap is defective, distorted, and the printing is qualified or not.
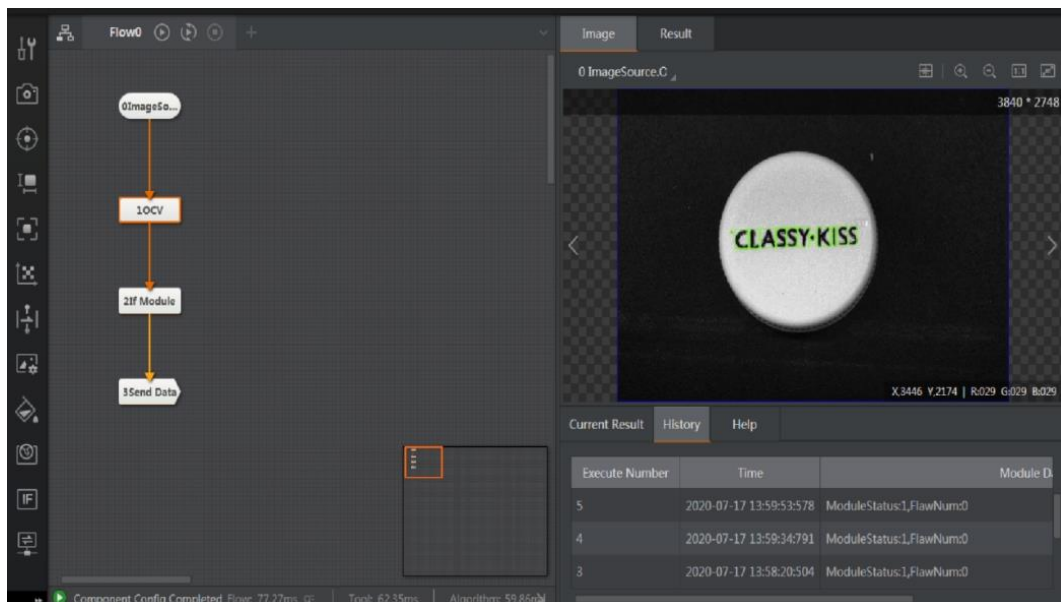
- Character Defect Section

Character training is required before executing character defect detection. The aim of the training is to put the OK model into the library for later comparison with NG images. You need to draw a ROI area first, and the area should be larger than the minimum circumscribed rectangle of the target string, otherwise training cannot be done. After selecting the ROI area, create a template in the character template, as shown below.
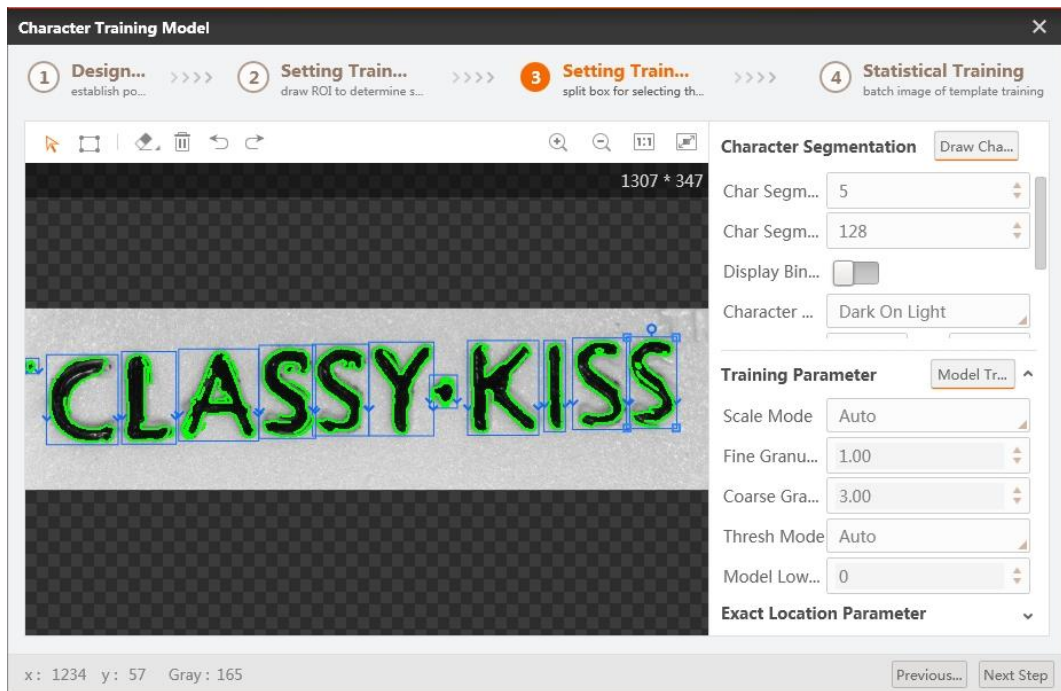
When the grayscale difference between the character and the background is small, it is recommended to enable binary image. When the font is inclined or the automatic segmentation is inaccurate, it is recommended to manually select characters and use default parameters for training parameters. After selection, click the training template to create character outline, and click next to enter the training interface as shown below.
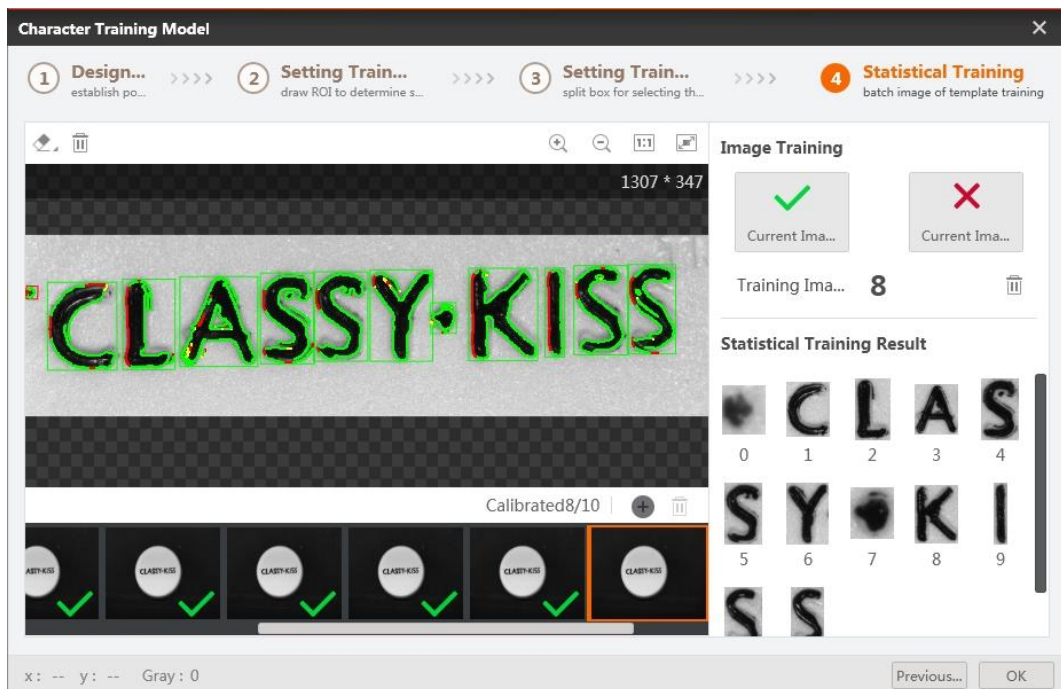
You need to train about 10 OK characters on the training interface. For NG images marked with red dots, you need to select "not count current image", and click OK to complete the training.

After the training is completed, the detection effect is verified and debugged. When the false detection occurs, you can refer to section OCV to adjust parameters.

- Condition Detection

Select int type data for conditional detection, and link with character defect detection number.

- Send Data

Send condition detection results to the data queue. For character defects on the bottle cap are not output separately, it is recommended to use data queue to integrate all defects to send the detection results of process 1 to the data queue.

Bottle Bottom Detection

You can refer to following solutions to recognize the black stains and deformation at the bottom of the bottle.
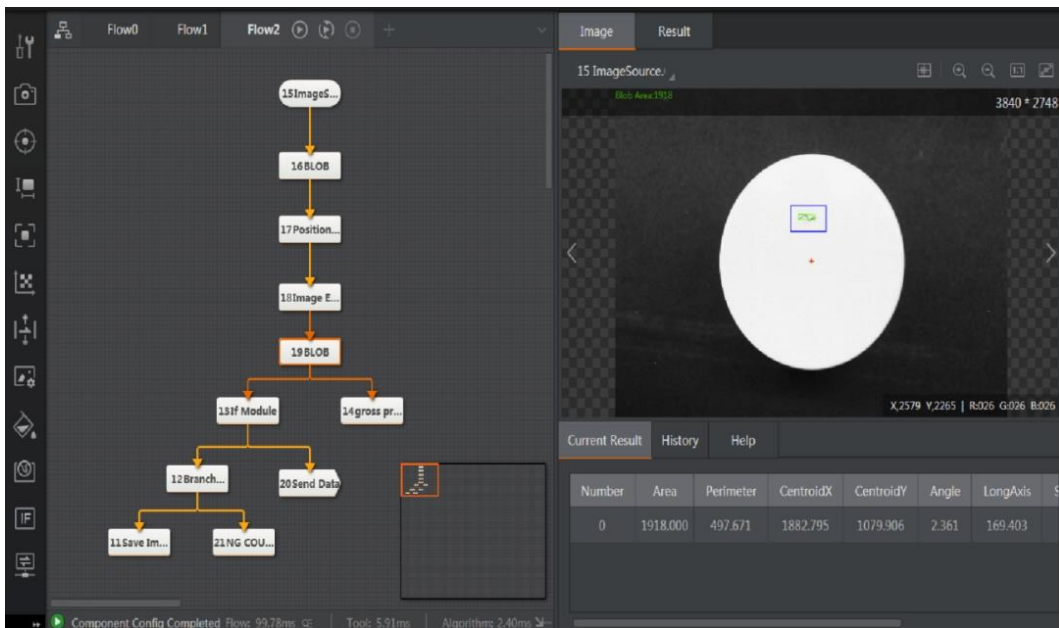
- Blob + Fixture

It is used to assist imagedeviation. The Blob can accurately find and locate the white bottle bottom. The function of Blob is similar to featuring matching tool, but here you need to detect and output the roundness of the bottle bottom, thus it is recommended to use Blob.

- Image Enhancement

The original image has low gray contrast, so image enhancement is used to make the contrast more obvious.

- Blob

This function is used to search image stains after image enhancement.

- Total Output

The variable calculation is used here, and the total output increases by 1 once the process is run.

- Condition Detection

It is used to detect the roundness of the bottle bottom.

- Send Data

Send detection results to the data queue, and integrate with results of bottle cap character detection.

- Branch Character

The branch character is used to control the execution of subsequent modules when the condition detection result is NG, including NG image saving and NG count accumulation, as shown below.

Results Output

You can refer to following to get detection results and send them to external machines via vision controller IO.
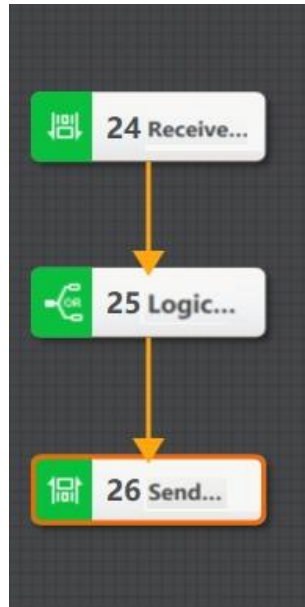
- Receive Data

Receiving data is used to receive the data in the data queue of queue0 and queue1.

- Logic

Link received data of var0 and var1 in logic tool. This means that the judgment result of the bottle cap and the bottle bottom.

- Send Data

The module of sending data is linked with the output of vision controller. Refer to section IO communication for details.

- Process timing control

Because the process 3 needs to receive the data sent by processes 1 and 2 , it is recommended to run process 3 after processes 1 and 2 are completed. At this time, use the global script to control the process running logic.

```
public void CheckWorkStatus(ImvsSdkPFDefine.IMVS_PF_MODULE_WORK_STAUS stWorkStatus)
{
    if(stWorkStatus.nProcessID==10001)
    {
        if(stWorkStatus.nWorkStatus == 1)
        {
            bProcess0RunOnce =1;
        }
        else if(stWorkStatus.nWorkStatus == 0)
        {
            if(bProcess0RunOnce == 1)
            {
                bProcess0RunOnce =2;
            }
        }
    }
    else if(stWorkStatus.nProcessID==10002)
    {
        if(stWorkStatus.nWorkStatus == 1)
        {
            bProcess1RunOnce =1;
        }
        else if(stWorkStatus.nWorkStatus == 0)
        {
            if(bProcess1RunOnce == 1)
            {
                bProcess1RunOnce =2;
            }
        }
    }

    if(bProcess0RunOnce == 2 && bProcess1RunOnce == 2)
    {
        Task.Run(()=>{
            ImvsPlatformSDK_API.IMVS_PF_ExecuteOnce_V30_CS(m_operateHandle,10003,null);
         });

        bProcess0RunOnce = 0;
        bProcess1RunOnce = 0;
    }
}
```

Detection Results

Finally, detection results and related information will be displayed on the operating interface, as shown below.
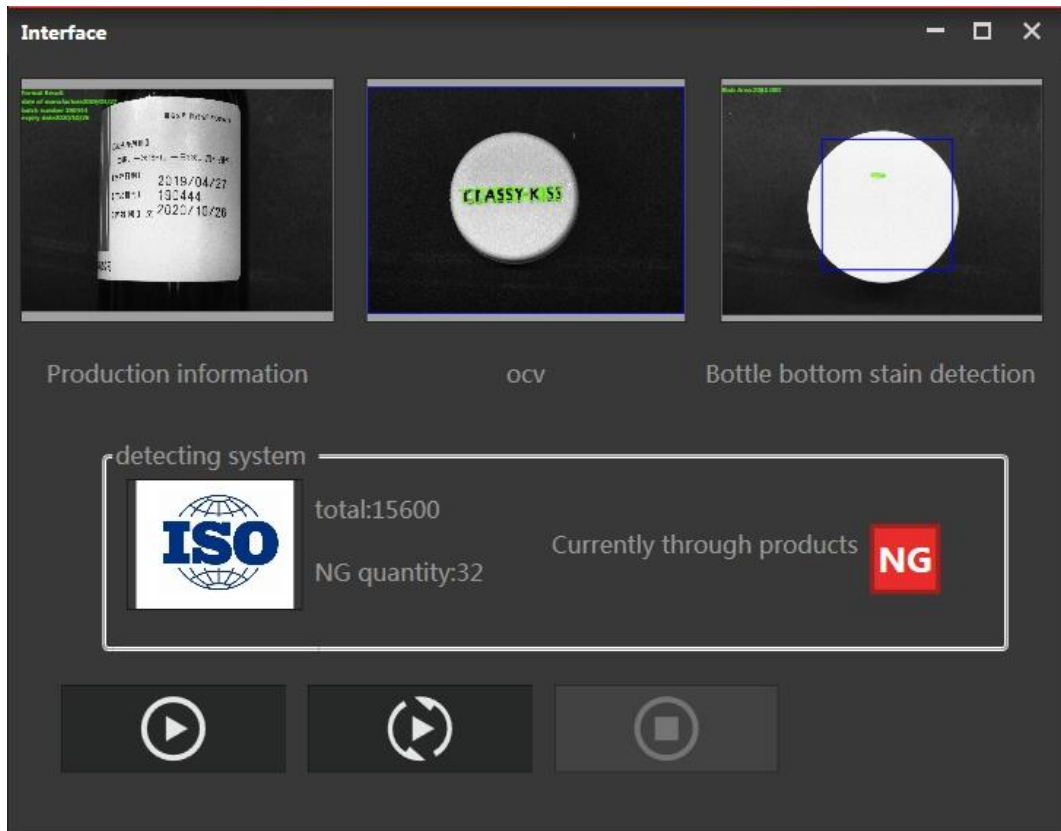
5.7 **Multi-Flow Communication**

Steps:

1. Judge the quantity of the three different samples and send the judgment result. The flow 1 in the figure below is to detect the quantity of lamps. If there is a missing one, it is unqualified.
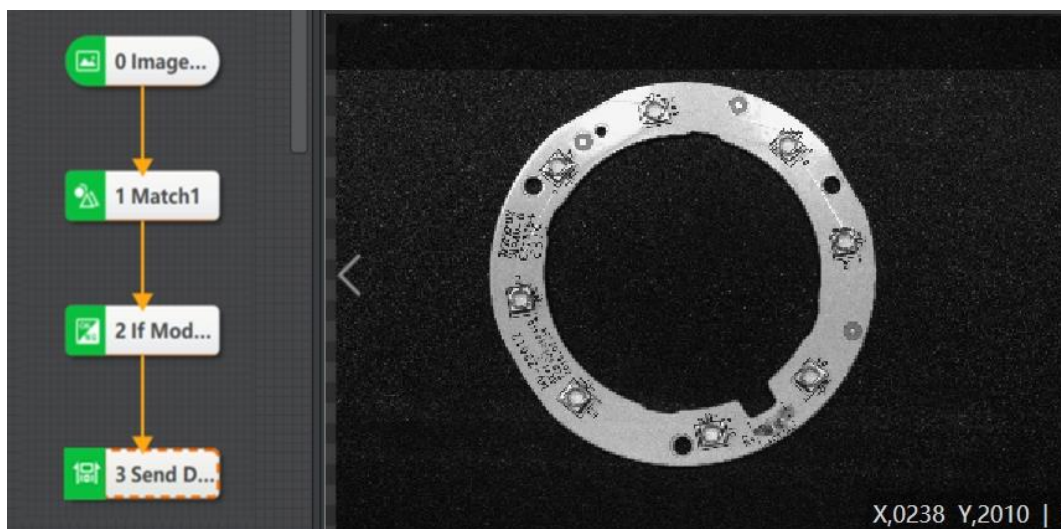
2. In order to combine these three detection results, you can send the judgment result to the data queue. Click ![icon] to enter the main flow, and set up the corresponding data queues here, as shown below.
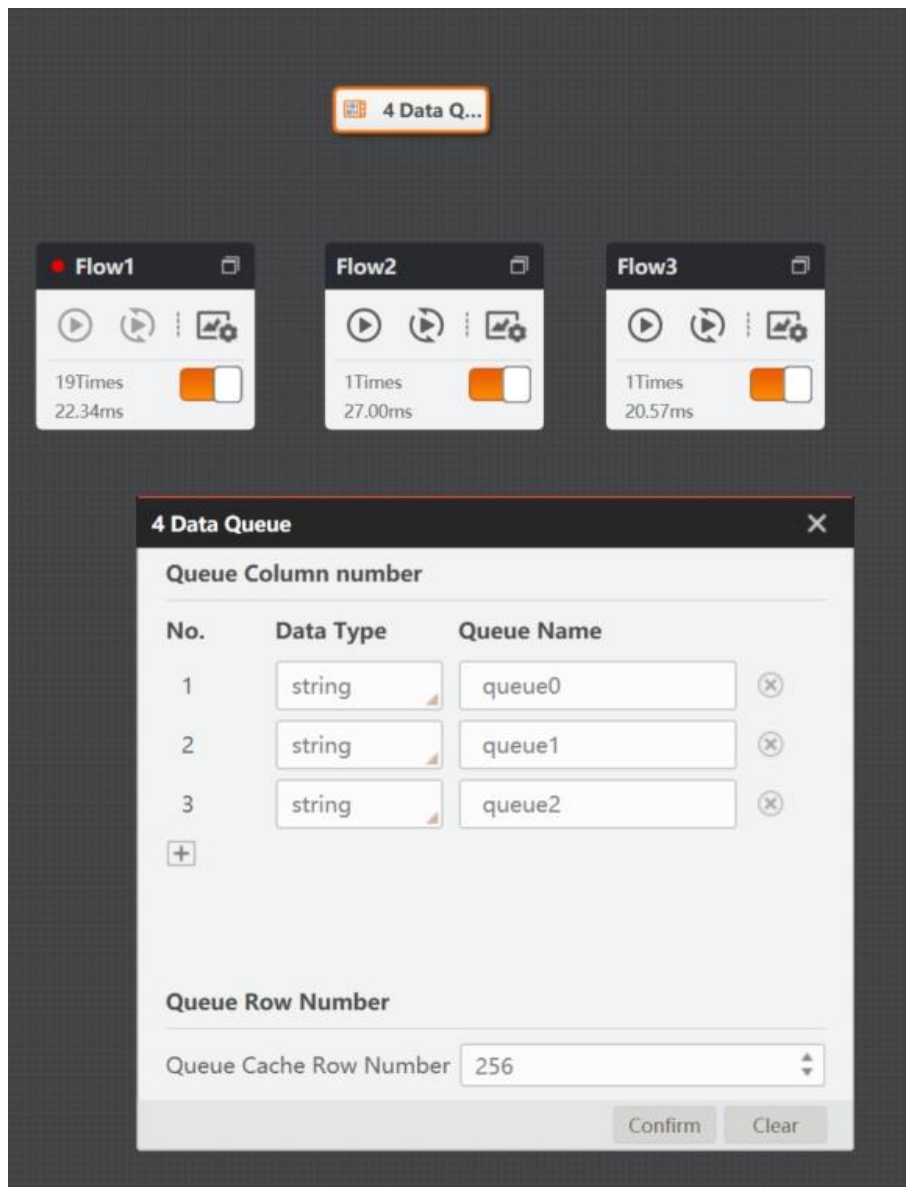
3. View the cache of the data queue in the history result.

4. Through the receiving data module, the flow can get the value of the data queue, and perform operation.
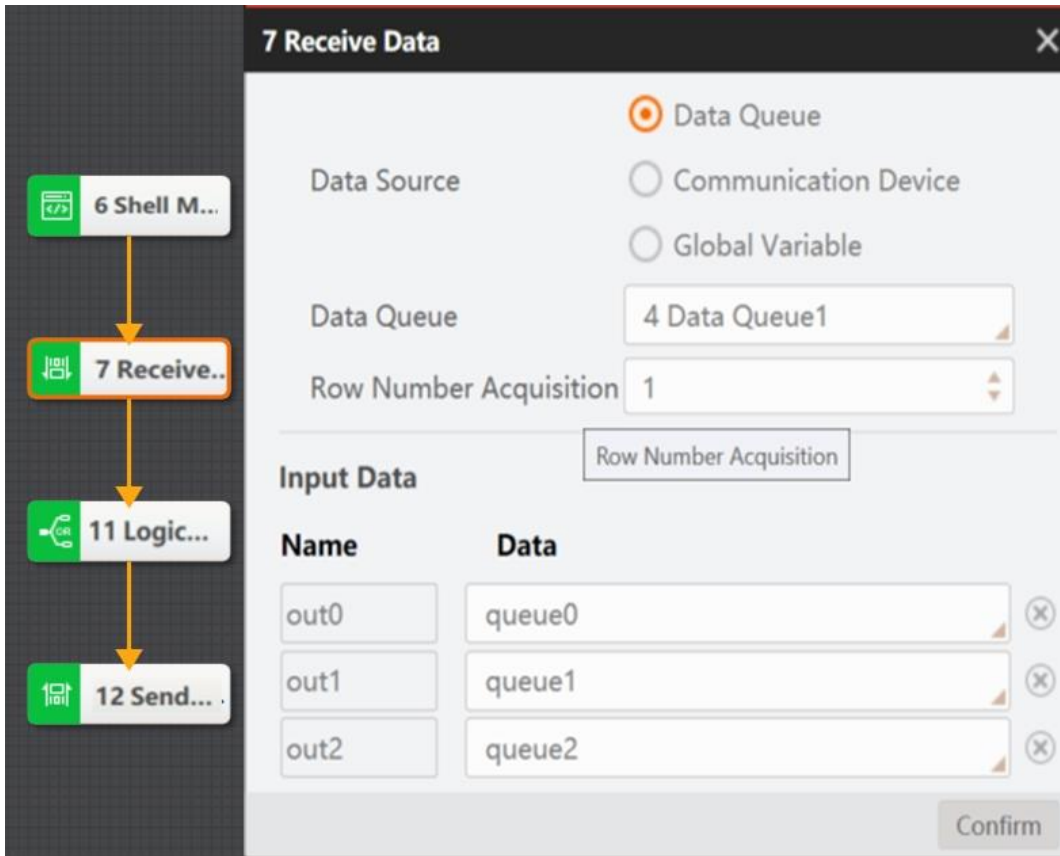
📖NOTE

- The script here acts as a delay because the data queue follows the principle of first-in-first-out and the data can only be taken out when the number in a row is full. Make sure that flows before the receiving data module has operated.

When the software trigger is selected and the global operation is performed in a single time, the solution can achieve the expected output, but if the hardware trigger is selected to trigger the flow 1, flow 2, and flow 3, and flow 4 cannot be triggered for receiving data. At this time, you can choose to use global variable.
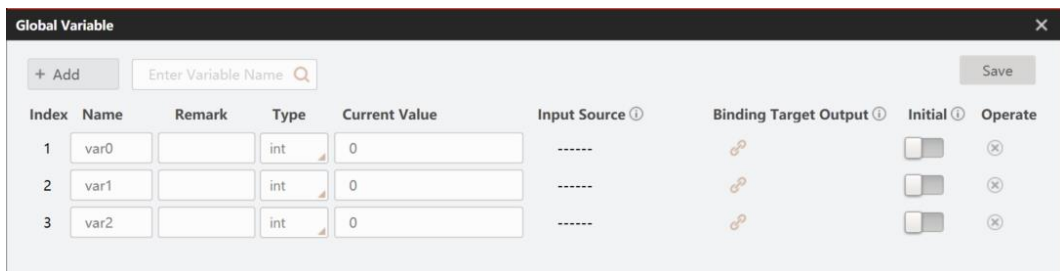
5. Flow 1, flow 2 and flow 3 send data to the global variable.

6. The result of global variables can be received at the end of any flow and the corresponding logical operations should be performed, but the timing must be controlled to ensure that the data is retrieved when all global variables receive values.

7. Finally, perform a logical and operation on all the received data, and output the result of the operation to a third-party device through TCP communication.

5.8 Communication Trigger Flow

Different bytes are used to trigger various processes via the established TCP communication. If the first two digits of the sent data are 0100, the flow 1 will be triggered. If the last two digits of the sent data are 0100, the flow 2 will be triggered. If the sent data is 01000100, two flows (flow 1 and flow 2) will be triggered, and a message will be returned by sending an event.

Solution:

- Establish two flows, namely, flow 1 and flow2.
- Establish TCP connection, and test if the connection is normal.
- Establish the received event according to actual demands.
- Configure the global trigger.

Steps:

8. Establish flow 1 and flow 2.

   The solution of flow 1 is shown below.

The solution of flow 2 is shown below.
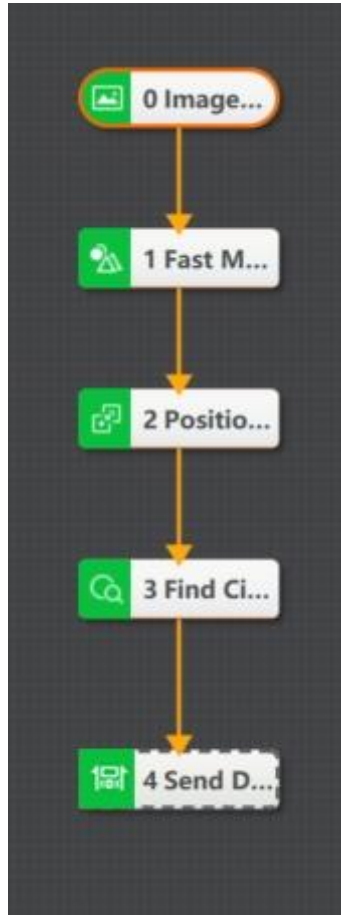
9. Establish TCP connection
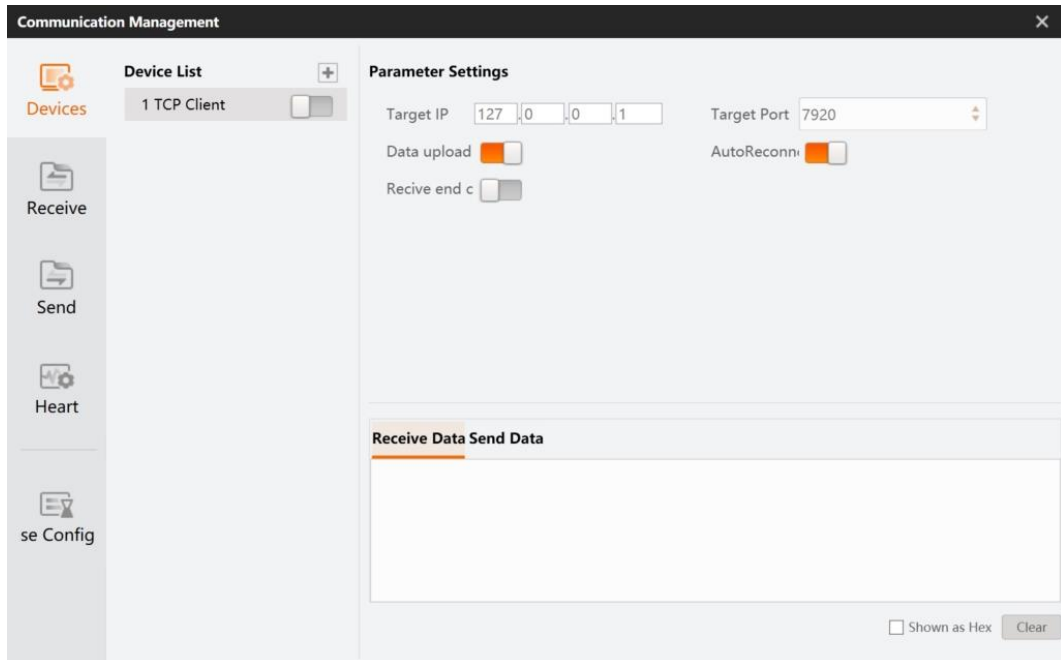
10. Establish two receiving events of byte match-protocol assembly. 0 byte match-protocol assembly trigger flow 1 and 1 byte match-protocol assembly trigger flow 2. The specific parameter settings are shown below.
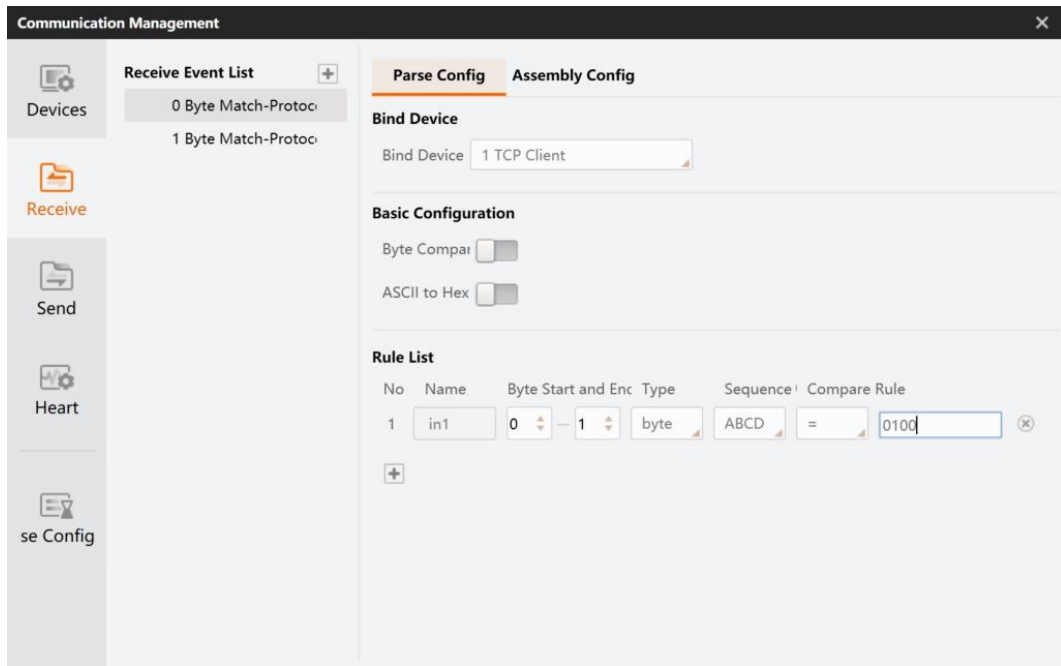
In the assembly configuration interface, the software can return the received data to the device.
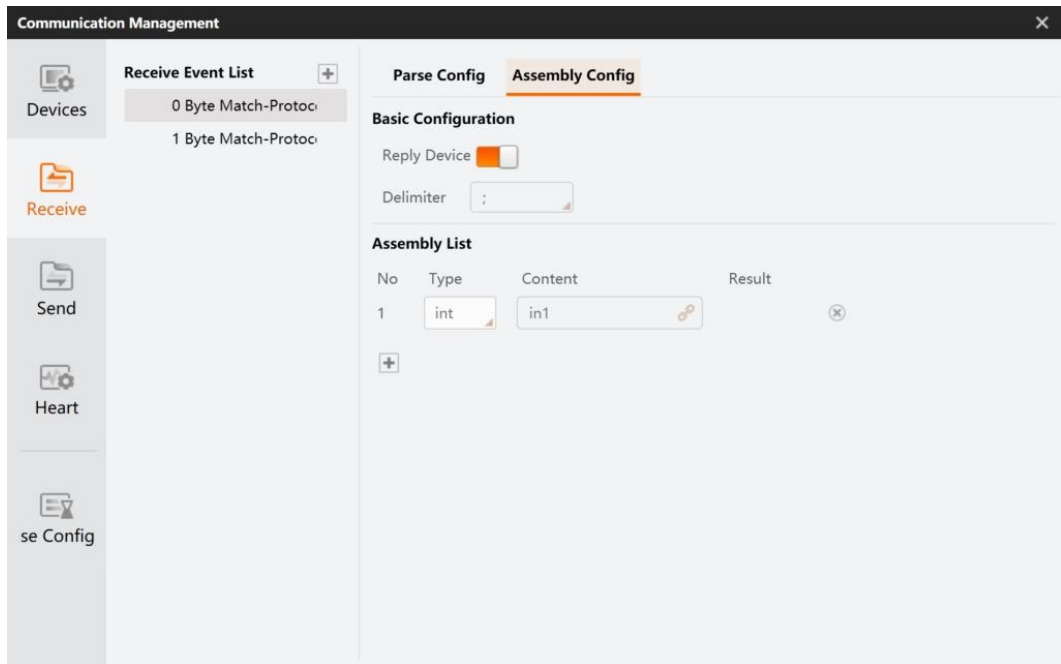
11. Configure the sending event. This module can send data via sending event, as shown below.
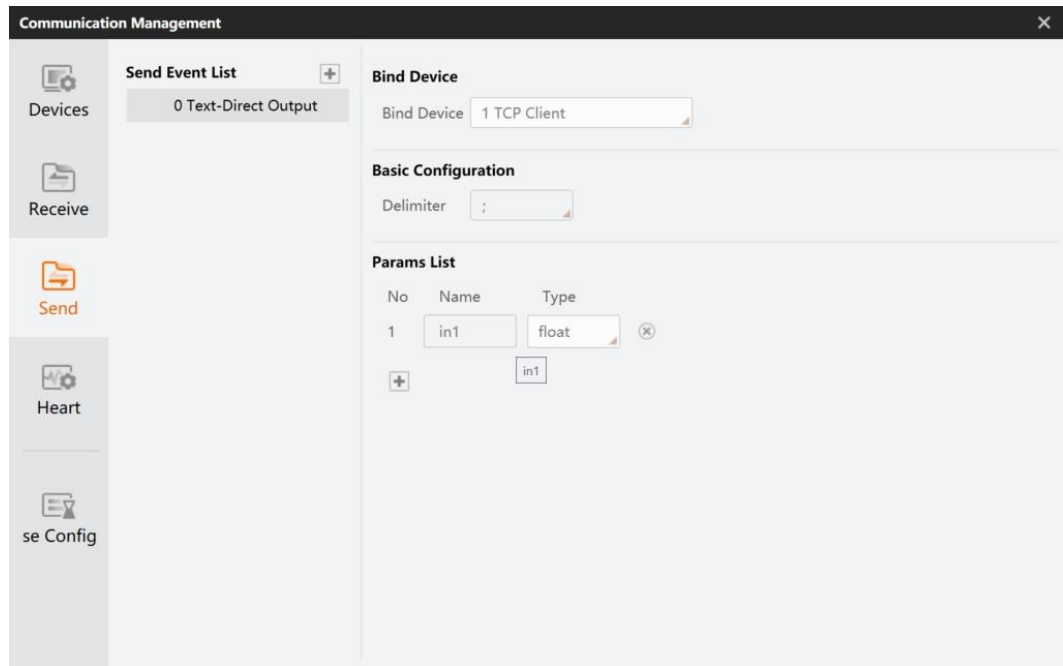
12. Configure the global trigger parameters.

13. Send communication data 01000000 to trigger flow 1 and send communication data 00000100 to trigger flow 2. After triggering, the software will send required data to the device via sending event.

6. **Dobot Magician Demo**

The demos in this chapter need to be used with Dobot Magician. For installation of Dobot Magician, see relevant manuals on Magician.

6.1 **Robot Calibration**

Objective: Make calibration files by calibration tools.

Step 1 Overall solution flow.
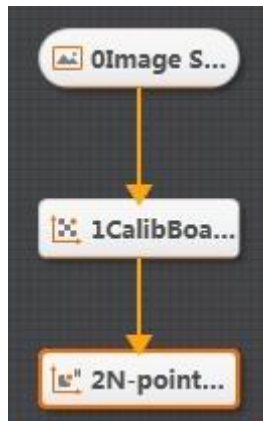
Step 2 Set camera.

1. Click **Camera**, as shown below. Select a camera, and set **Pixel Format** to **MONO8**. You can adjust the brightness of camera by adjusting aperture, exposure-time and light, if the photograph is not bright enough. Set **Trigger Source** to **SOFTWARE** in **Trigger Settings**.
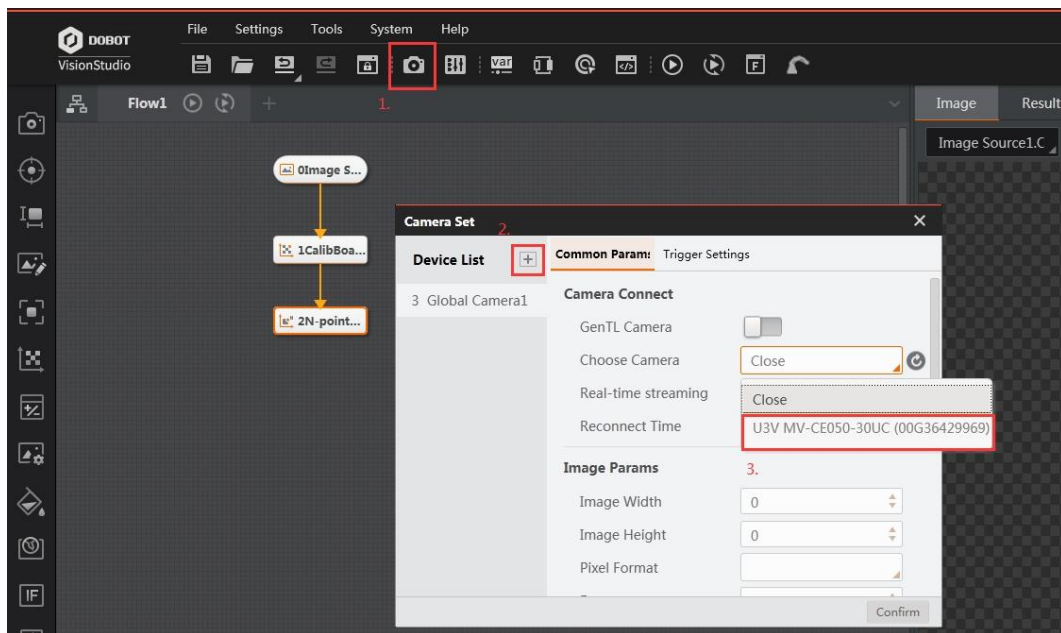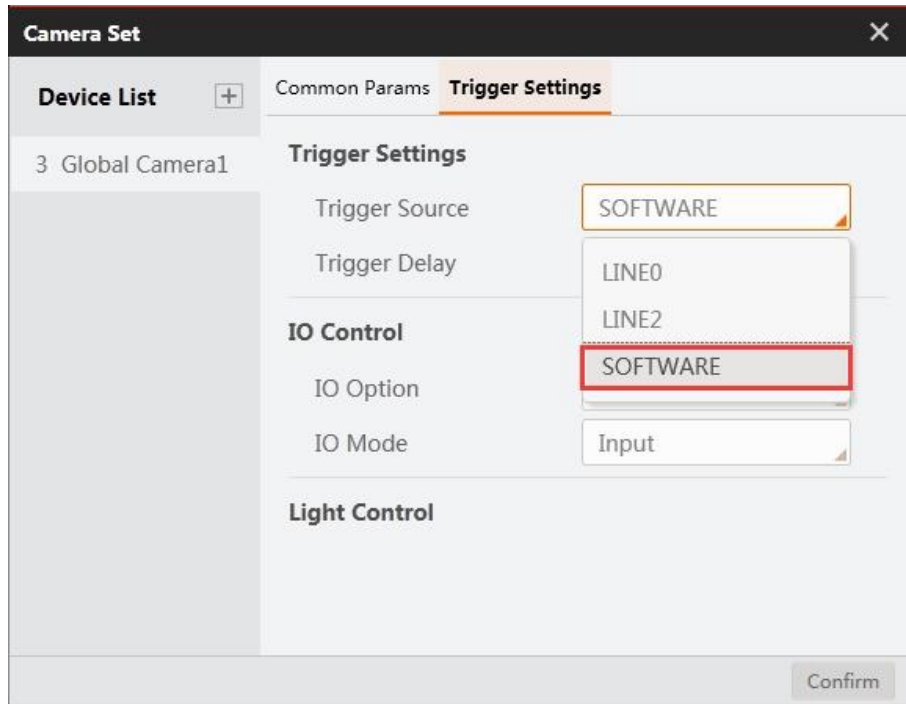
2. Click **Image Source** module. Set **Image Source** to **Camera**, and set **Relate Camera** to the global camera that you set above.
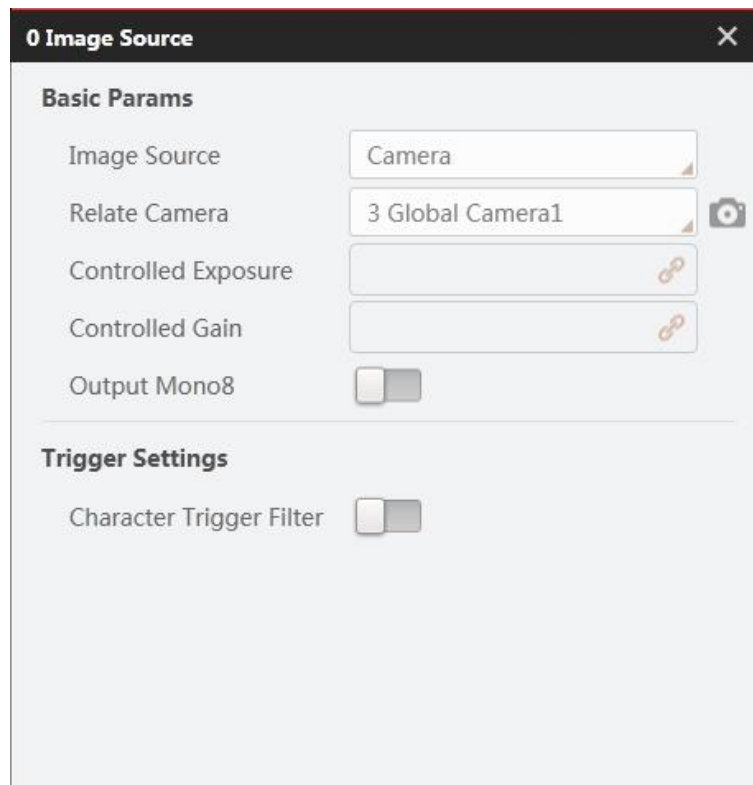
Step 3   Output image.

You can get an image by clicking ⊙ or a series of images by clicking ⊙ in **SOFTWARE** mode. Meanwhile, you can adjust parameters based on site requirements. An image is shown below.
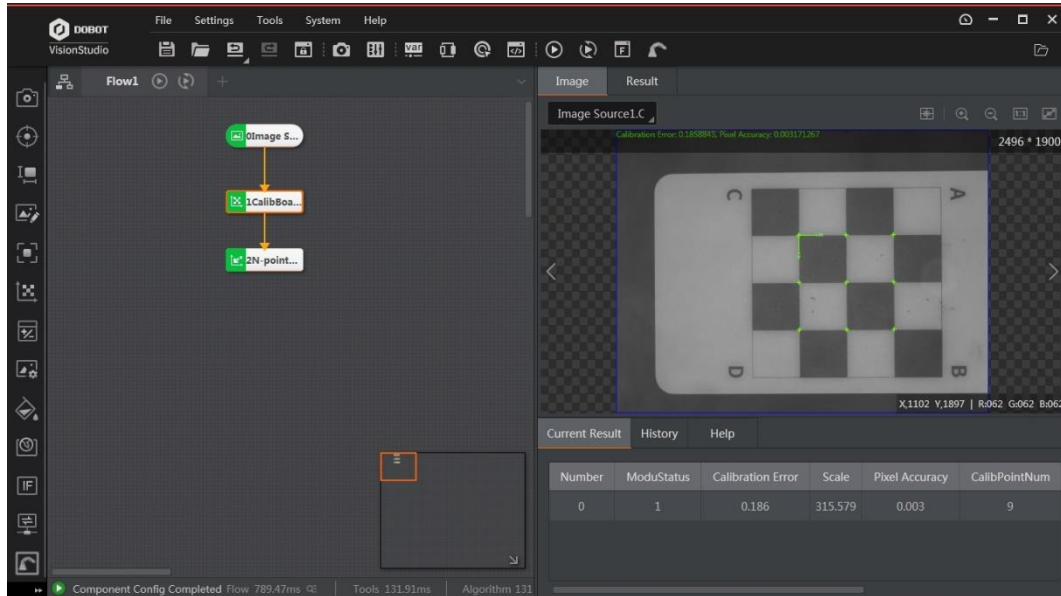
Step 4   Set calibration plate.

Set **Input Source** to **Input Source.ImageData. Set Calibration Board Type** to **Checkboard Calibration Board.** Then click **Confirm**.
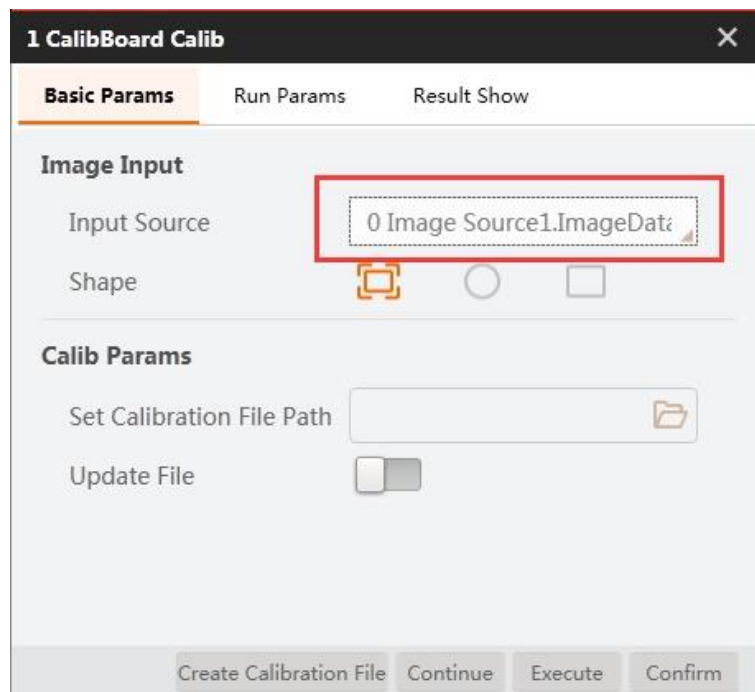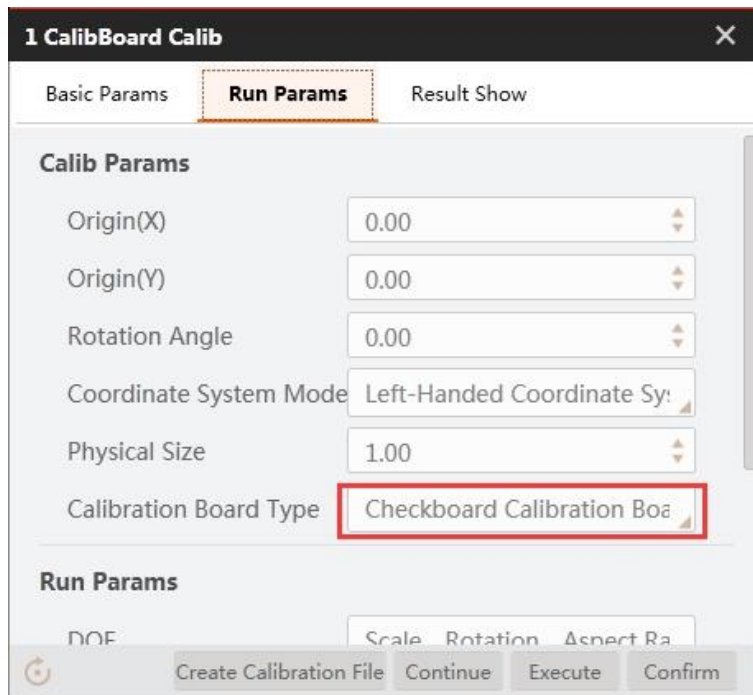
Step 5   N-point calibration.

1.   Set **Translation Number** to 9. Click to get image, as shown below. Calibrate 9 points in the order of the green arrow shown in the figure below.
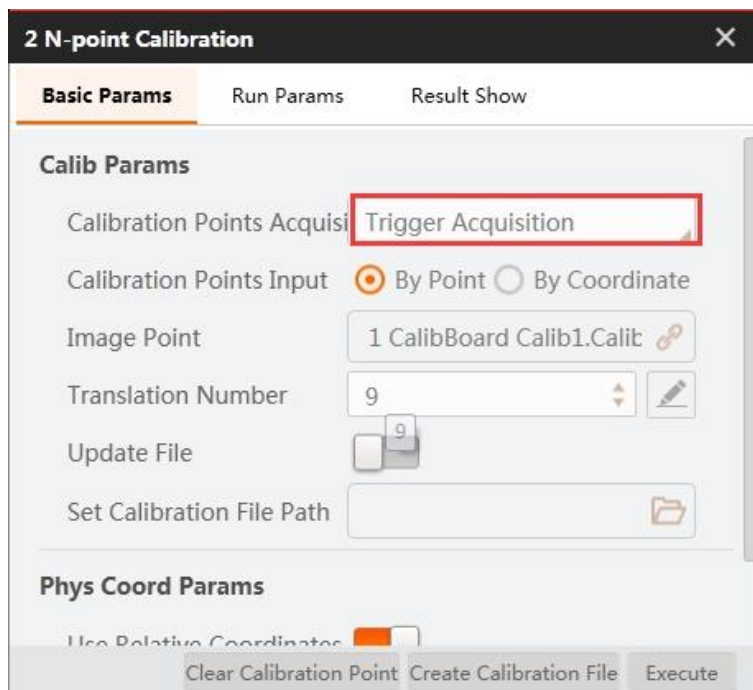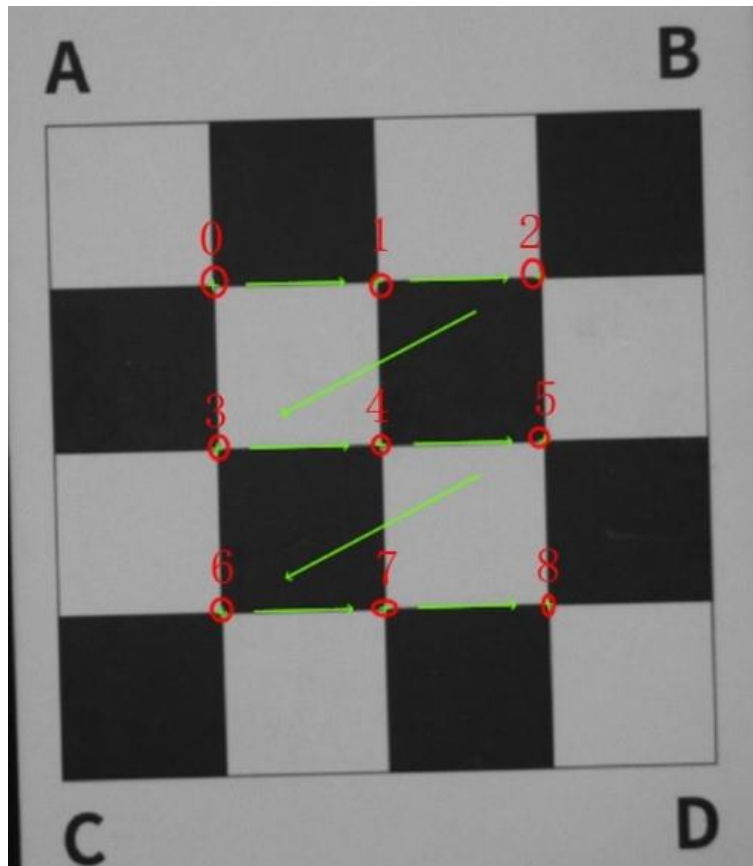
2. Click [icon] on the toolbar to open DobotStudio. Choose Magician and click **Connect**. Set **Pen** as the end-effector of Magician.
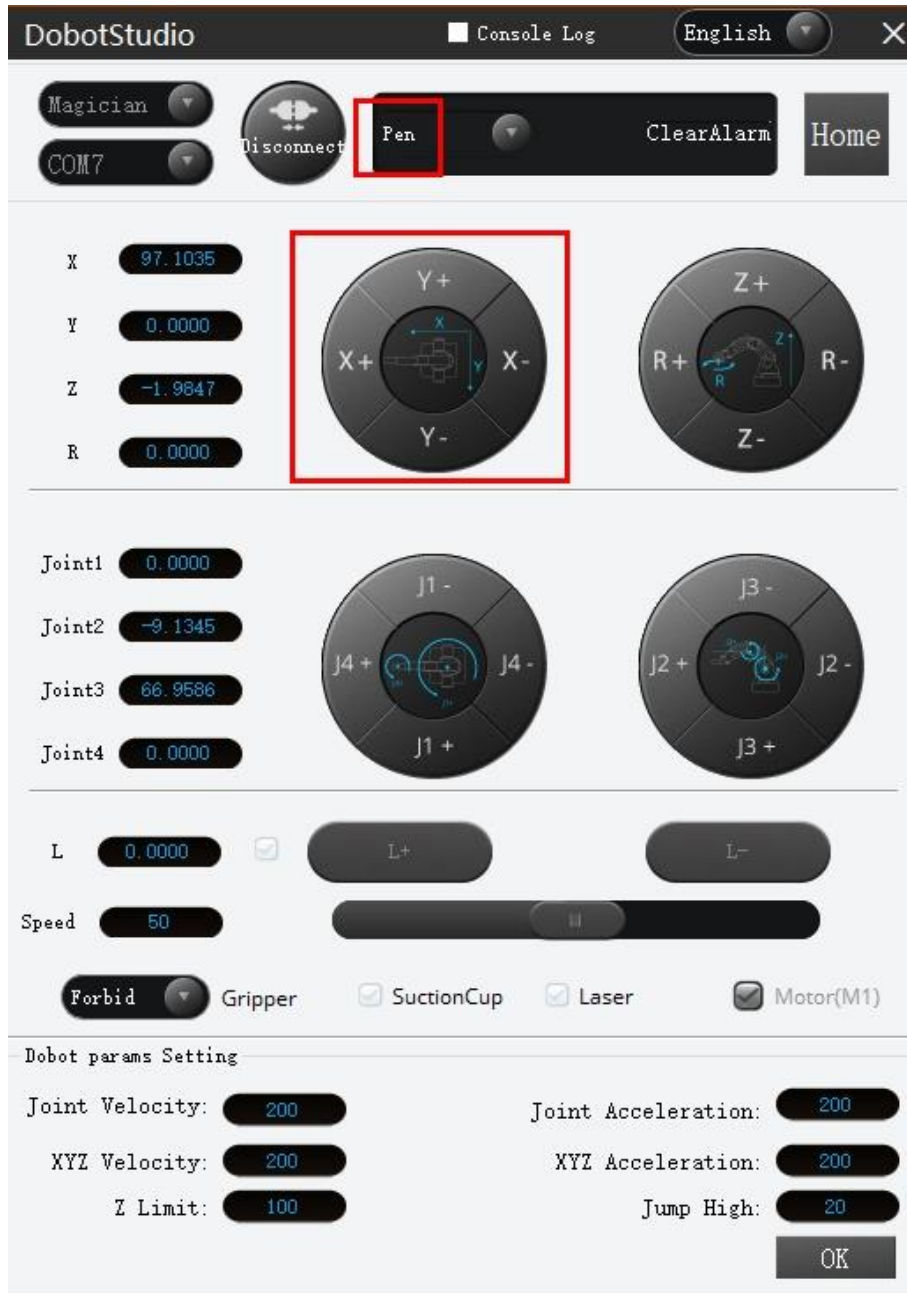
3. Jog X-axis and Y-axis on DobotStudio to make the pen move to the nine points in the order of the green arrow which is shown above. Write down every point value according to the corresponding ID on **Edit Calibration Points** page. You can click on the right side to directly acquire the current X coordinate and Y coordinate, or manually input the coordinates. Then click **Confirm**.
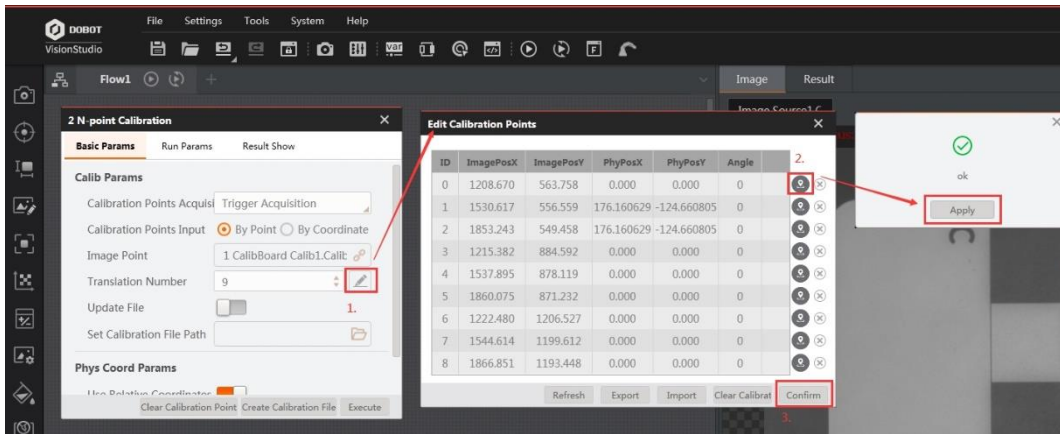
4. Click **Create Calibration File** to save the calibration file.
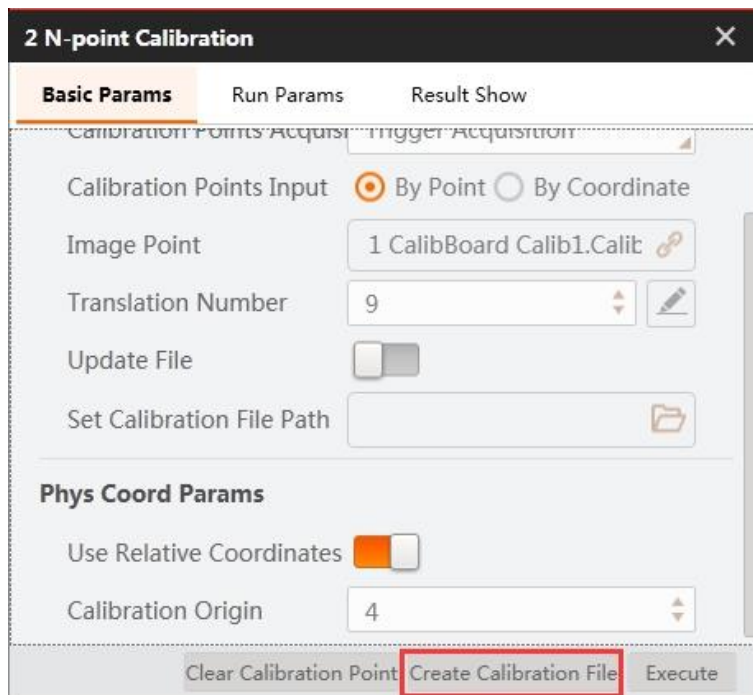
📖NOTE

• The calibration file will be used in the following demos. If the relative position between camera and Magician is changed or Magician loses steps, you have to create the calibration file again.

6.2 Color Sorting

Objective: Detect the color of blocks and sort them, as shown below.

📖NOTE

• Calibration file needs to be generated beforehand.
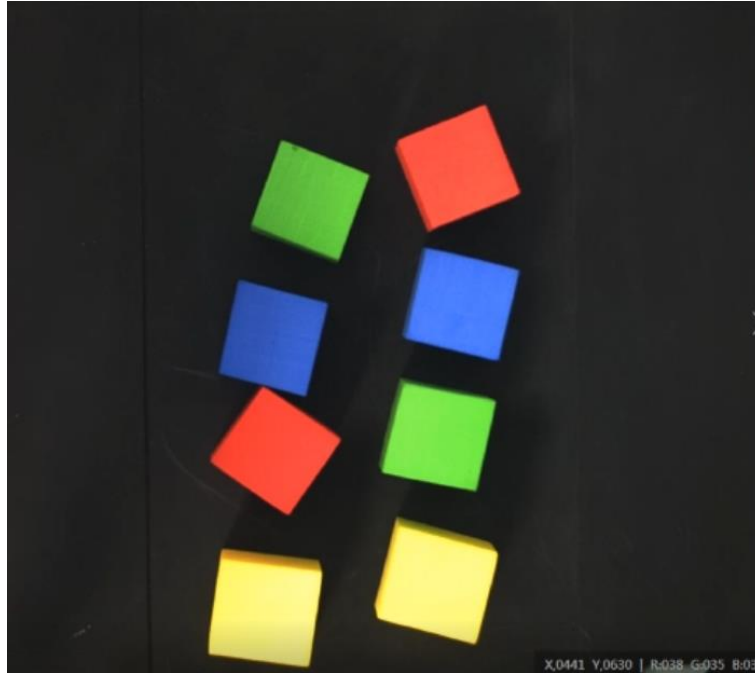
Step 1 Solution establishment idea.

- Extract the sorted color in the camera image, and sort corresponding blocks according to color.

- Convert image coordinate to physical coordinate according to the calibration file.

- Sort the specified color blocks by Dobot Magician.

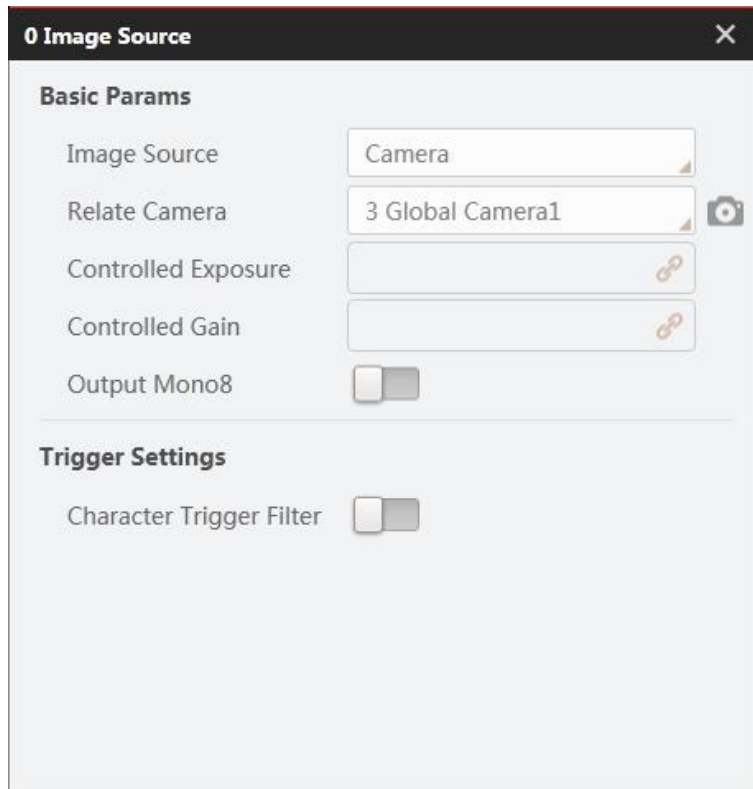The overall solution flow is shown below.

Step 2 Set camera.

1. Click **Camera**, as shown below. Select a camera, and set **Pixel Format** to **RGB 8**. You can adjust the brightness of camera by adjusting aperture, exposure-time and light, if the photograph is not bright enough. Set **Trigger Source** to **SOFTWARE** in **Trigger Settings**.
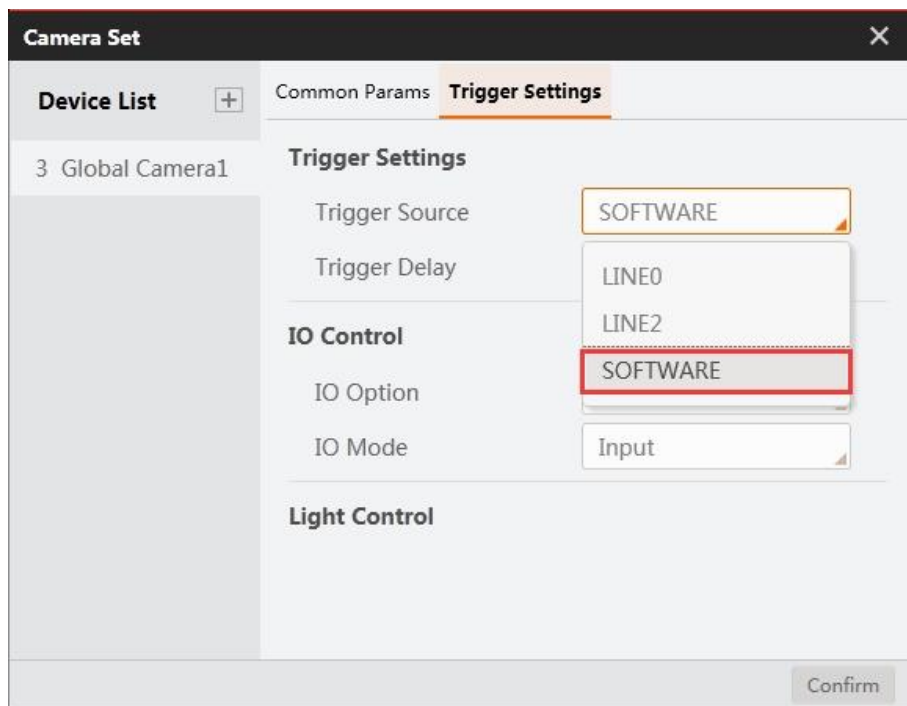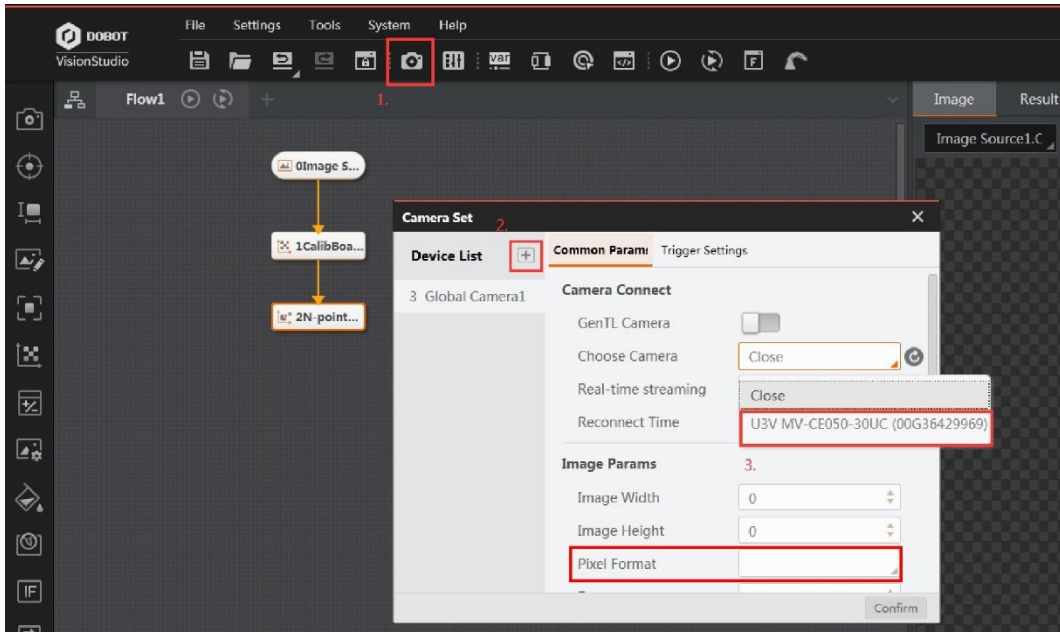
2. Click **Image Source**, as shown below. Select **Camera** as **Image source**. Select the global camera device that you set above as **Relate Camera**.
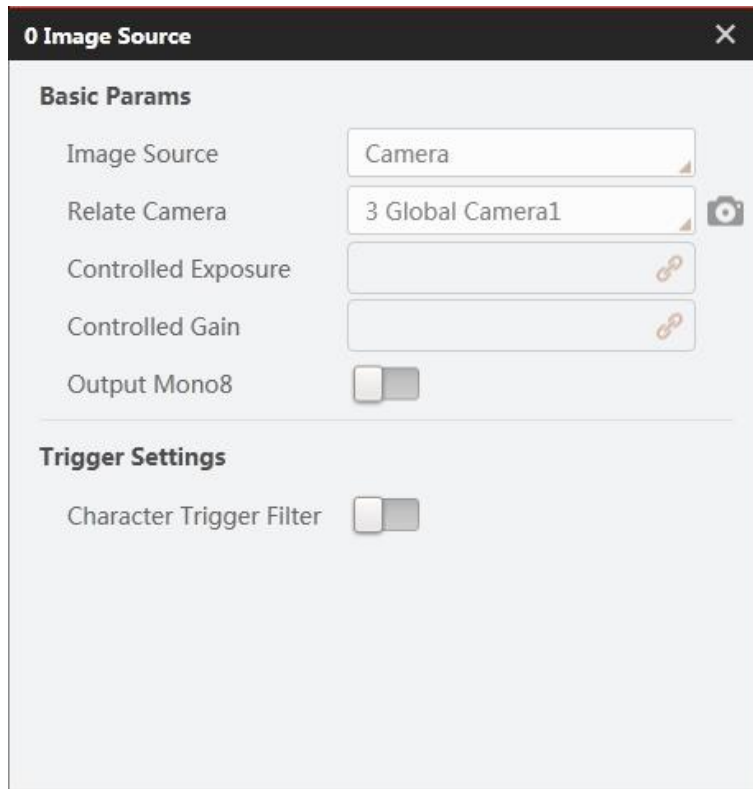
Step 3 Extract color.

Refer to Color Extraction. Take red as an example. Set **Color Space** to **RGB**, and set the value of every channel. Extract the specified color and output an image.
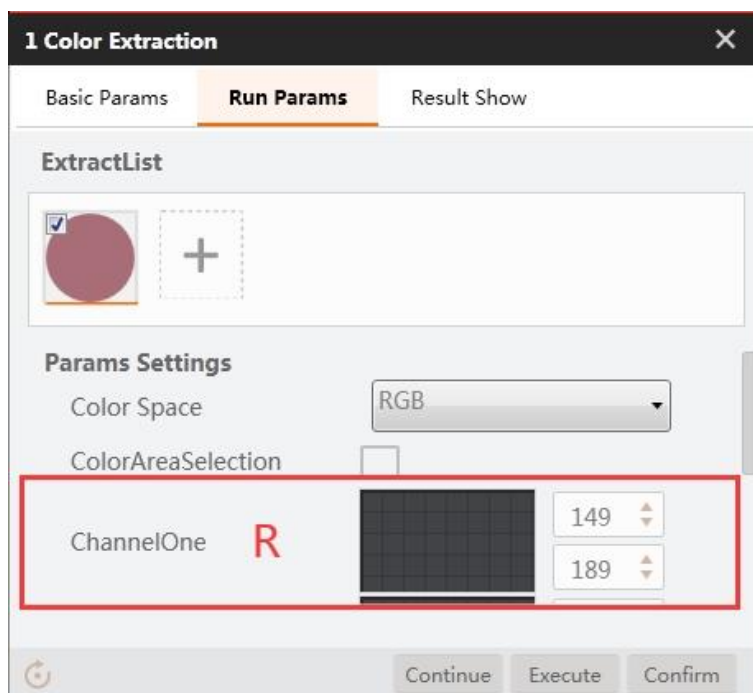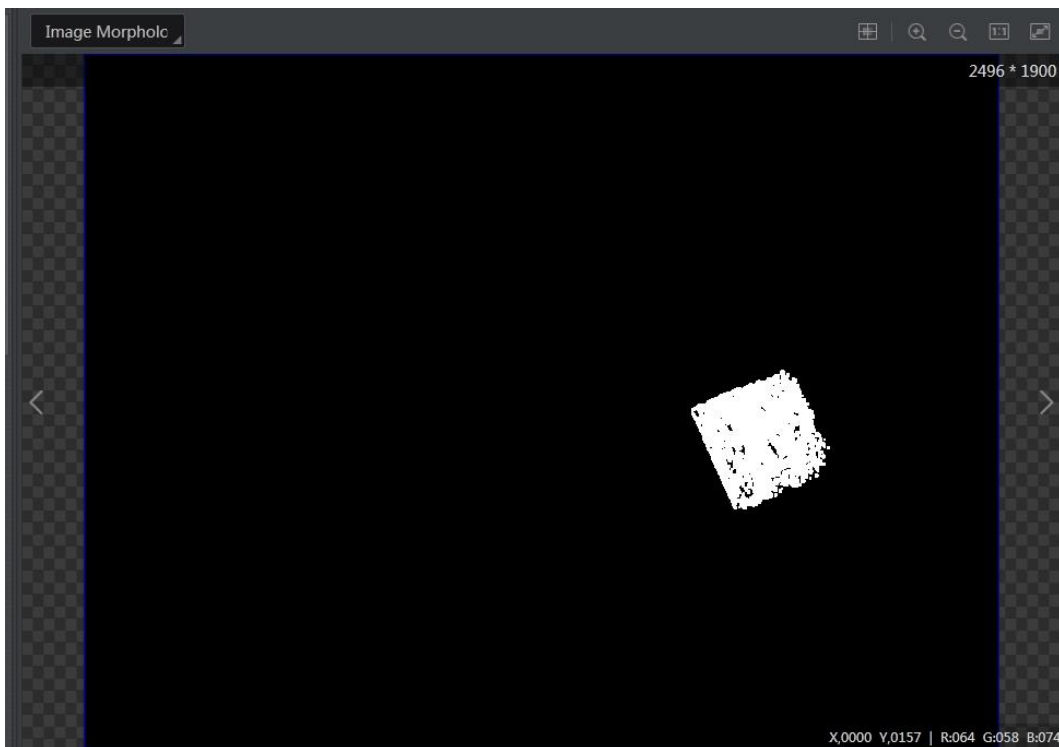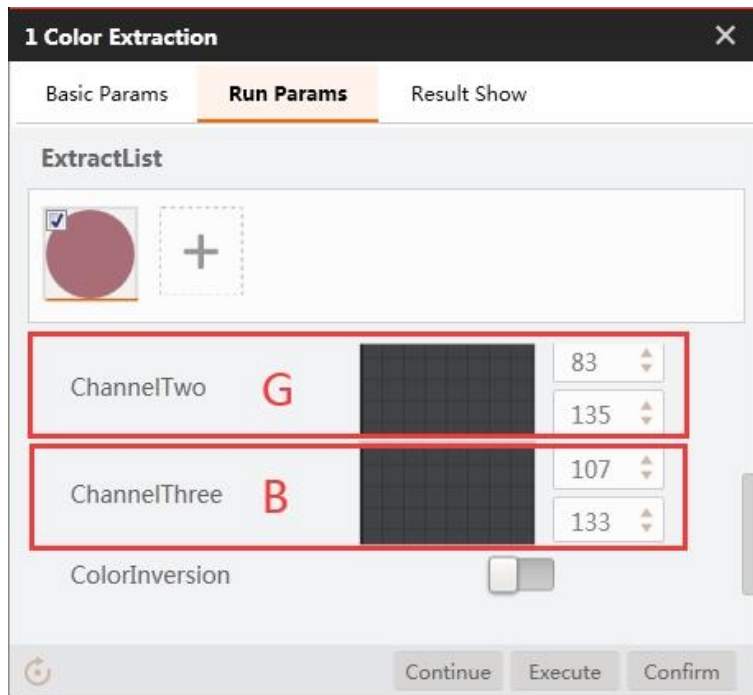
☐NOTE

- You can get RGB channel values by moving the mouse on the block in color that you want to sort. The values are shown in the right lower corner of the page.
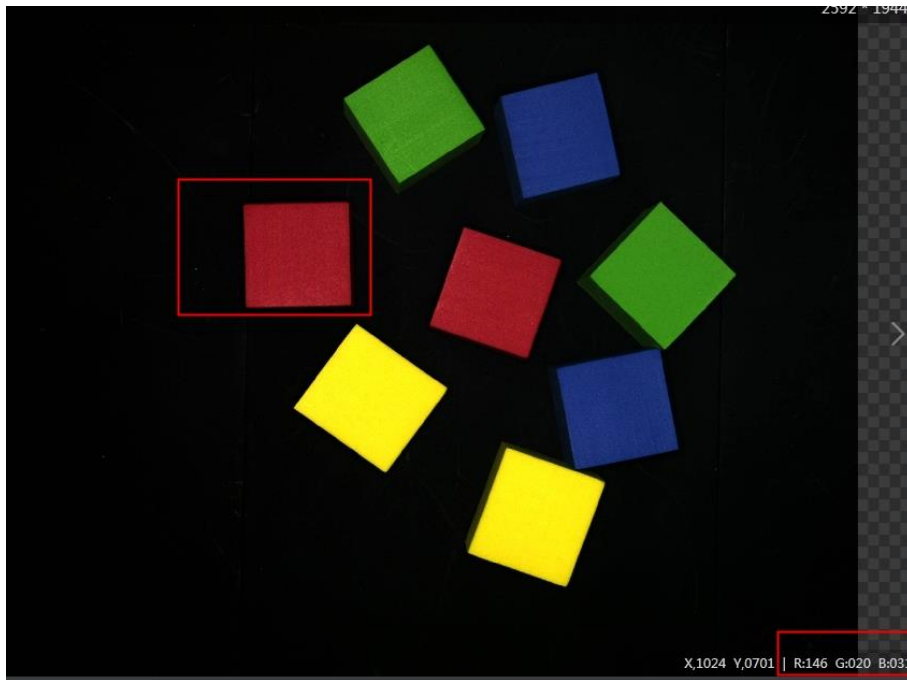
Step 4 Image morph.

1. Set **Input Source** to the image that you want to use, and set **ROI Creation** to **Draw.** Click **Confirm**.
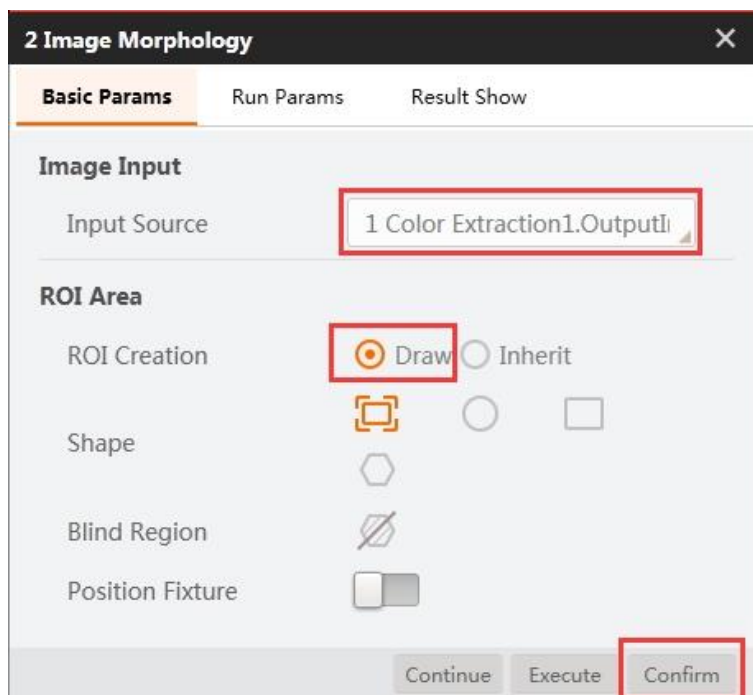
2. Set **Morphology Type** based on site requirements (Set it to **Dilation** in the demo). Set **Structuring Element** to **Rect**, then click **Confirm**.
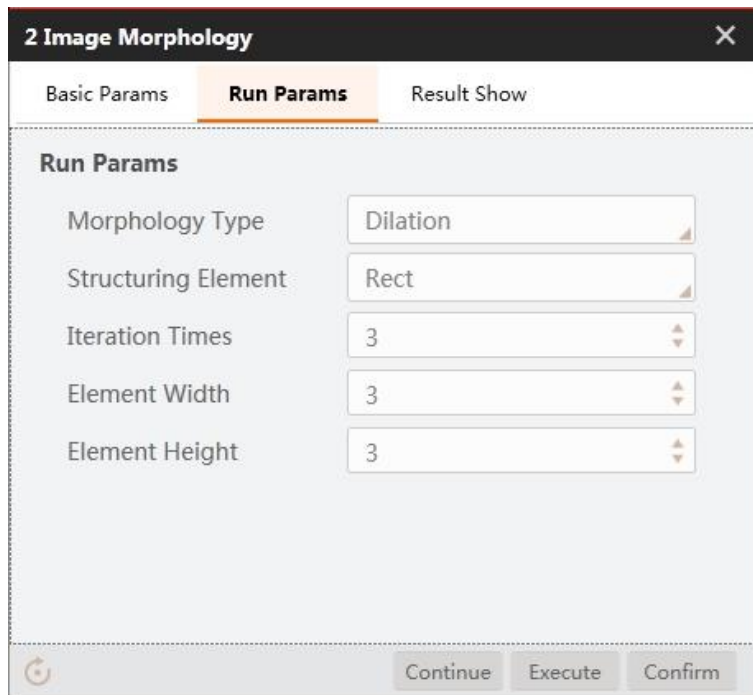
Step 5 Blob analysis.

1. Set **Input Source** to the image that you want to use, and set **ROI Creation** to **Draw**.
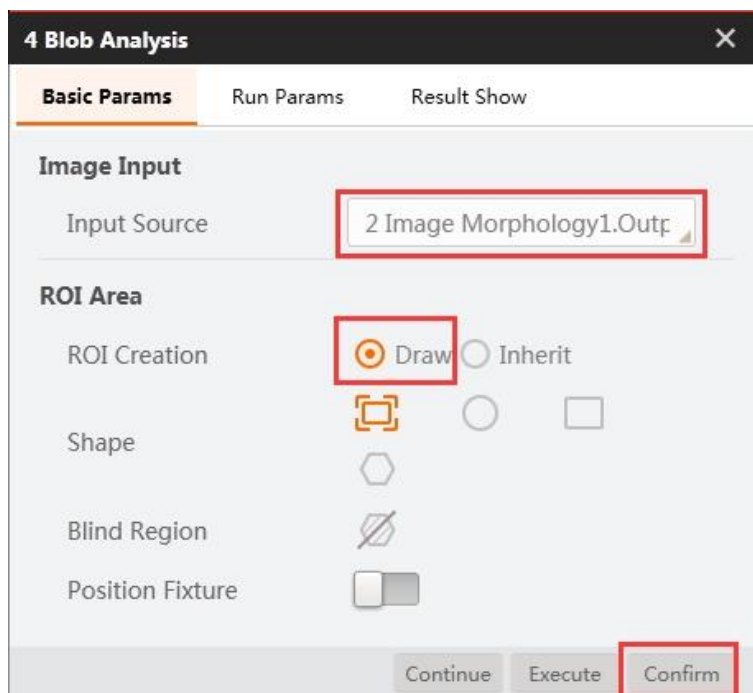
2. Set **Run Params**, as shown below.
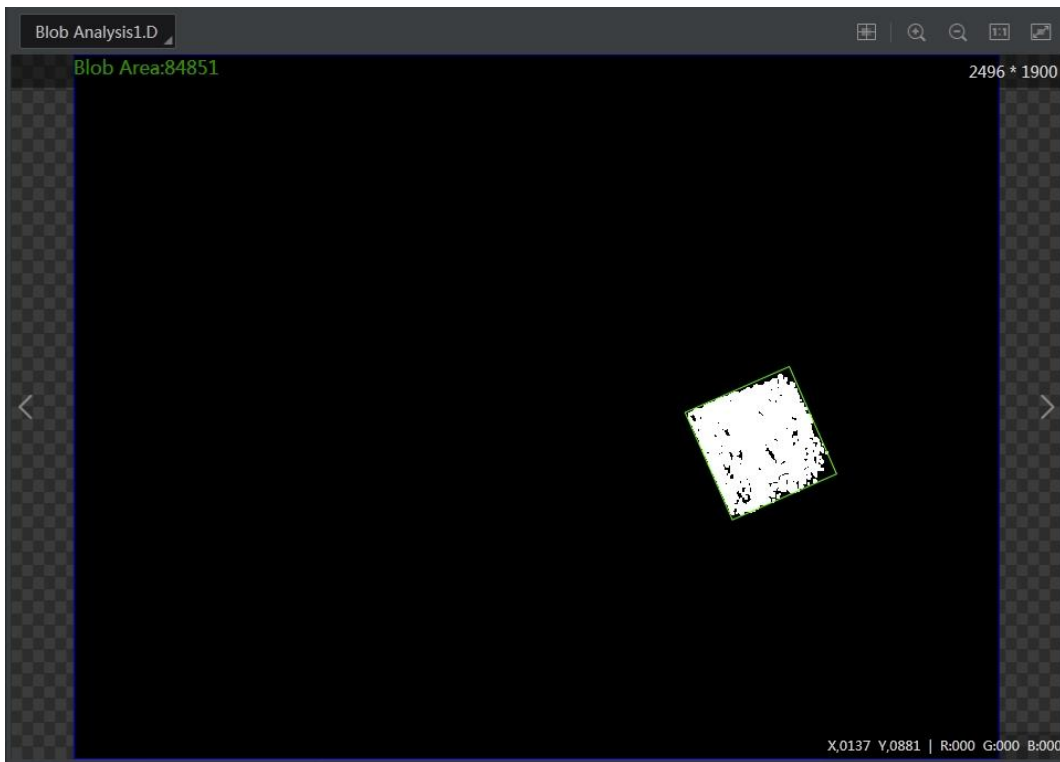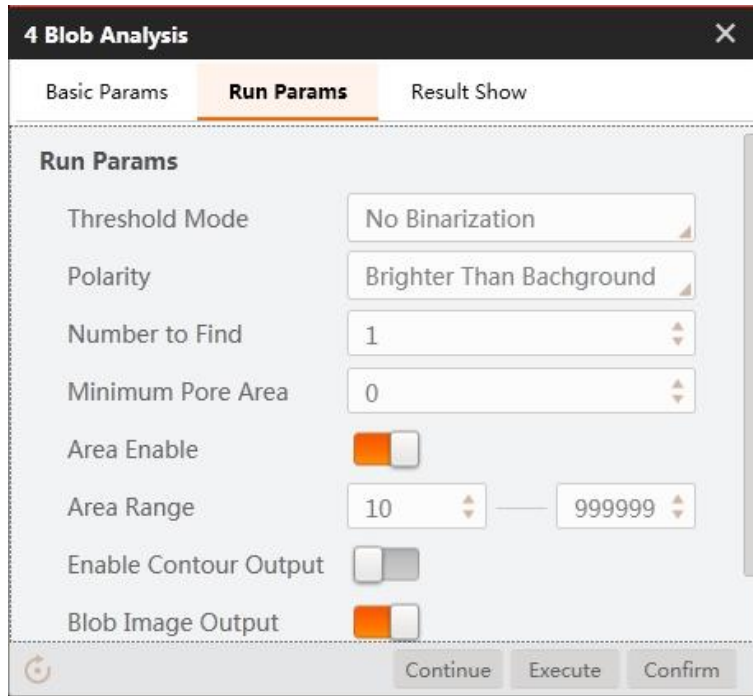
Step 6 Convert image coordinate to physical coordinate.

Set **Input Source** and **Input Mode**, as shown below. Load the calibration file and click **Confirm.**
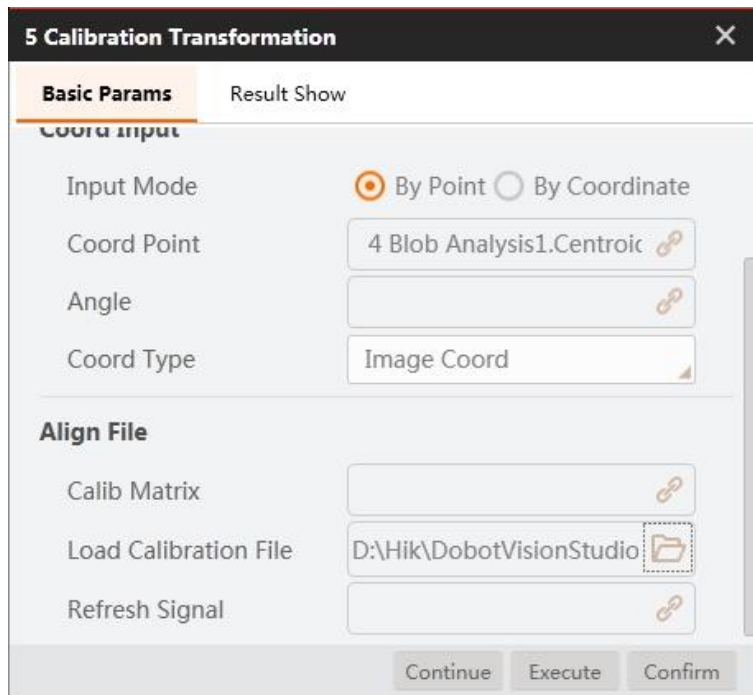
Step 7 Move to a point.

Set motion mode. For details, refer to Moving to a Point. Select the corresponding physical coordinates, and set the Z-axis value based on site requirements.
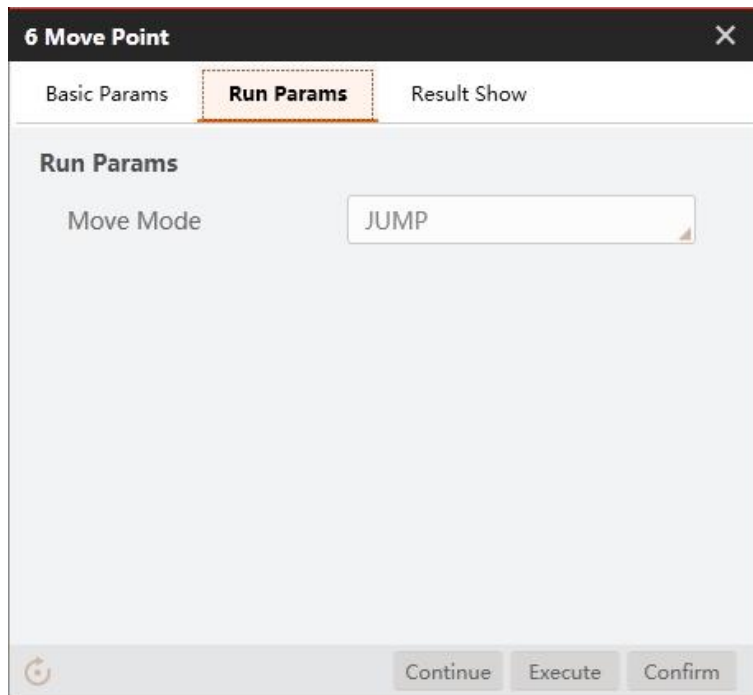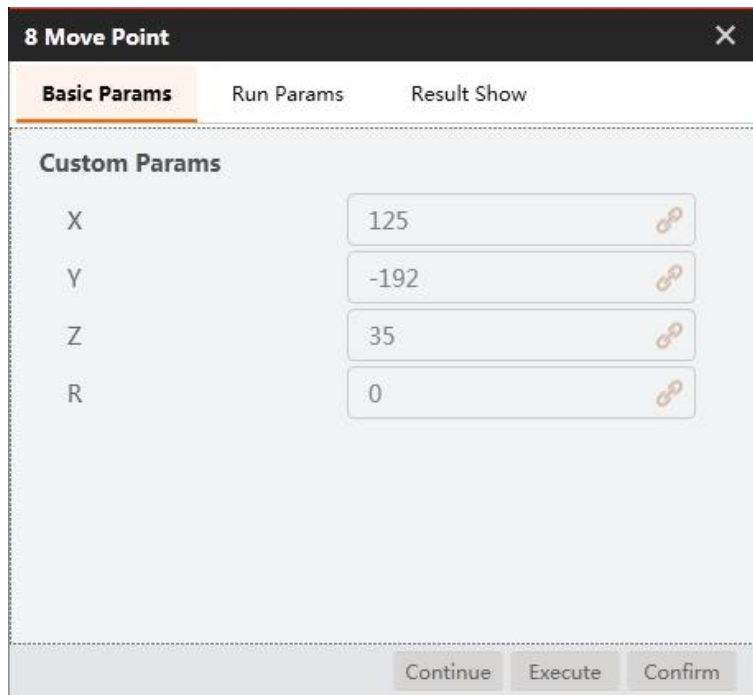
Step 8 Set suction cup.

Set suction cup to **ON** or **CLOSE** based on site requirements.
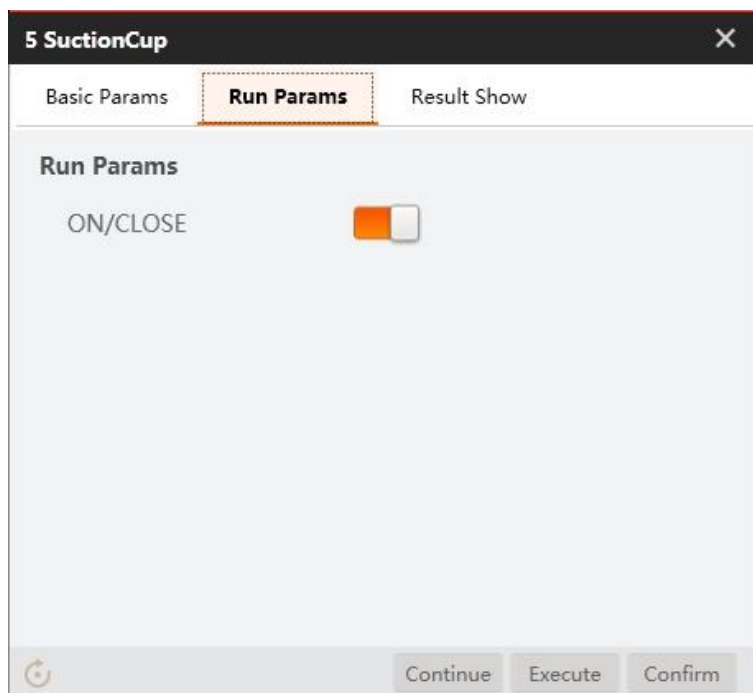
Step 9 Set placing position.

Set placing positions of blocks according to different colors.

6.3 Character Defect Detection

Objective: Detect whether characters have defects like characters missing and redundancy.
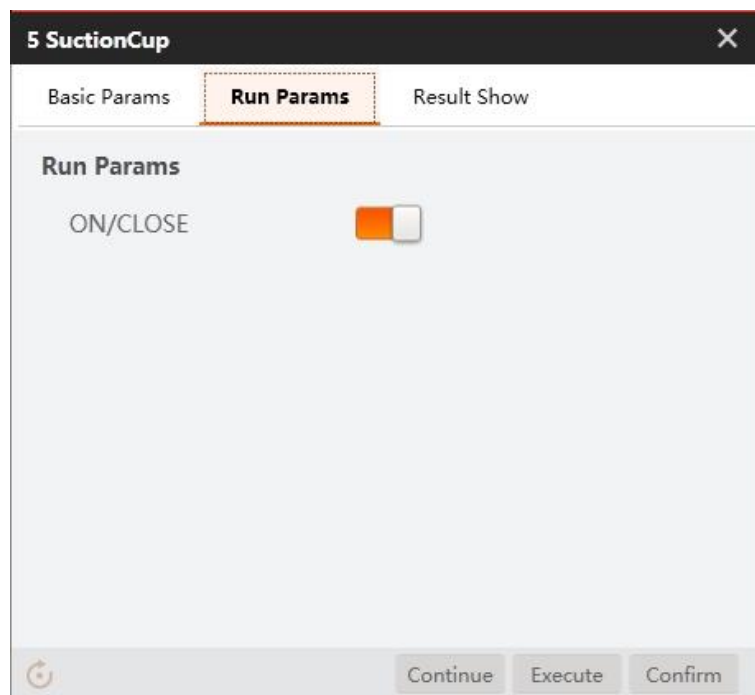
  📖NOTE

- Calibration file needs to be generated beforehand.
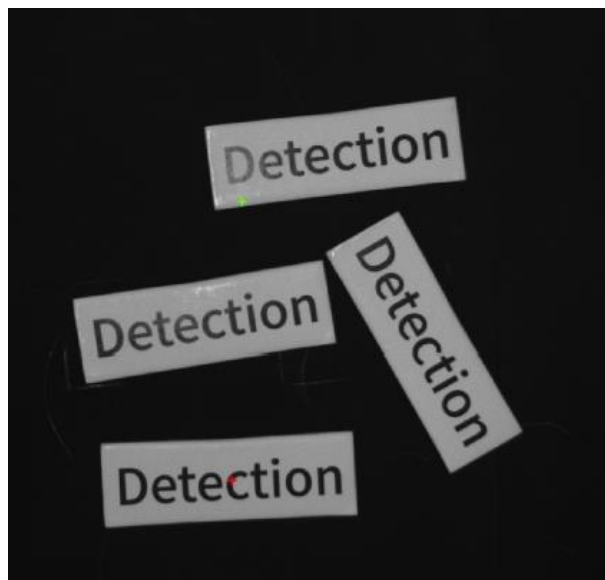
Step 1 Solution establishment idea.

Create the template of the standard characters and train them. Compare the trained characters with the target characters to find detects.

Analyze the result and sort characters with Dobot Magician.

The overall solution flow is shown below.
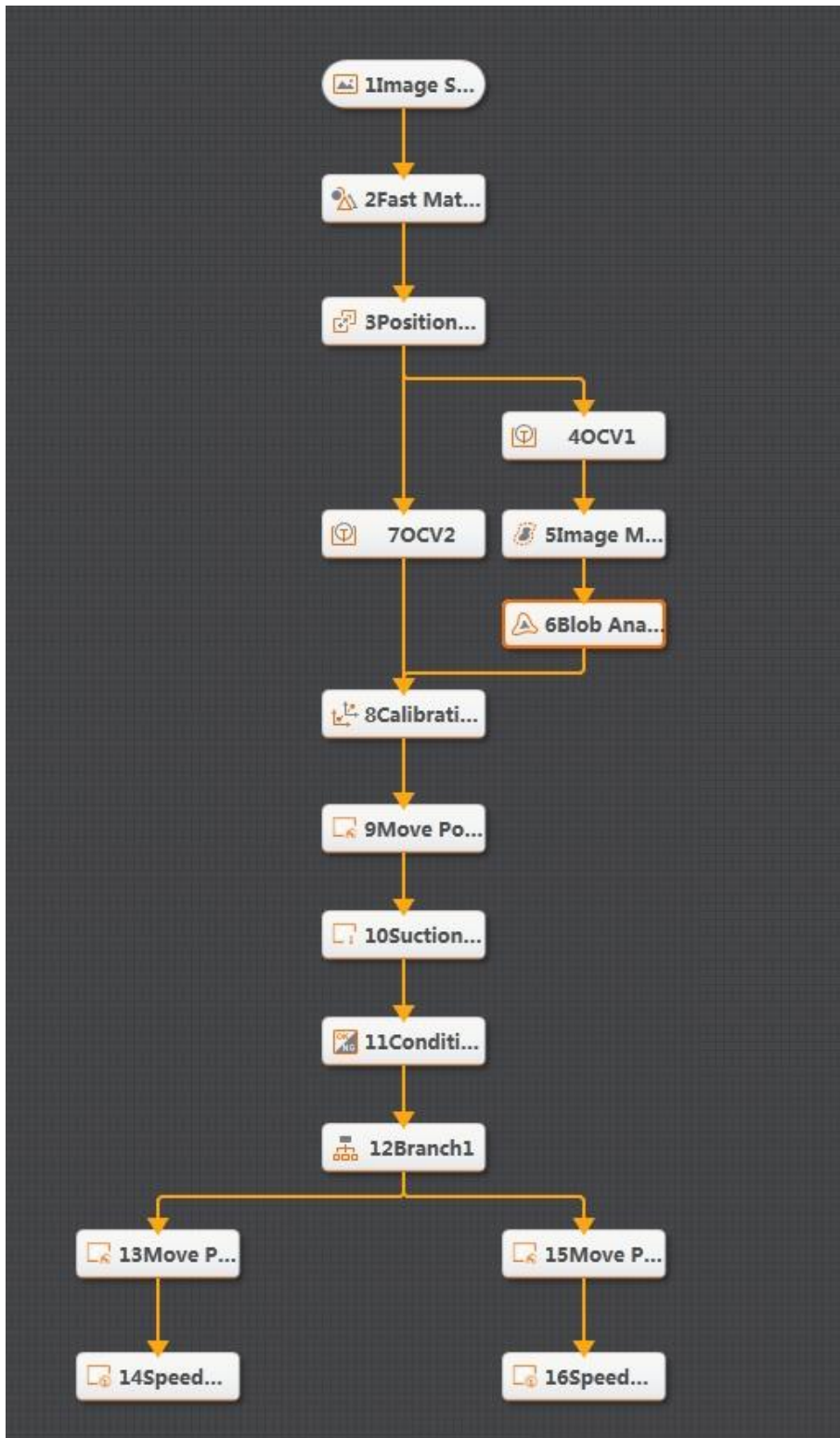
Step 2 Set camera.

1. Click **Camera**, as shown below. Select a camera, and set **Pixel Format** to **MONO8**. You can adjust the brightness of camera by adjusting aperture, exposure-time and light, if the photograph is not bright enough. Set Trigger Source to **SOFTWARE** in **Trigger Settings**.
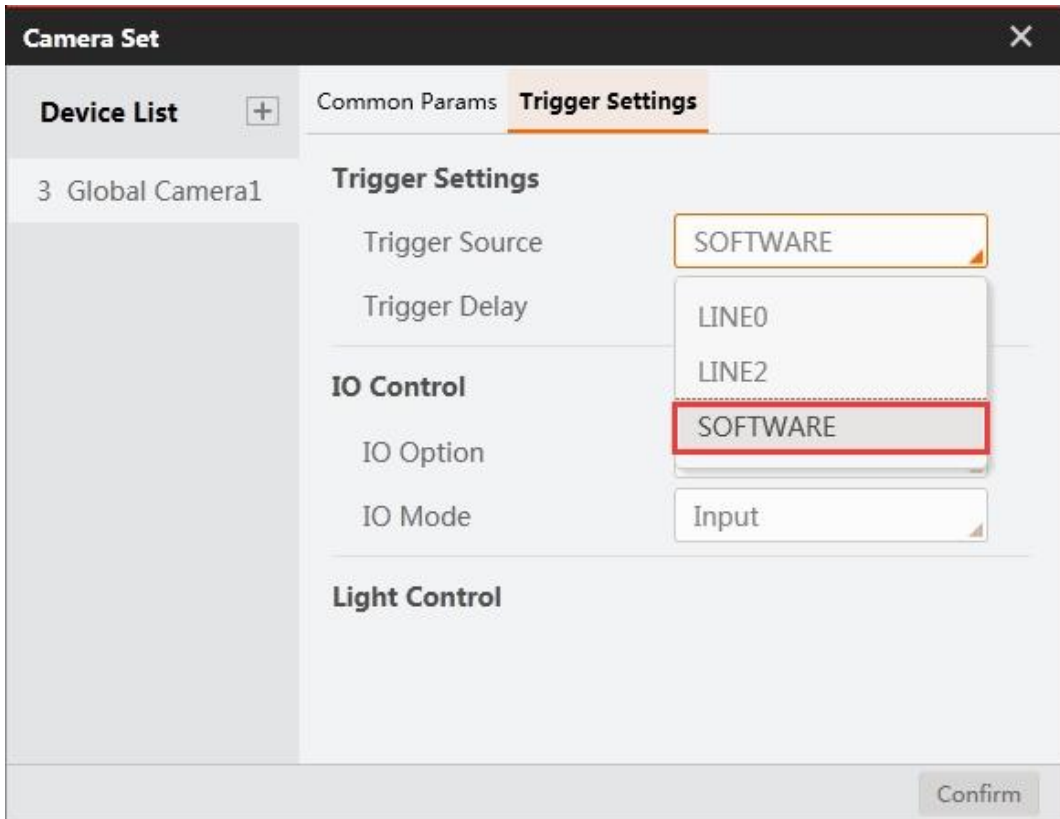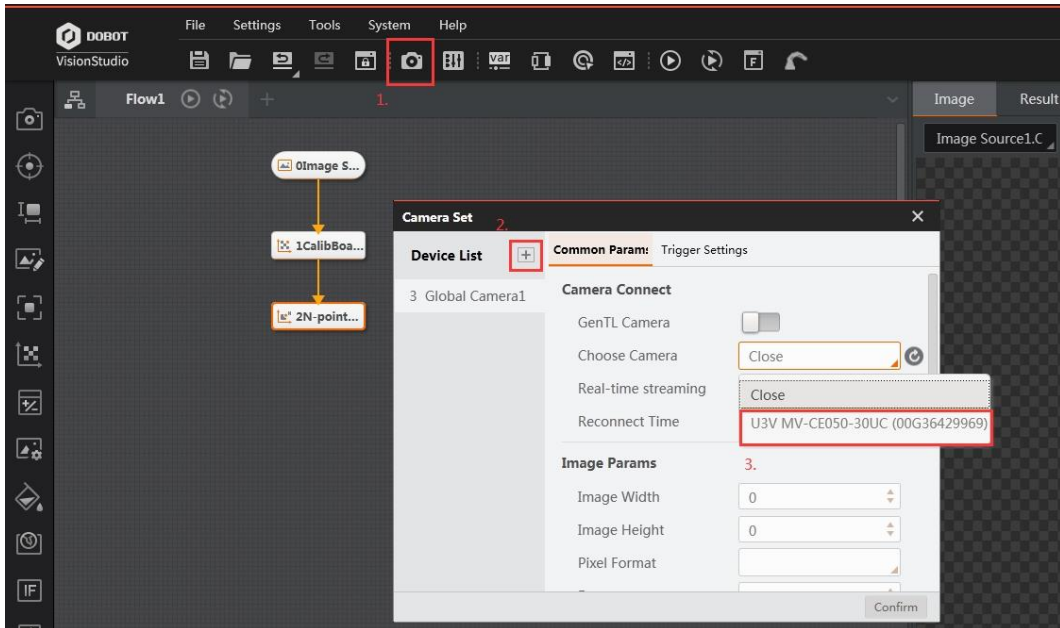
2. Click Image Source module. Set Image Source to Camera, and set Relate Camera to the global camera that you set above.
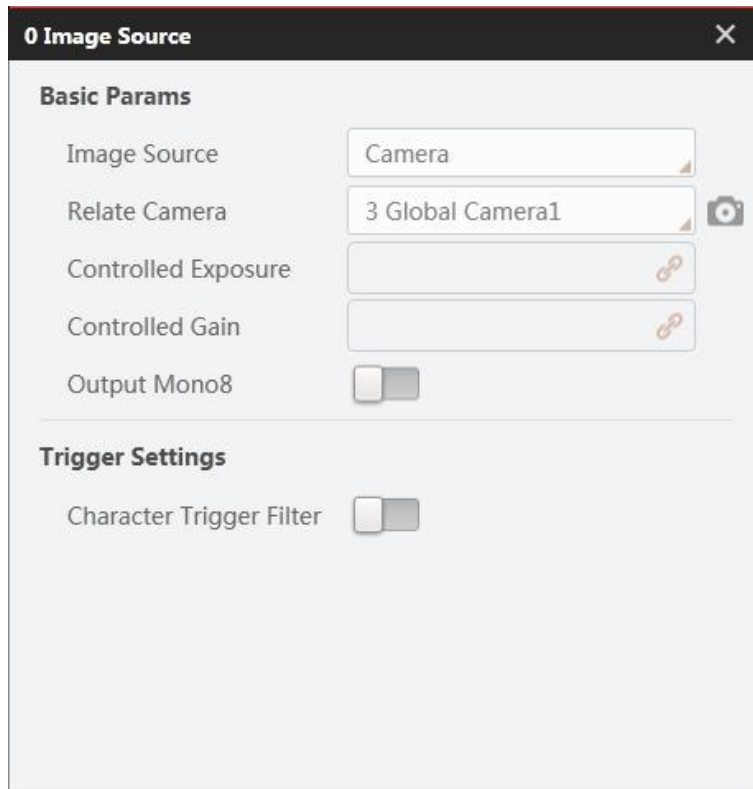
Step 3 Match feature.

Create feature models by Fast Match module, as shown below. You can set **Scale Mode** to **Manual** to select manually. Set the roughness and the contrast threshold based on site requirements.
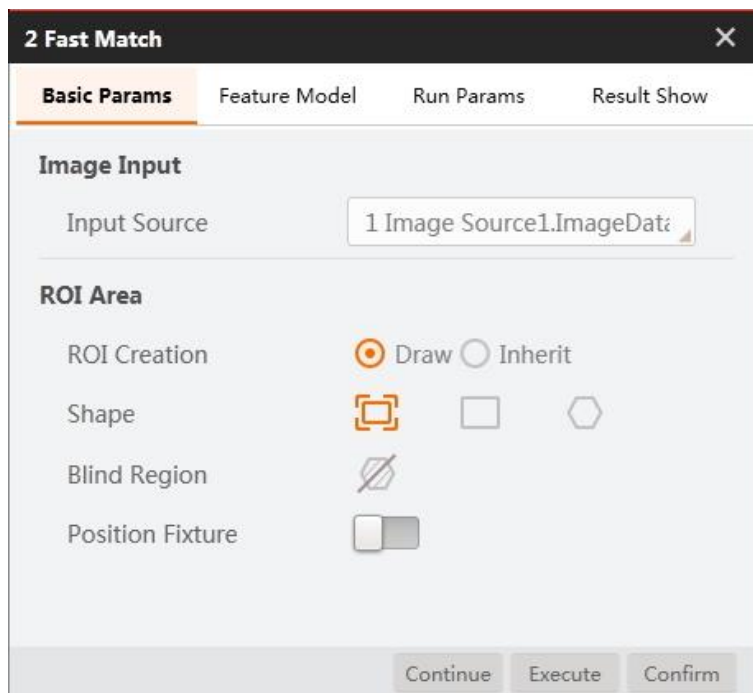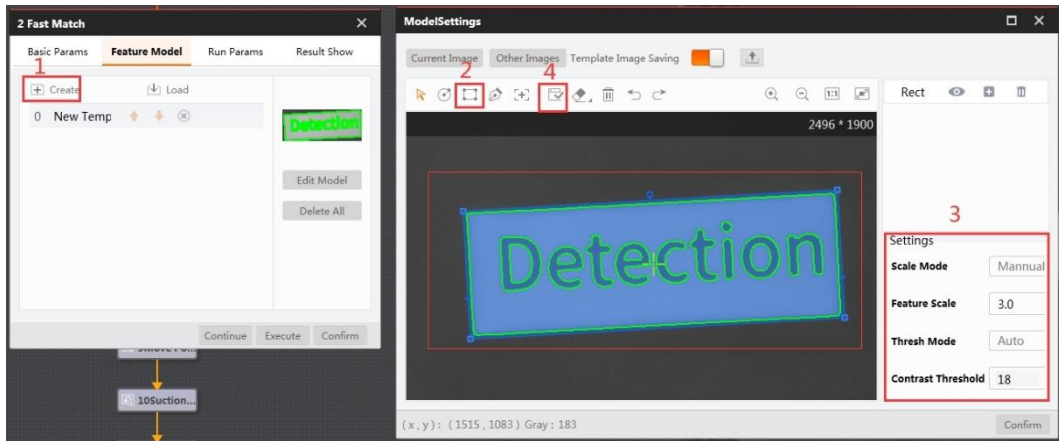
Step 4 Correct position.

Create the reference of position deviation according to the match point and angle. As shown below, set **Input Source** to the image that you want to use, and set **Choose Mode** to **By Point**. Click **Create Reference**, as shown below.
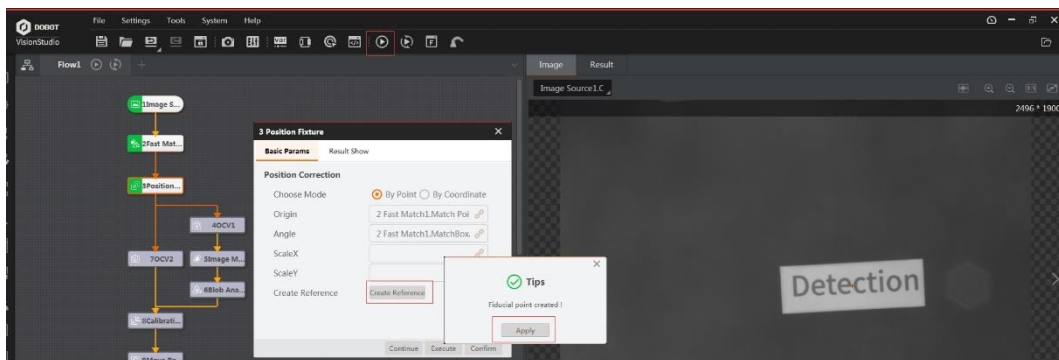
Step 5 Detect defect.

1. Click **Train Model** to create a character model.
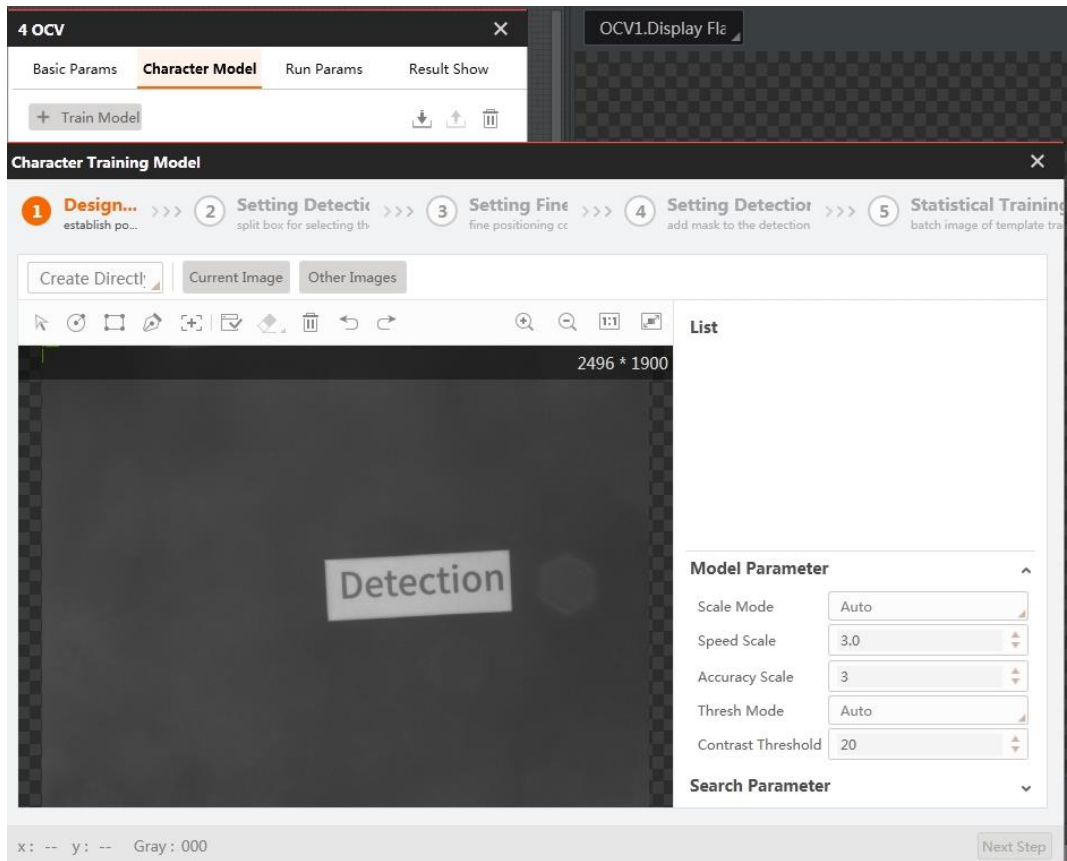
2. The process of training is shown below. Create a rectangular mask and generate a model. Click **Next**.
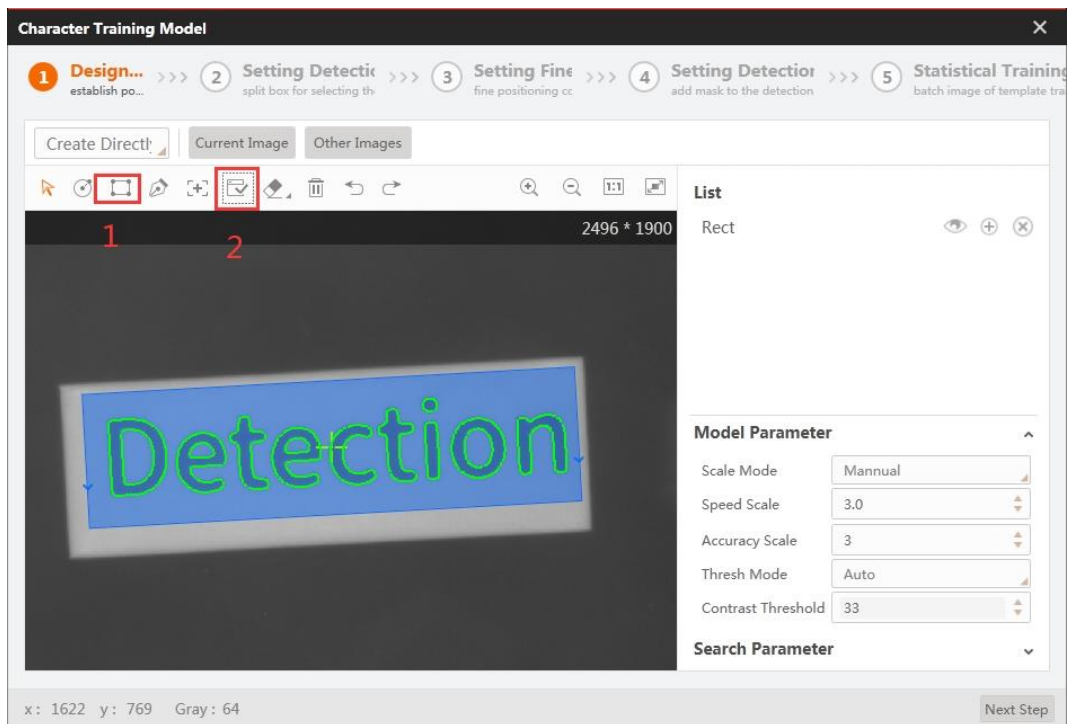
3. Extract characters following the figure below. Click **Next Step**.
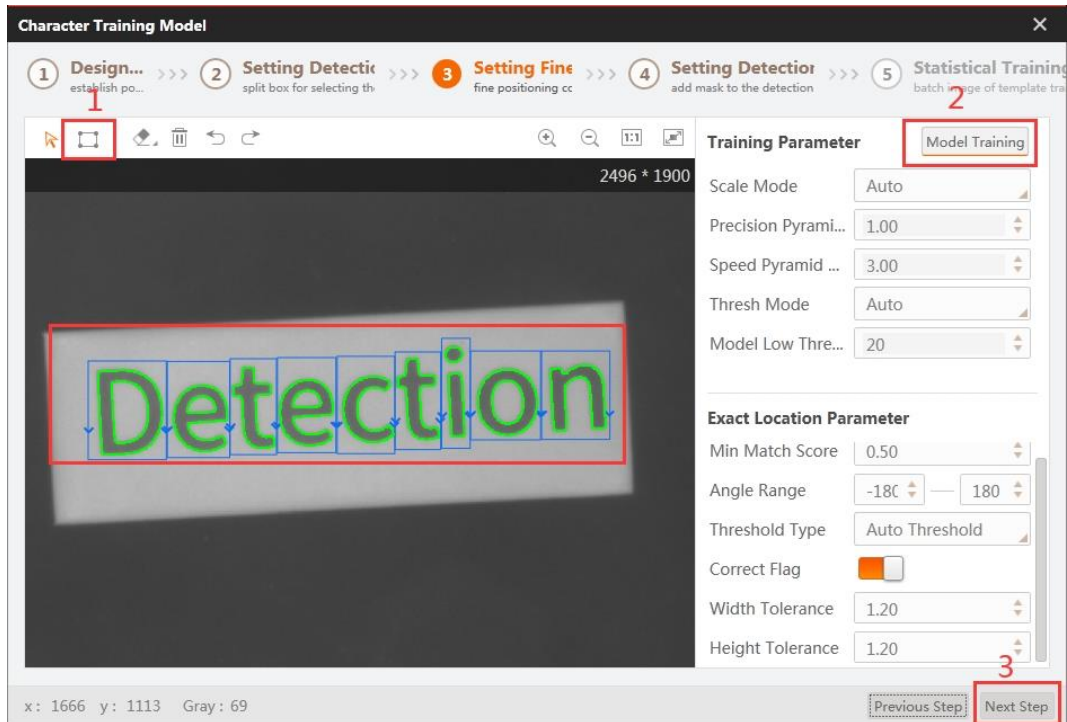
4. Select characters manually for fine positioning, as shown below. Click **Model Training**. Then click **Next Step**.
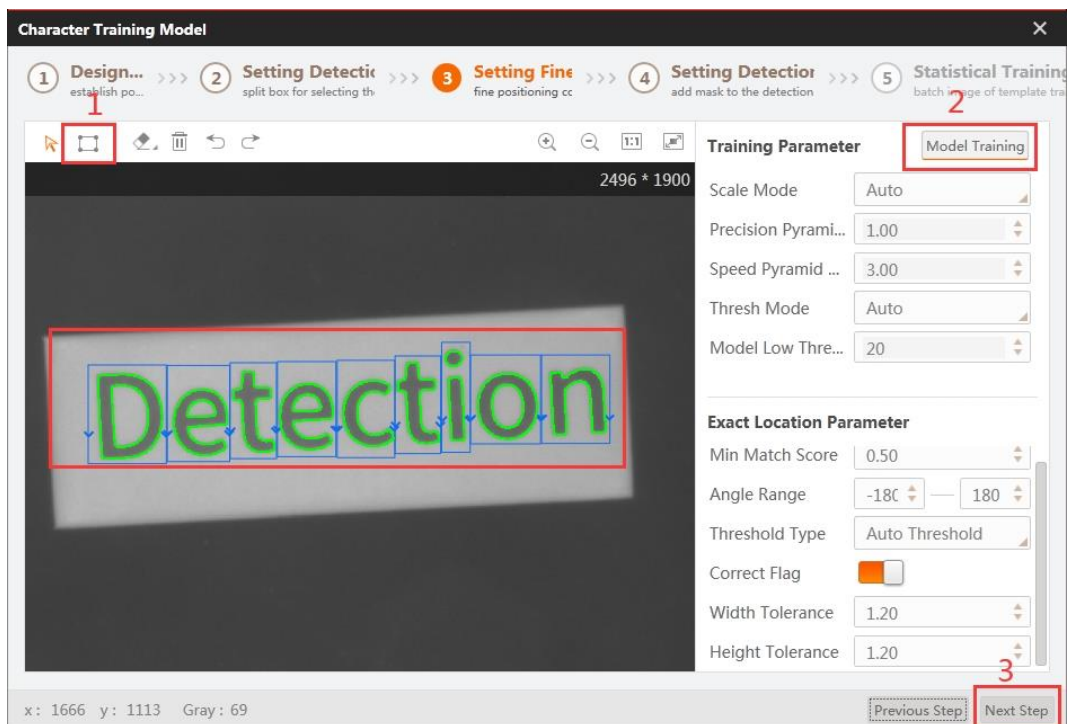
5. The process of setting detection area mask is shown below. After setting the mask, you will see the **Set Successfully** pop-up window. Then click **Next Step**.
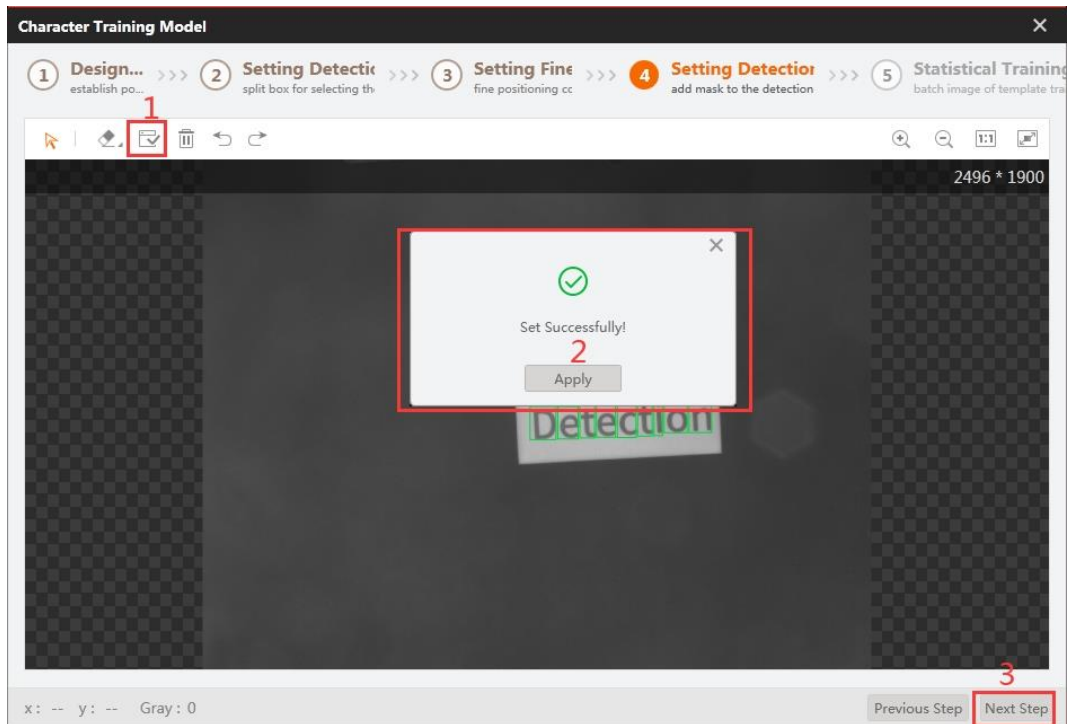
6. The process of statistical training is shown below. Click ⊕ to choose **Current Image**. Click **Current Image Statistics**, and you will see the result in the lower right corner. Click **OK**.
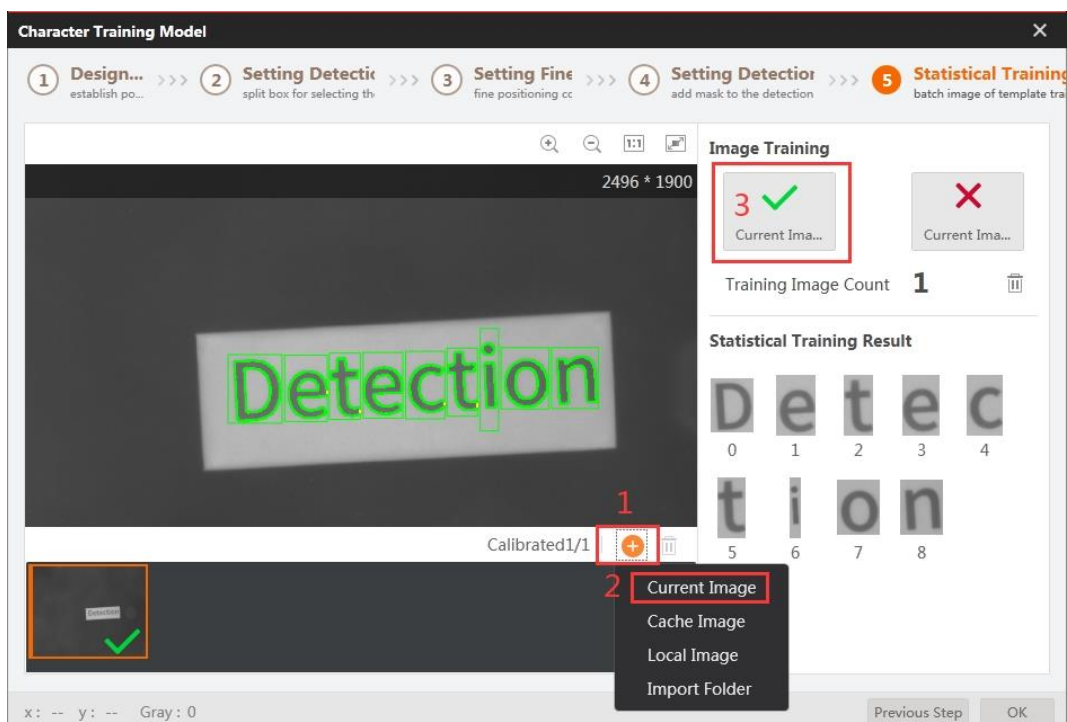
7. Now you have completed the configuration of character defect detection. Click **OK** to exit.
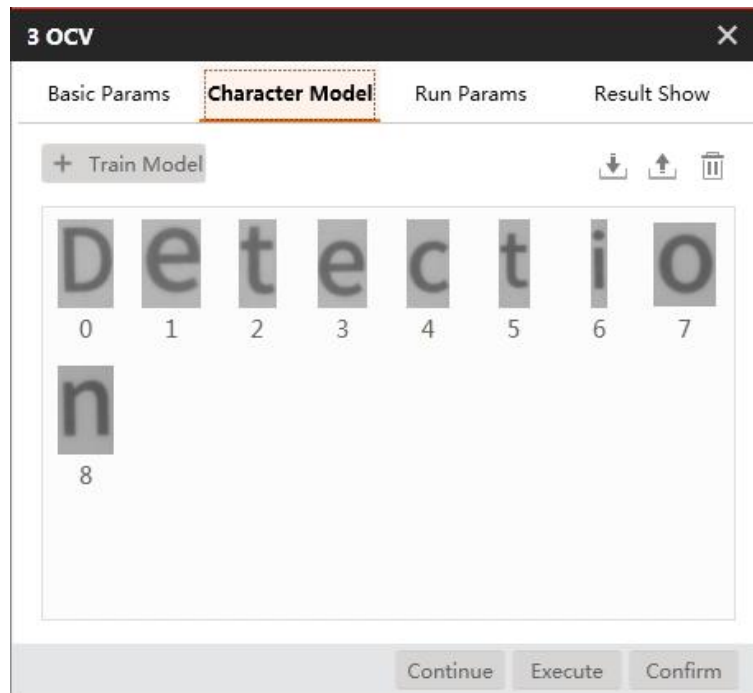
Step 6 Image morph.

1. Set **Input Source** to the image that you want to use, and set **ROI Creation** to **Draw**.
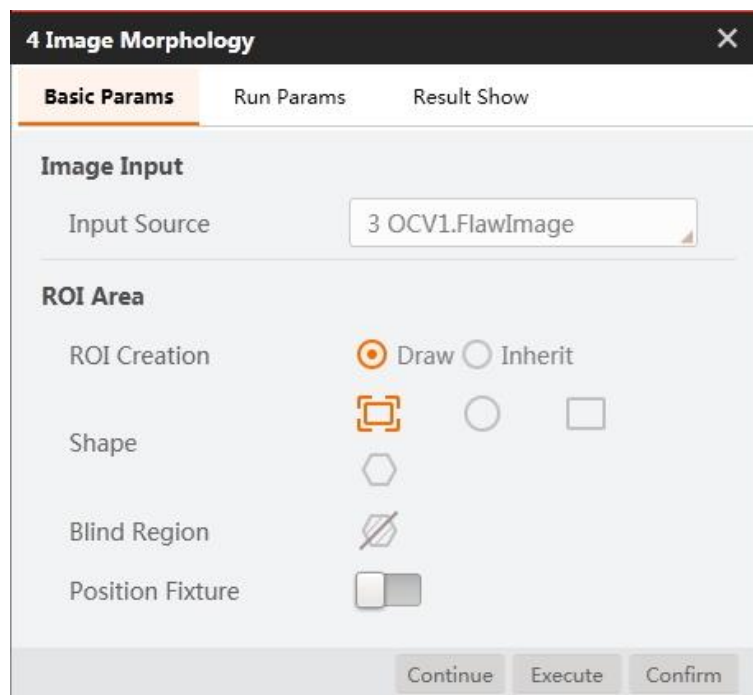
2. Set **Morphology Type** to **Opening**. Set **Structuring Element** to **Ellipse**. You can set other parameters according to site requirements. Click **Confirm**.
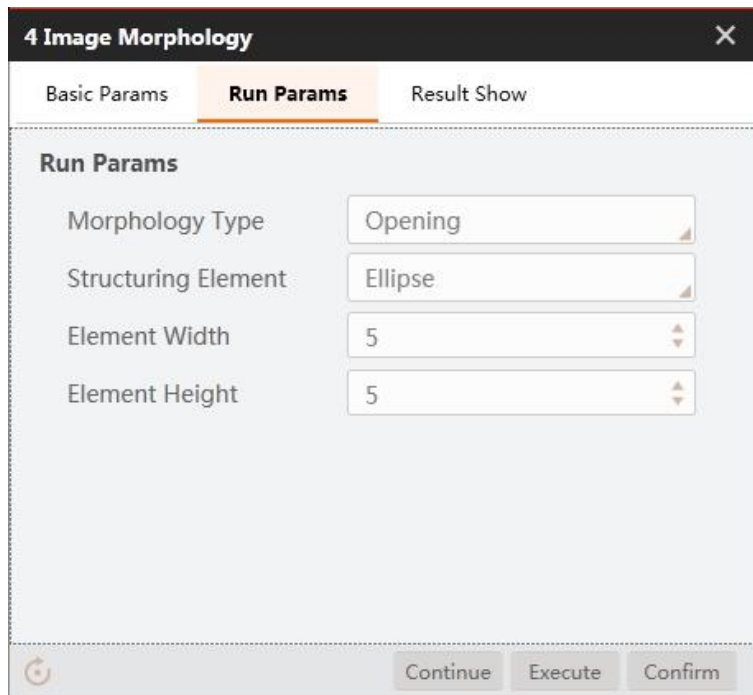
Step 7   Blob analysis.

1.   Set **Input Source** to the image that you want to use, and set **ROI Creation** to **Draw**.
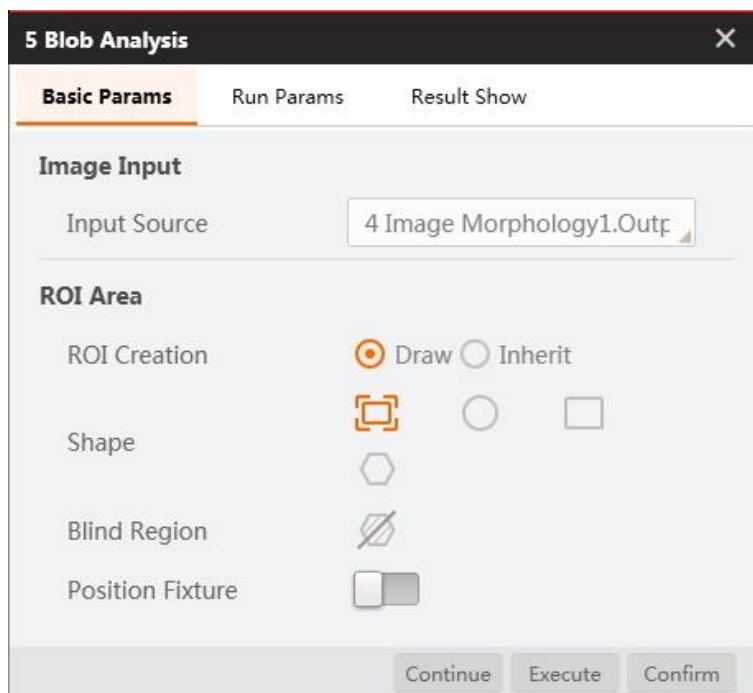
2.   Set **Run Params**, as shown below.
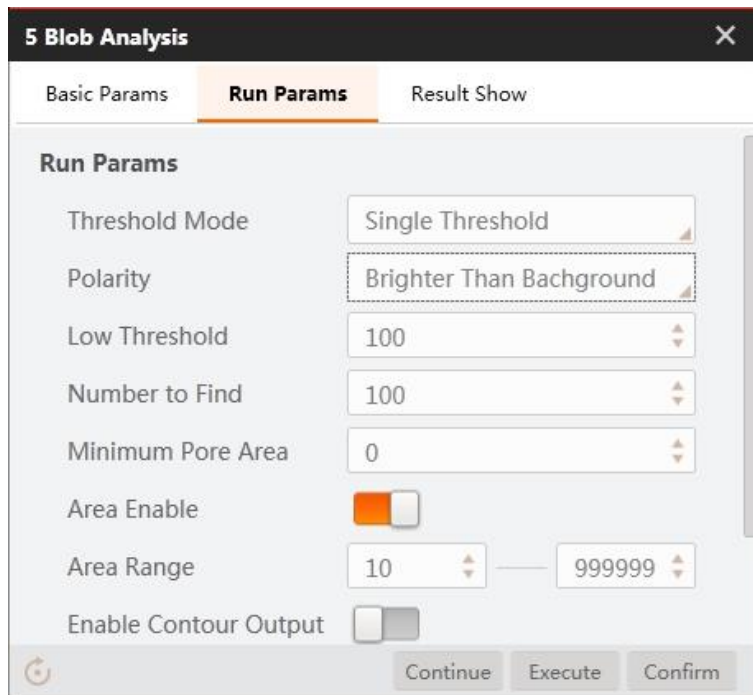
Step 8   Convert image coordinate to physical coordinate.

Set **Input Source** and **Input Mode**, as shown below. Load calibration file and click **Confirm**.
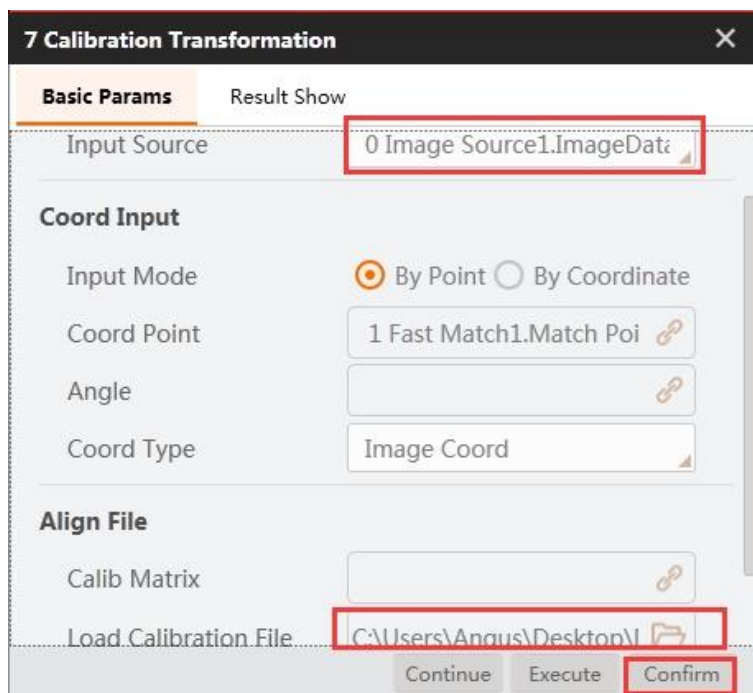
Step 9   Move to a point.

Set motion mode. For details, refer to Moving to a Point. Select the corresponding physical coordinates, and set the Z-axis value based on site requirements.
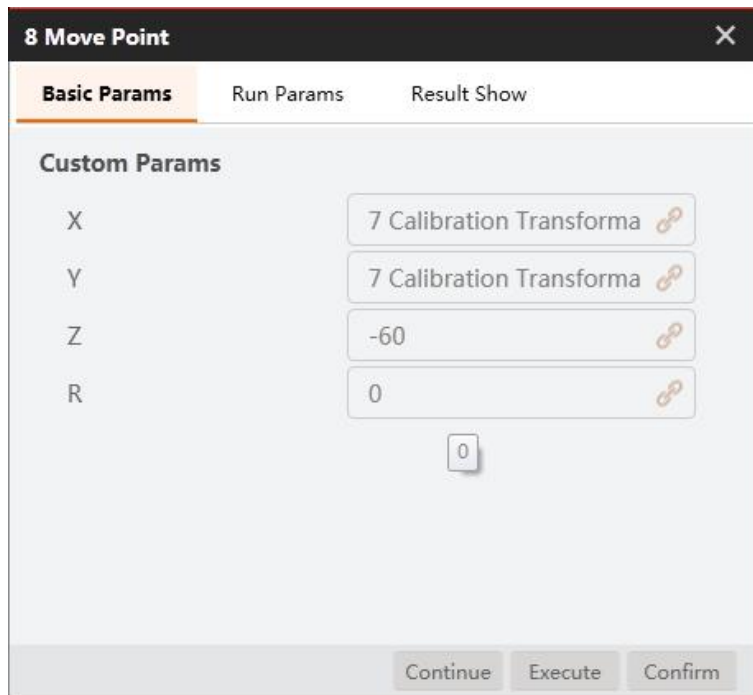
Step 10 Set suction cup.

Set suction cup to **ON** or **CLOSE** based on site requirements.
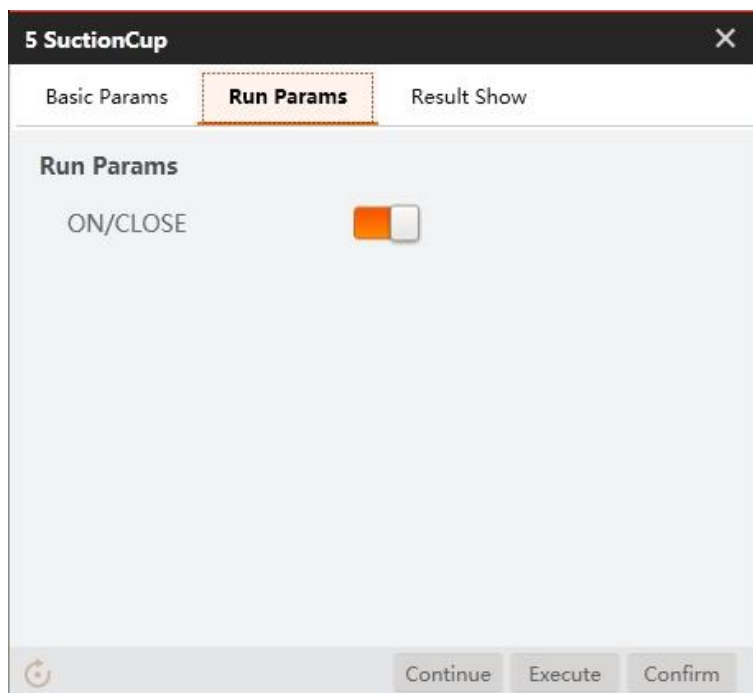
Step 11 Condition detection.

Set conditions as follows. Return the result value 0 or 1 by judging the number of defective characters. 0 means that there are character defects, and 1 means no character defects.

Step 12 Branch module.

Execute different branch modules according to the detection results. If the result is 1, execute branch 12, otherwise, execute branch 15.

Step 13 Set placing position.

Set placing positions for normal characters and defective characters.
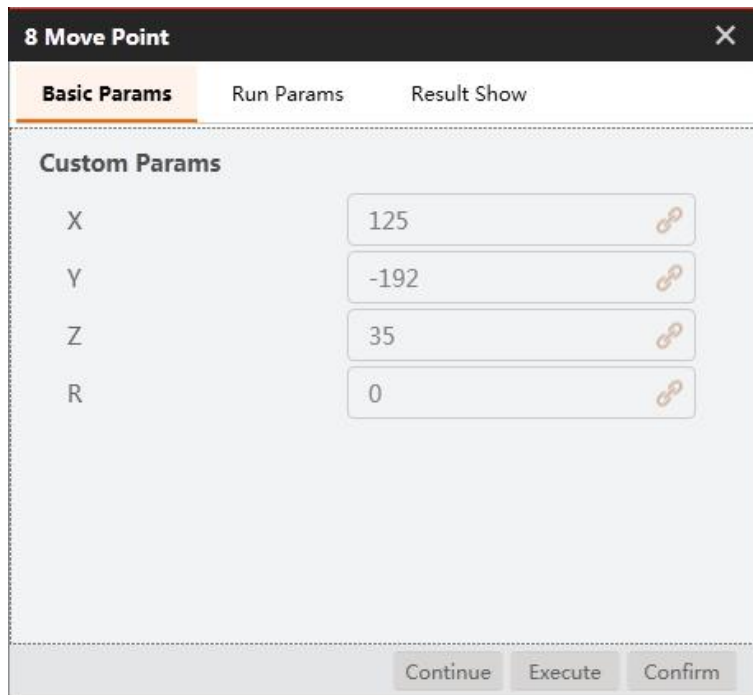
Step 14 Detection result.

The detection results are shown below.
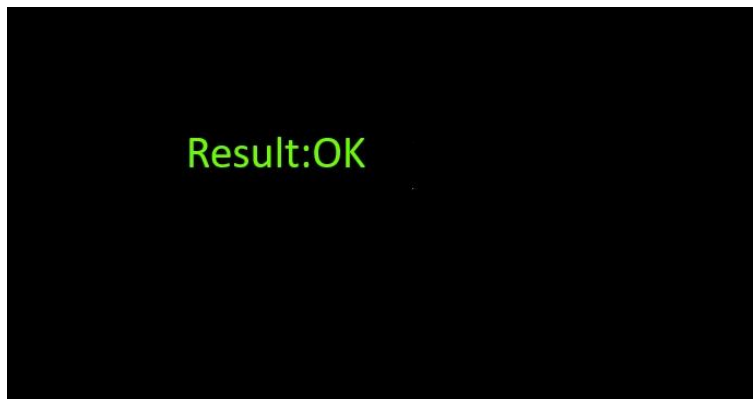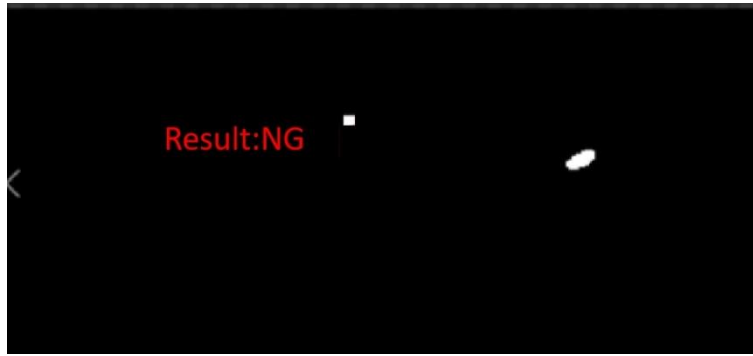
6.4 Diameter Measurement

Objective: Measure the diameter of objects and judge the location of the object.

📖NOTE

- Calibration file needs to be generated beforehand.

Step 1 Solution establishment idea

- To find the measured objects by **find circle** module.

- Convert image size to physical size by scale transformation.

- Convert image coordinate to physical coordinate by calibration tools.

- Sort eligible objects.

The overall solution flow is shown below.
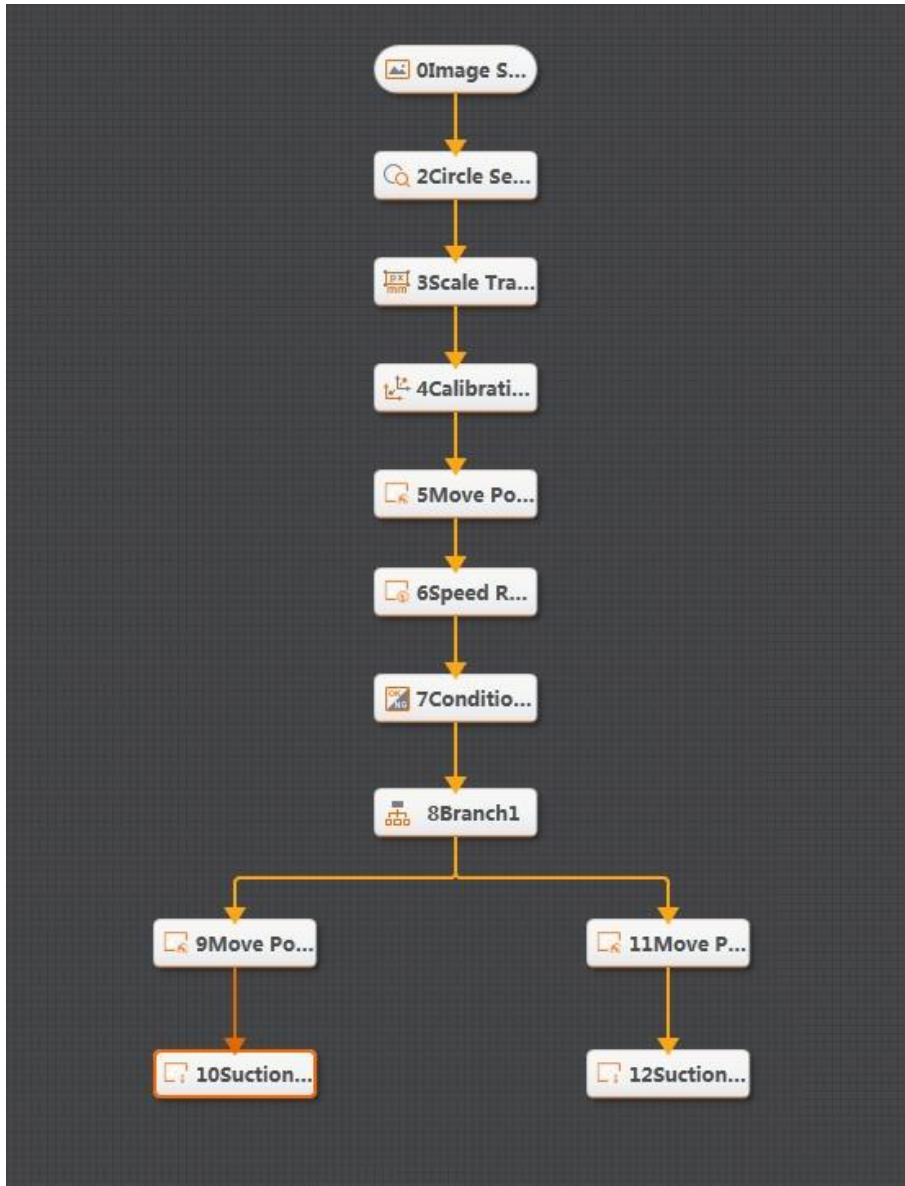
Step 2 Set camera.

1. Click **Camera**, as shown below. Select a camera, and set **Pixel Format** to **MONO8**. You can adjust the brightness of camera by adjusting aperture, exposure-time and light, if the photograph is not bright enough. Set **Trigger Source** to **SOFTWARE** in **Trigger Settings**.
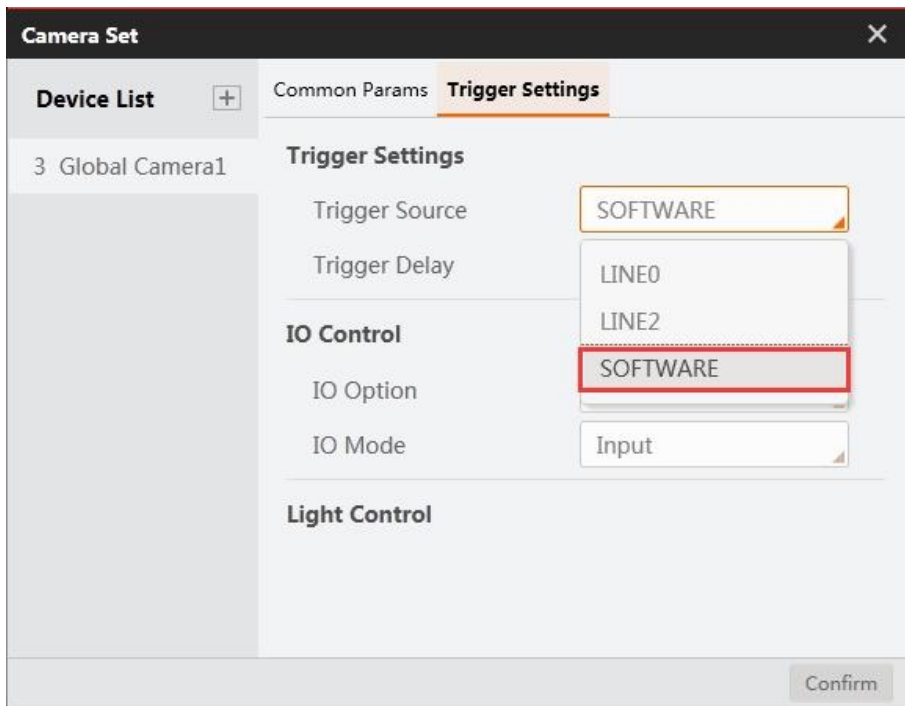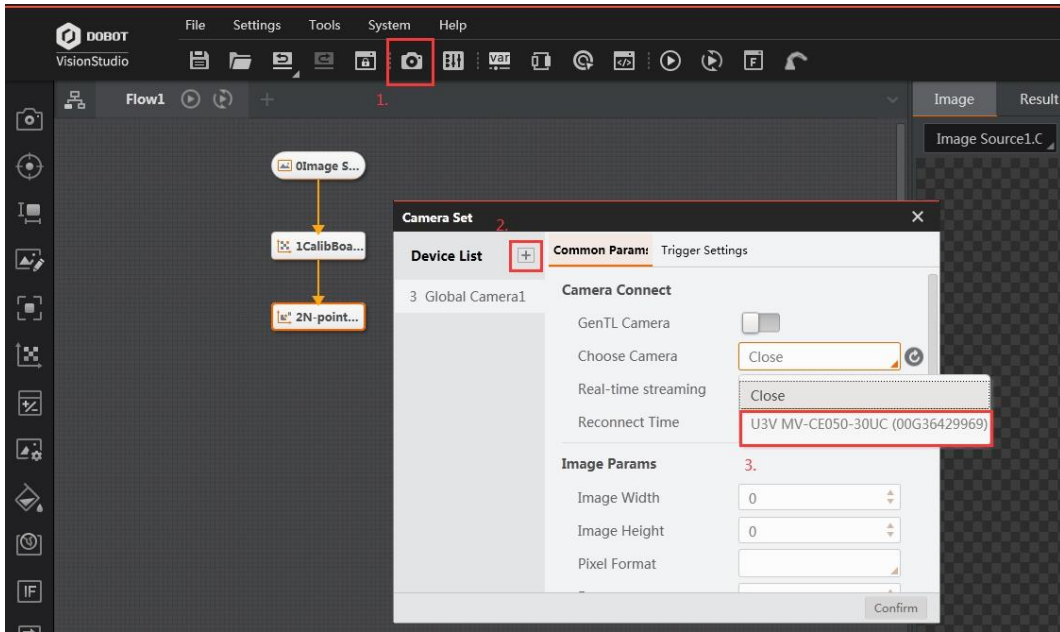
2. Click **Image Source** module. Set **Image Source** to **Camera**, and set **Relate Camera** to the global camera that you set above.

Step 3 Find circle.

1. Set **Input Source** to the image that you want to use, and set **ROI Creation** to **Draw**.
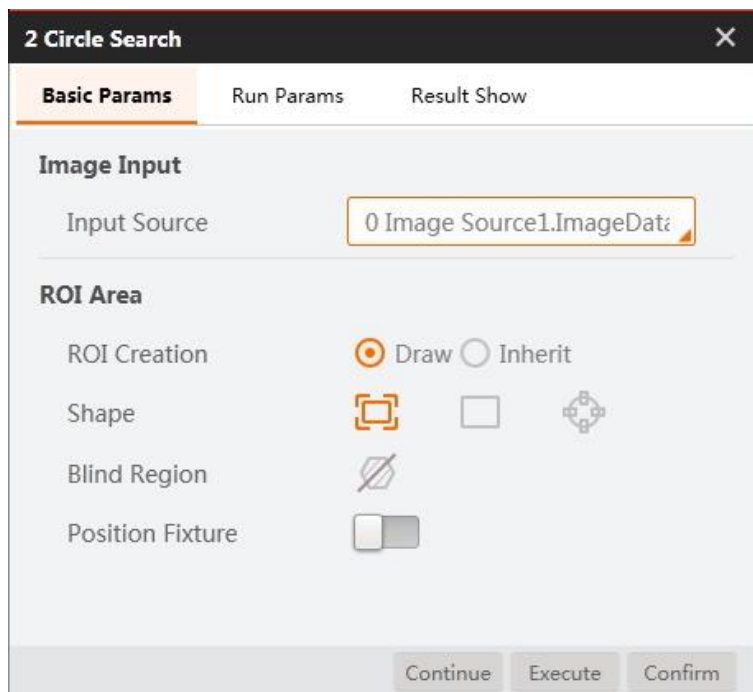
2. Acquire the range of radius according to the following figures. Click **Confirm**.
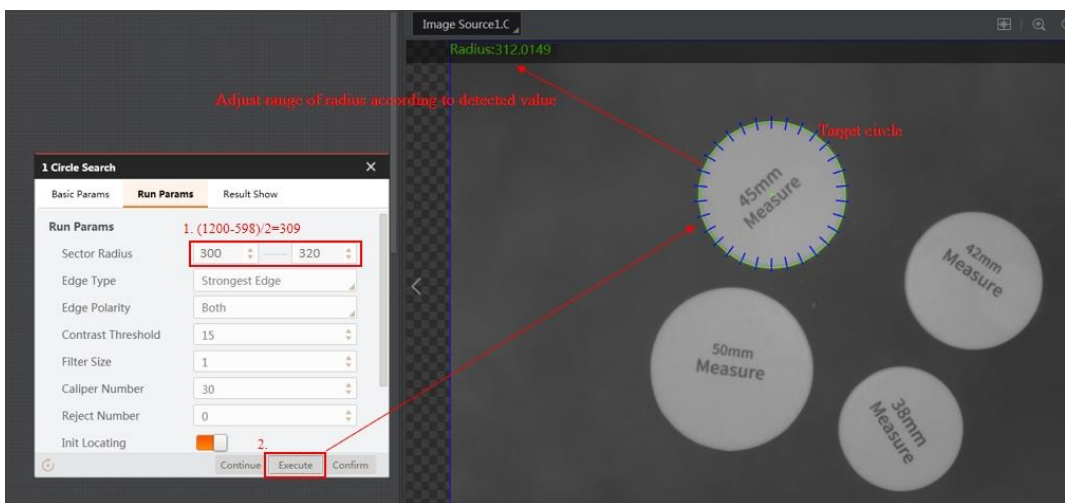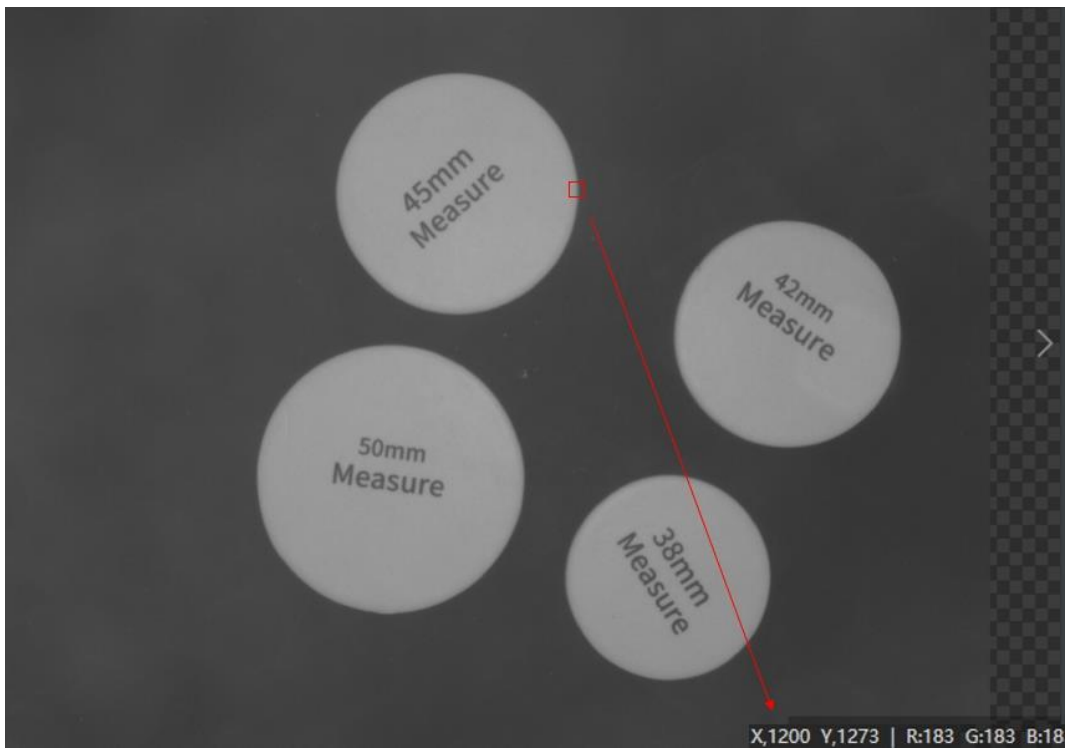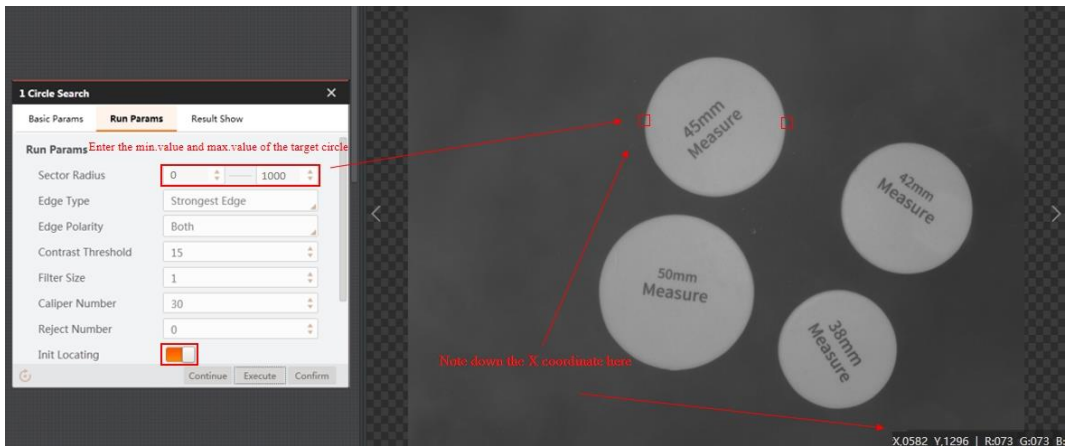
Step 4   Scale transformation

Set **Input Source** and **Pixel Interval**. Convert pixel unit to physical unit by scale transformation tools. Click **Confirm**.
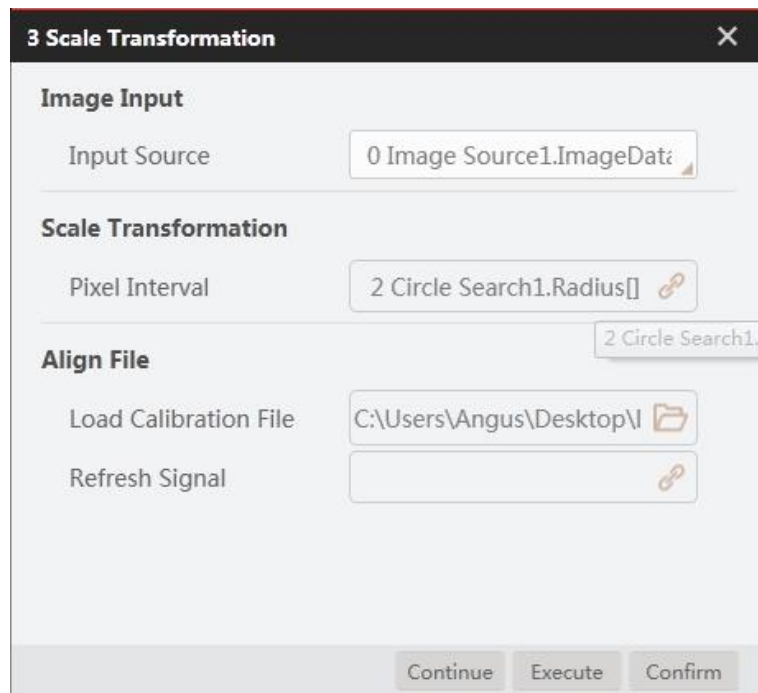
Step 5   Convert image coordinate to physical coordinate.

Set **Input Source** and **Input Mode**, as shown below. Load calibration file and click **Confirm**.
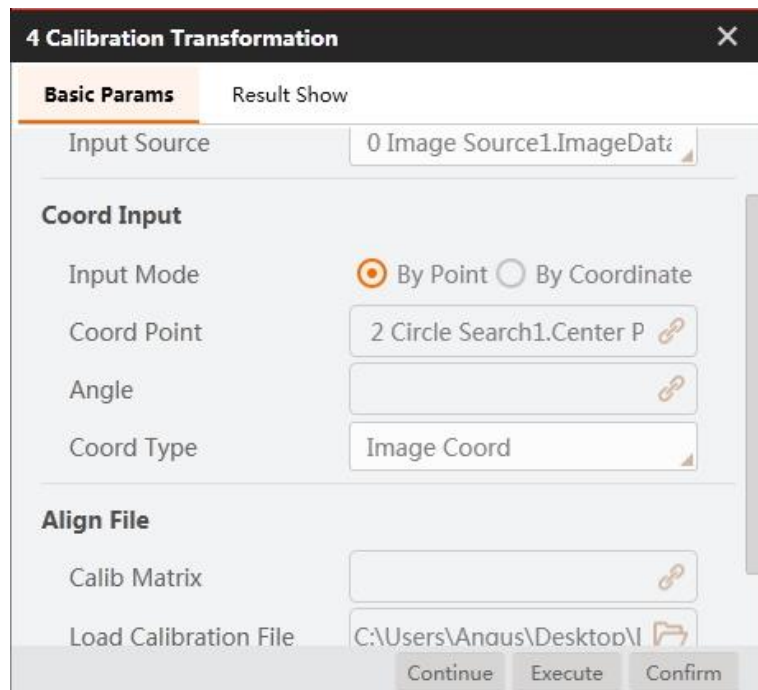
Step 6   Move to a point.

Set motion mode. For details, refer to Moving to a Point. Select the corresponding physical coordinates, and set the Z-axis value based on site requirements.
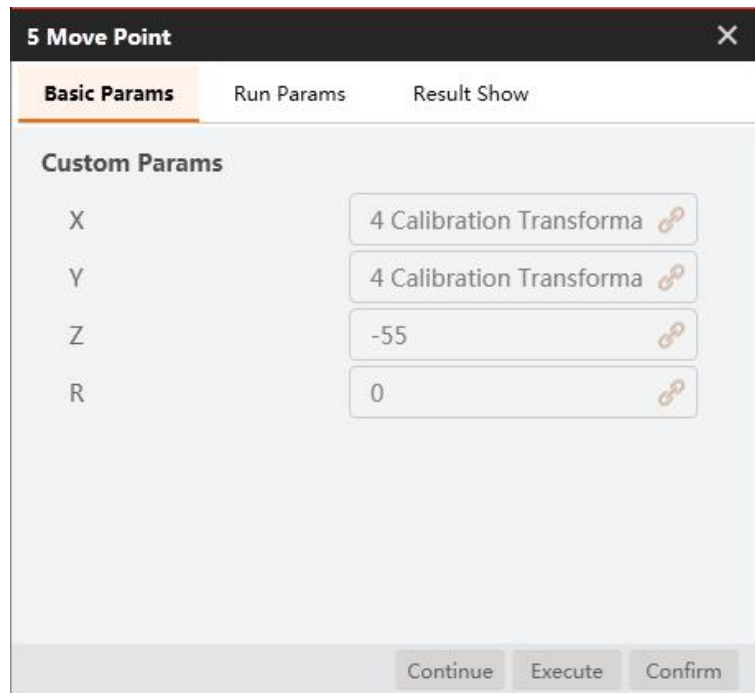
Step 7 Set suction cup.

Set suction cup to **ON** or **CLOSE** based on site requirements.

Step 8 Condition detection

Set valid range of physical radius, as shown below.
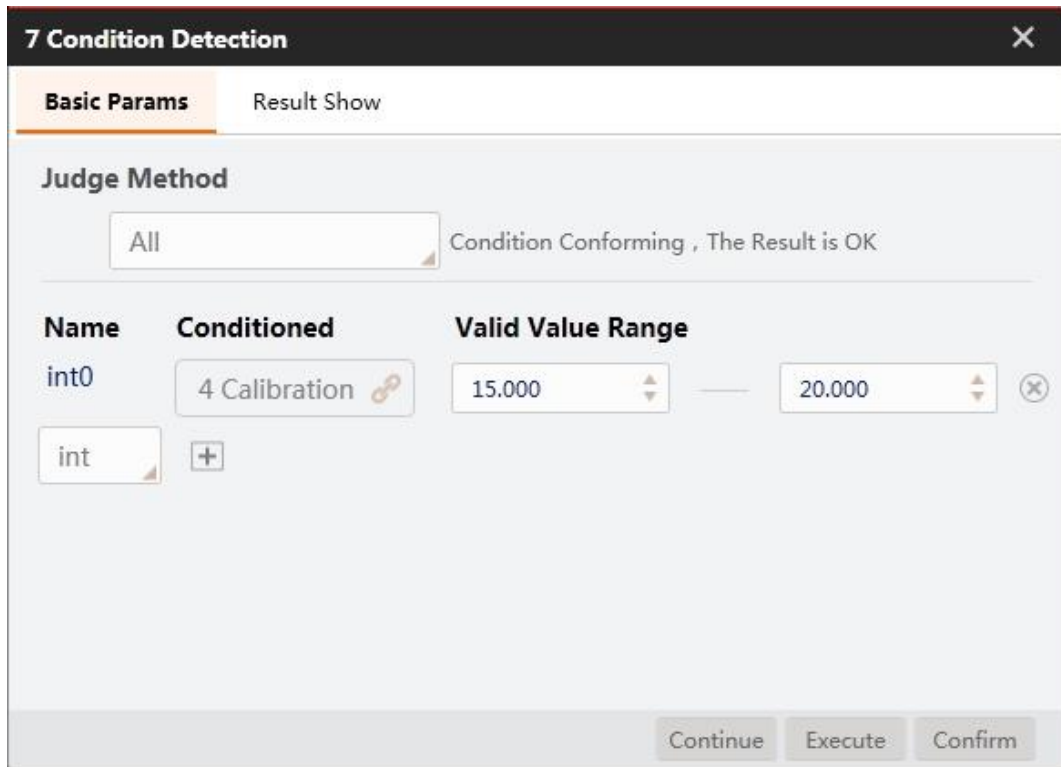
Step 9 Branch module.

Place different circles according to the measured results. If the result is 1, execute branch 8, otherwise execute branch 7.
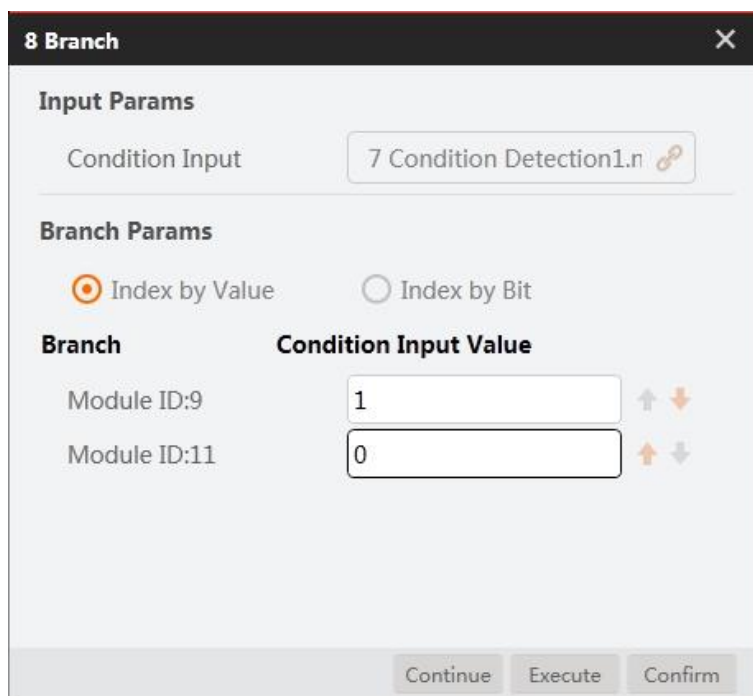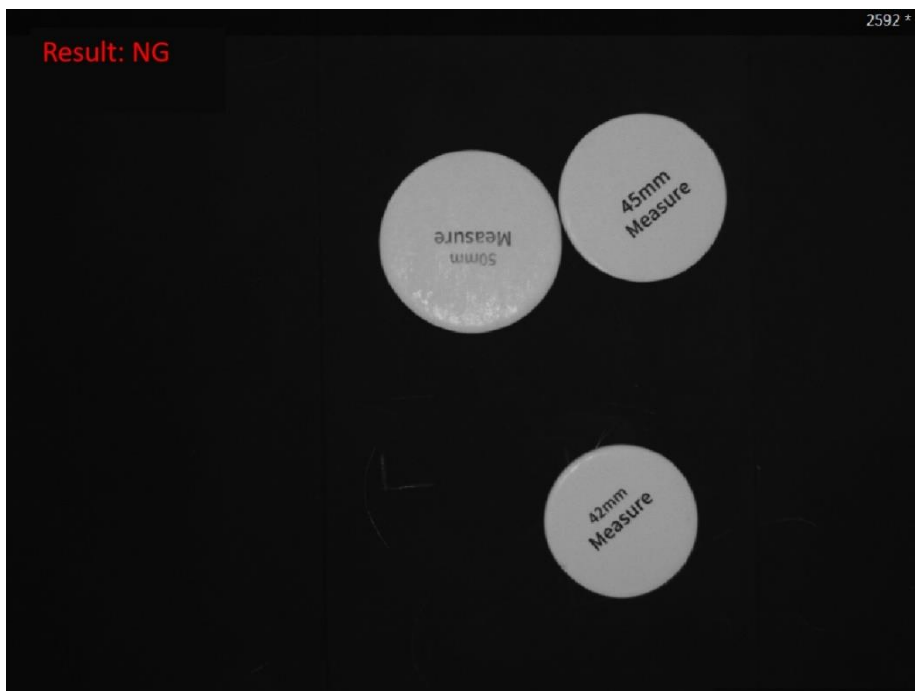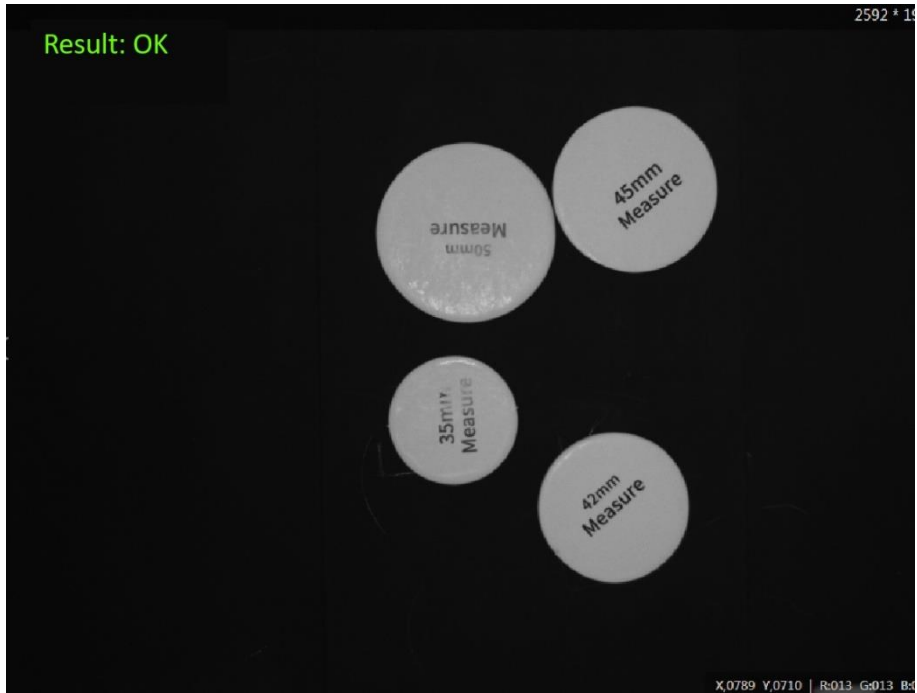
Step 10 Set placing position.

Set placing positions for objects according to the detection results.

6.5 Rectangle Template Match

Objective: Find rectangles and put them to the corresponding template through angle calculation and model match, as shown below.

📖NOTE

- Calibration file needs to be generated beforehand.
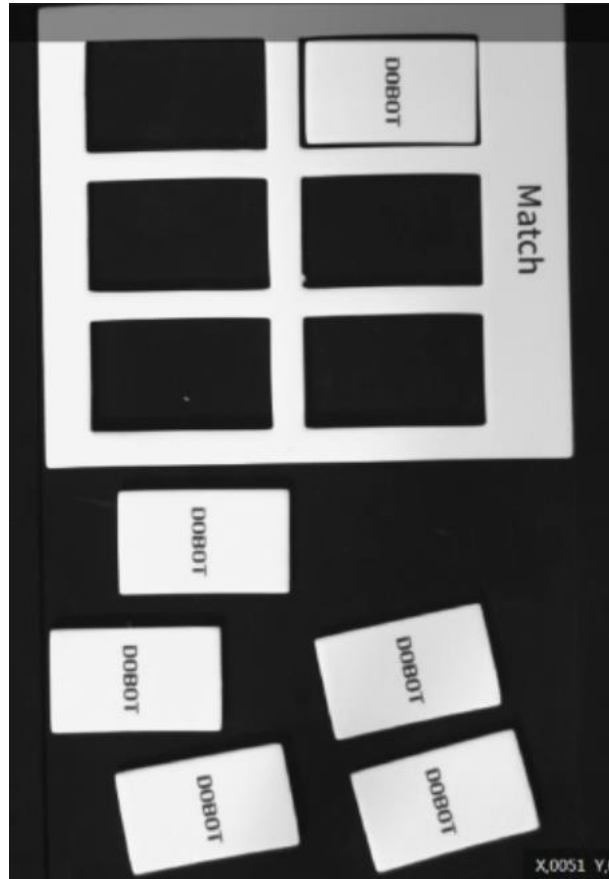
Step 1 Solution establishment idea.

Create feature templates for rectangle and rectangle model by feature match module.

📖NOTE

- There are two feature matches in this demo to determine ROI, which are used for searching rectangle and rectangle model respectively.
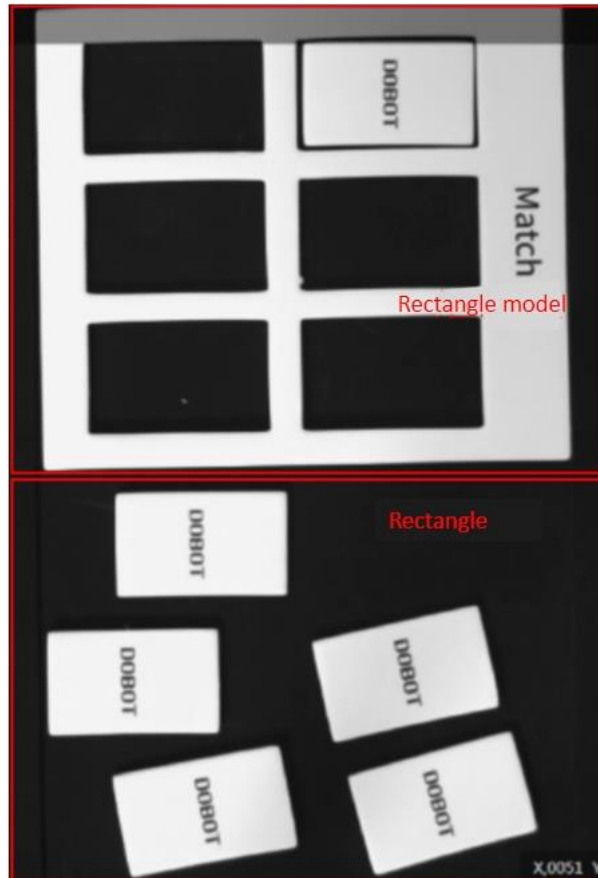
- Calculate the angle of rectangle and rectangle model by variables to adjust the matching angle.

  📖NOTE
  - The angle of end-effector of Magician is -150°to 150 °. As the angle of model matching may be -150 °to -180 °or 150 °to 180 °, script is used to transform the matching angle into an executable angle for Magician.

- Convert image coordinate to physical coordinate by calibration transformation.
- Match rectangle by controlling Magician.

The overall solution flow is shown below.

Step 2 Set camera.

1. Click **Camera**, as shown below. Select camera, and set **Pixel Format** to **MONO8**. You can adjust the brightness of camera by adjusting aperture, exposure-time and light, if the photograph is not bright enough. Set **Trigger Source** to **SOFTWARE** in **Trigger Settings**.
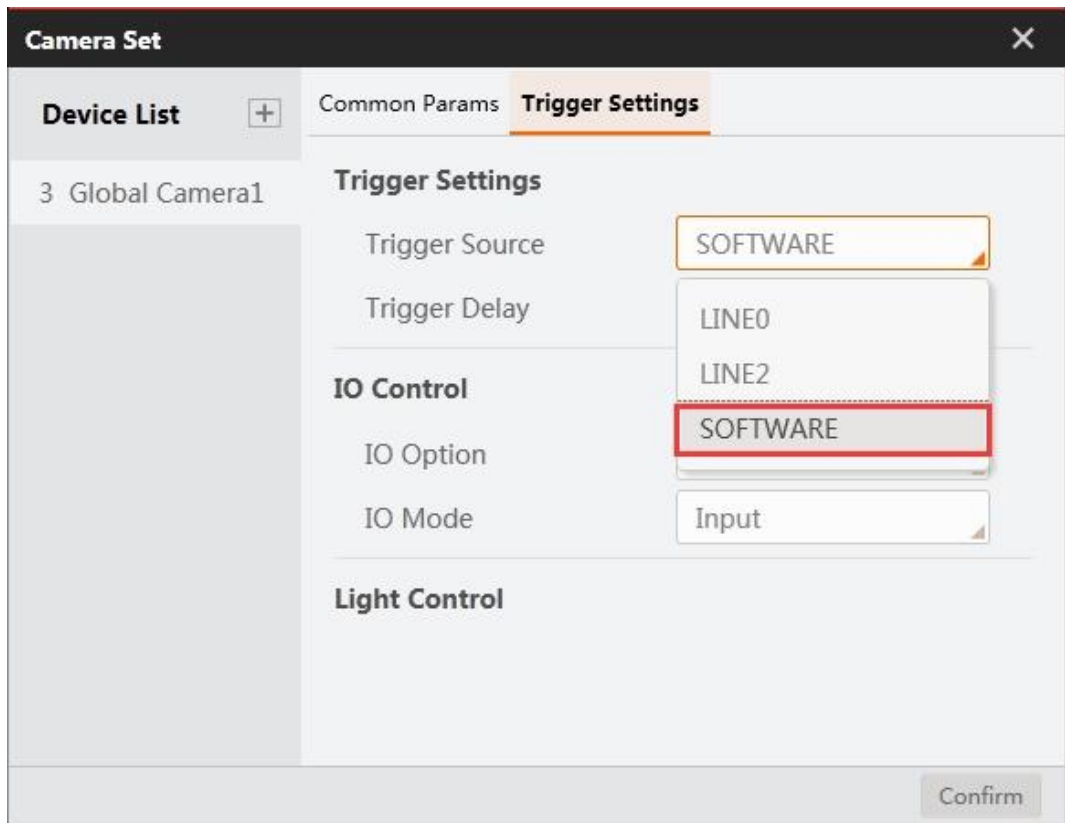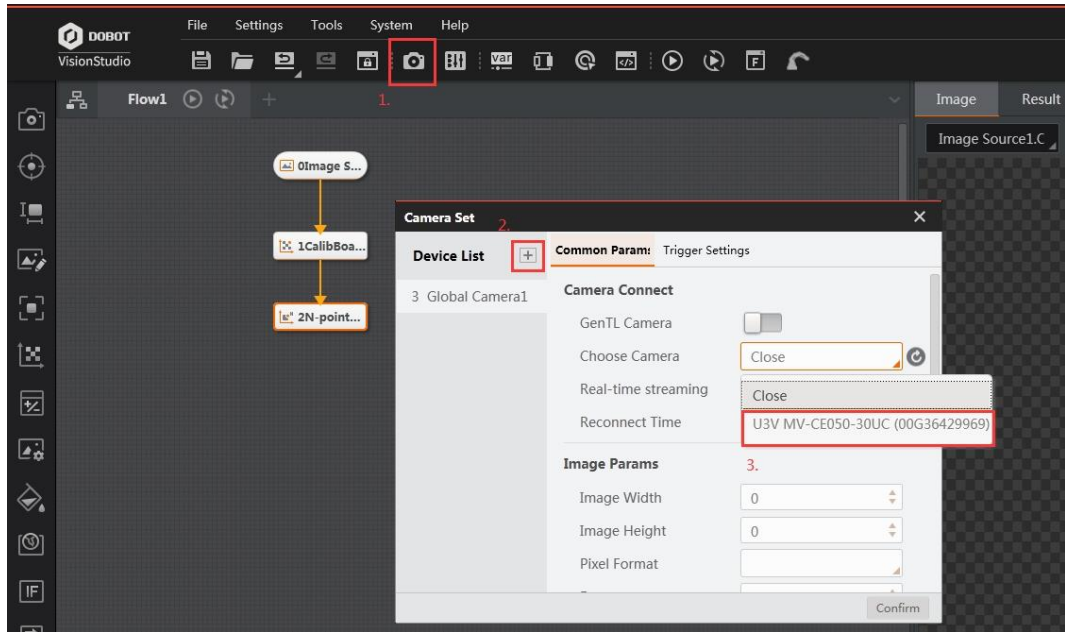
2. Click **Image Source**, as shown below. Select **Camera** as **Image source**. Select the global camera device that you set above as **Relate Camera**.
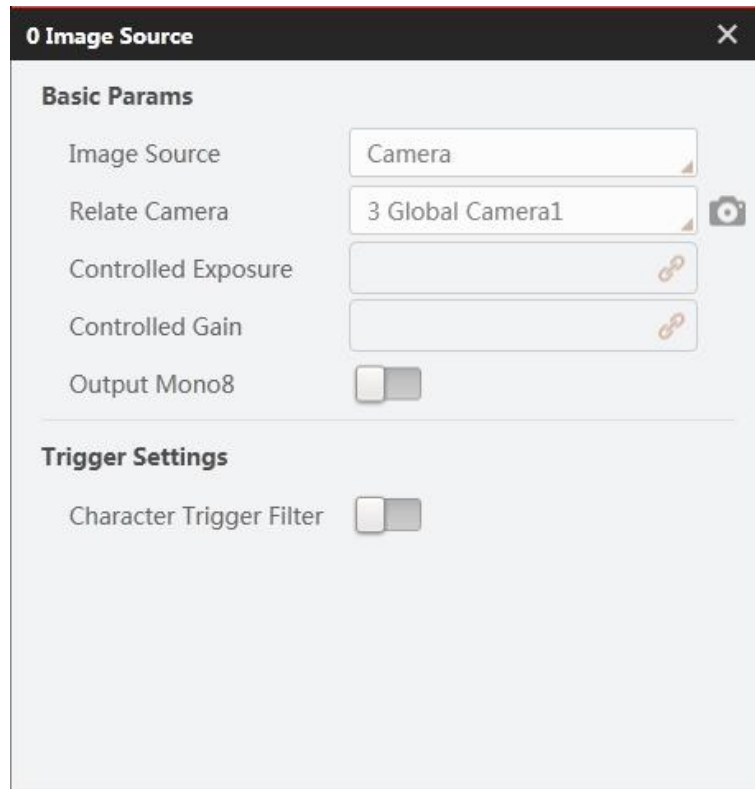
Step 3 Rectangle feature match.

1. Set **Input Source** to the image that you want to use. Set **ROI Creation** to **Draw** , and draw ROI area with mouse.
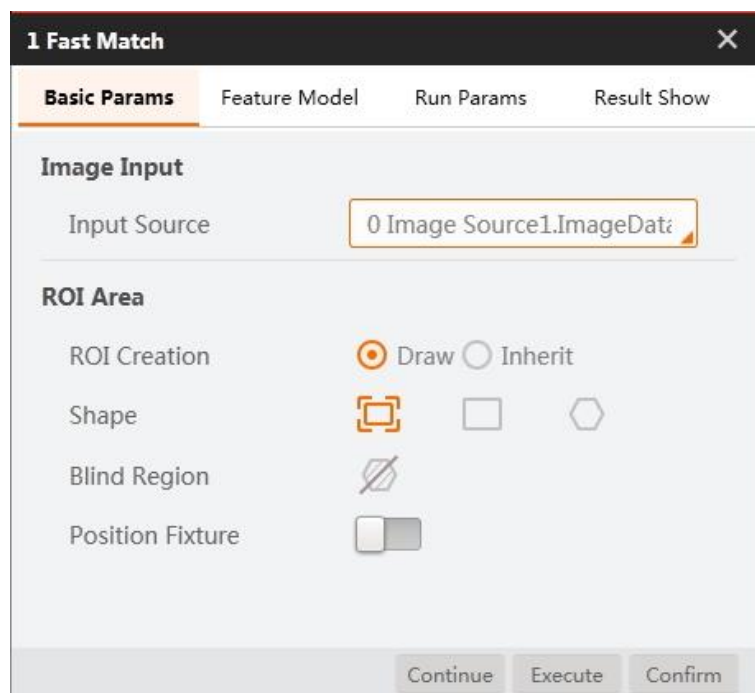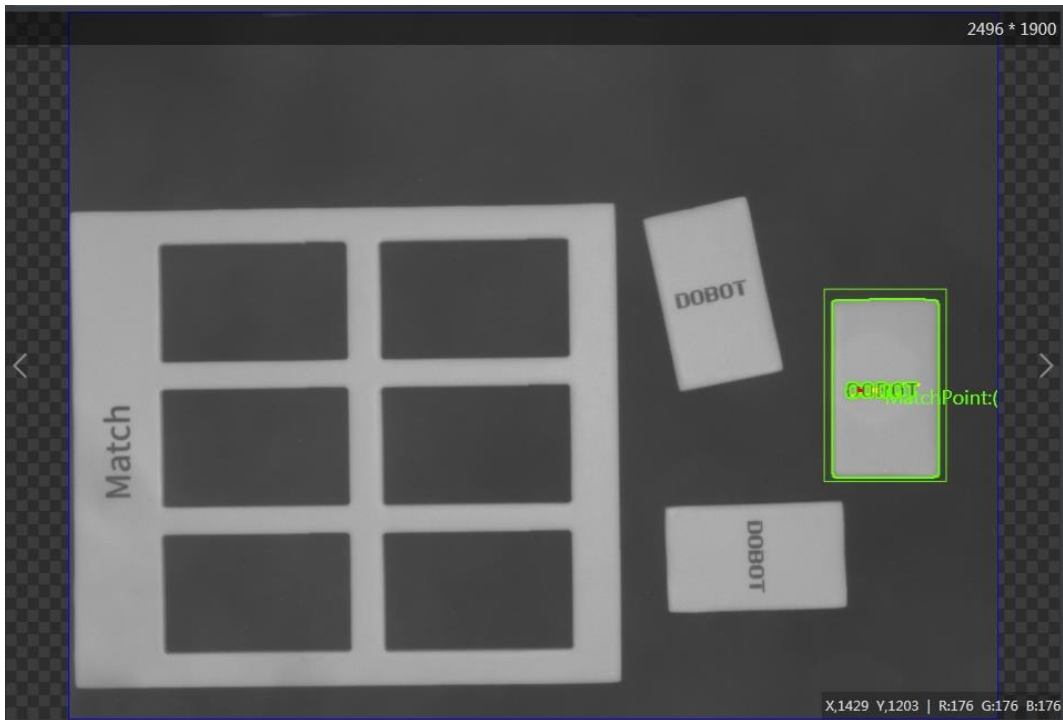
2. Create feature templates, as shown below. You need to select all characters completely enclosed by a green box. You can set **Scale Mode** to **Manual** to select characters manually if the green box cannot cover all characters. Then set the roughness and contrast threshold based on site requirements.
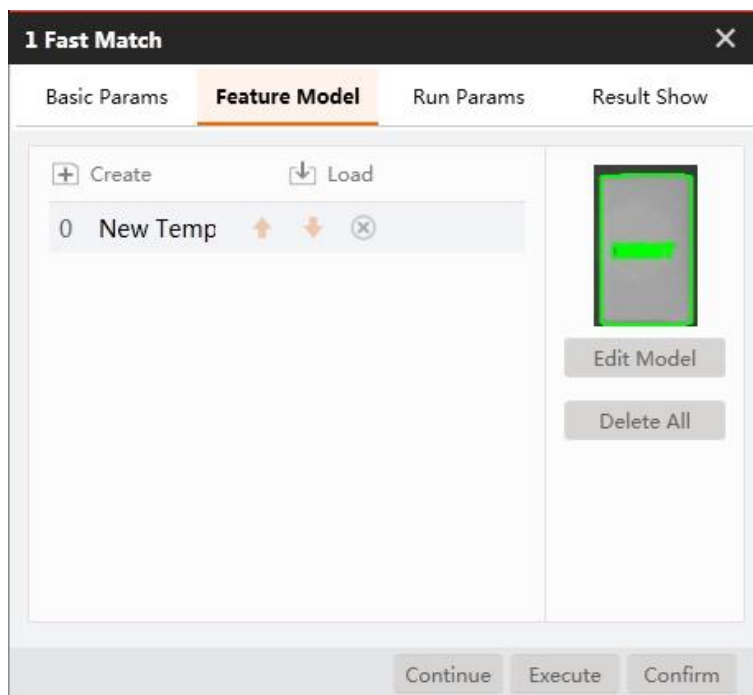
Step 4 Rectangle template match

1. Set **Input Source** to the image that you want to use. Set ROI area to **Draw**, and draw ROI area with mouse.
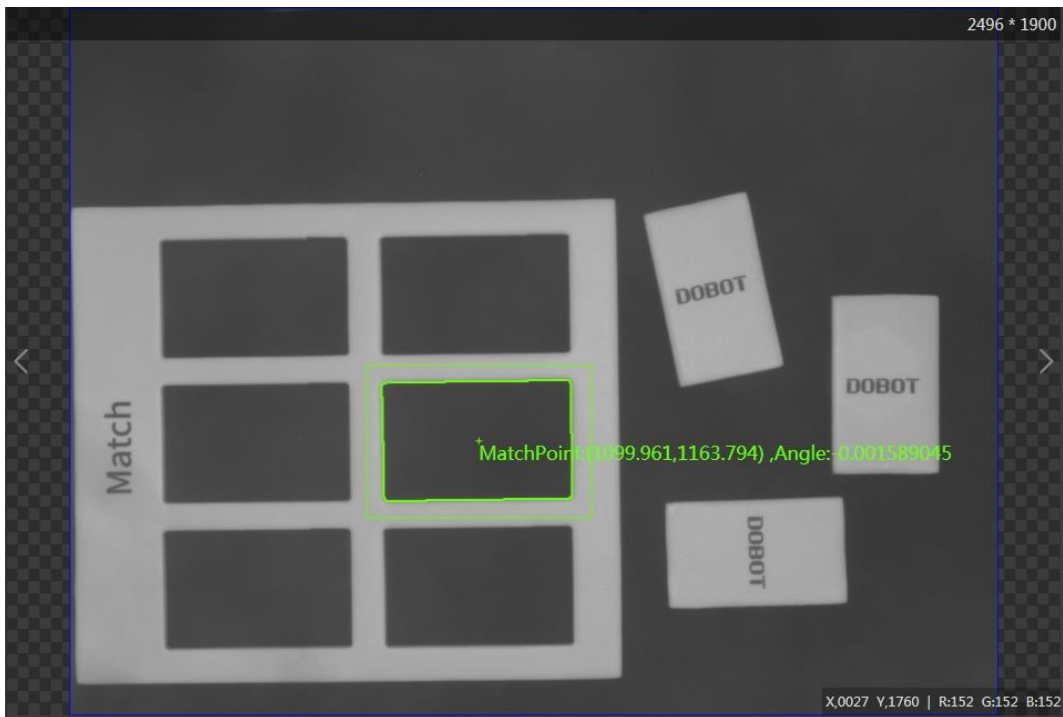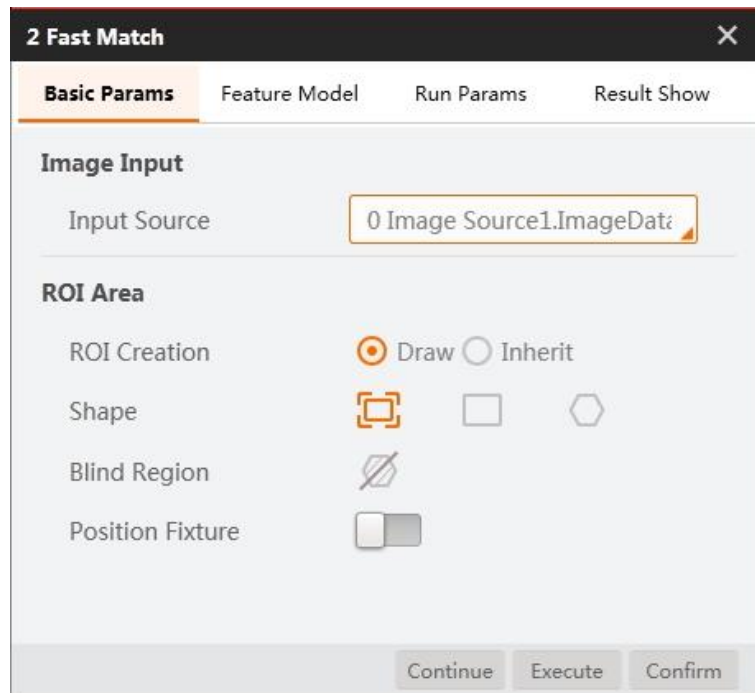
2. Create feature templates, as shown below. You need to select all characters completely enclosed by a green box. You can set **Scale Mode** to **Manual** to select characters manually if the green box cannot cover all characters. Then set the roughness and contrast threshold based on site requirements.
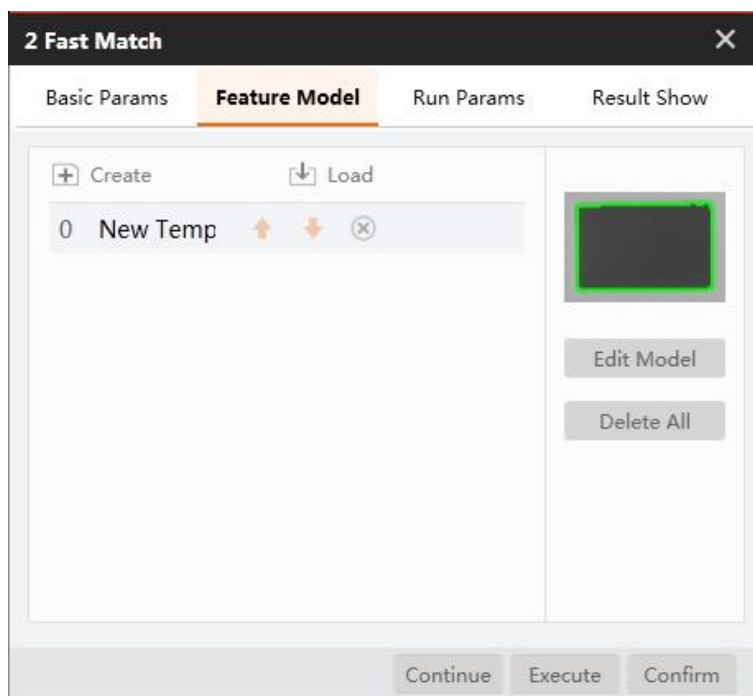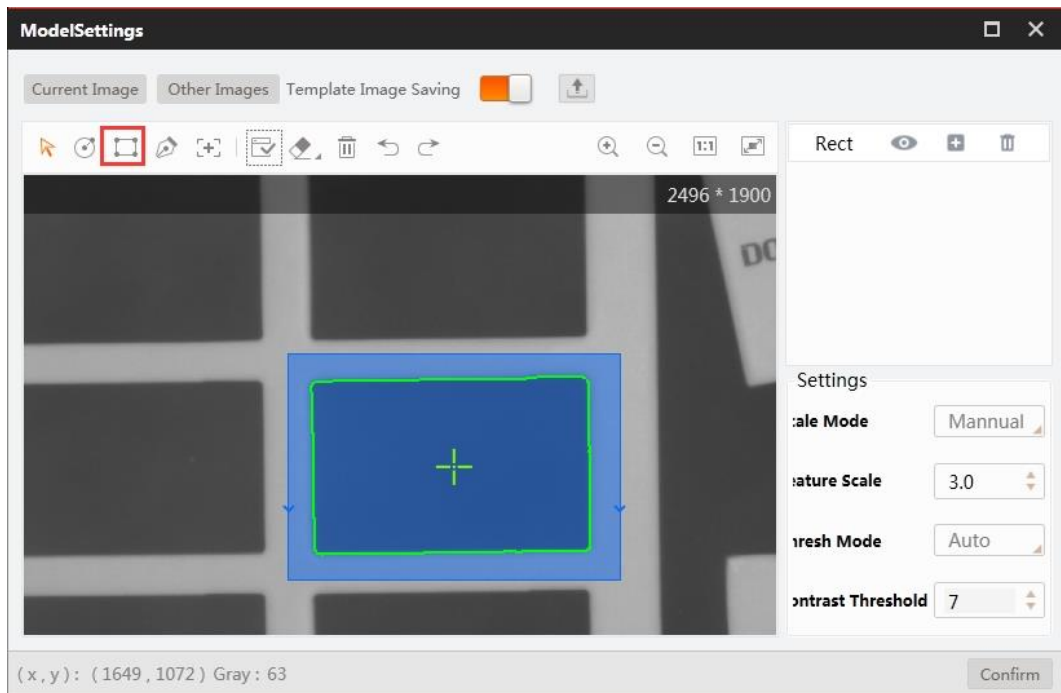
Step 5   Correct the position of the rectangle.

Establish the position offset baseline according to the feature matching point and angle, As shown in the figure below, set **Input Source** to the image to be processed. Select **By Point** in **Choose Mode**, and click **Create Reference**.
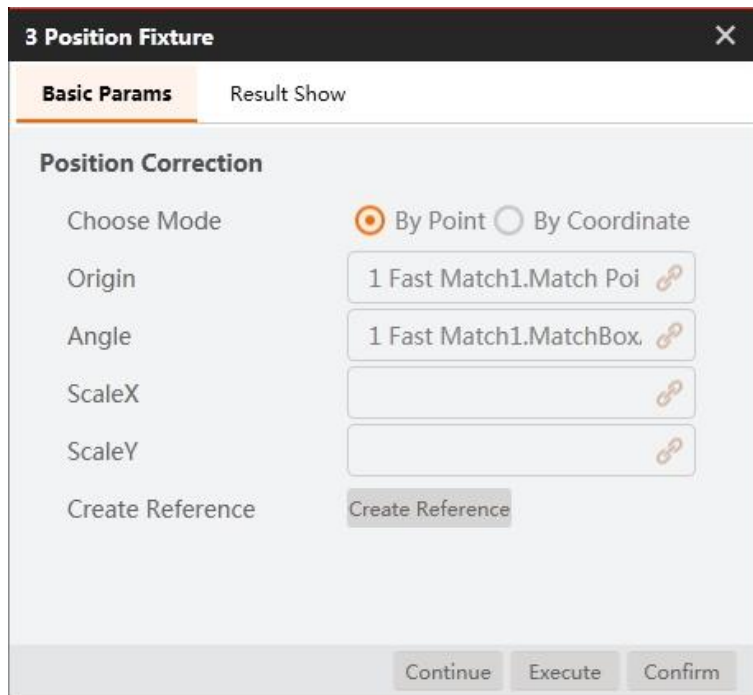
Step 6 Correct the position of the rectangle model.

Establish the position offset baseline according to the feature matching point and angle, As shown in the figure below, set **Input Source** to the image to be processed. Select **By Point** in **Choose Mode**, and click **Create Reference**.
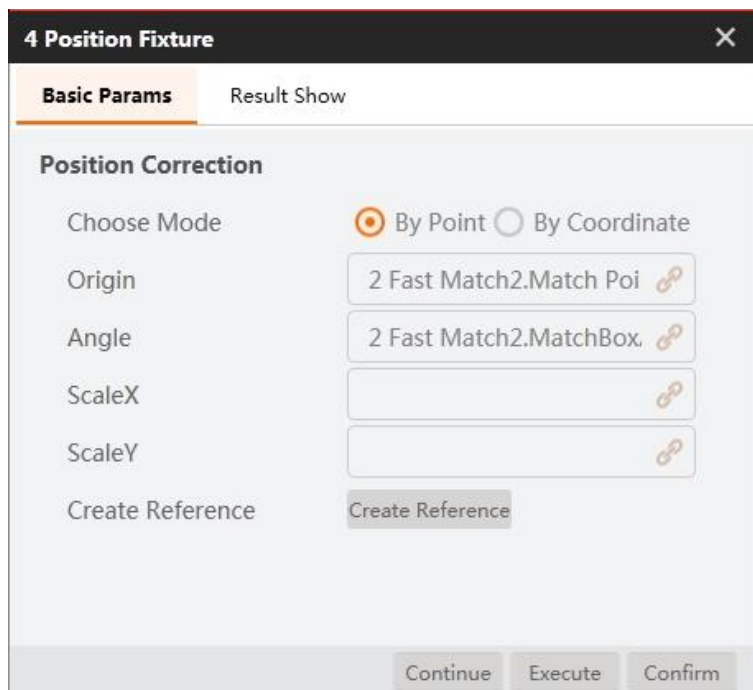
Step 7 Line search for rectangle.

Set **Input Source** to the image to be processed. Set **ROI Creation** to **Draw. Set** the position correction information of the rectangle. As shown in the figure below, set line search for the target side in **Shape**. Click **Execute.**
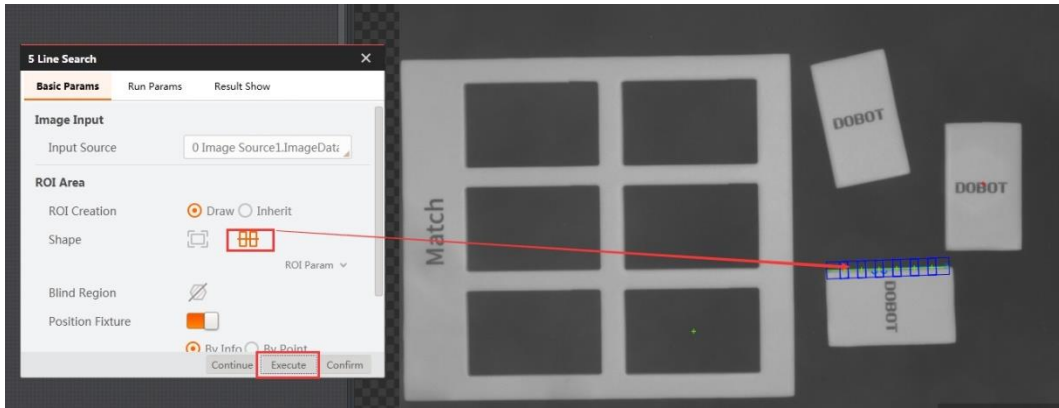
Step 8 Line search for rectangle template.

Set **Input Source** to the image that you want to use. Set **ROI Creation** to **Draw**. Set the position correction information of the rectangle. As shown in the figure below, set line search for the target side in **Shape**. Click **Execute.**
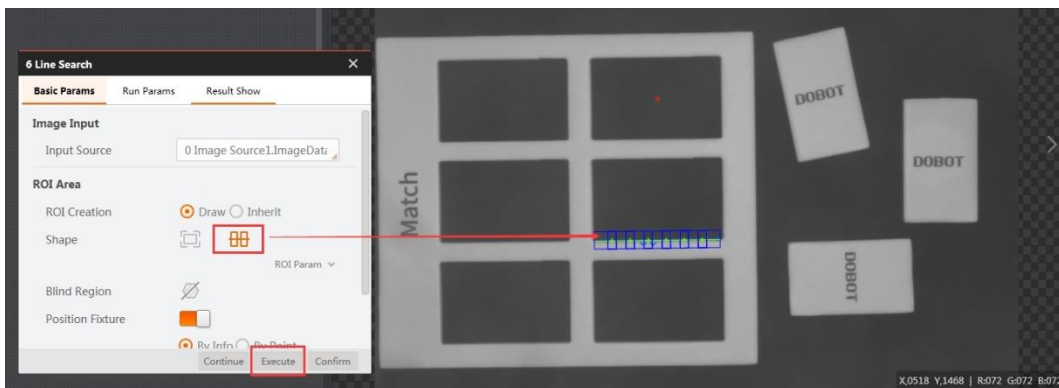
Step 9 Variable calculation

Calculate as shown in the figure.
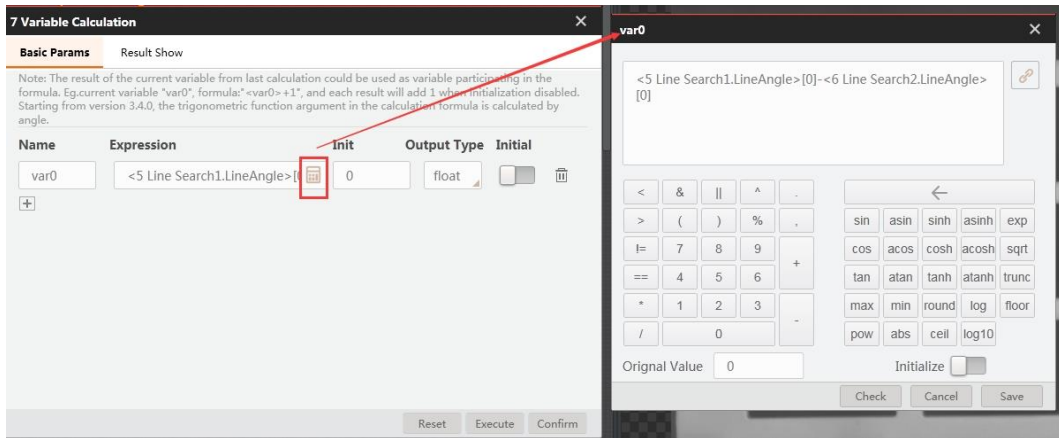
Step 10 Convert image coordinate to physical coordinate.

Set **Input Source** and **Input Mode**, as shown below. Load calibration file and click **Confirm**.
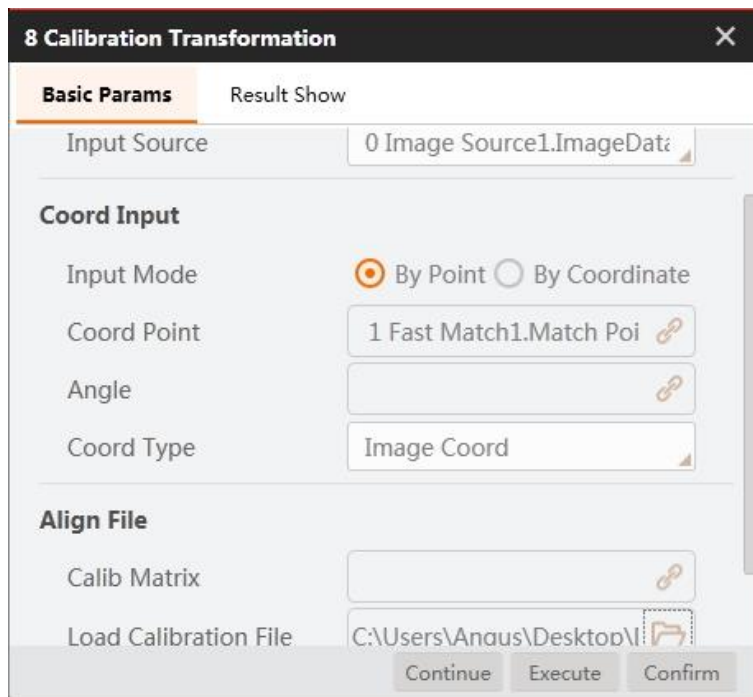
Step 11 Move to a point.

Select the corresponding physical coordinates, and set the Z-axis value based on site requirements.
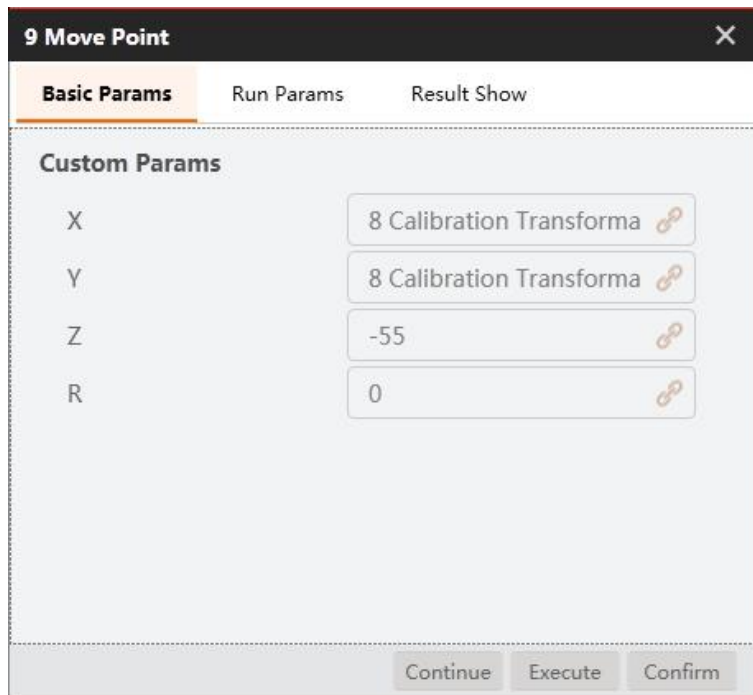
Step 12 Open suction cup.
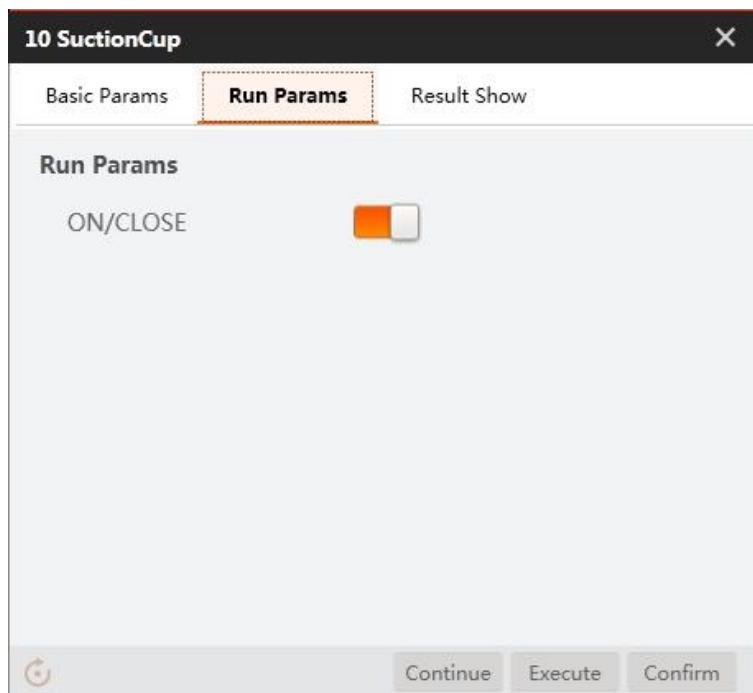
Step 13 Move to a point.

Set R-axis to the output of variable calculation.
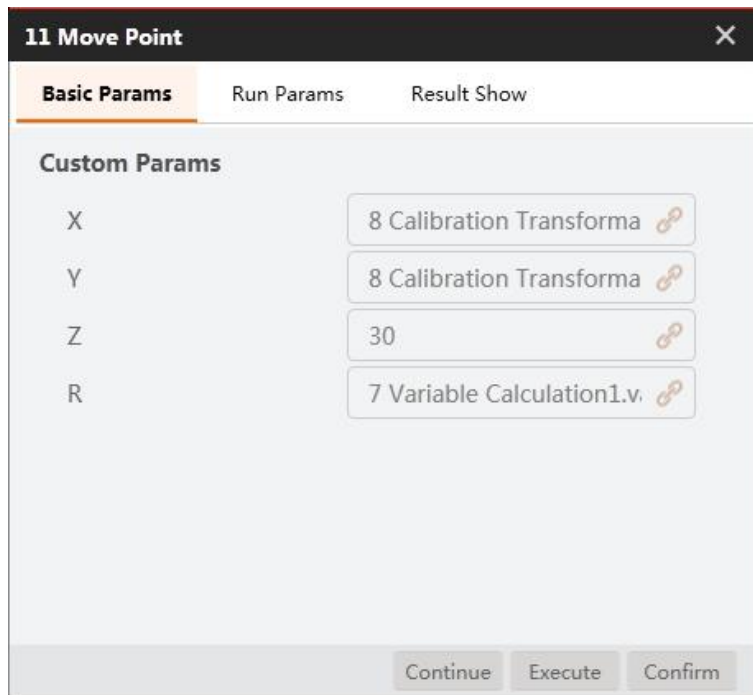
Step 14 Convert image coordinate to physical coordinate.

Set **Input Source**, **Input Mode** and **Coord Point**, as shown below. Load calibration file and click **Confirm**.
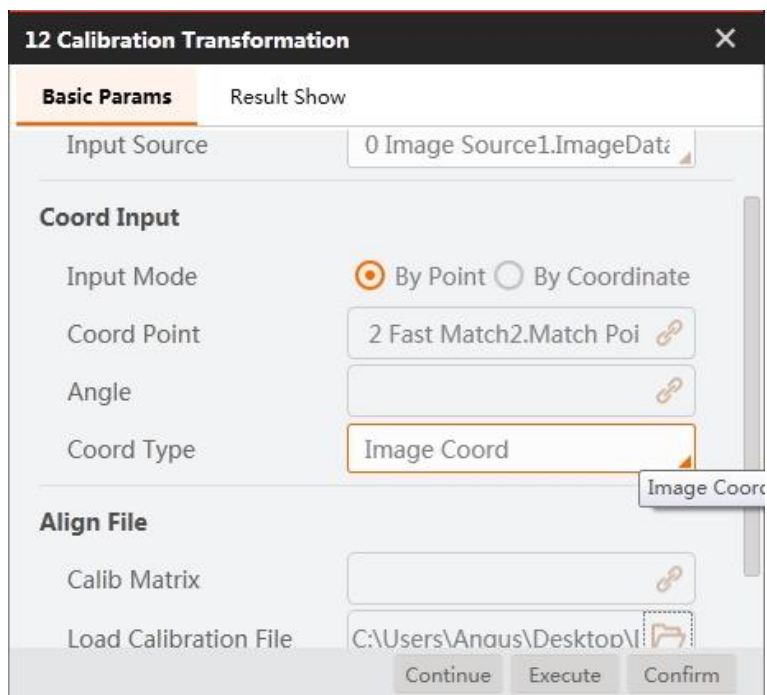
Step 15 Move to a point.

Select the corresponding physical coordinates, and set the Z-axis value based on site requirements.
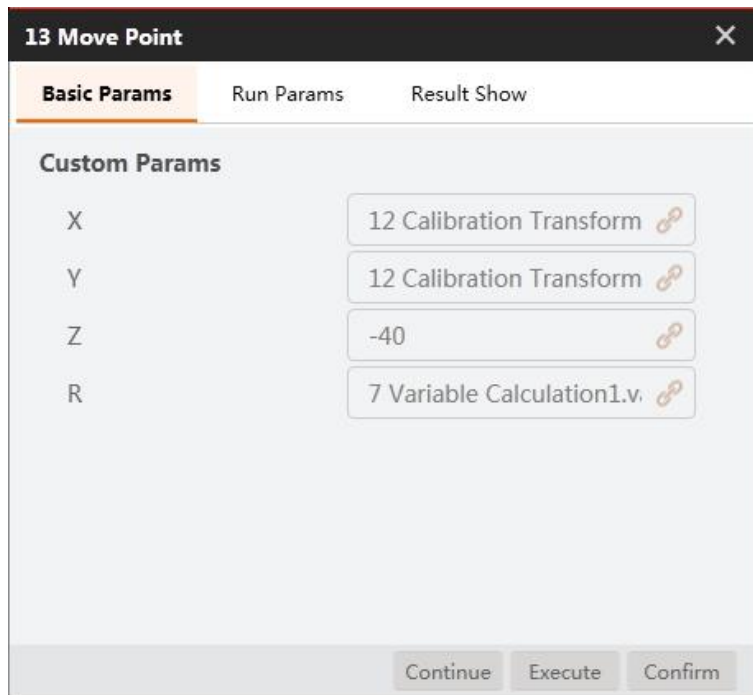
Step 16   Close suction cup.
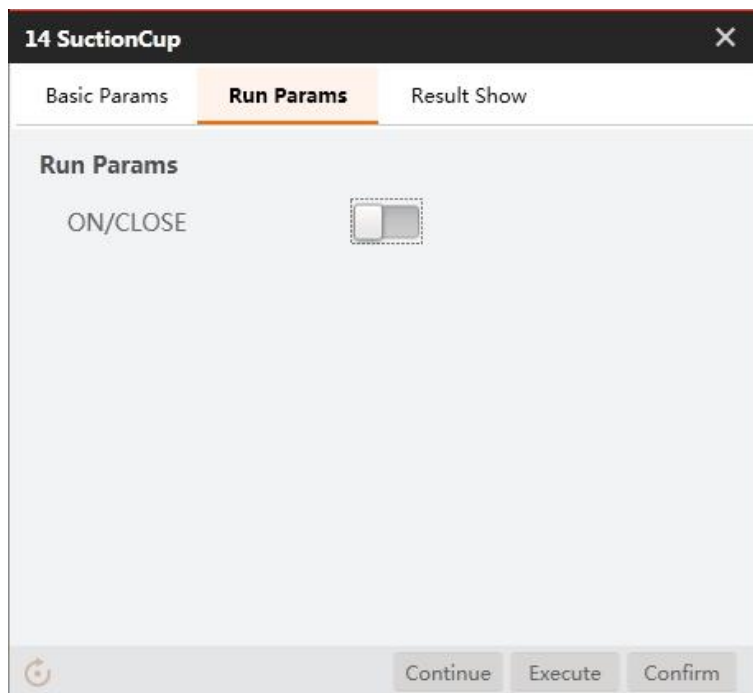
6.6   **Circle Template Match**

Objective: Measure the diameter of circles and put them into the corresponding model as shown below.

📖NOTE

• Calibration file needs to be generated beforehand.
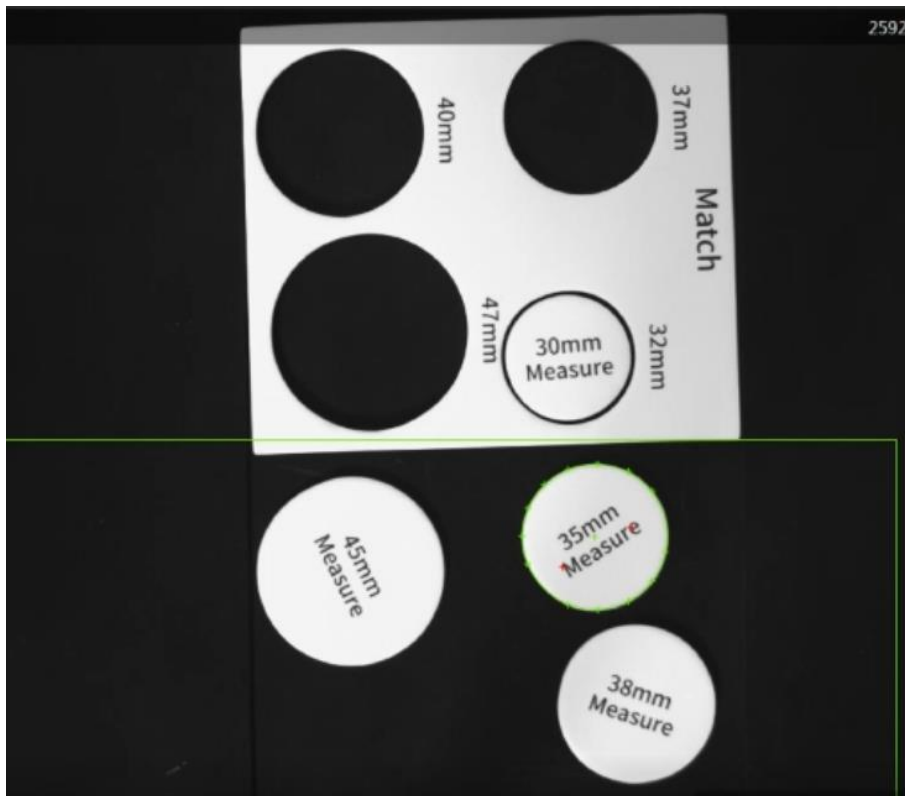
Step 1 Solution establishment idea.

• Find the measured circle by Circle Search module.

• Convert image coordinate to physical coordinate by calibration tools.

• Put circles to corresponding circle models by Dobot Magician.

The overall solution flow is shown below.
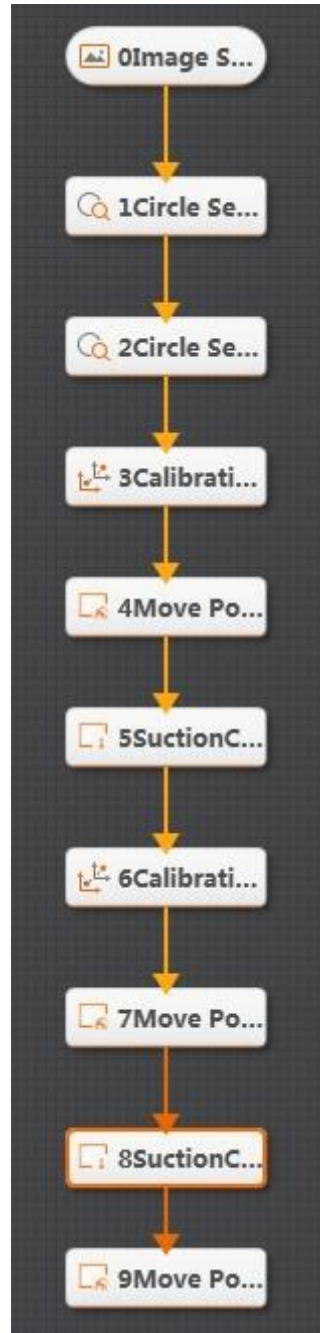
Step 2 Set camera.

1. Click **Camera**, as shown below. Set **Pixel Format** to **MONO8**. You can adjust the brightness of camera by adjusting aperture, exposure-time and light, if the photograph is not bright enough. Set **Trigger Source** to **SOFTWARE** in **Trigger Settings**.
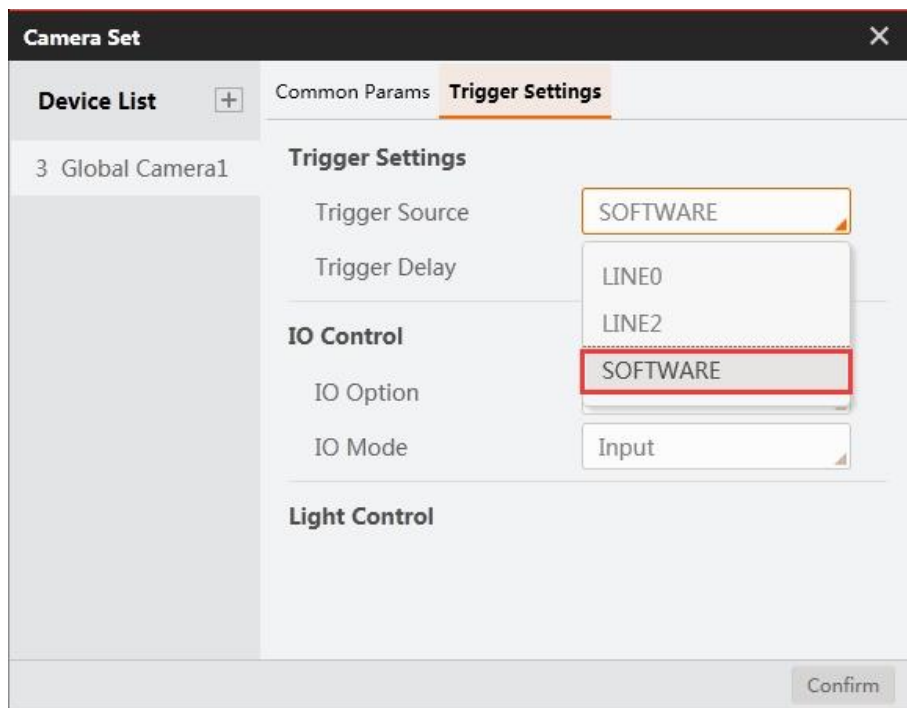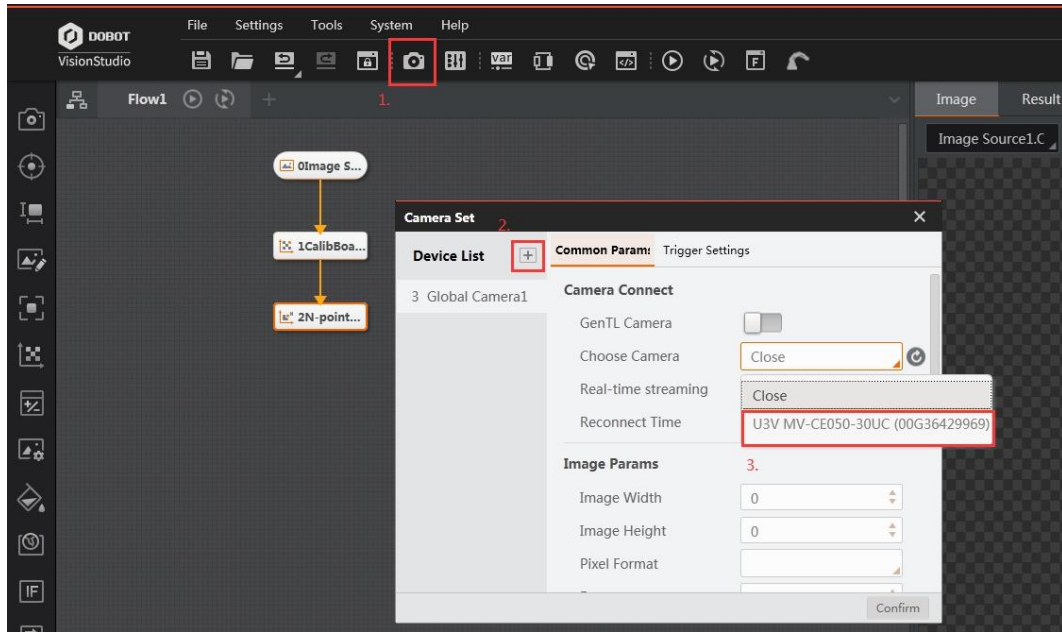
2. Click **Image Source**, as shown below. Select **Camera** as **Image source**. Select the global camera device that you set above as **Relate Camera**.

Step 3   Search circle.

1.   Set the range of circle search. Set **Input Source** to the image that you want to use. Set **ROI Creation** to **Draw**, and draw ROI area with mouse.
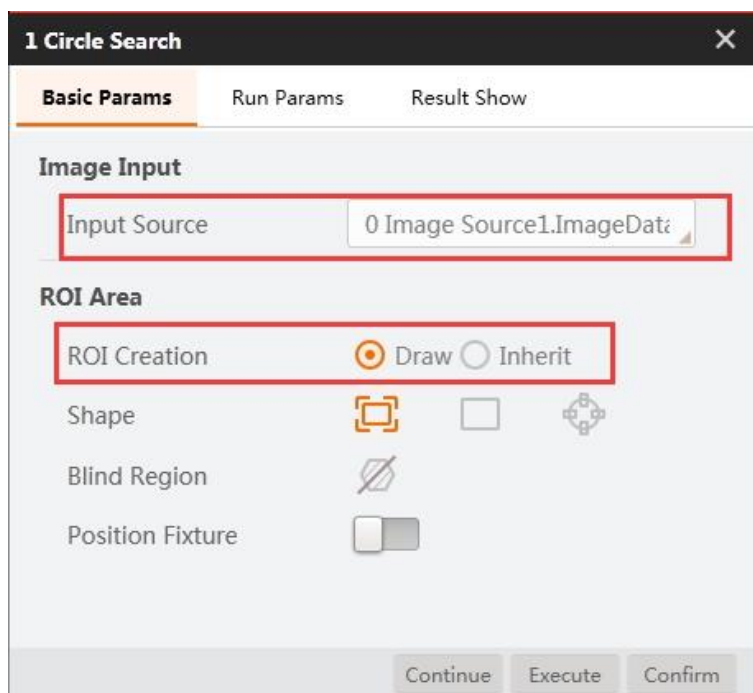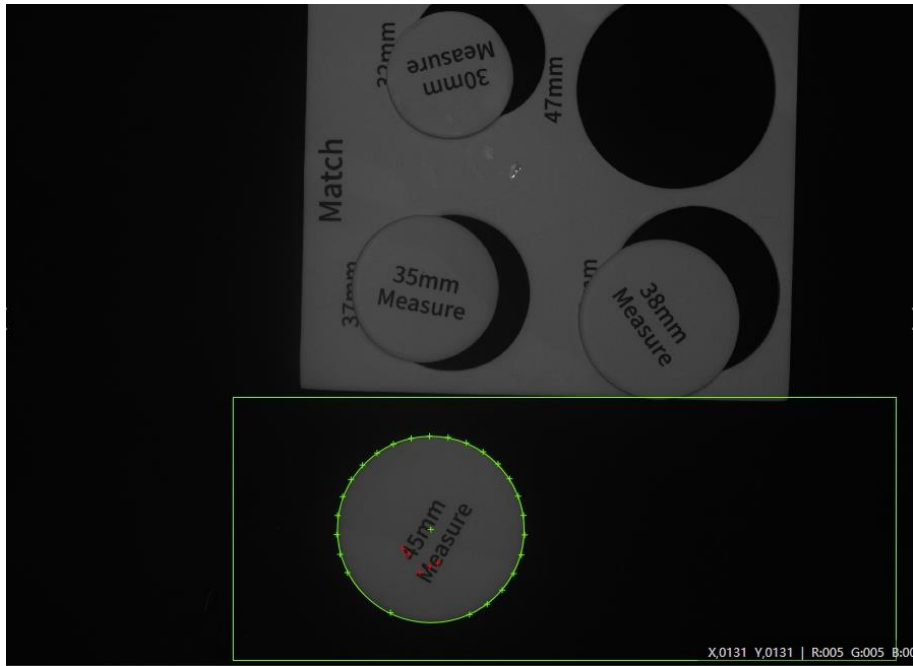
2. Set radius and mode parameters to search eligible circles. Then click **Confirm**.
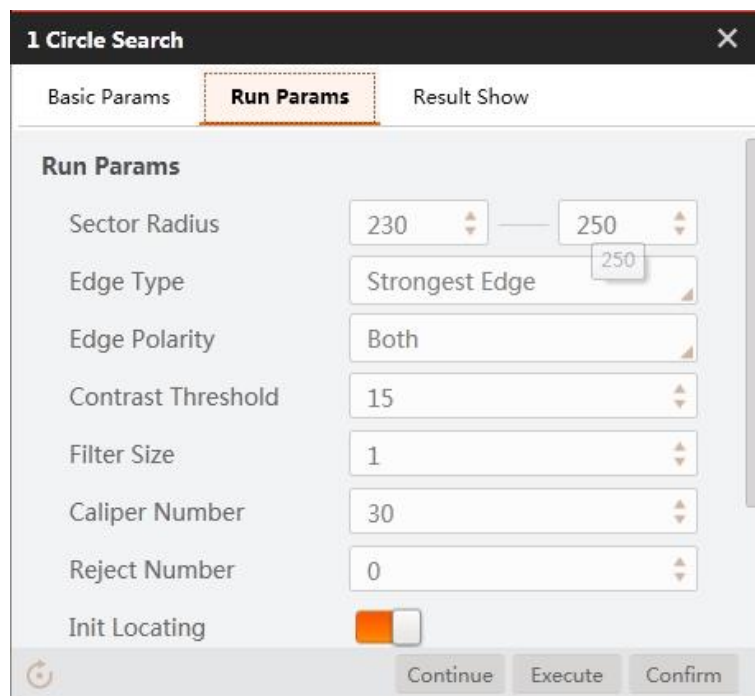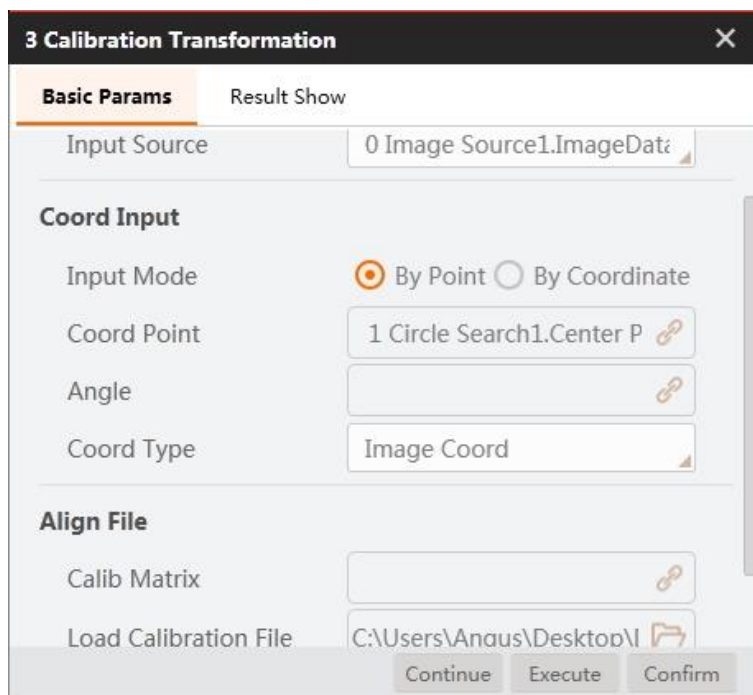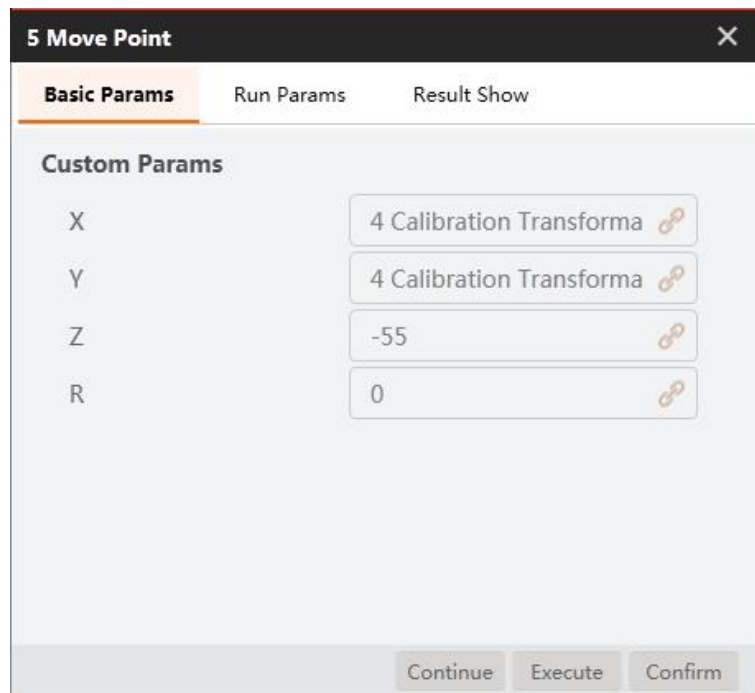

Step 4 Find circle model.

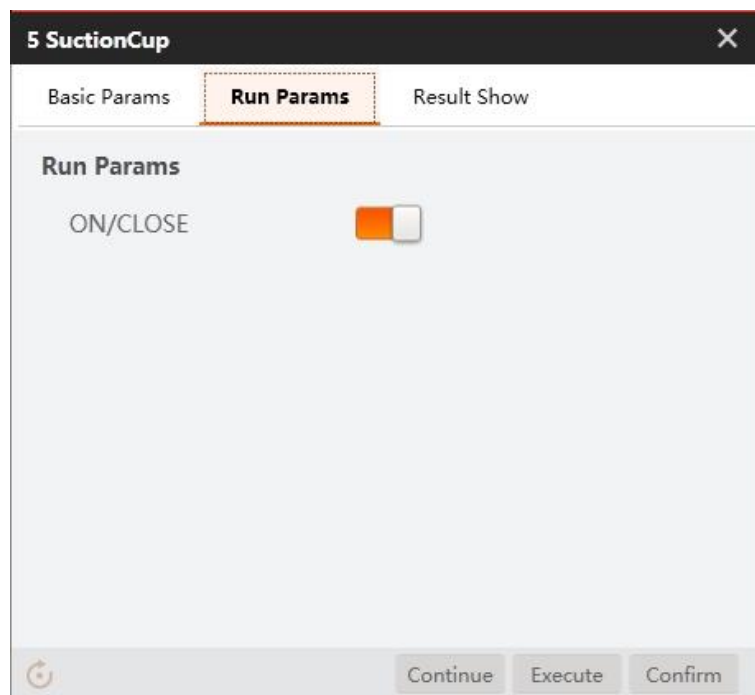Please refer to Step 3 to set model parameters.
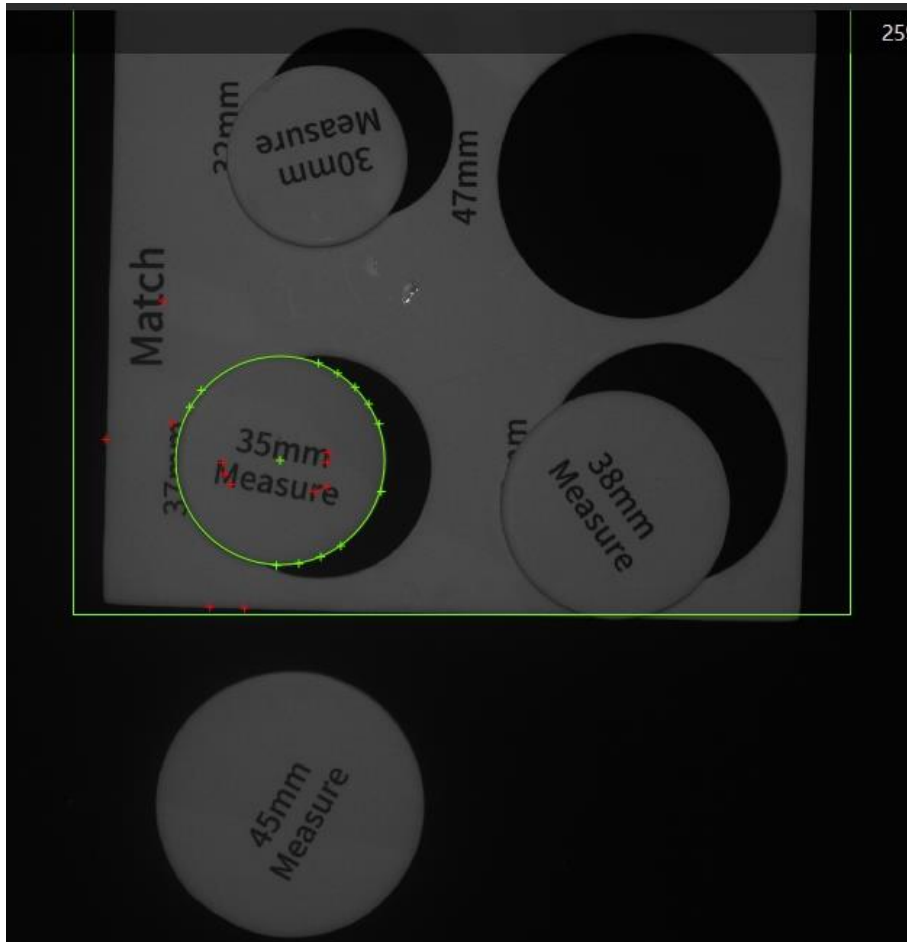
Step 5   Convert image coordinate to physical coordinate.

Set **Input Source** and **Input Mode**, as shown below. Load calibration file and click **Confirm**.
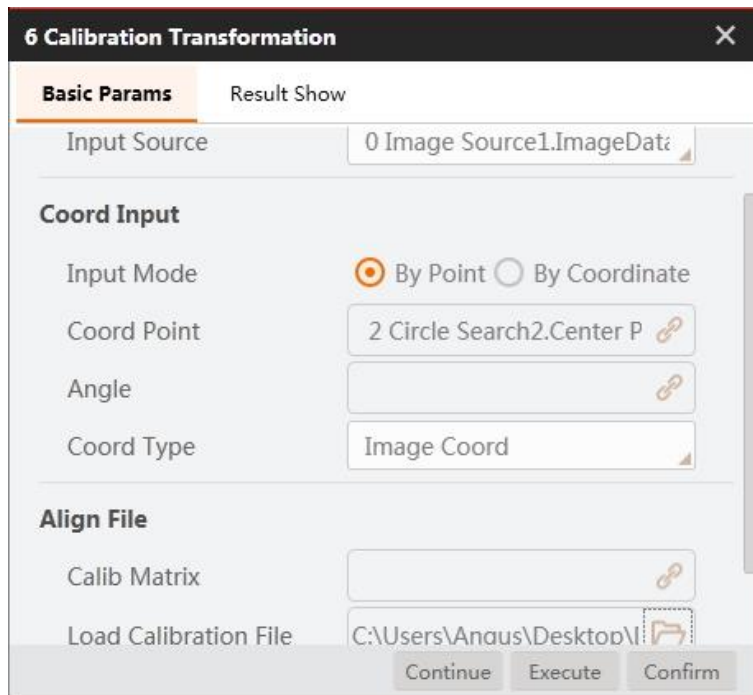
Step 6   Move to a point

Set the grasping position of Magician. For details about motion mode, refer to Moving to a Point. Set the Z-axis value based on site requirements.
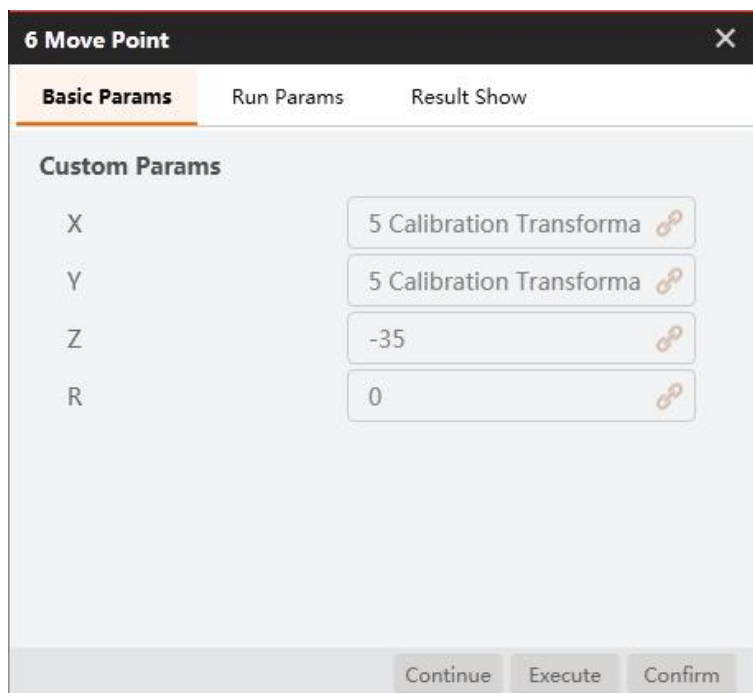

Step 7   Open suction cup.

Step 8   Convert image coordinate to physical coordinate.

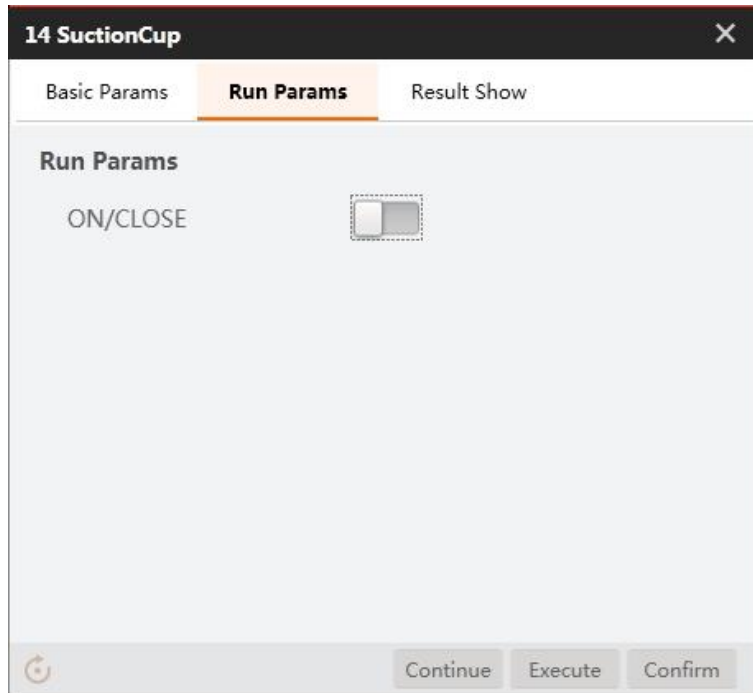Set **Input Source** and **Input Mode**, as shown below. Load calibration file and click **Confirm**.

Step 9   Move to a point.

Set the match position. For details about motion mode, refer to Moving to a Point. Set the Z-axis value based on site requirements.

Step 10   Set suction cup.

Close suction cup.

Step 11 Match the result

All circles are matched successfully.