FANUC Robot series

R-30*i*B CONTROLLER

*i*RVision

OPERATOR'S MANUAL (Reference)

B-83304EN/01

• Original Instructions

Before using the Robot, be sure to read the "FANUC Robot Safety Manual (B-80687EN)" and understand the content.

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Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

SAFETY PRECAUTIONS

Thank you for purchasing FANUC Robot.
This chapter describes the precautions which must be observed to ensure the safe use of the robot.
Before attempting to use the robot, be sure to read this chapter thoroughly.

Before using the functions related to robot operation, read the relevant operator's manual to become familiar with those functions.

If any description in this chapter differs from that in the other part of this manual, the description given in this chapter shall take precedence.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral devices installed in a work cell.
In addition, refer to the “FANUC Robot SAFETY HANDBOOK (B-80687EN)”.

1 WORKING PERSON

The personnel can be classified as follows.

Operator:
- Turns robot controller power ON/OFF
- Starts robot program from operator’s panel

Programmer or teaching operator:
- Operates the robot
- Teaches robot inside the safety fence

Maintenance engineer:
- Operates the robot
- Teaches robot inside the safety fence
- Maintenance (adjustment, replacement)

- An operator cannot work inside the safety fence.
- A programmer, teaching operator, and maintenance engineer can work inside the safety fence. The working activities inside the safety fence include lifting, setting, teaching, adjusting, maintenance, etc..
- To work inside the fence, the person must be trained on proper robot operation.

During the operation, programming, and maintenance of your robotic system, the programmer, teaching operator, and maintenance engineer should take additional care of their safety by using the following safety precautions.

- Use adequate clothing or uniforms during system operation
- Wear safety shoes
- Use helmet

2 DEFINITION OF WARNING, CAUTION AND NOTE

To ensure the safety of user and prevent damage to the machine, this manual indicates each precaution on safety with "Warning" or "Caution" according to its severity. Supplementary information is indicated by "Note". Read the contents of each "Warning", "Caution" and "Note" before attempting to use the oscillator.

⚠WARING
Applied when there is a danger of the user being injured or when there is a danger of both the user being injured and the equipment being damaged if the approved procedure is not observed.

⚠CAUTION
Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

NOTE
Notes are used to indicate supplementary information other than Warnings and Cautions.

- Read this manual carefully, and store it in a sales place.

3 WORKING PERSON SAFETY

Working person safety is the primary safety consideration. Because it is very dangerous to enter the operating space of the robot during automatic operation, adequate safety precautions must be observed.
The following lists the general safety precautions. Careful consideration must be made to ensure working person safety.

(1) Have the robot system working persons attend the training courses held by FANUC.

FANUC provides various training courses. Contact our sales office for details.

(2) Even when the robot is stationary, it is possible that the robot is still in a ready to move state, and is waiting for a signal. In this state, the robot is regarded as still in motion. To ensure working person safety, provide the system with an alarm to indicate visually or aurally that the robot is in motion.
(3) Install a safety fence with a gate so that no working person can enter the work area without passing through the gate. Install an interlocking device, a safety plug, and so forth in the safety gate so that the robot is stopped as the safety gate is opened.

The controller is designed to receive this interlocking signal of the door switch. When the gate is opened and this signal received, the controller stops the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). For connection, see Fig.2 (a) and Fig.2 (b).

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).
(5) Try to install the peripheral devices outside the work area.
(6) Draw an outline on the floor, clearly indicating the range of the robot motion, including the tools such as a hand.
(7) Install a mat switch or photoelectric switch on the floor with an interlock to a visual or aural alarm that stops the robot when a working person enters the work area.
(8) If necessary, install a safety lock so that no one except the working person in charge can turn on the power of the robot.

The circuit breaker installed in the controller is designed to disable anyone from turning it on when it is locked with a padlock.

(9) When adjusting each peripheral device independently, be sure to turn off the power of the robot
(10) Operators should be ungloved while manipulating the operator's panel or teach pendant. Operation with gloved fingers could cause an operation error.
(11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident.
(12) The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
(13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
(14) Before the robot is started, it should be checked that no one is in the area of the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.
(15) When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
- Avoid using the robot in a flammable environment.
- Avoid using the robot in an explosive environment.
- Avoid using the robot in an environment full of radiation.
- Avoid using the robot under water or at high humidity.
- Avoid using the robot to carry a person or animal.
- Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)
(16) When connecting the peripheral devices related to stop(safety fence etc.) and each signal (external emergency , fence etc.) of robot. be sure to confirm the stop movement and do not take the wrong connection.

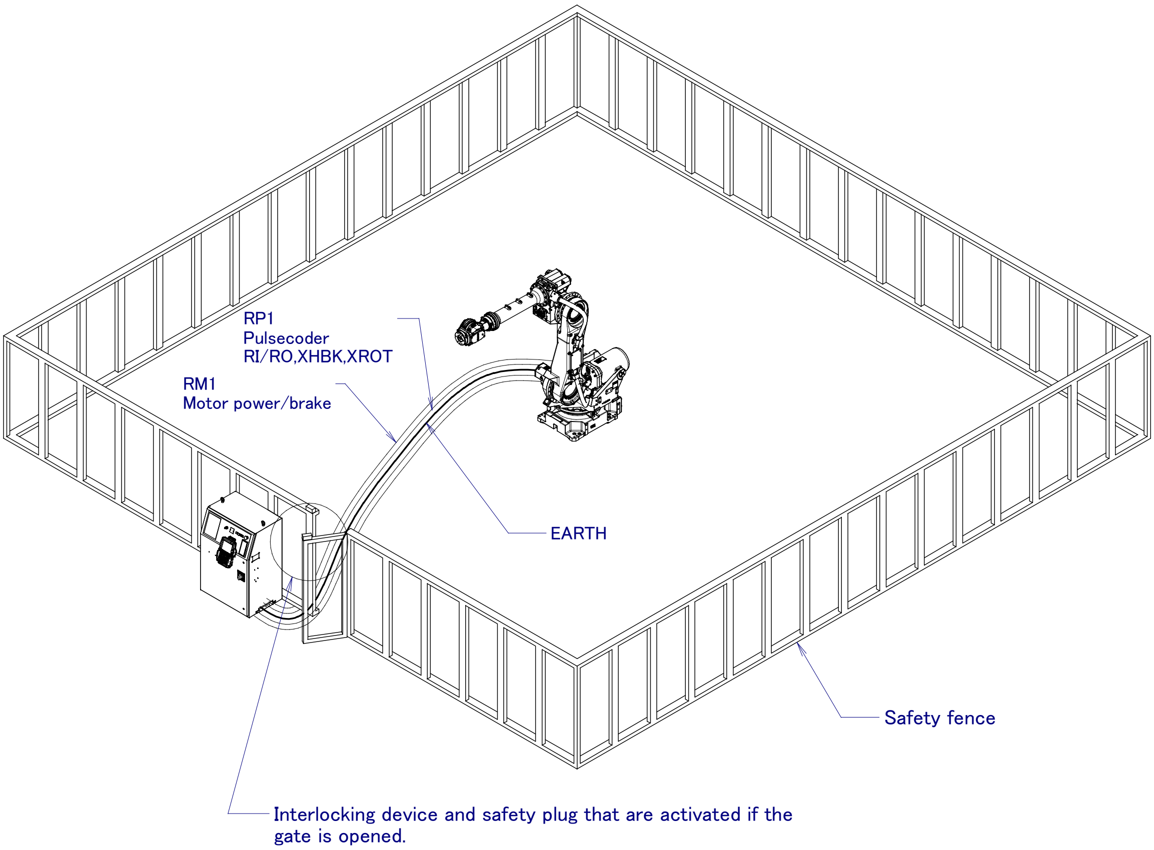

Fig. 3 (a) Safety fence and safety gate

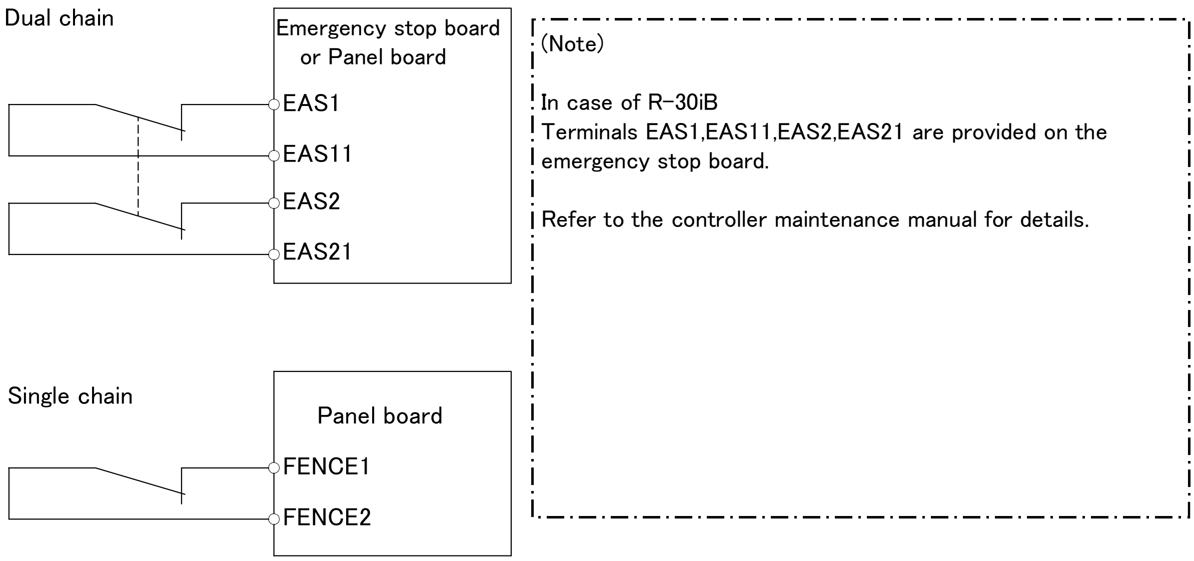

Fig. 3 (b) Limit switch circuit diagram of the safety fence

3.1 OPERATOR SAFETY

The operator is a person who operates the robot system. In this sense, a worker who operates the teach pendant is also an operator. However, this section does not apply to teach pendant operators.

(1) If you do not have to operate the robot, turn off the power of the robot controller or press the EMERGENCY STOP button, and then proceed with necessary work.

(2) Operate the robot system at a location outside of the safety fence
(3) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the work area unexpectedly and to prevent the worker from entering a dangerous area.
(4) Install an EMERGENCY STOP button within the operator's reach.

The robot controller is designed to be connected to an external EMERGENCY STOP button. With this connection, the controller stops the robot operation (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type), when the external EMERGENCY STOP button is pressed. See the diagram below for connection.

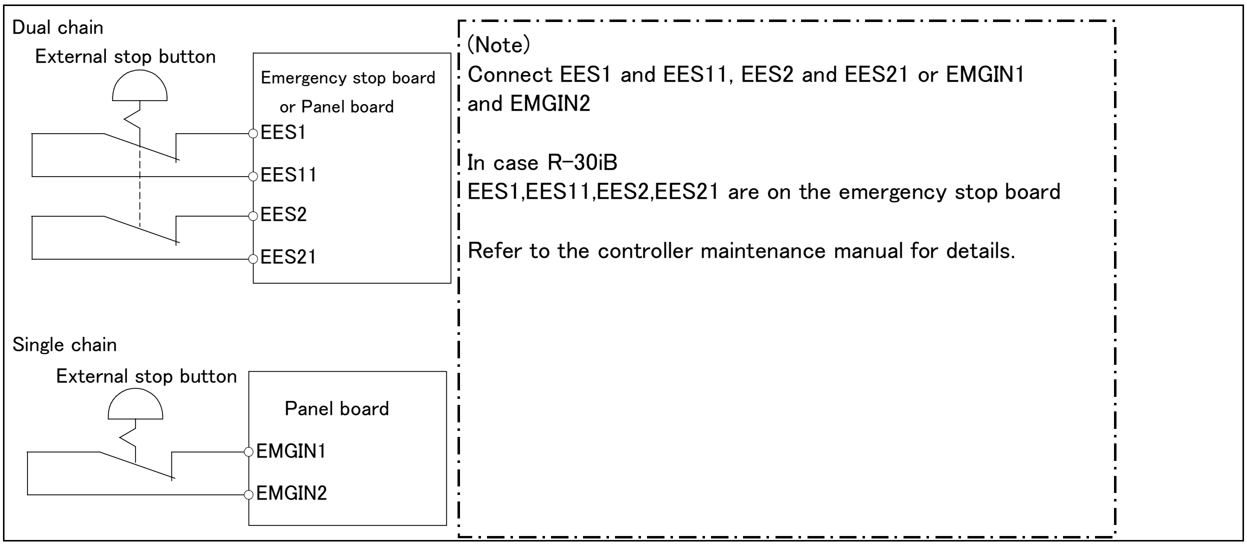

Fig.3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator must enter the work area of the robot. The operator must ensure the safety of the teach pendant operator especially.

(1) Unless it is specifically necessary to enter the robot work area, carry out all tasks outside the area.
(2) Before teaching the robot, check that the robot and its peripheral devices are all in the normal operating condition.
(3) If it is inevitable to enter the robot work area to teach the robot, check the locations, settings, and other conditions of the safety devices (such as the EMERGENCY STOP button, the DEADMAN switch on the teach pendant) before entering the area.
(4) The programmer must be extremely careful not to let anyone else enter the robot work area.
(5) Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer should take the following precautions:
   - Before entering the area of the safety fence, ensure that there is no risk of dangerous situations in the area.
   - Be prepared to press the emergency stop button whenever necessary.
   - Robot motions should be made at low speeds.
   - Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would be dangerous to the user.

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation mode set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence.

Our teach pendant is provided with a DEADMAN switch as well as an emergency stop button. These button and switch function as follows:

(1) Emergency stop button: Causes an emergency stop (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type) when pressed.

(2) DEADMAN switch: Functions differently depending on the teach pendant enable/disable switch setting status.
 (a) Disable: The DEADMAN switch is disabled.
 (b) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
 Note) The DEADMAN switch is provided to stop the robot when the operator releases the teach pendant or presses the pendant strongly in case of emergency. The R-30*i*B employs a 3-position DEADMAN switch, which allows the robot to operate when the 3-position DEADMAN switch is pressed to its intermediate point. When the operator releases the DEADMAN switch or presses the switch strongly, the robot stops immediately.

The operator's intention of starting teaching is determined by the controller through the dual operation of setting the teach pendant enable/disable switch to the enable position and pressing the DEADMAN switch. The operator should make sure that the robot could operate in such conditions and be responsible in carrying out tasks safely.

The teach pendant, operator panel, and peripheral device interface send each robot start signal. However the validity of each signal changes as follows depending on the mode switch and the DEADMAN switch of the operator panel, the teach pendant enable switch and the remote condition on the software.

In case of R-30*i*B Controller

Mode	Teach pendant enable switch	Software remote condition	Teach pendant	Operator panel	Peripheral device
AUTO mode	On	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed
	Off	Local	Not allowed	Allowed to start	Not allowed
		Remote	Not allowed	Not allowed	Allowed to start
T1, T2 mode	On	Local	Allowed to start	Not allowed	Not allowed
		Remote	Allowed to start	Not allowed	Not allowed
	Off	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed

T1,T2 mode: DEADMAN switch is effective.

(6) To start the system using the operator's panel, make certain that nobody is the robot work area and that there are no abnormal conditions in the robot work area.

(7) When a program is completed, be sure to carry out a test run according to the procedure below.
 (a) Run the program for at least one operation cycle in the single step mode at low speed.
 (b) Run the program for at least one operation cycle in the continuous operation mode at low speed.
 (c) Run the program for one operation cycle in the continuous operation mode at the intermediate speed and check that no abnormalities occur due to a delay in timing.
 (d) Run the program for one operation cycle in the continuous operation mode at the normal operating speed and check that the system operates automatically without trouble.

(e) After checking the completeness of the program through the test run above, execute it in the automatic operation mode.

(8) While operating the system in the automatic operation mode, the teach pendant operator should leave the robot work area.

3.3 SAFETY OF THE MAINTENANCE ENGINEER

For the safety of maintenance engineer personnel, pay utmost attention to the following.

(1) During operation, never enter the robot work area.
(2) A hazardous situation may arise when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system should be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed.
(3) If it becomes necessary to enter the robot operation range while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the range. The maintenance personnel must indicate that maintenance work is in progress and be careful not to allow other people to operate the robot carelessly.
(4) When entering the area enclosed by the safety fence, the maintenance worker must check the entire system in order to make sure no dangerous situations exist. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and entire system status must be carefully monitored.
(5) Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.
(6) Before the start of teaching, check that the robot and its peripheral devices are all in the normal operating condition.
(7) Do not operate the robot in the automatic mode while anybody is in the robot work area.
(8) When you maintain the robot alongside a wall or instrument, or when multiple workers are working nearby, make certain that their escape path is not obstructed.
(9) When a tool is mounted on the robot, or when any moving device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.
(10) If necessary, have a worker who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the worker should be ready to press the EMERGENCY STOP button at any time.
(11) When replacing a part, please contact FANUC service center. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the worker.
(12) When replacing or reinstalling components, take care to prevent foreign matter from entering the system.
(13) When handling each unit or printed circuit board in the controller during inspection, turn off the circuit breaker to protect against electric shock.
If there are two cabinets, turn off the both circuit breaker.
(14) A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
(15) When restarting the robot system after completing maintenance work, make sure in advance that there is no person in the work area and that the robot and the peripheral devices are not abnormal.
(16) When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.
(17) Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.
(18) The following parts are heated. If a maintenance worker needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.
   - Servo motor

－ Inside the controller

(19) Maintenance should be done under suitable light. Care must be taken that the light would not cause any danger.

(20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.

(21) The robot should not be stepped on or climbed up during maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.

(22) After the maintenance is completed, spilled oil or water and metal chips should be removed from the floor around the robot and within the safety fence.

(23) When a part is replaced, all bolts and other related components should put back into their original places. A careful check must be given to ensure that no components are missing or left not mounted.

(24) In case robot motion is required during maintenance, the following precautions should be taken :
- Foresee an escape route. And during the maintenance motion itself, monitor continuously the whole system so that your escape route will not become blocked by the robot, or by peripheral equipment.
- Always pay attention to potentially dangerous situations, and be prepared to press the emergency stop button whenever necessary.

(25) The robot should be periodically inspected. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can adversely affect the performance or service life of the robot and may cause an accident

(26) After a part is replaced, a test execution should be given for the robot according to a predetermined method. (See the program execution of “Operator’s manual of the controller”.) During the test execution, the maintenance staff should work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL DEVICES

4.1 PRECAUTIONS IN PROGRAMMING

(1) Use a limit switch or other sensor to detect a dangerous condition and, if necessary, design the program to stop the robot when the sensor signal is received.

(2) Design the program to stop the robot when an abnormal condition occurs in any other robots or peripheral devices, even though the robot itself is normal.

(3) For a system in which the robot and its peripheral devices are in synchronous motion, particular care must be taken in programming so that they do not interfere with each other.

(4) Provide a suitable interface between the robot and its peripheral devices so that the robot can detect the states of all devices in the system and can be stopped according to the states.

4.2 PRECAUTIONS FOR MECHANISM

(1) Keep the component cells of the robot system clean, and operate the robot in an environment free of grease, water, and dust.

(2) Don’t use unconfirmed liquid for cutting fluid and cleaning fluid.

(3) Employ a limit switch or mechanical stopper to limit the robot motion so that the robot or cable does not strike against its peripheral devices or tools.

(4) Observe the following precautions about the mechanical unit cables. When theses attentions are not kept, unexpected troubles might occur.
- Use mechanical unit cable that have required user interface.

- Don’t add user cable or hose to inside of mechanical unit.
- Please do not obstruct the movement of the mechanical unit cable when cables are added to outside of mechanical unit.
- In the case of the model that a cable is exposed, Please do not perform remodeling (Adding a protective cover and fix an outside cable more) obstructing the behavior of the outcrop of the cable.
- Please do not interfere with the other parts of mechanical unit when install equipments in the robot.

(5) The frequent power-off stop for the robot during operation causes the trouble of the robot. Please avoid the system construction that power-off stop would be operated routinely. (Refer to bad case example.) Please execute power-off stop after reducing the speed of the robot and stopping it by hold stop or cycle stop when it is not urgent. (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type.)
(Bad case example)
- Whenever poor product is generated, a line stops by emergency stop.
- When alteration was necessary, safety switch is operated by opening safety fence and power-off stop is executed for the robot during operation.
- An operator pushes the emergency stop button frequently, and a line stops.
- An area sensor or a mat switch connected to safety signal operate routinely and power-off stop is executed for the robot.

(6) Robot stops urgently when collision detection alarm (SV050) etc. occurs. The frequent urgent stop by alarm causes the trouble of the robot, too. So remove the causes of the alarm.

5 SAFETY OF THE ROBOT MECHANISM

5.1 PRECAUTIONS IN OPERATION

(1) When operating the robot in the jog mode, set it at an appropriate speed so that the operator can manage the robot in any eventuality.
(2) Before pressing the jog key, be sure you know in advance what motion the robot will perform in the jog mode.

5.2 PRECAUTIONS IN PROGRAMMING

(1) When the work areas of robots overlap, make certain that the motions of the robots do not interfere with each other.
(2) Be sure to specify the predetermined work origin in a motion program for the robot and program the motion so that it starts from the origin and terminates at the origin.
Make it possible for the operator to easily distinguish at a glance that the robot motion has terminated.

5.3 PRECAUTIONS FOR MECHANISMS

(1) Keep the work areas of the robot clean, and operate the robot in an environment free of grease, water, and dust.

5.4 PROCEDURE TO MOVE ARM WITHOUT DRIVE POWER IN EMERGENCY OR ABNORMAL SITUATIONS

For emergency or abnormal situations (e.g. persons trapped in or by the robot), brake release unit can be used to move the robot axes without drive power.
Please refer to controller maintenance manual and mechanical unit operator’s manual for using method of brake release unit and method of supporting robot.

6 SAFETY OF THE END EFFECTOR

6.1 PRECAUTIONS IN PROGRAMMING

(1) To control the pneumatic, hydraulic and electric actuators, carefully consider the necessary time delay after issuing each control command up to actual motion and ensure safe control.
(2) Provide the end effector with a limit switch, and control the robot system by monitoring the state of the end effector.

7 STOP TYPE OF ROBOT

The following three robot stop types exist:

Power-Off Stop (Category 0 following IEC 60204-1)

Servo power is turned off and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.
The following processing is performed at Power-Off stop.
- An alarm is generated and servo power is turned off.
- The robot operation is stopped immediately. Execution of the program is paused.

Controlled stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
The following processing is performed at Controlled stop.
- The alarm "SRVO-199 Controlled stop" occurs along with a decelerated stop. Execution of the program is paused.
- An alarm is generated and servo power is turned off.

Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.
The following processing is performed at Hold.
- The robot operation is decelerated until it stops. Execution of the program is paused.

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time of Power-Off stop. A risk assessment for the whole robot system, which takes into consideration the increased stopping distance and stopping time, is necessary when Controlled stop is used.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Power-Off stop or Controlled stop. The configuration of stop type for each situation is called *stop pattern*. The stop pattern is different according to the controller type or option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Servo disconnect
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
B	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
C	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	C-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop

P-Stop: Power-Off stop
C-Stop: Controlled stop
-: Disable

The following table indicates the Stop pattern according to the controller type or option configuration.

Option	R-30*i*B
Standard	A (*)
Controlled stop by E-Stop (A05B-2600-J570)	C (*)

(*) R-30*i*B does not have servo disconnect.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer to "Software version" in operator's manual of controller for the detail of software version screen.

"Controlled stop by E-Stop" option

When "Controlled stop by E-Stop" (A05B-2600-J570) option is specified, the stop type of the following alarms becomes
Controlled stop but only in AUTO mode. In T1 or T2 mode, the stop type is Power-Off stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*B controller)
SRVO-218 Ext.E-stop/Servo Disconnect	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*B controller)
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Controlled stop is different from Power-Off stop as follows:

- In Controlled stop, the robot is stopped on the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Controlled stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.

- The stopping distance and stopping time of Controlled stop is longer than the stopping distance and stopping time of Power-Off stop, depending on the robot model and axis. Please refer to the operator's manual of a particular robot model for the data of stopping distance and stopping time.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time of Power-Off stop. A risk assessment for the whole robot system, which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

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1 PREFACE

This chapter describes an overview of this manual which should be noted before operating the *i*RVision function.

1.1 OVERVIEW OF THE MANUAL

Overview

This manual is the reference manual for *i*RVision on the R-30*i*B controller. This manual describes each functions which are provided by *i*RVision. When you would like to know the meanings (e.g. the items on *i*RVision setup screen, the arguments of the instruction, and so on), please refer to this manual. When you start up the robot system which use *i*RVision, please refer to manuals which is introduced in "1.2 Related manuals".

> ⚠ **CAUTION**
> This manual is based on the R-30*i*B system software version V8.10P/02. Note that the functions and settings not described in this manual may be available, and some notation differences are present, depending on the software version.

Contents of this manual

Chapter 1	Preface
Chapter 2	Describes the vision guide robot motion
Chapter 3	Describes the basic operations
Chapter 4	Describes how to set up camera set up tools
Chapter 5	Describes how to set up camera calibration tools
Chapter 6	Describes how to set up vision processes
Chapter 7	Describes how to set up the command tools
Chapter 8	Describes how to set up application data
Chapter 9	Describes how to start *i*RVision from a robot program
Chapter 10	Describes how to use *i*RVision utility menus
Chapter 11	Describes the calibration grid and how to set up the calibration grid frame
Chapter 12	Describes how to use the vision support tools
Appendix A	Describes how to setup a PC for *i*RVision and how to open *i*RVision pages on the PC

1.2 RELATED MANUALS

This section introduces related manual.

R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation) B-83284EN

This is the main manual of R-30*i*B Controller. This manual describes the following items for manipulating workpieces with the robot:

- Setting the system for manipulating workpieces
- Operating the robot
- Creating and changing a program
- Executing a program
- Status indications
- Backup and restore robot programs.

This manual is used on an applicable design, robot installation, robot teaching.

R-30*i*B CONTROLLER MAINTENANCE MANUAL B-83195EN
This manual describes the maintenance and connection of R-30*i*B Controller.

R-30*i*B CONTROLLER OPERATOR’S MANUAL (Alarm Code List) B-83284EN-1
This manual describes the error code listings, causes, and remedies of R-30*i*B Controller.

R-30*i*B CONTROLLER Sensor Mechanical / Control unit OPERATOR’S MANUAL B-83434EN
This manual describes the connection between sensors which is a camera or 3D Laser Sensor and R-30*i*B Controller, and maintenance of sensors.

R-30*i*B CONTROLLER *i*RVision 2D Vision Application OPERATOR’S MANUAL B-83304EN-1
This manual is desired to first refer to when you start up systems of *i*RVision 2D Compensation and 2.5D Compensation. This manual describes startup procedures of *i*RVision 2D Compensation and 2.5D Compensation system, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision 3D Laser Vision Sensor Application OPERATOR’S MANUAL B-83304EN-2
This manual is desired to first refer to when you start up systems of *i*RVision 3D Laser Sensor Compensation. This manual describes startup procedures of *i*RVision 3D Laser Sensor Compensation, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision Inspection Application OPERATOR'S MANUAL B-83304EN-3
This manual is desired to first refer to when you start up systems of inspection which uses *i*RVision. This manual describes startup procedures of inspection system which uses *i*RVision, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision Visual Tracking Application OPERATOR'S MANUAL B-83304EN-4
This manual is desired to first refer to when you start up systems of *i*RVision Visual Tracking. This manual describes startup procedures of *i*RVision Visual Tracking system, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL B-83304EN-5
This manual is desired to first refer to when you start up systems of *i*RVision Bin Picking. This manual describes startup procedures of *i*RVision Bin Picking system, creating programs, caution, technical know-how, responce to several cases, and so on.

2 ABOUT VISION SYSTEM

This chapter explains vision-guided robot motion using *i*RVision (*i*ntegral Robot Vision).

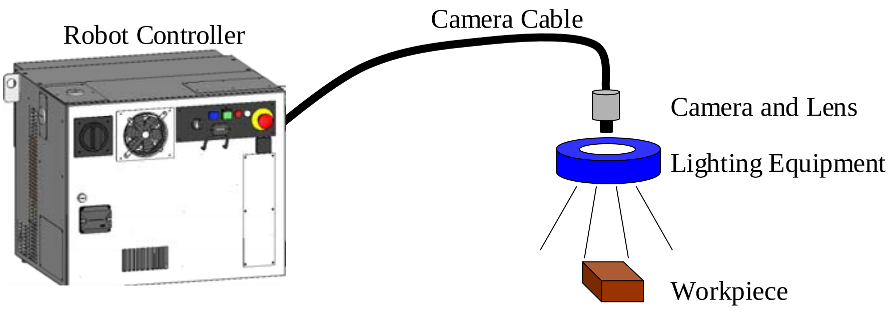
2.1 BASIC CONFIGURATION

This section describes the basic configuration of the *i*RVision system.

This manual describes the standard *i*RVision configuration. Some applications might require special components. Refer to the application-specific *i*RVision OPERATOR'S MANUAL for more information.

*i*RVision consists of the following components:
- Camera and lens, or three-dimensional laser sensor
- Camera cable
- Lighting Equipment
- Camera multiplexer (used if needed)

> ⚠ **CAUTION**
> The components marked with an asterisk (*) are necessary only for setting up *i*RVision and can be removed during production operation. These components are not provided by FANUC and need to be purchased by the user.



For detailed information about the connection method between the Robot Controller and a camera, please refer to “R-30*i*B CONTROLLER Sensor Mechanical / Control unit OPERATOR’S MANUAL”.

2.2 VISION-GUIDED ROBOT MOTION

FANUC robots are teaching-playback robots. In a teaching-playback system, specific tasks are taught to robots in advance, which then in turn work exactly as they are taught. A series of instructions that specify what robots are to do is called a *robot program*. The process of generating robot programs is called *teaching*, and the act of executing the taught robot programs is called *playback*. Teaching-playback robots play back the motion just as it was taught. Conversely speaking, what this type of robot can do is limited to what it is taught in advance. This means that, if you want the robot to manipulate every workpiece in the same way, you need to place every workpiece at exactly the same position. *i*RVision is a visual sensor system designed to eliminate such restrictions. *i*RVision measures the position of each workpiece by using cameras, and it adjusts the robot motion so that the robot can manipulate the workpiece in the same way as programmed even if the position of the workpiece is different from the workpiece position set when the robot program was taught.

Relative position offset

There are two methods for vision-guided robot motion - *absolute positioning* and *relative position offset*. With absolute positioning, the sensor measures the absolute position of the workpiece and the robot moves directly to that position. With relative position offset, the sensor measures how the workpiece has moved relative to the position set when the robot program was taught. The robot then adjusts the taught position by this relative position before moving to it. *i*RVision adopts the latter approach - relative position offset.

Reference position and actual position

The relative position of the workpiece used for offsetting the robot position is called the *offset data*. Offset data is calculated from the position of the workpiece set when the robot program was taught and the current workpiece position. The position of the workpiece set when the robot program was taught is called as the *reference position*, and the current workpiece position is called the *actual position*. The offset data is the difference between the reference position and the actual position. *i*RVision measures the reference position when a robot program is taught, and stores it internally. The operation of teaching the reference position to *i*RVision is called *reference position setting*.

2.3 FIXED FRAME OFFSET AND TOOL OFFSET

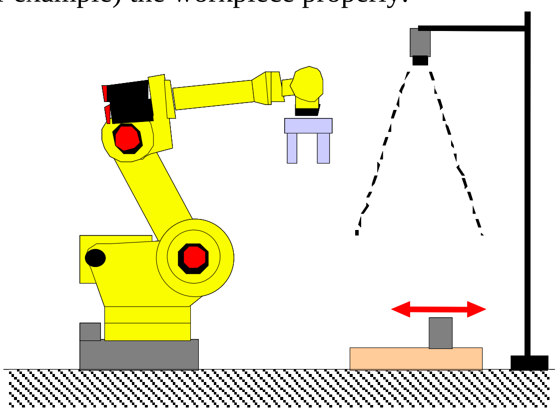
There are two kinds of robot position offset, *fixed frame offset* and *tool offset*. *i*RVision supports both kinds of robot position offset.

Fixed frame offset

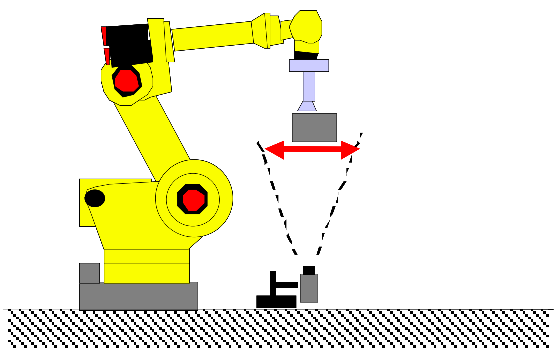
With fixed frame offset, the workpiece offset is measured in a coordinate frame fixed with respect to the robot base. A workpiece placed on a fixed surface or a container is viewed by a camera, and the vision system measures its position. The robot then adjusts its taught positions so that it can manipulate (pick up, for example) the workpiece properly.

Tool offset

With tool offset, the workpiece offset is measured in a coordinate frame that moves with the robot tool. This method is useful for grippers where the part position in the gripper can vary, such as vacuum grippers. A workpiece held by the robot is viewed by a camera, and the vision system measures its position relative to the gripper. The robot then offsets its taught positions so that it can manipulate (place, for example) the workpiece properly.



Fixed frame offset



Tool offset

2.4 FIXED CAMERA AND ROBOT-MOUNTED CAMERA

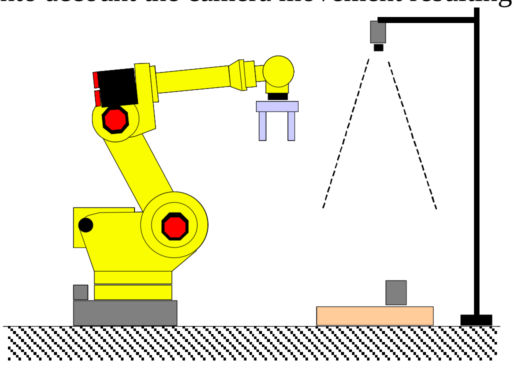
A camera can be installed as a fixed camera or a robot-mounted camera. *i*RVision supports both of these positioning methods.

Fixed camera

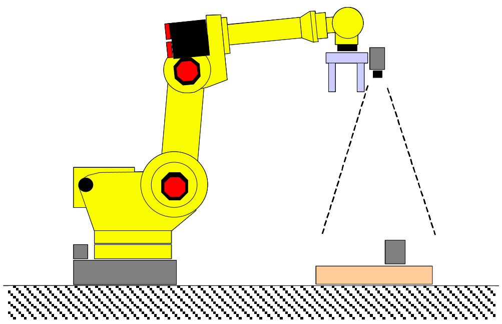
A fixed camera is attached to the top of the pedestal or another fixed structure. In this method, the camera always sees the same view from the same distance. An advantage of a fixed camera is that the robot cycle time can be reduced because *i*RVision can take and process a picture while the robot performs another task.

Robot-mounted camera

The robot-mounted camera is mounted on the wrist unit of the robot. By moving the robot, measurement can be done at different locations or with different distances between the workpiece and the camera. When a robot-mounted camera is used, *i*RVision calculates the position of the workpiece while taking into account the camera movement resulting from the robot being moved.



Fixed camera



Robot mounted camera

2.5 VISION DATA

Data entered by the user during *i*RVision setup is called *vision data*. Like robot programs and I/O settings, vision data is stored in memory in the robot controller.

2.5.1 Types of Vision Data

There are four types of vision data:

Camera Setup

Camera Setup data sets the camera port number, the type of the camera, the camera mounting method, and so on.

Camera Calibration

Camera Calibration data establishes the mathematical correspondence between the coordinate system of camera images and the coordinate system in which the robot moves.

Vision Process

Vision Process data is defining the image processing, location, and measurement to be performed by *i*RVision during production operation.

Application Data

Application data are settings specific to an application.

2.5.2 Maximum Vision Data That Can Be Created

Maximum number of vision data that can be created on your robot controller cannot be generally determined because it varies with various conditions. A guide for roughly estimating the maximum number of vision data that can be created on your robot controller is given here.

Vision data is stored in FROM of the robot controller. Accordingly, the capacity for storing vision data depends on the amount of free space in FROM of your robot controller. The more options that are installed, the smaller the free space of FROM. The free space of FROM of your robot controller can be checked by selecting STATUS / Memory on the teach pendant.

The R-30*i*B controller has the automatic backup function, which automatically stores the backup of all user data such as robot programs periodically. The default destination of automatic backup is FROM (FRA:) and the two latest backups are saved by default. Accordingly, the capacity that can be used to store vision data is approximately one fourth of (free space – 1 Mbytes) of FROM.

The maximum number of vision data that can be created also depends on the size of the vision data to be created. Generally, a vision process has the greatest size and its size depends on the model pattern taught in the locator tools. The size of a vision process ranges from about several Kbytes to hundreds Kbytes.

For example, assume that the free space of FROM is 10 Mbytes and the average size of vision data is 100 Kbytes. The capacity that can be used to store vision data would be about 2.2 Mbytes, which is one fourth of 9 Mbytes. Thus, the estimated number of vision data that can be created is approximately 22 (2.2 Mbytes/10 Kbytes).

2.5.3 To Create More Vision Data

Vision data is stored in the F-ROM module of the robot controller. When free space on the F-ROM module is used up, no more vision data can be created. To create more vision data, free space can be increased as described below.

Disable automatic backup

By default, the R-30*i*B controller is configured to make the backup automatically. By default, automatic backups are stored on the F-ROM and the most recent two sets are preserved. By disabling automatic backup, vision data about three times larger can be created. For the procedure for modifying the setting of the automatic backup function, refer to the "R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation)".

Change the automatic backup destination to MC:

By default, automatic backups are stored on the F-ROM and the most recent two sets are preserved. By changing the automatic backup destination device from FRA: (F-ROM) to MC:, vision data about three times larger can be created on the F-ROM. For the procedure for modifying the setting of the automatic backup function, refer to "R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation)".

Exchange the F-ROM module

For use with the R-30*i*B controller, F-ROM modules of three different sizes are available: 32MB, 64MB and 128MB. If the size of the F-ROM module on your controller is not enough, replace the F-ROM module with a larger F-ROM module. By doing so, more vision data can be created. For F-ROM module replacement, consult with your FANUC technical representative.

2.6 USER FRAME AND USER TOOL

Position and posture of the robot are represented based on the frames. The user frame defines the working space for the robot to work. The user tool defines the position and orientation of the tooling (end effector). The origin of the user tool is also called TCP (Tool Center Point).

FANUC robots are teaching-playback robots. Robots of this method play back taught motion only. Therefore, in robot systems that do not use vision, you do not have to use frames because the robots just repeat the taught motion regardless of how accurate the frames are set up.

On the other hand, in robot systems that use a vision system, frames are very important. For instance, when the vision system returns the instruction to move 10 mm in X direction or to rotate 30 degrees around the Z-axis, the robot motion completely depends on the accurate definition of the frames.

User Frame

The user frame defines the working space in which the robot works. The offset data from the vision system, (for example to move 10 mm in X direction or to rotate 30 degrees around the Z-axis,) are all respective to the user frame. Therefore it is very important to teach the user frame as accurately as possible. If the user frame was set up inaccurately, the robot would move to an incorrect direction or rotate around an incorrect axis.

In the case of a 2-dimensional fixed-frame offset vision application, the user frame covers another important role. It defines the 2-dimensional work plane in the real 3-dimensional space. The 2-D work plane for *i*RVision must be parallel to the X-Y plane of the user frame.

See also the "R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation)" for information regarding detailed user frame setup procedures.

> **NOTE**
> Do not change the posture of the robot while teaching a user frame. If it is changed, the taught user frame will be less accurate.

User Tool

The user tool defines the position and orientation of the robot tooling (end effector). In a robot system that uses vision, it is very important to teach an accurate TCP (Tool Center Point) of the pointer tool that is used during teaching the user frame. If the TCP is less accurate, the taught user frame will also be less accurate. In the case of a 2-dimensional tool-offset vision application, the user tool covers another important role, namely defining the 2-dimensional work plane.

See also the "R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation)" for information regarding detailed user tool setup procedures.

Sharing User Frame

When two or more robots work together, it is necessary to configure the system so that these robots physically share the same user frame. This is called the sharing of the user frame. Specifically, the sharing of the user frame is needed in the following cases:

- Multiple robots are offset with a single set of offset data.
- The robot to be offset is different from the robot that has the camera.

User frame sharing requires that all robots use the same user frame number. For example, user frame 5 of robot 1 needs to be physically the same as user frame 5 of robot 2.

> ⚠ **CAUTION**
> If robots share user frames of different numbers, *i*RVision cannot offset the robots correctly. Make sure that the robots share the same user frame number.

3 BASIC OPERATIONS

This chapter describes the basic operations for using *i*RVision.

If you select "8 iRVision" from MENUS, the following sub menus are displayed.

Vision Setup

Displays the Vision Setup screen. For details, see Section 3.1, “VISION SEUTP”.

Vision Runtime

Displays the Vision Runtime screen. For details, see Section 3.2, “VISION RUN-TIME”.

Vision Log

Displays the Vision Log screen. For details, see Section 3.3, “VISION LOG”.

Vision Config

Displays the Vision Config screen. For details, see Section 3.4, “VISION CONFIG”.

Vision Utilities

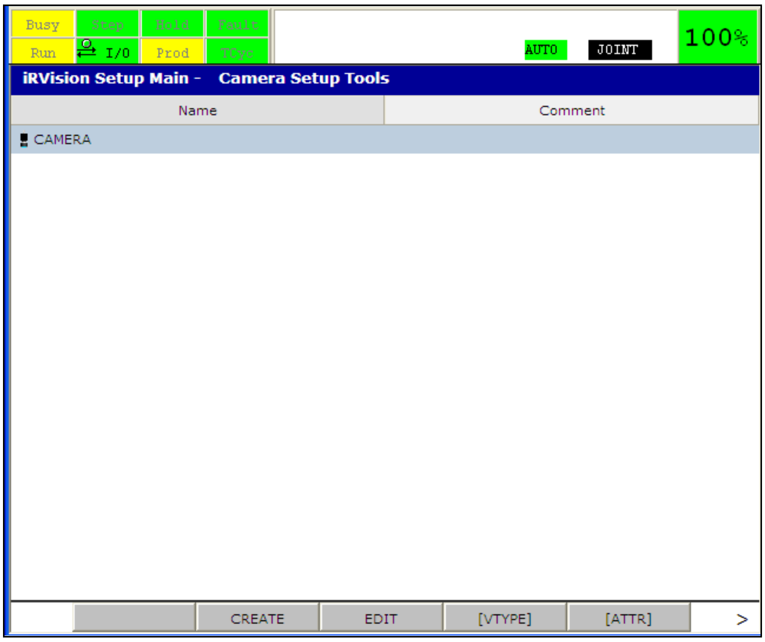
Displays the Vision Utilities screen. For details, see Chapter 10, “VISION UTILITIES”.

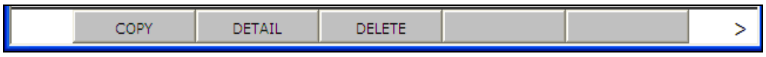
3.1 VISION SETUP

On the Vision Setup screen, you can create, teach and test vision data. The Vision Setup screen is displayed with the following steps.

1. Press MENUS on the *i*Pendant.
2. Select [8 iRVision], and then [1 Vision Setup].

3. The *i*Pendant displays the Vision Setup screen.





The Vision Setup screen shows the list of vision data. The following items can be displayed in the list.

Name
The name of vision data is displayed. A name of up to 34 alphanumeric characters can be set.

Comment
Any character string is indicated to provide additional information about vision data. A comment consisting of up to 50 one-byte or 25 two-byte characters can be set.

Type
The type of vision data is displayed.

Created
The time and date at which corresponding vision data was created for the first time is indicated.

Modified
The time and date at which corresponding vision data was modified last is indicated.

Size
The size of a vision data file in bytes is indicated.

F1 [TYPE]
Brings you to another *i*RVision menu screen.

F2 CREATE
Creates a new vision data. For details, see Section 3.1.1, “Creating New Vision Data”.

F3 EDIT
Opens the vision data edit screen. For details, see Section 3.1.5, “Editing Vision Data”.

F4 [VTYPE]

Selects a type of vision data to be displayed in the vision data list.

- Camera Setup Tools
- Camera Calibration Tools
- Vision Process Tools
- Application Setup Tools

F5 [ATTR]

Selects an item to be displayed in the second column of the vision data list.

- Comment
- Type
- Created
- Modified
- Size

F6 COPY

Makes a copy of the vision data. For details, see Section 3.1.3, “Copy vision data”.

F7 DETAIL

Displays the vision data detail screen. In vision data detail screen, you can verify type, created date and time, last modified date and time of the vision data. And you can also change name and comment of the vision data. For details, see Section 3.1.4, “Verifying Vision Data Detail Information”.

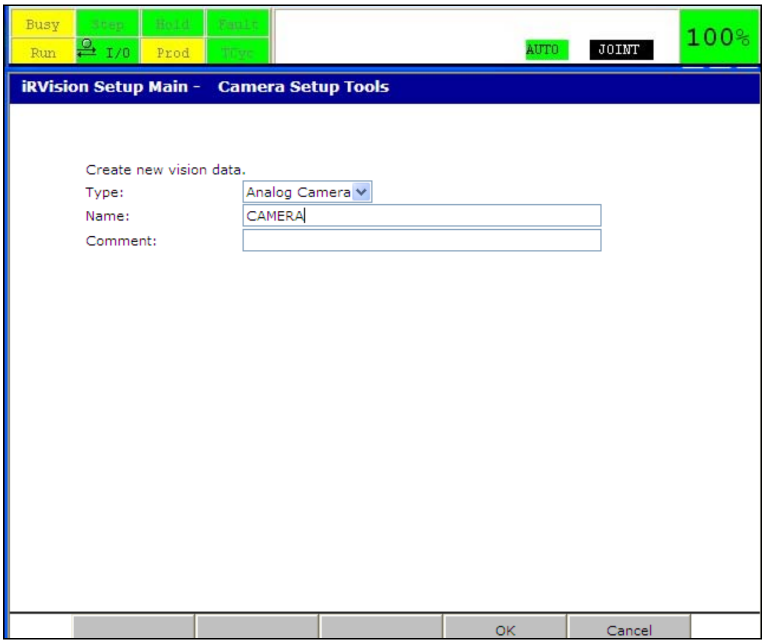
F8 DELETE

Deletes the vision data. For details, see Section 3.1.2, “Deleting Vision Data”.

3.1.1 Creating New Vision Data

To create new vision data, perform the following steps.

1. Press F2 CREATE.



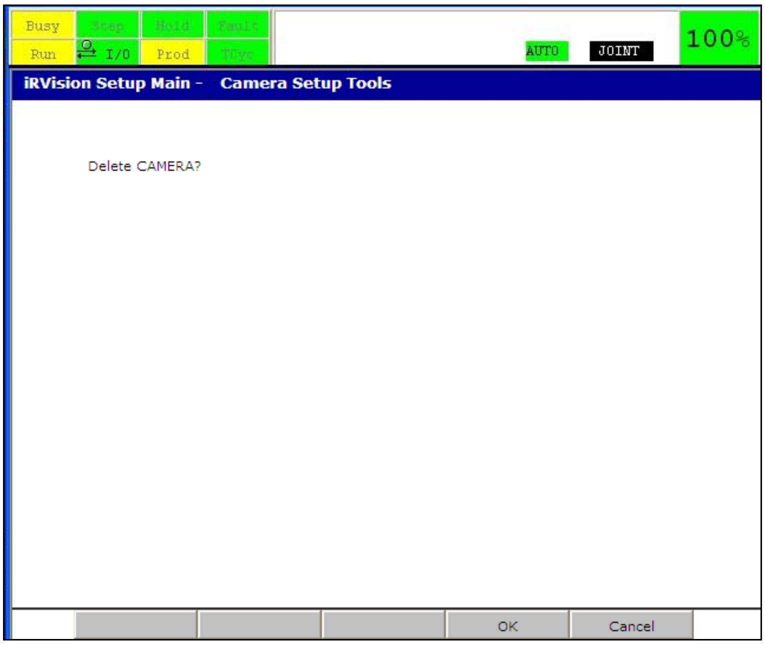
2. In [Type], select the type of the vision data you are going to create.

3. In [Name], enter the name of the vision data you are going to create. The name can be up to 34 alphanumeric characters in length.
4. In [Comment], enter any character string providing additional information about the vision data if necessary. The comment can be up to 50 one-byte or 25 two-byte characters.
5. Press F4 OK.

3.1.2 Deleting Vision Data

To delete vision data, perform the following steps.

1. In the list, select the vision data to be deleted.
2. Press F8 DELETE.

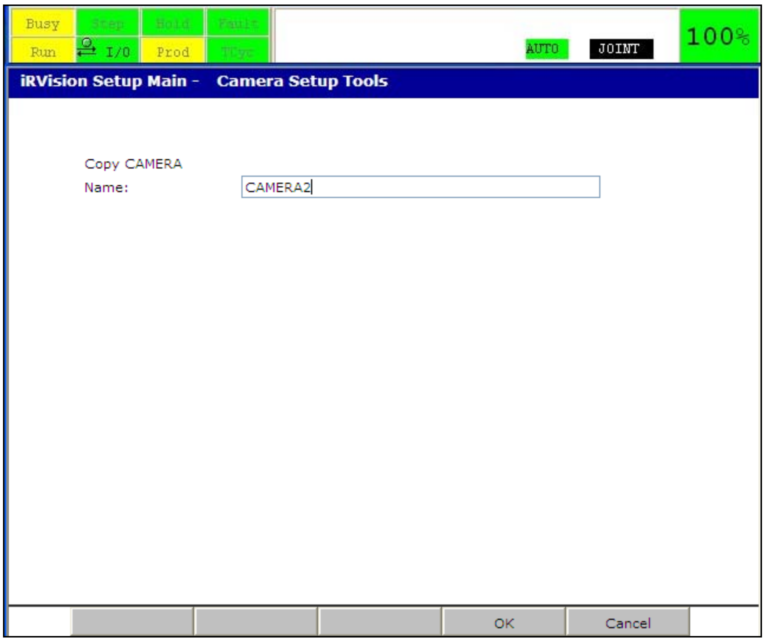


3. Press F4 OK.

3.1.3 Copying Vision Data

To make a copy of vision data, perform the following steps.

1. In the list, tap the vision data to be copied.
2. Press F6 COPY.

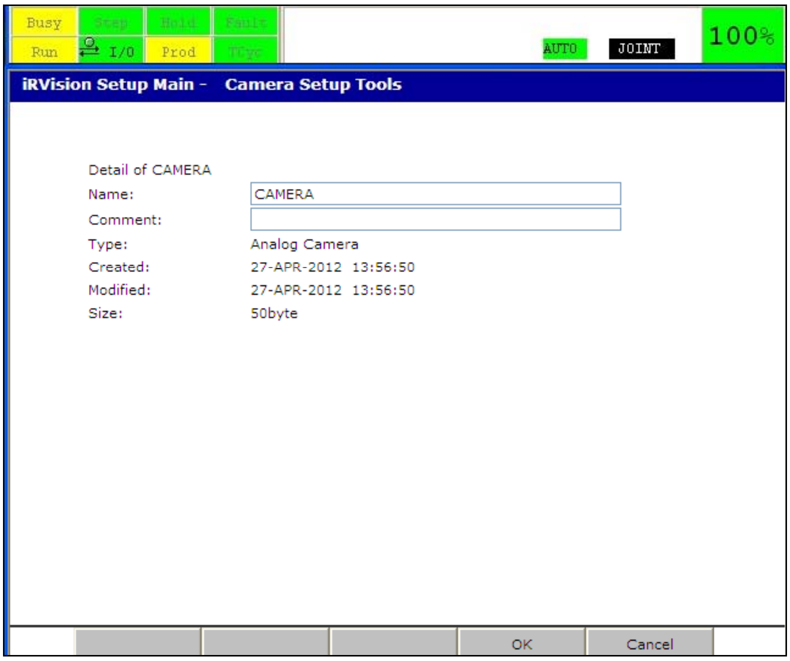


3. In [Name], enter the vision data name of the copy destination.
4. Press F4 OK.

3.1.4 Verifying Vision Data Detail Information

To display detailed information of vision data, perform the following steps.

1. In the list, tap the vision data to be verified.
2. Press F7 DETAIL.



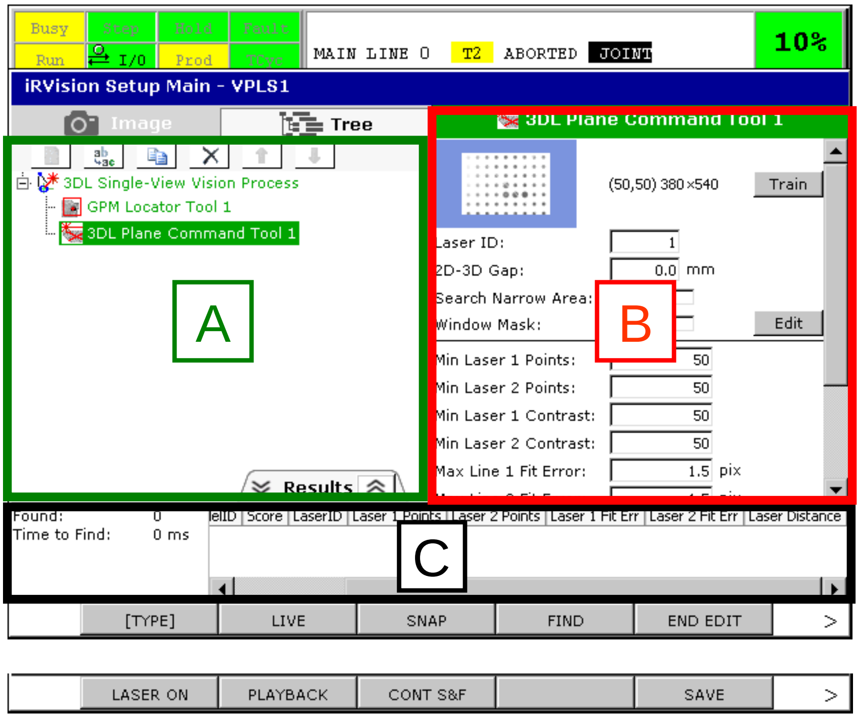
3. In [Name], enter a new vision data name if you want to rename the vision data.
4. In [Comment], enter a new comment string if you want to change the comment.
5. Press F4 OK.

3.1.5 Editing Vision Data

To edit vision data, perform the following steps.

1. In the list, tap the vision data to be edited.
2. Press F3 EDIT.

The vision data edit screen has the following structure.



A This area shows either the image display control, which shows an image from the camera, or the tree view, which describes the vision data structure. When a tool is selected in the tree view, the setting items for the tool are indicated in area B. For information on how to use the image display control, see Subsection 3.7.4, “Image Display Control”. For details about the tree view, see Subsection 3.7.5, “Tree View”.

B This area shows the setting items for a vision tool selected in the tree view. At the top of this area, the name of the selected vision tool is displayed. Background of the vision tool name will be green when the vision tool is trained, or red when not trained. For details about setting items of individual vision tools, see Chapter 6, “VISION PROCESS”, and Chapter 7, “COMMAND TOOL”.

C This area shows testing result of a vision tool selected in the tree view. This area is closed by default, and can be opened by pressing the “Result” tab. For details, see Chapter 6, “VISION PROCESS”, and Chapter 7, “COMMAND TOOL”.

F1 [TYPE]

Brings you to another *i*RVision menu screen.

F2 LIVE

Starts the camera live image display. See also 3.7.4 “Image Display Control”.

F3 SNAP

Snaps a new camera image. See also 3.7.4 “Image Display Control”.

F4 FIND

Performs a test detection of the selected vision tool. For details, see Chapter 6, “VISION PROCESS”, and Chapter 7, “COMMAND TOOL”.

F5 END_EDIT

Ends editing the vision data and brings you back to the vision data list screen. When the vision data is modified, a popup message will appear to confirm if you want to save the changes.

F6 LASER ON/OFF

Turns on or off the slit lasers of the 3D laser vision sensor. This operation is available only when the selected camera is the 3D laser vision sensor. See also Subsection 3.7.4 “Image Display Control”.

F7 PLAYBACK

Brings you to the image playback mode. About the image playback mode, see Subsection 3.7.13 “Image Playback”.

F8 CONT_S&F

Continuously performs image snapping and test detection.

F10 SAVE

Saves the vision data.

⚠ CAUTION

1. The new settings made by modifying the contents of the vision data edit screen are not saved until F5 END_EDIT or F10 SAVE is pressed. You need to save the vision data so that the new settings are effective to the production operation.
2. Visiting another menu screen such as DATA/REGISTER does not save the vision data. The vision data is still under edit, and you can continue to edit the vision data after visiting back the *i*RVision Setup screen.
3. The maximum number of vision data edit screen that you can open at the same time is limited to 1.
4. The vision data edit screen can be opened even during production operation to tune or change parameters. However, operations that can affect the production operation, i.e. snapping an image or performing test detection, are prohibit. When you want to make such operation, enable the Teach Pendant, or switch to the T1/T2 mode. Meantime, it is recommended that the vision data edit screen is not opened or left opened during production operation.

TIP

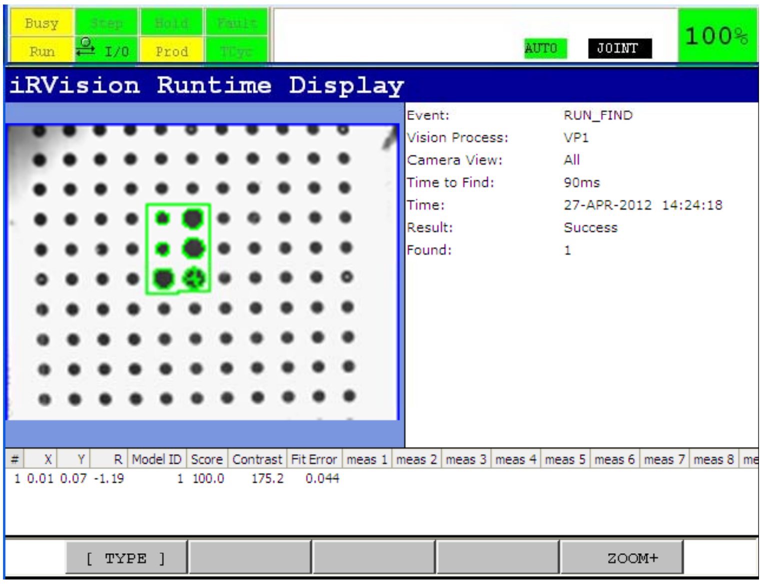
To restore the original data after making modifications to the contents of the edit screen, close the edit screen by pressing F5 END_EDIT without pressing F5 SAVE. The popup message to confirm if you want to save the modifications. Then press F5 CANCEL.

3.2 VISION RUN-TIME

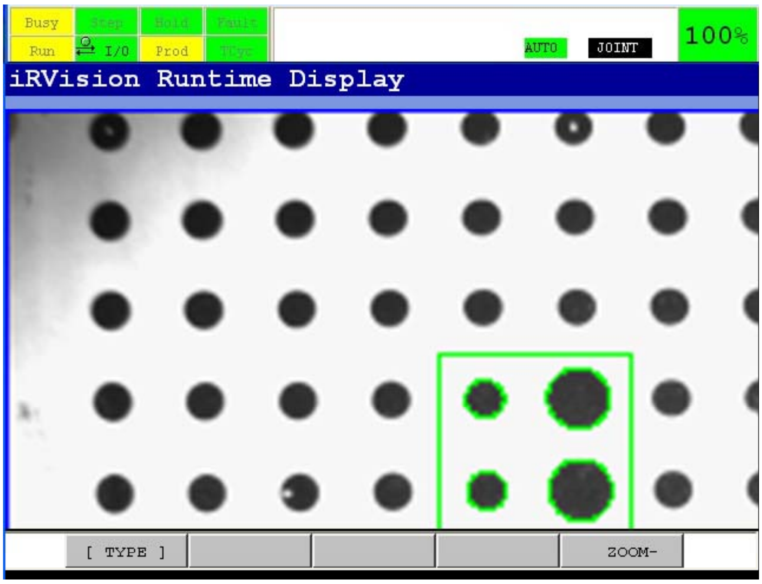
On the Vision Runtime screen, you can monitor execution of vision processes during production operation. The Vision Runtime screen is displayed with the following steps.

1. Press MENUS on the *i*Pendant.

2. Select [8 iRVision], and then [2 Vision Runtime].
3. The *i*Pendant displays the vision runtime monitor screen.



Press F5 ZOOM+ to display the image larger.



Press F5 ZOOM– to change the display back.

3.3 VISION LOG

*i*RVision can write information about the execution of vision processes to the vision log.

Recording the Vision Log

By default, *i*RVision is configured to NOT record the vision log. To enable the vision log, please refer to 3.4 “VISION CONFIG”.

The vision log is recorded in the memory card inserted into the MAIN board. If no memory card is inserted, the vision log is not recorded even when *i*RVision is configured to record the vision log. When the free space of a memory card is less than the specified value (2 Mbytes by default), old vision logs are deleted to make enough free space for writing a new vision log. *i*RVision can delete only vision logs when the free space of a memory card is less than the specified value. If there are no vision logs which can be deleted, CVIS-130 “No free disk space to log” alarm is posted and the vision log will not be recorded.

⚠ **CAUTION**

1 Deleting old vision logs takes time. To avoid the need to do so, it is recommended to delete or to export vision logs to an external device on a regular basis to ensure that the memory card has enough free space. For information about how to export vision logs to an external device or how to delete them, see Section 10.3, "VISION LOG MENU".
2 If the free space of a memory card falls below the specified value as a result of other files being written to the memory card, the vision log function will try to delete vision logs until the free space is larger than the required value in the next vision execution. In this case, it may take time before the next vision execution can start, if there is a lot of data to be deleted. For example, storing everything to the memory card could cause such a case. However, it will not cause any problems if there is a backup already written to the memory card and its size is as large as that of new backup.
3 If you have vision logs recorded in a memory card with one controller and then execute a vision process with that memory card inserted into another controller, the vision logs recorded with the original controller may get overwritten.

Logging Images

Images snapped by vision processes can be saved along with the vision log. The logged images that are saved can be used for future troubleshooting, as well as when performing a test run of a vision process. For information about how to run a test using logged images, see Subsection 3.7.13, "Image Playback". Images are saved as a part of the vision log on a memory card. Whether to save images to the vision log is specified for each vision process. In the edit screen for a vision process, select one of the following:

Don’t Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

⚠ **CAUTION**

If you choose to save logged images, it can take much longer to record the vision log. Select [Log All Images] only when necessary for troubleshooting. Normally, select [Don't Log] or [Log Failed Images]. The time required to log vision data depends on the type of vision process; see the section pertaining to the vision process concerned. The speed of the memory card is also a factor. Insert a high-speed memory card for applications where speed is crucial.

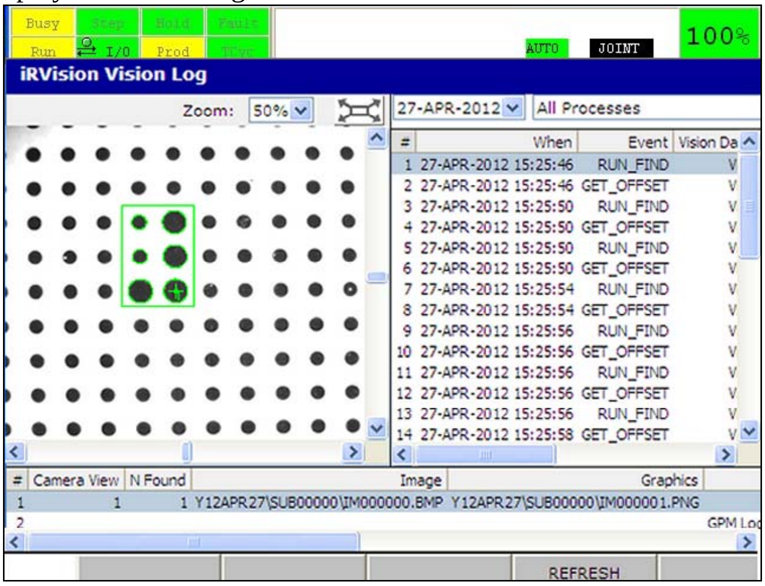
NOTE

If you have the vision log disabled in the system variable, logged images are not saved even when you set the vision process to save logged images.

Viewing the Vision Log

On the Vision Log screen, you can view recorded vision logs. The Vision Runtime screen is displayed with the following steps.

1. Press MENUS on the *i*Pendant.
2. Select [8 iRVision], and then [Vision Log].
3. The *i*Pendant displays the vision log viewer screen.



From the dropdown boxes in the upper right part of the screen, select the date and vision data name you want to view. If you want to view the vision logs of all available dates, select [All Dates]. If you want to view vision logs of all existing vision data, select [All Data]. Note that, if you select [All Dates], [All Data] is not available.

The vision logs of the selected vision data recorded on the selected date are displayed on the right side of the screen. Tap a line in the list on the right side of the screen. The list in the lower part of the screen displays the detailed results of the selected execution. If any image has been saved during that execution, the saved image is displayed in the upper left part.

File Configuration of the Vision Log

By default, the vision log is recorded in the folder MC:/VISION/LOG/. A sub-folder is created for each day under the folder and the vision log and images for the day are saved in the created sub-folder. For example,

MC:/VISION/LOG/Y12APR10/

is the sub-folder for April 10, 2012.

Under the sub-folder for the sub-folder of each day, three types of files are saved.

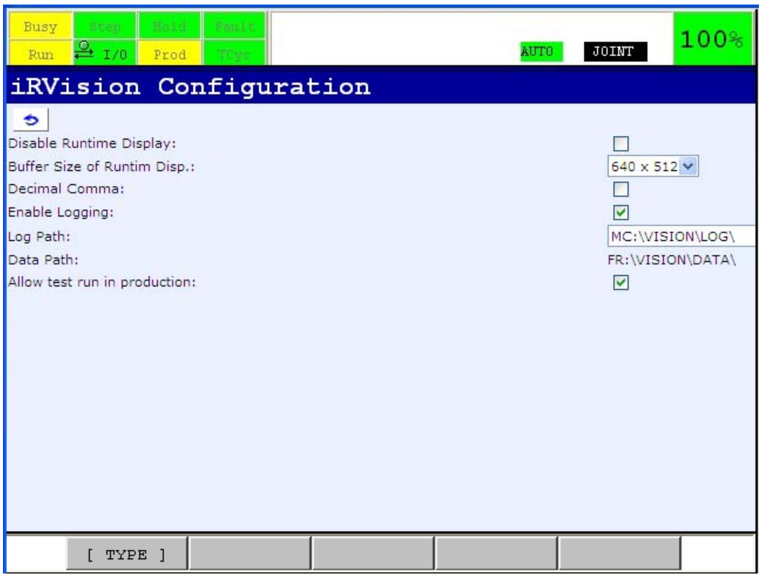
.VL	Logged data file
.BMP	Logged image file(Original Image)
.PNG	Logged image file(Graphics)

> ⚠ **CAUTION**
> If the file name, the folder name or the folder structure was changed, the correspondence between the logged data and logged image becomes incorrect, and eventually the file cannot be utilized. Therefore, do not change the folder structure and file name when you copy them to another device.

3.4 VISION CONFIG

On the Vision Config screen, you can set the system variables related to *i*RVision. The Vision Config screen is displayed with the following steps.

1. Press MENUS on the *i*Pendant.
2. Select [8 iRVision], and then [4 Vision Config].
3. The *i*Pendant displays the Vision Config screen.



Disable Runtime Display

When this item is checked, the system does not perform any processing related to the vision runtime display and the Vision Runtime screen does not display any information. Network traffic as well as the time required for vision processing is reduced. By default, it is not checked.

Buffer Size of Runtime Disp.

The buffer size for images to be displayed on the Vision Runtime is selected from the following two items.

640 x 512

By default, this size is selected. When the camera image is larger than this size, the image will be shrunk to fit the buffer, and displayed on the Vision Runtime screen.

1280 x 1024

The buffer size is configured 4 times the default size. When you use a digital camera and you select a camera mode which is larger than 640x480 pixels, images displayed on the Vision Runtime can be high-resolution.

> ⚠**CAUTION**
> The memory usage increases about 2 MByte when the "1280 x 1024" is selected as the buffer size. Please verify free space of temporary pool before selecting the "1280 x 1024" mode as the buffer size.

Decimal Comma

When this item is checked, a comma (,) is used in place of a period (.) as a decimal point. This item is provided for use in Europe. By default, it is not checked.

Enable Logging
When this item is not checked, the system does not perform any processing related to saving of the vision log or logged images. By default, it is not checked. To enable the vision log, check it on.

Log Path
This item is used to specify the destination folder of the vision log or logged images. The default value is MC:/VISION/LOG.

Data Path
This item is used to specify the destination folder of vision data. This folder is read-only and cannot be changed.

Allow test run in production
The vision data edit screen can be displayed even during production operation, namely when the teach pendant is disabled and the controller is in the AUTO mode. However, operations which can affect production operation (e.g., snapping an image, doing a test detection and so on) are forbidden on the edit screen during production operation. If this item is checked, you are allowed to do such operations even during production operation.

> ⚠ **CAUTION**
> Snapping an image or performing a test during production operation may increase cycle time, stop the system due to lack of memories, and so on.

3.5 BACKING UP VISION DATA

Vision Data is considered as the part of robot data (e.g., program). So, backing up and restoring Vision Data are considered as robot data.

3.5.1 Backing up Vision Data

Vision Data is saved when “All of the Above” is selected from the [Backup] function key on the FILE menu on the teach pendant of the robot. For details, refer to the the "R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation)".

3.5.2 Restoring Vision Data

Vision Data can be restored in two ways. One is to restore all Vision Data together with other robot data at Controlled Start. The other is to restore a specific Vision Data in the FILE menu. To restore a specific Vision Data, get a list of files with the extension VD and specify the file you want to restore. For details of the procedure, refer to the the "R-30*i*B CONTROLLER OPERATOR’S MANUAL (Basic Operation)".

3.6 INTER-CONTROLLER COMMUNICATION

*i*RVision communicates with another robot controller in the following cases:
- Visual tracking system in which multiple robots participate
- Car body compensation system in which multiple robots uses the same vision offset
- Robot system in which a camera is mounted on a robot connected to another robot
- Robot system in which a camera calibration plate is held by a robot connected to another robot

For these inter-controller communications, ROS Interface Packet over Ethernet (RIPE) function is used. For details about the RIPE function, please refer to "R-30*i*B Controller Ethernet Function Operator's Manual".

3.7 FREQUENTLY-USED OPERATIONS

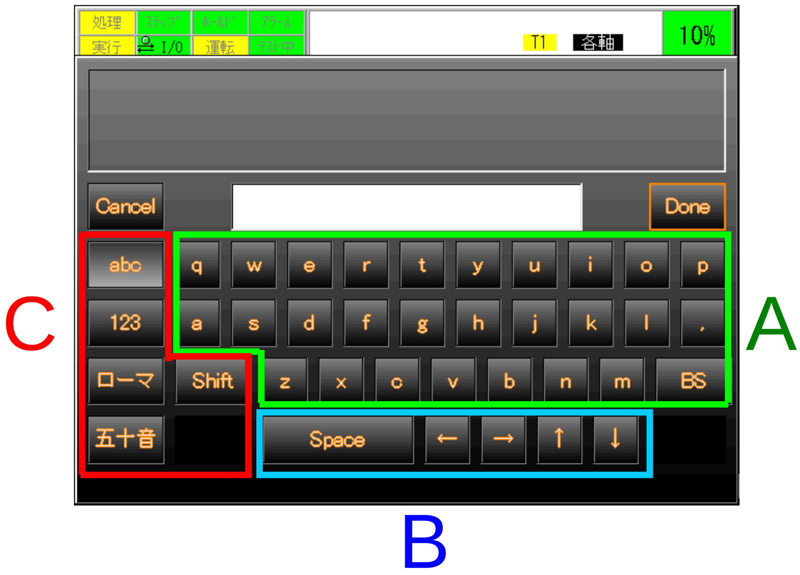
This section describes operations frequently used during *i*RVision setup.

3.7.1 Text Box

In a text box, a value or a character string is entered.

1. Tap a text box.
2. Numeric values are inputted by using value hardkeys of *i*Pendant.
3. Text strings are inputted by using software keyboard.

If a text box for a text string is tapped, the software keyboard automatically appears on the screen of *i*Pendant as follows.



A Inputting keys.
B Cursor keys and Space key.
C Exchanging keys of inputting keys. You can input one byte character if [abc] is tapped. You can input numeric number and special symbol (e.g., @, #, $, %) if [123] is tapped.

To finish inputting string, tap the [Done] button.
For more information of software keyboard, please refer to "R-30iB CONTROLLER OPERATOR’S MANUAL (Basic Operation)".

3.7.2 Drop-Down Box

An item is selected from options.

1. Tap a drop-down box.
2. From the displayed options, select a desired item.

3.7.3 List View

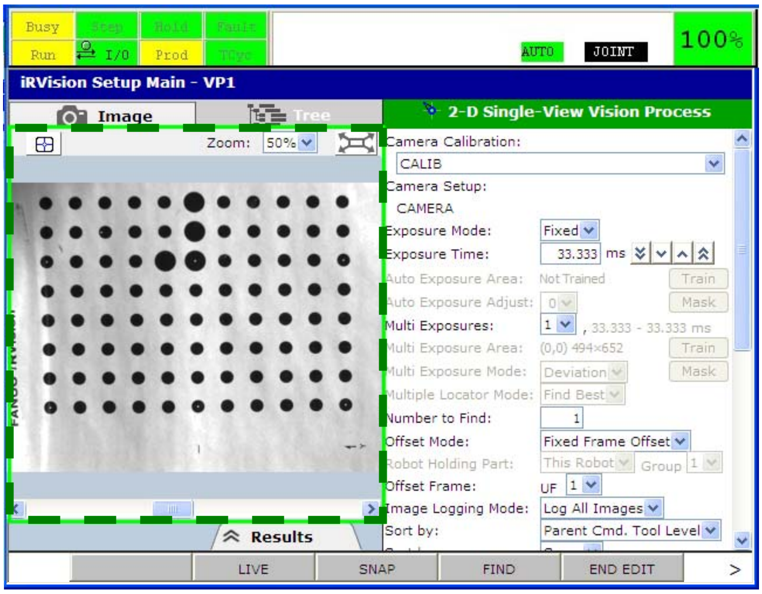
A list view is a table for displaying found results and other data.

#	Row(V)	Column(H)	Score	Contrast	Fit Error	Angle
1	132.6	479.4	99.8	173.4	0.163	-0.2
2	33.1	478.1	78.9	173.2	0.274	179.7

1. When a column header of the table is tapped, the table contents are sorted by the values of the column.
2. When a row of a table is tapped, the tapped line is highlighted.

3.7.4 Image Display Control

An image is displayed.



Displaying live image

A live image from the camera is displayed. This is used when making camera and lens adjustments.

1. To start displaying the live image, press F2 LIVE.
2. To stop displaying the live image, press F2 STOP.

> ⚠ **CAUTION**
> While the live image is being displayed, no other operation can be performed. Before another operation can be performed, the live image display must be stopped.

Snapping an image

One image is snapped from the camera.

1. Press F3 SNAP.

Turning the lasers of the 3D laser sensor ON or OFF

The laser of the three-dimensional laser sensor is turned on or off.

1. Press F6 Laser ON
2. When the F6 Laser OFF, the laser is turned off.

> **TIP**
> TheF6 LASER ON/OFF is only available only when the vision data is related to the three-dimensional laser sensor.

Zoom Level

The zoom level dropdown box is used to change display magnification of the image.

The following zoom levels are available.

- 12.5%
- 25%
- 33.3%
- 50%
- 100%
- 200%
- 400%
- 800%

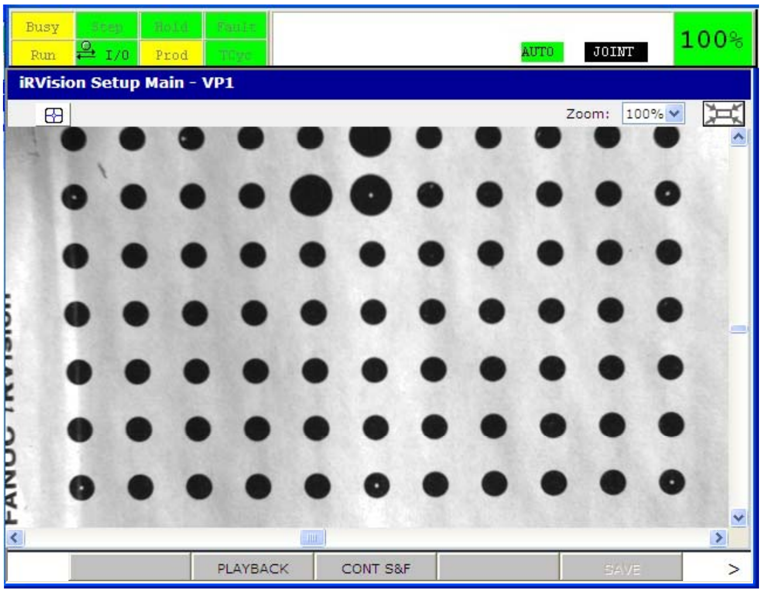
Scrolling an image

When an image cannot fit in the display area, scroll bars are displayed on the image display control.

1. Tap on the scroll bar displayed on the right side or at the bottom of the image and move the bar vertically or horizontally. Or swipe the touch panel of *i*Pendant.

Maximizing the Image Display Control

The size of the image display control can be maximized.



1. Tap button to maximize image.
2. Tap button to turn back.

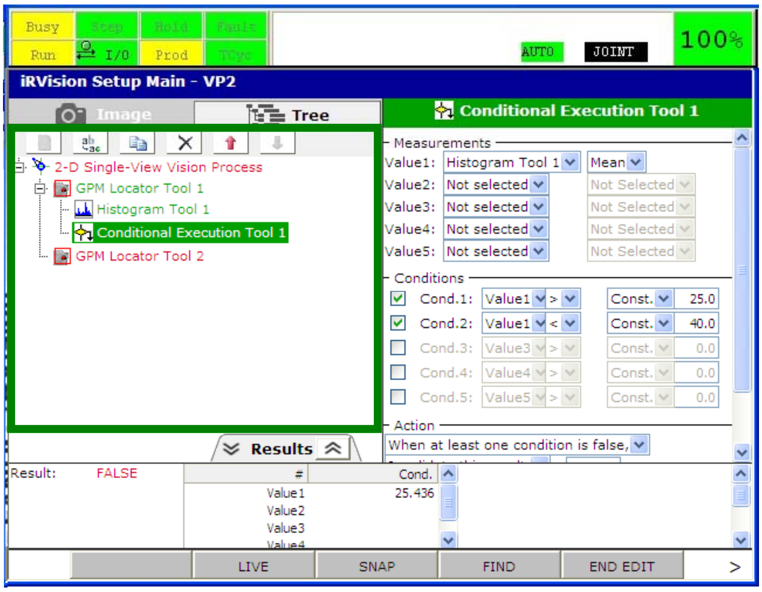
Displaying Center Line

Image center line can be displayed on the image display control.

1. Tap button to display center line.
2. Tap button to turn back.

3.7.5 Tree View

The tree view indicates the structure of vision data.



In the above figure, for example, the 2D single-view vision process includes two GPM locator tools. Under the GPM Locator Tool 1, one histogram tool and one conditional execution tool is present. Elements that make up a vision process, such as the GPM locator tools, histogram tool, and conditional execution tool are called *command tools*.

When a vision process is executed, its command tools are executed sequentially from the top, and finally the vision process calculates offset data.

The measurement window of a command tool such as the Histogram 1 that is placed under the GPM Locator Tool 1 is shifted and rotated dynamically according to the position of the found workpiece by the GPM Locator Tool 1.

One of the tools displayed in the tree view is always highlighted. It is the tool currently selected in the setup window, and setting and testing can be performed for this tool.

The color of each tool displayed in the tree view indicates the setup status of the tool. When a tool is displayed in green, setup is complete for the tool. When a tool is displayed in red, at least one item requires setup. When all tools of a vision process are displayed in green, the vision process is completely set up.

Selecting a tool

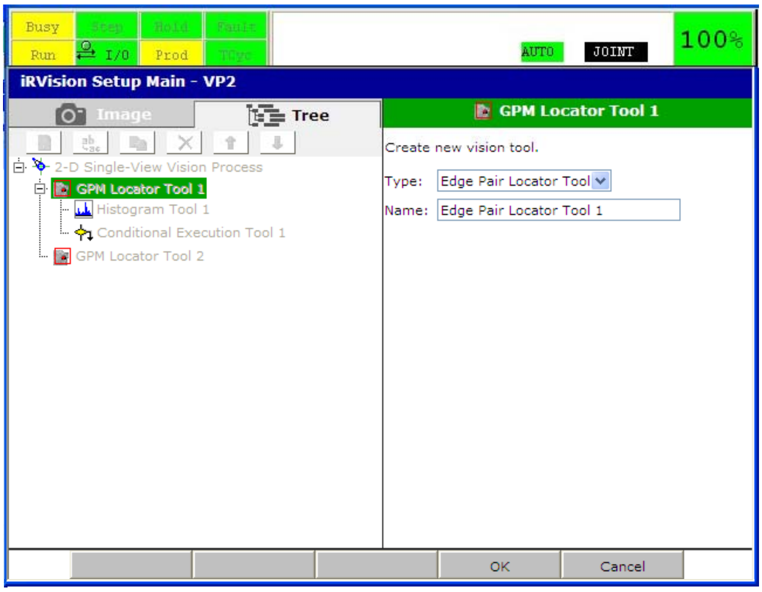
Select the tool to be set up.

1. Tap the icon or the name of a tool in the tree view.
2. The tapped tool is highlighted, and the corresponding setting page and test page are displayed.

Adding a tool

A new command tool is added to a vision data.

1. Select a parent tool (one level higher) under which a new tool is to be inserted.
2. Tap button.

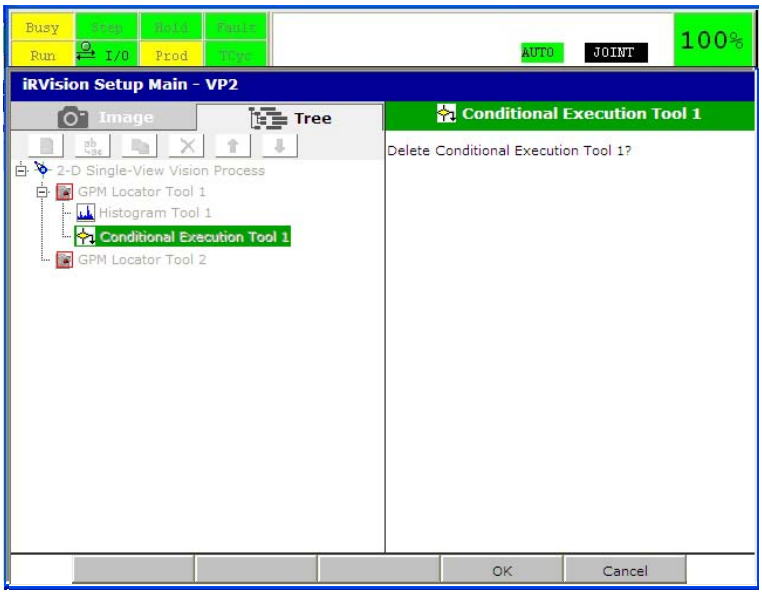


3. In [Type], select the type of the command tool to be inserted.
4. In [Name], enter the name of the command tool to be inserted.
5. Press F4 OK.

Deleting a tool

A command tool is deleted from a vision process.

1. Select the command tool to be deleted.
2. Tap button.



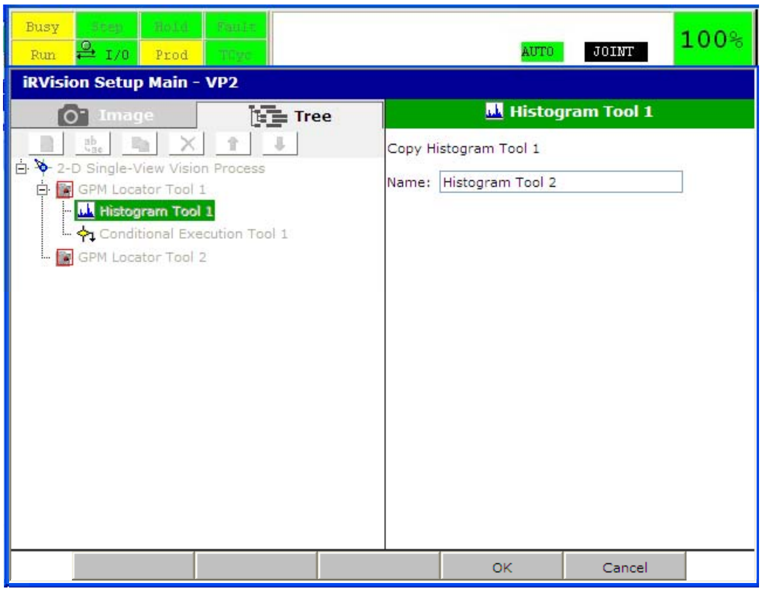
3. Press F4 OK.

> ⚠ **CAUTION**
> After a command tool is deleted, it cannot be restored. If a command tool is deleted by mistake, end editing the vision data without saving it, then open the edit screen for the vision data again to start over using the original vision data.

Copying a tool

A copy of a command tool in a vision data is made.

1. Select the command tool to be copied.
2. Tap  button.

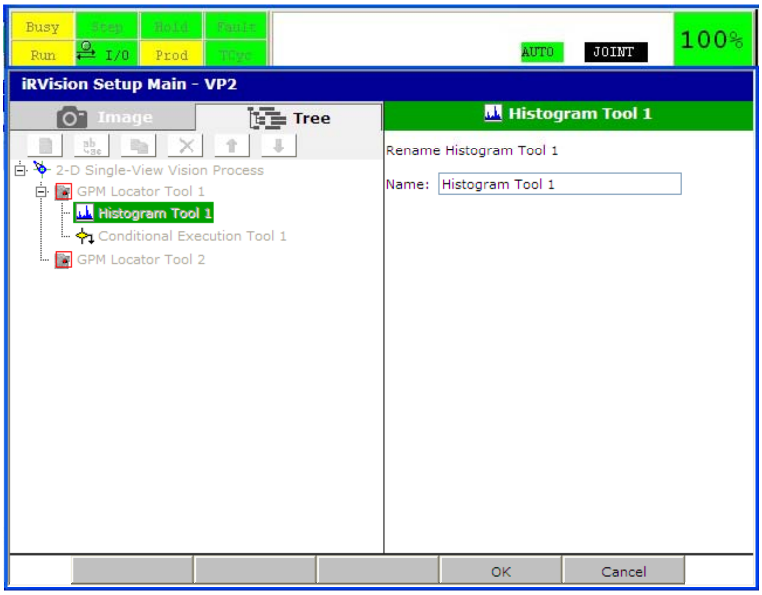


3. In [Name], enter the copy destination name.
4. Press F4 OK.

Renaming a tool

The name of a command tool in a vision process is changed.

1. Select the tool to be renamed.
2. Tap  button.



3. Type a new tool name.
4. Press F4 OK.

TIP
The name of the top-level tool (the vision process) is also shown in the comment field of that vision process in the main vision process list page.

Changing the order of a tool

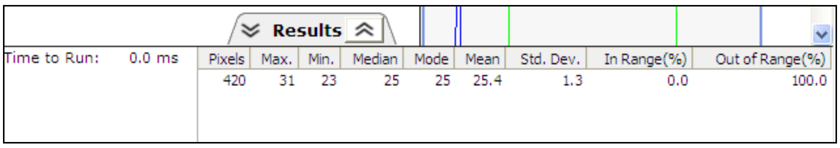
The order of a command tool is changed to change the execution sequence.

1. Select a command tool of which order is to be changed.
2. To move the command tool upward, tap button.
3. To move the command tool downward, tap button.

TIP
It is not possible to change the level of a command tool in the tree hierarchy.

3.7.6 Result View

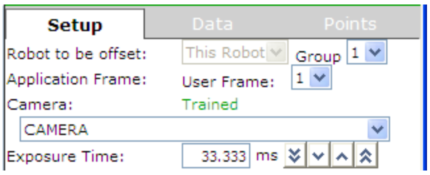
Result View displays the detection results of vision process or command tool.



By default, Result View is invisible. Result View is displayed by tapping button of the result tab. If button is tapped again, the display area of Result View expands. Tap button to close the result view.

3.7.7 Tab

When setting items cannot fit in a window, the screen display is changed by using tabs.

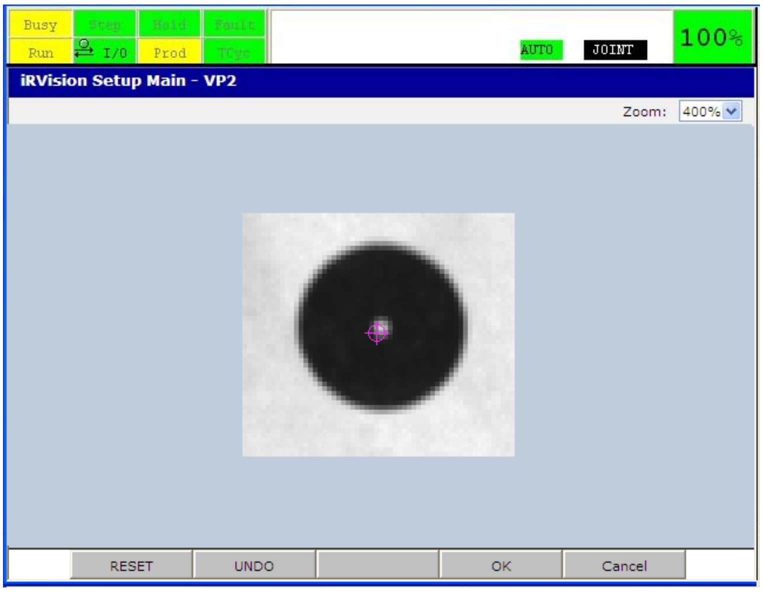


In the above example, there are three tabs, [Setup], [Data] and [Points], and the white tab with black font, which is [Setup], is currently selected. To switch to another tab, press a light-colored tab.

3.7.8 Setting Points

Positions such as the model origin are set on an image graphically.

1. When the button for setting a point is tapped in the setup window for a tool, the display of the image display control changes as follows:



2. Tap the position of the point which you want to configure on the image.
3. Adjust the position of  by using the cursor keys of the *i*Pendant. Or tap the position to which you want to move  on the image.
4. To change the position of  back to the default, press F1 RESET.
5. To cancel the previous operation, press F2 UNDO.
6. To complete the setting, press F4 OK.
7. To cancel the setting, press F5 CANCEL.

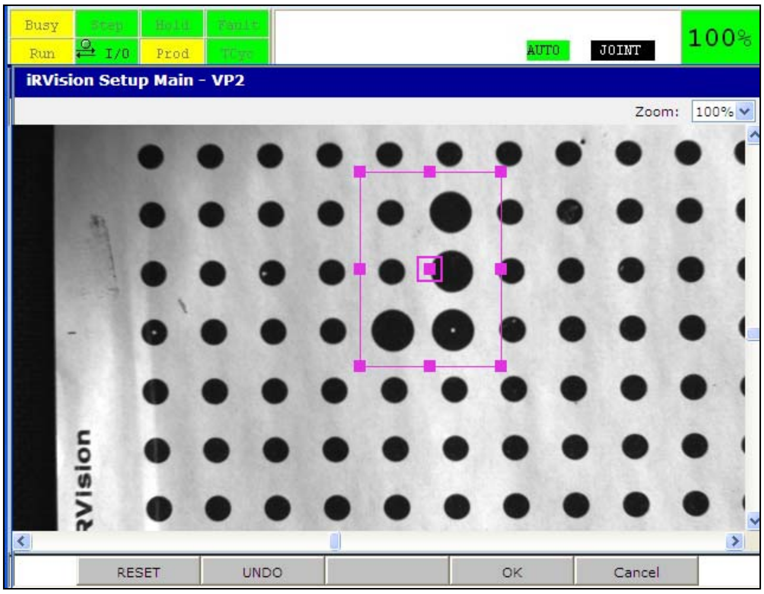
TIP

While setting points, it is also possible to zoom in/out and scroll the image to make operations easy.

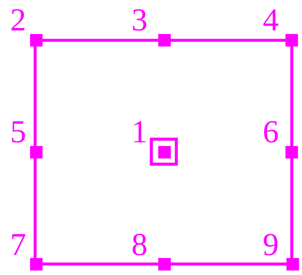
3.7.9 Window Setup

A window such as a search area is set graphically on the image.

1. When the button for setting an area is tapped in the setup screen for a tool, the display of the image display control changes as follows:



2. The position and size of the window is controlled by moving the control points. As shown below, a window has 9 control points. The position of the window can be moved by moving the control point 1. The size of the window can be changed by moving the control points 2 to 9. A control point is displayed as small solid square. The midair square is displayed around the selected control point. In the figure below, the control point 1 is selected. By tapping arbitrary position on the image, the selected control point moves to the tapped position. If a control point except the selected one is tapped, the tapped control point gets selected.

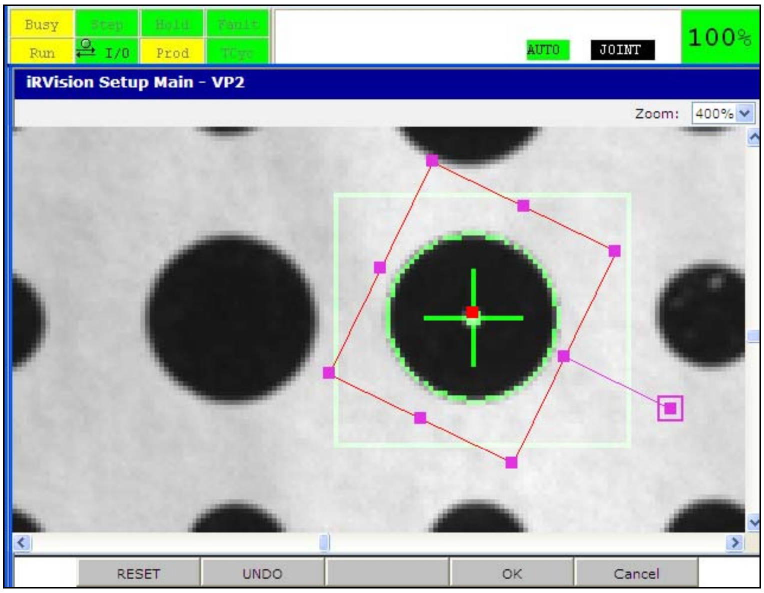


3. To move the position of the window, select the control point 1, and then tap the position which you want to move the control point to on the image.
4. To change the size of the window, select one of the control points 2 to 9, and then tap the position which you want to move the selected control point to on the image.
5. To put the size and position of the window back on the original, press F1 RESET.
6. To undo the previous operation, press F2 UNDO.
7. To complete the window setting, press F4 OK.
8. To cancel the window setting, press F5 CANCEL.

TIP

During window setup, it is also possible to zoom in/out and scroll the image to make operations easy.

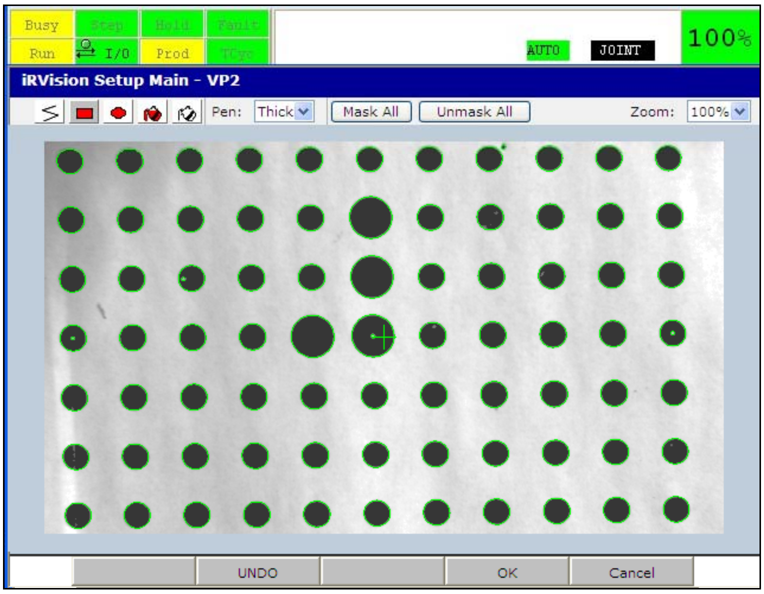
Some tools such as the histogram tool and the edge pair locator tool allow you to rotate the rectangular window. In this case, you will see an additional horizontal line from the rectangular window as shown below. An additional line has the control point for rotation on the tip. You can rotate the rectangular window by selecting the control point and moving it.



3.7.10 Editing Masks

Masks are edited on the image graphically.

1. When the button for editing masks is tapped in the setup screen for a tool, the display of the image display control changes as follows:



TIP

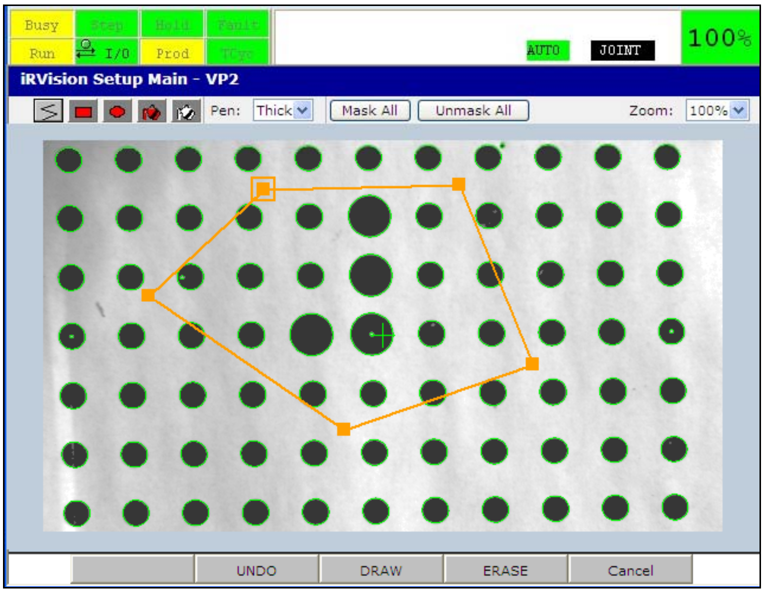
1 Masked parts are filled in red. When mask editing is performed for the first time, begin with the display where no red part is present.

2 In the window for editing masks, it is also possible to enlarge, reduce, and scroll the image to make operations easy.

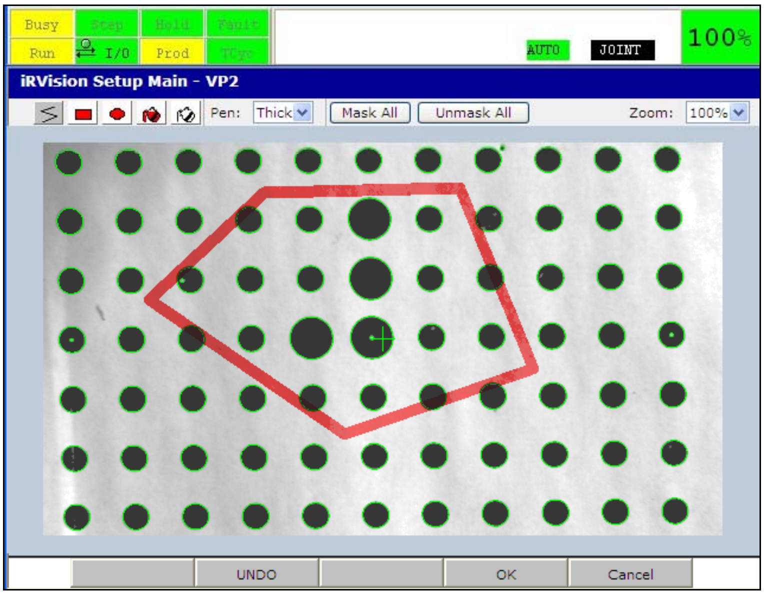
Drawing polygonal lines

A mask is drawn with polygonal lines.

1. Tap button.
2. Select the thickness of pen from thee items "Thin", "Medium" and "Thick" by using the drop-down box of pen.
3. Tap vertex of polygonal lines in turn on the image.
4. If the first vertex of the polygonal lines is tapped, the polygonal lines get closed and create a polygon. Vertices of polygon become control points. The control points can be selected moved in a similar manner as Subsection 3.7.9 "Window Setup".



5. If you press F3 DRAW, the mask in the shape of the configured polygonal lines is drawn.
6. If you press F4 ERASE, the mask is erased along the configured polygonal lines.

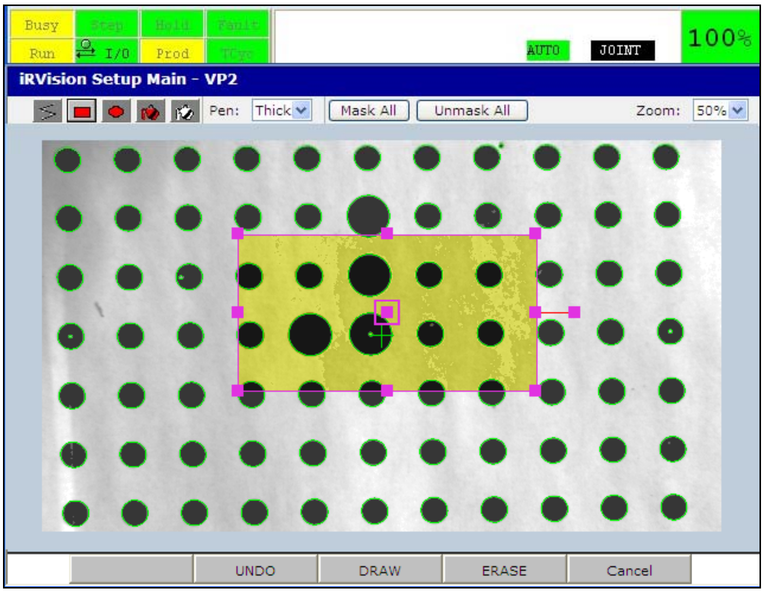


Drawing a rectangle

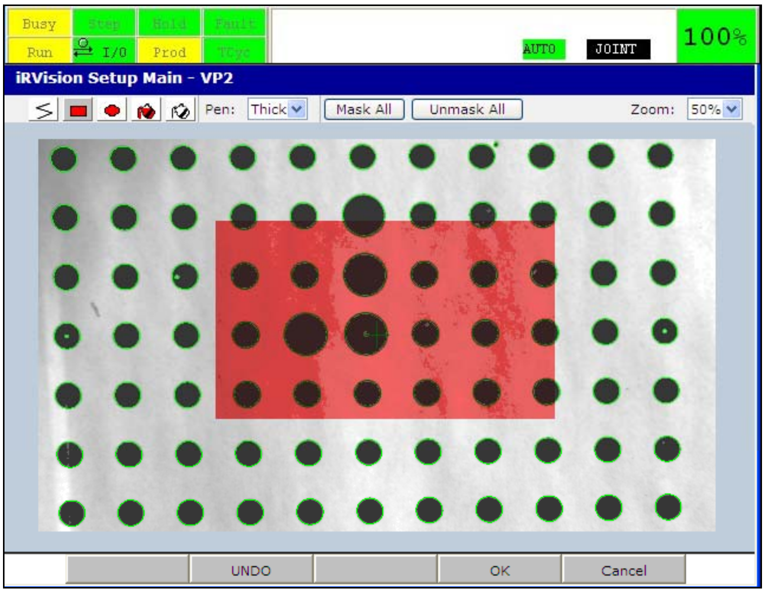
A filled rectangle is drawn.

1. Tap button.

2. Tap an arbitrary position on the image, then a rectangle is displayed.



3. A rectangle has 9 control points and can be moved in a similar manner as Subsection 3.7.9 "Window Setup".
4. If you press F3 DRAW, the mask in the shape of the rectangle is drawn.
5. If you press F4 ERASE, the mask in the shape of the rectangle is erased.

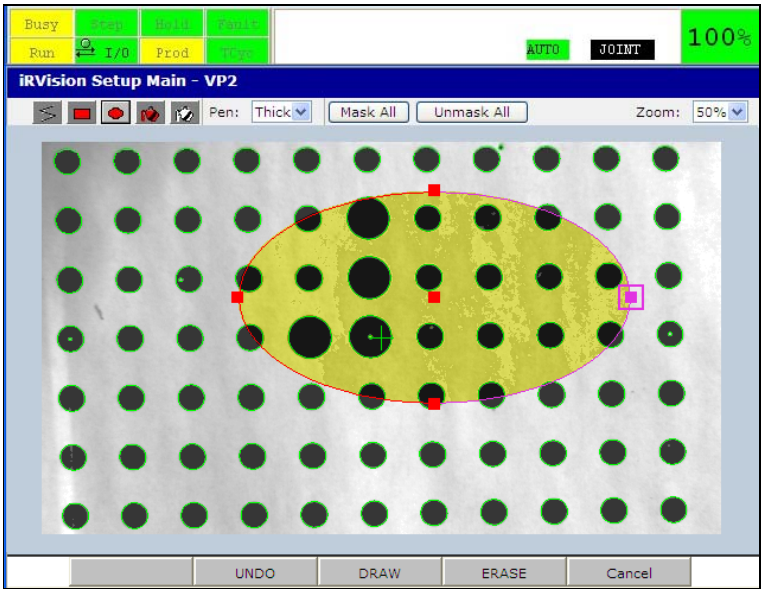


Drawing a circle or ellipse

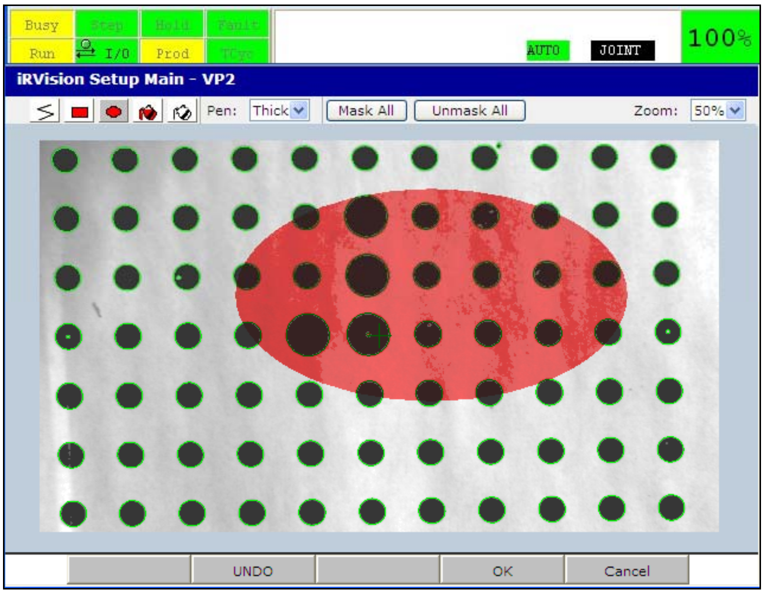
A filled circle or ellipse is drawn.

1. Tap button.

2. Tap an arbitrary position on the image, then an ellipse is displayed.



3. An ellipse has 5 control points, and can be moved in a similar manner as Subsection 3.7.9 "Window Setup".
4. If you press F3 DRAW, the mask in the shape of the ellipse is drawn.
5. If you press F4 ERASE, the mask in the shape of the ellipse is erased.



Filling in a closed area

An enclosed area is filled.

1. Tap  button.
2. Tap the position which you want to fill on the image.

> **TIP**
> If the tapped area is not completely enclosed by a red line, the entire image is filled. So, when drawing freehand or with polygonal lines, make sure that the contour line is connected properly.

Clearing in a closed area

An enclosed area is unmasked.

1. Tap  button.
2. Tap the position which you want to erase on the image.

Filling the entire image

The entire image is filled.

1. Tap [Mask All] button.

Clearing the entire image

The entire image is unmasked.

1. Tap [Unmask All] button.

Undoing

The most recently performed operation is canceled to restore the previous state.

1. Press F2 UNDO.

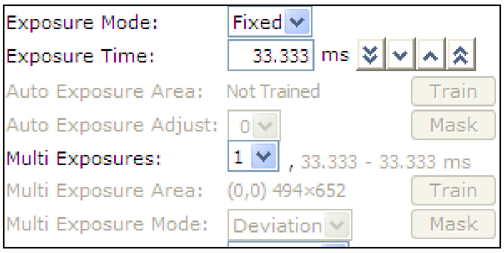
Ending editing

Mask editing is ended.

1. To complete mask editing, press F4 OK.
2. To cancel mask editing, press F5 CANCEL.

3.7.11 Setting Exposure Mode

Most vision processes, except some vision processes such as visual tracking, support image snap functions called *automatic exposure* and *multi-exposure* as well as usual image snapping where a specified exposure time is used. Vision processes use the same user interface to set an exposure mode.



Exposure Mode

Select an exposure mode.

Fixed

Always uses a specified exposure time for image snapping.

Auto

Automatically selects an exposure time for image snapping according to the brightness of the surrounding environment that changes from time to time. By saving a reference image in advance, an appropriate exposure time is selected so that the snapped image has the same brightness as that of the reference image.

Exposure Time

This item also called the electronic shutter speed. When [Fixed] is specified in [Exposure Mode], specify an exposure time. When [Auto] is specified in [Exposure Mode], this item cannot be modified, and the exposure time selected by software when the latest image was snapped is shown.

Auto Exposure Area

Specify the photometric area for automatic exposure. The image displayed when the photometric area is set is used as the reference image for automatic exposure.

Perform the following steps to set the photometric area:

1. Set [Fixed] in [Exposure Mode].
2. Adjust the exposure time to obtain appropriate brightness for the image.
3. Set [Auto] in [Exposure Mode].
4. Tap the [Train] button in [Auto Exposure Area] to set the photometric area. For the operation method, see Subsection 3.7.9, “Window Setup”.
5. If there is any area to be ignored in the photometric area, tap the [Mask] button to mask the area to be ignored. For information on how to set a mask, see Subsection 3.7.10, “Editing Masks".

TIP

1 In [Auto Exposure Mode], a completely white or black area of the image cannot be specified. Set an area in intermediate gray shades as the photometric area.

2 Areas that show large changes in brightness are not appropriate for [Auto Exposure Area]. For example, in an area that might contain a workpiece, it is impossible to make stable measurements because the visible brightness changes largely depending on whether the workpiece is present or not. Choose a background area instead.

Auto Exposure Adjust

Fine adjustments can be made for automatic exposure to obtain slightly brighter or darker images than the set reference image. A value from -5 to +5 can be selected. As the value increases in the positive direction, snapped images become brighter, and as the value decreases in the negative direction, snapped images become darker.

Number of Exposure

The multi-exposure function snaps multiple images by changing exposure time and combines them to generate an image with a wide dynamic range. Specify the number of images to be snapped.
A value from 1 to 6 can be specified. As more images are snapped, a wider dynamic range results, but a longer time is required for image snapping.

Multi Exposure Area

Specify the photometric area used for multi-exposure. Image synthesis is performed based on the brightness in the photometric area.

To set the photometric area, tap the [Train] button to set a window. For information on how to set a window, see Subsection 3.7.9, “Window Setup”.

When the photometric area includes an area of which brightness is to be ignored, tap the [Mask] button to mask the area to be ignored. For information on how to set a mask, see Subsection 3.7.10, “Editing Masks".

Multi Exposure Mode

Select a method for image synthesis in multi-exposure.

Deviation

The standard deviation of the image brightness in the photometric area is calculated, and synthesis is performed so that slight halation occurs in the image. This is the default setting.

Maximum

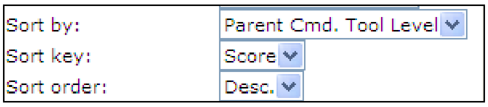
Synthesis is performed so that no halation occurs in the image in the photometric area. If halation occurs at even one point in the photometric area, the other part becomes relatively dark.

Average

Synthesis is performed simply averaging the gray level of pixels. This method can provide the widest dynamic range but might make the entire image darker.

3.7.12 Sorting

Some vision processes support a function for sorting detected targets based on the specified value. The operation of the sort function is common to the vision processes.



1. Select a sort level used as the sort key in the [Sort By] drop-down box.
2. Select a measurement value used as the sort key in the [Sort Key] drop-down box.
3. Select an order of sort in the [Sort Order] drop-down box.

The following items are provided for the [Sort By] drop-down box.

Vision Process Level

Targets are sorted based on a value such as X, Y, or Z which are calculated by the vision process.

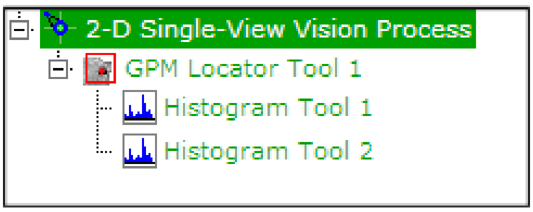
Parent Command Tool Level

Targets are sorted based on a measurement value such as Vt, Hz, the size, or the score of the parent locator tool.

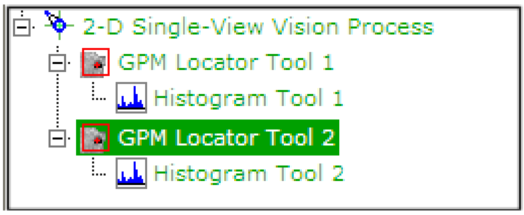
Child Command Tool Level

Targets are sorted based on a measurement value of the child tool, such as histogram or length measurement, placed under the locator tool.

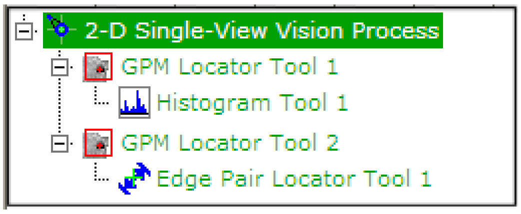
When found results are to be sorted by the measurement results of a child tool added to a locator tool, such as a histogram, the child tool must be placed as the first child tool. In the configuration shown below, for example, when sorting by the results of Histogram 2 is to be performed, change the order of Histogram 1 and Histogram 2.



When there are multiple locator tools, and sorting by the results of child tools of the locator tools is to be performed, the results of the child tools can be used as the sorting key only when the first child tools of all locator tools are of the same type. In case of (a) below, for example, sorting by histogram results is possible; in case of (b), however, sorting by histogram results and length measurement results is not permitted.



(a)



(b)

Some types of vision processes allows you to sort found results with the following methods. To use the following methods, select [Vision Process Level] for the [Sort By] dropdown box.

Shortest Path

The shortest path sorting method sorts the found results to minimize the total (X, Y) distance traveled to send the robot to each result in sequence along a continuous path. If the robot has a multi-pick gripper that can pick up all of the parts, and if the parts are to be picked up with only (X, Y) offsets, this sorting option will minimize the length of the robot path.

Shortest Path Theta

The shortest path Theta sorting method sorts the found results to minimize the total (X, Y, Theta) distance traveled to send the robot to each result in sequence along a continuous path. The angle Theta is scaled such that a rotation of 180 degrees is equivalent to an (X, Y) displacement from the top left corner of the image to the bottom right corner of the image. If the robot has a multi-pick gripper that can pick up all of the parts, and if the parts are to be picked up with (X, Y) and rotation offsets, this sorting option will minimize the length and wrist rotation of the robot path.

3.7.13 Image Playback

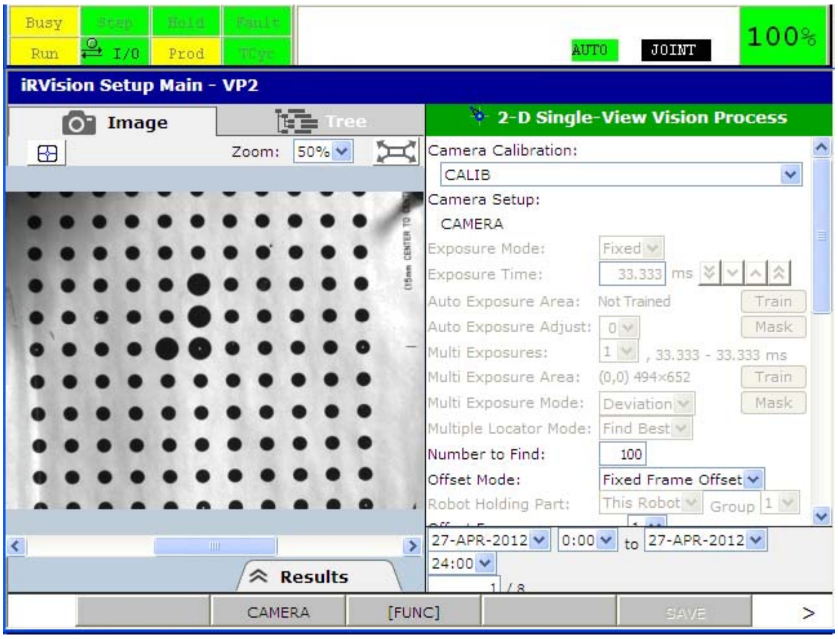
Images logged during production operation can be used to test and adjust location parameters. When location parameters have been changed, for example, this function is useful to use past images to check for any problem.

When the camera is mounted on a robot, both the image and the robot's position are logged, so it is possible to reproduce the situation in which production operation was performed including the position data of the robot.

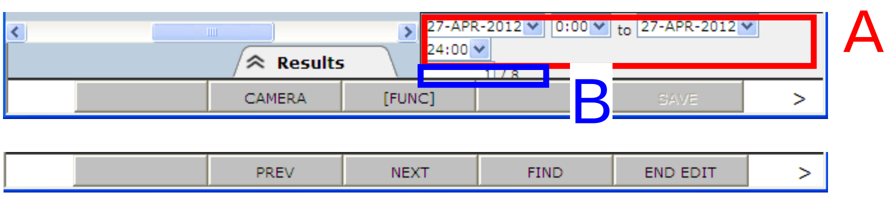
For information on how to save logged images, see Section 3.3, "VISION LOG".

Below are the steps for image playback,

1. Press F7 PLAYBACK.



2. The bottom of the setup frame and the function key labels change as follows.



A Select the time zone which logged image was saved. When you first start image playback mode, all logged image which can use on the vision process are selected. If you want to use the image which is saved on the specified time zone, select the specified time zone. Such as the above example, the image which is saved from 0:00 to 24:00 on April 27 of 2012.

B Display the total number of the logged image which is saved in the time zone which is specified on "A" and the logged image number which is displayed on the screen. The above example shows that there are 8 images which are saved from 0:00 to 24:00 on April 27 of 2012, and the first image of these images is displayed.

F1 [TYPE]

Brings you to another *i*RVision menu screen.

F2 PREV

Loads the previous image.

F3 NEXT

Loads the next image.

F4 FIND

Performs a test detection by using the image displayed on the image display.

F5 END_EDIT

Ends editing the vision data and brings you back to the vision data list screen. When the vision data is modified, a popup message will appear to confirm if you want to save the changes.

F7 CAMERA

Finish the image playback mode.

F8 [FUNC]

Performs the following operation.

- First image: Loads the first logged image.
- Last image: Loads the last logged image.
- Forward playback: Executes the operation which loads the next image and performs a test detection by using it repeatedly.
- Reverse playback: Executes the operation which loads the previous image and performs a test detection by using it repeatedly.

F10 SAVE

Saves the vision data.

TIP

Even in the image playback mode, it is possible to change parameters or perform a test detection of individual vision tools.

⚠ **CAUTION**

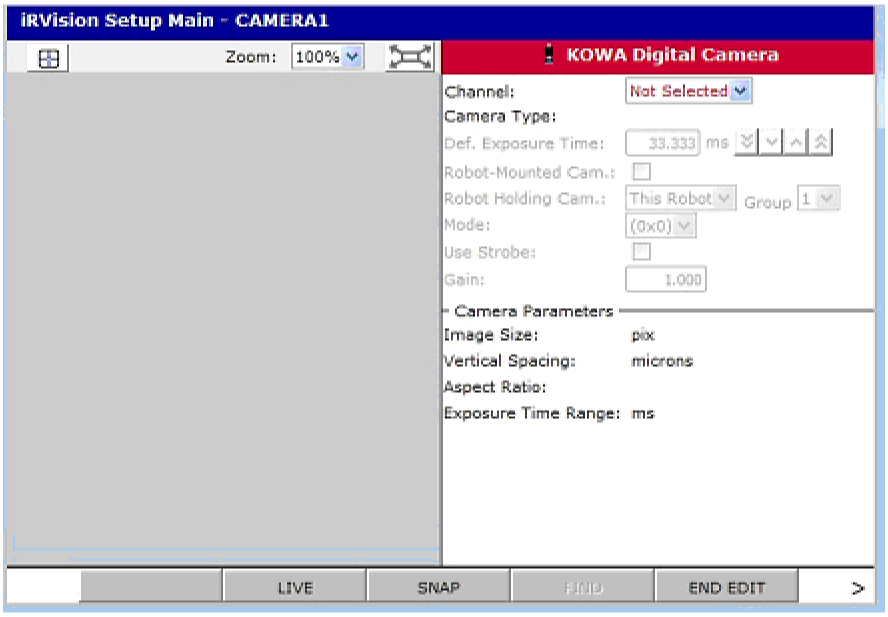
In the image playback mode, F2 LIVE, F3 SNAP, F6 LASER ON/ OFF are not available.

4 CAMERA SETUP

This chapter describes how to set up camera setup tools.

4.1 KOWA DIGITAL CAMERA

When the KOWA Digital Camera setup window is opened, the following screen is displayed.



Channel
Select the channel to which the camera is connected. When multiplexers are not used, only a camera can be connected. When multiplexers are used, up to 16 cameras can be connected.

Camera Type
The type of the connected camera is displayed.

Def. Exposure Time
Set the exposure time for capturing images in this window.

Robot Mounted Cam.
Check this check box when the camera is mounted on the robot end of arm tool.

Robot Holding Cam.
When a robot-mounted camera is used, set the robot that is holding the camera.

Use Strobe
Check this check box when a stroboscopic light is used.

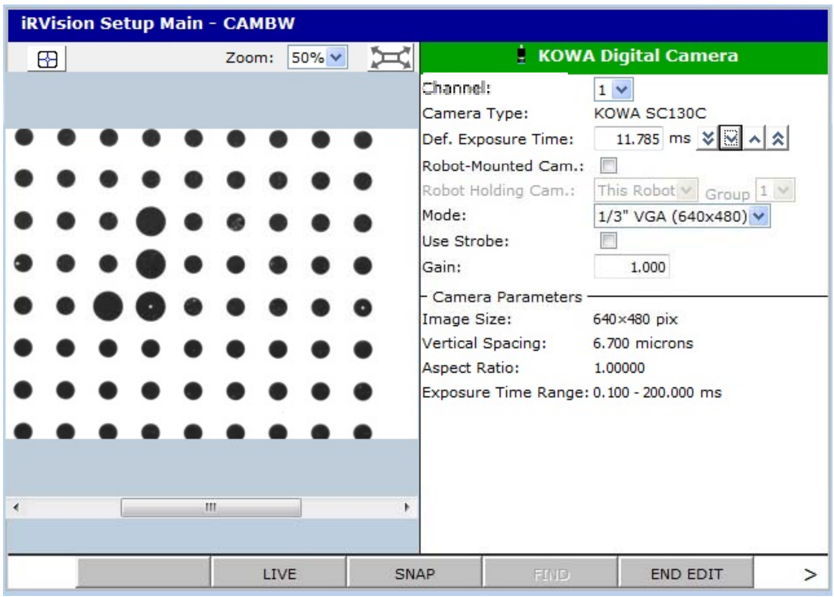
Gain
Change this value to adjust the brightness of an image. The image becomes brighter when this value is increased, and the image becomes darker when this value is decreased. But the image becomes noisy when this value is increased too much. The default value is 1.

Camera Parameters

The internal specifications of the selected camera are indicated.

4.1.1 Grayscale Camera

When a grayscale camera is connected to the selected channel, the following screen is displayed.



Mode

Select a camera mode (image size) from the following:

1/6" QVGA (320x240)

The acquired image size is 320x240 pixels.

1/3" VGA (640x480)

The acquired image size is 640x480 pixels. By default, this mode is selected.

2/3" VGA (640x480)

The acquired image size is 640x480 pixels. Compared to the "1/3" VGA (640x480)", the camera has doubled size of FOV.

1/2" XGA (1024x768)

The acquired image size is 1024x768 pixels.

2/3" SXGA (1280x1024)

The acquired image size is 1280x1024 pixels.

VGA-WIDE (1280x480)

The acquired image size is 1280x480 pixels.

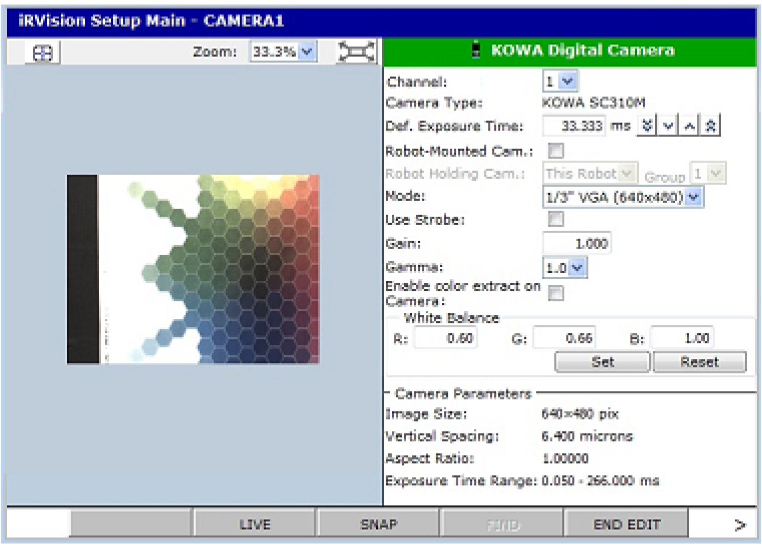
VGA-TALL (640x960)

The acquired image size is 640x960 pixels.

⚠ CAUTION
When you changed this Mode, you need to re-calibrate cameras and retrain locator tools, and so on.

4.1.2 Color Camera

When a color camera is connected to the selected channel, the following screen is displayed.



Mode

Select a camera mode (image size) from the following:

1/6" QVGA (320x240)

The acquired image size is 320x240 pixels.

1/3" VGA (640x480)

The acquired image size is 640x480 pixels. By default, this mode is selected.

1/2" XGA (1024x768)

The acquired image size is 1024x768 pixels.

Gamma

From the drop-down box, select a gamma value to be used from 1.0, 1.4, and 2.0. The dynamic range of an image becomes larger (dark areas become brighter and bright areas become darker) when this value is increased. But the resolution of color is declined when this value is increased. The default value is 1.

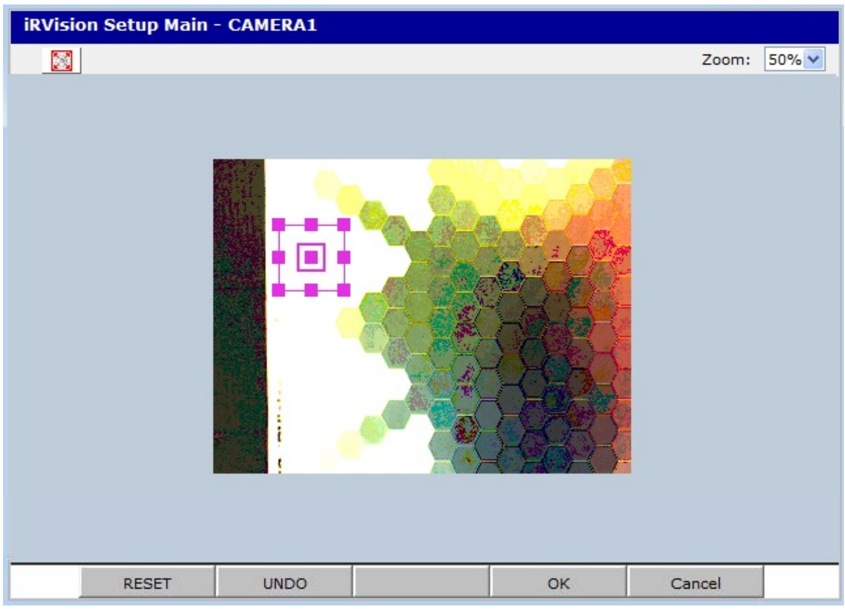
Enable color extract on Camera

Check this check box to allow color extraction on Camera.

Usually, color extraction is performed by the Color Extraction Tool inserted in a vision process. But when this check box is checked and the vision process has only a single Color Extraction Tool, color extraction is performed on camera. When color extraction is performed on camera, the camera transfers a color extracted grayscale image to the controller instead of a color image. A color extracted grayscale image is smaller than a color image in size, so the vision process execution time will be shorter. About the Color Extraction Tool, please refer to Section 7.27 "Color Extraction Tool".

White Balance

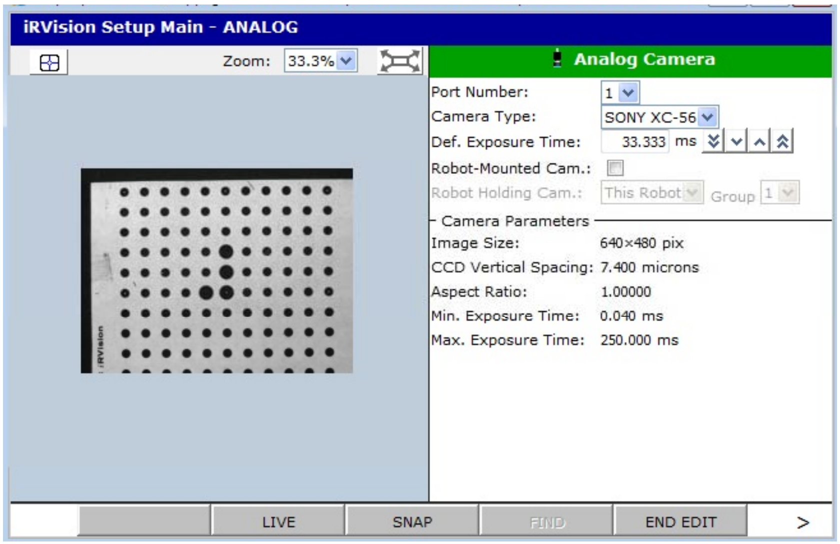
Adjust the proportion of RGB gains to capture a white object as white pixels on an image.



Put a white object in the field of view and tap the [Set] button to set a measurement area on the white target, then the proportion of RGB gains is calculated. At this time, the measurement area must not include any colors except white. When the [Reset] button is tapped, the proportion of RGB gains is set to the default value. The image becomes reddish when the R gain is increased, the image becomes greenish when the G gain is increased, the image becomes bluish when the B gain is increased. The default value is (1.0:1.0:1.0).

4.2 ANALOG CAMERA

When the Analog Camera setup window is opened, the following screen is displayed:



Port Number

Select the port number of the port to which the camera is connected. When a multiplexer is not connected, only port 1 can be selected. When a multiplexer is connected, port 1 to 4 can be specified.

Camera Type
Select the type of the camera connected.

Def. Exposure Time
Set the exposure time to be applied when camera images are snapped using this window.

Robot Mounted Cam.
Check this check box when the camera is mounted on the robot end of arm tooling.

Robot Holding the Cam.
When a robot-mounted camera is used, set the robot that is holding the camera.

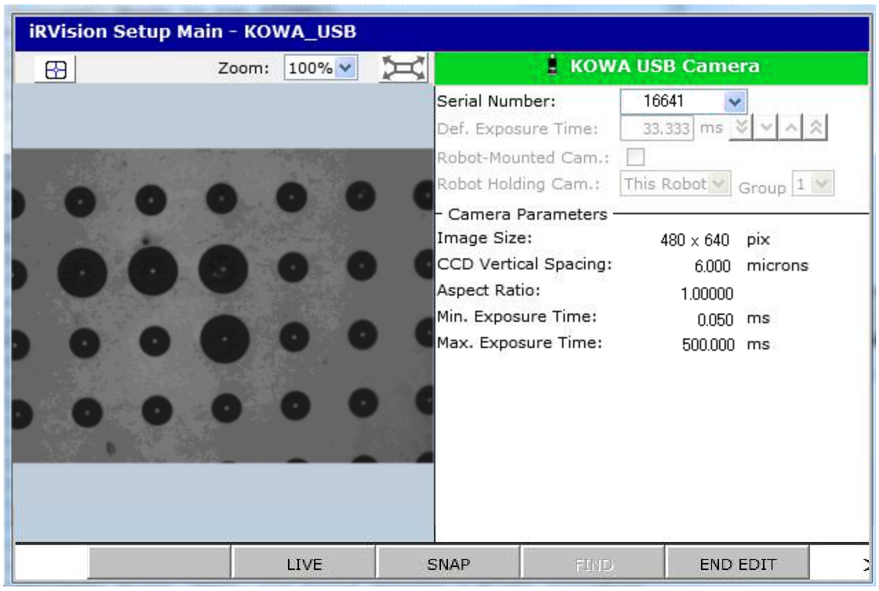
Camera Parameters
The internal specifications of the selected camera are indicated.

4.3 KOWA USB CAMERA

The Kowa USB camera is used when the iRVision function is used on ROBOGUIDE.

> ⚠ **CAUTION**
> 1 To use USB Camera, you must install driver software in your PC. If your OS of PC is Windows XP, please install software by using the CD which is bundled in KOWA USB Camera. If your OS of PC is Windows 7, please contact your FANUC technical representative. Windows Vista is not supported.
> 2 Connect the USB camera before starting the ROBOGUIDE.

When the KOWA USB Camera window is opened, the following screen is displayed:



Serial Number
Select a camera from a list of USB cameras currently connected to the PC.

Exposure Time
Set the exposure time used to snap a camera image on this screen.

Robot Mounted Cam.

Check this box when using a hand camera.

Robot Holding the Cam.

When using a hand camera, set the robot having the camera.

Camera Parameters

These items indicate the internal specification of the selected camera.

4.4 CAMERA SETUP FOR IMAGE FILES

The camera setup for image files is a camera setup that points to images in a user specified folder instead of a camera. This camera setup displays the next image in the folder with each camera snap. This camera setup can be used in setup or runtime.

The images the camera setup can read do not necessarily have to have been created by *i*RVision. But the camera setup for image files camera can read images in only two formats, 8-bit gray scale BMP and 8-bit gray scale PNG. JPEG and other image formats must be converted to 8-bit gray scale images. Microsoft® Photo Editor or another image editing program can be used to convert the images into the proper format. The extension, BMP or PNG, must be in all caps. The file system will not recognize lower case file extensions.

If using Microsoft® Photo Editor

1. Open the image in Microsoft® Photo Editor
2. Select Save As
3. Save As Type: Windows Bitmap (*.bmp)
4. Manually type the BMP extension in all caps, the default bmp extension in lower case will not work.
5. Select More for more save as options
6. Convert to: Gray Scale 8-Bit
7. Compression: None
8. Save

Standard versions of Microsoft® Paint do not have the ability to save images in 8-bit gray scale.

When the camera setup for image files window is opened, the following screen is displayed:

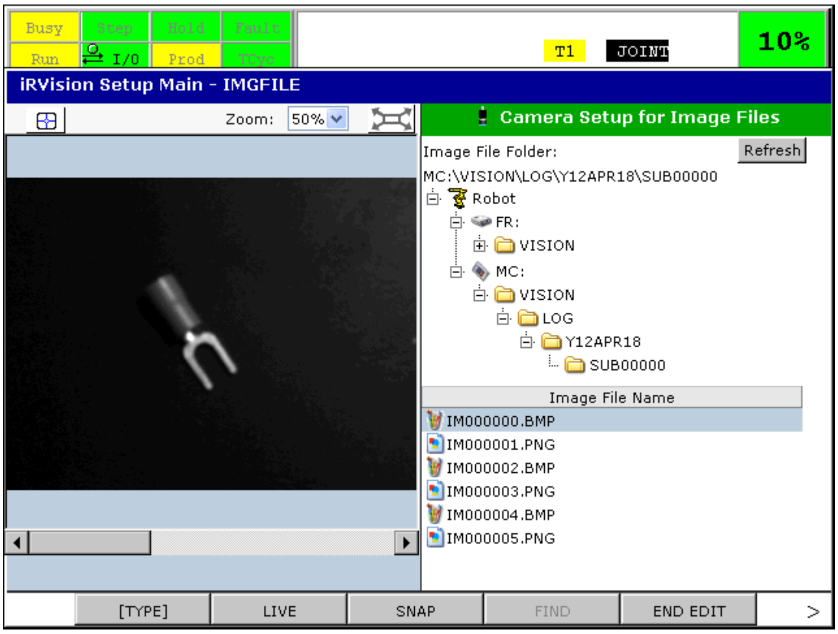


Image File Folder

This item displays the currently selected image file folder.

Refresh Button

The Refresh button refreshes the file folder tree and the image file list. Use it when you change memory cards or change the contents of a folder.

File Folder Tree

This item displays the tree of file folders on the robot. Tap on a “+” character to expand a folder, “-” to collapse it. Tap on a folder name to select it.

Image File List

This item displays the list of image files in the selected folder. Tap on an image file to open and display it.

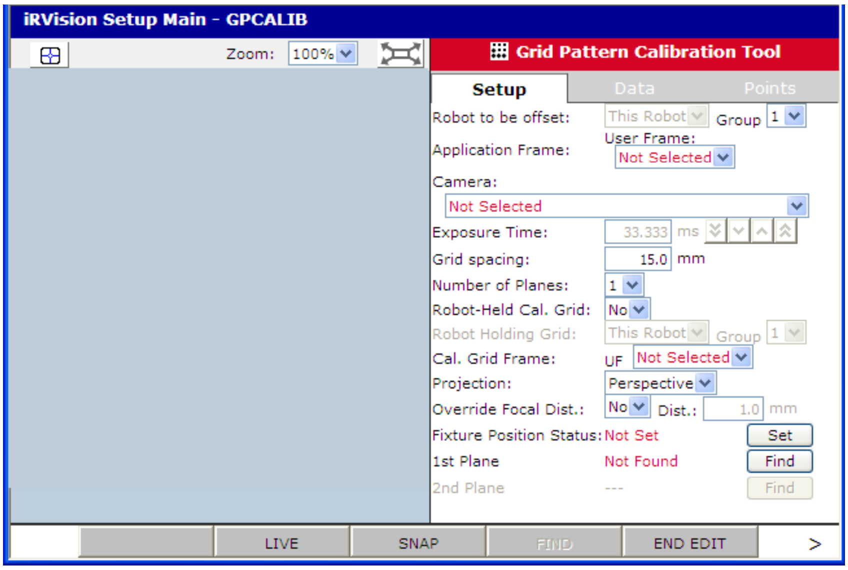
5 CAMERA CALIBRATION

This chapter describes how to set up camera calibration tools.

5.1 GRID PATTERN CALIBRATION

The grid pattern calibration is the standard method to calibrate the camera, and can be used in many vision applications. A fixture called the calibration grid is used to calibrate a camera. For information about the calibration grid, see Chapter 11, "CALIBRATION GRID".

When the grid pattern calibration setup window is opened, the following is displayed:



5.1.1 Calibrating Camera

Calibrate the camera.

Robot to be offset

Specify the target robot position offset by setting its controller and group number.

Application Frame

Specify the robot's user frame to be used for camera calibration. Measurement results are converted to values in the set this frame before output.

In many cases, the base frame of the Robot is set up in [Application Frame].
In the following cases, the user frame is set up and is set up in [Application Frame].

- The camera is mounted in other robot which is not the robot for compensation .
- The calibration grid is mounted in other robot which is not the robot for compensation.

> ⚠ **CAUTION**
> The application frame must be set before the camera calibration is performed. If the application frame is changed after calibrating the camera, calibrate the camera again.

Camera

Select the camera you want to calibrate.

Exposure Time

Set the exposure time to be applied when camera images are snapped using this window.

> ⚠ **CAUTION**
> The value you set here will not be used during vision process runtime.

Grid Spacing

Set the spacing between grid points on the calibration grid to be used.

Number of Planes

Choose between 1-plane calibration and 2-plane calibration.

When a robot-mounted camera is used or when the calibration grid plate is mounted on the robot end of arm tooling, 2-plane calibration should be selected. When a fixed camera and stationary fixture are used, 1-plane calibration should be selected.

Robot-Held Cal. Grid

Select the installation method of the calibration grid.

No

The calibration grid is secured to a table or another place to perform calibration.

Yes

The calibration grid is mounted on the robot end of arm tooling to perform calibration.

Robot Holding Grid

If you choose [Yes] for [Calib. Grid Held by Robot], specify the robot that is holding the calibration grid.

Cal. Grid Frame

Calibration grid frame indicates the position and orientation of the calibration grid when the camera calibration was performed.

When the calibration grid is secured in a fixed location, its position relative to the robot base frame should be set in a user frame area. On this screen, you select the user frame number in which the calibration grid frame information has been set.

When the calibration grid is attached to the robot end of arm tooling, its position relative to the robot mechanical interface frame (the robot wrist flange) should be set in a user tool area. On this screen, you select the user tool number in which the calibration grid frame information has been set.

Detailed information on how to teach the calibration grid frame is described in Section 10.2, "GRID FRAME SETTING".

Projection

Select [Perspective].

Override Focal Dist.

Usually, leave this item set to [No]. When the grid pattern is found, the focal distance will be calculated automatically. When 2-plane calibration is performed, a value close to the nominal focal distance of the lens is calculated. (For example, when the nominal f value of the lens used is 12 mm, 12.1 mm might be calculated.) A correct calibration can be regarded as having been made if the calculated value is close to the nominal value. When the calibration grid is placed to be perpendicular to the optical axis of the camera and 1-plane calibration is performed, select [Yes] and set the value of the nominal focal distance of the lens because theoretically it is difficult to calculate a correct focal distance.

Fixture Position Status

When the calibration grid is in a fixed location, tap the [Set] button. Based on the data of the specified frames, *i*RVision calculates how and where the calibration grid is positioned in the application user frame, and saves the result.

> ⚠ **CAUTION**
> If the position of the calibration grid is changed, e.g., when re-calibrating the camera, it is necessary to recalculate the fixture position by setting the user frame again that contains the calibration grid frame and then tapping the [Set] button to update the fixture position.

When the calibration grid is mounted on the robot end of arm tooling, this button is disabled. The positioning information of the grid pattern is calculated and saved when you perform the next step of finding the grid pattern.

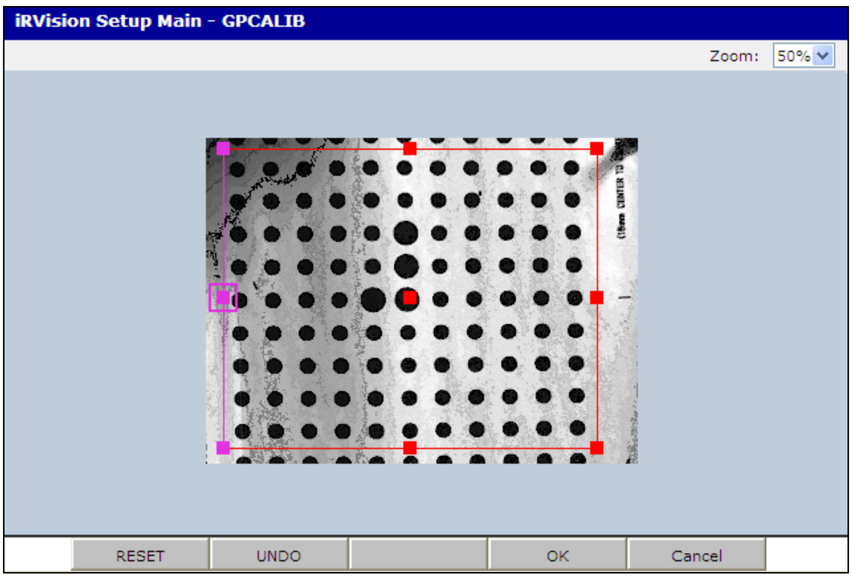
Finding the grid pattern

The grid pattern is found to calculate calibration data.

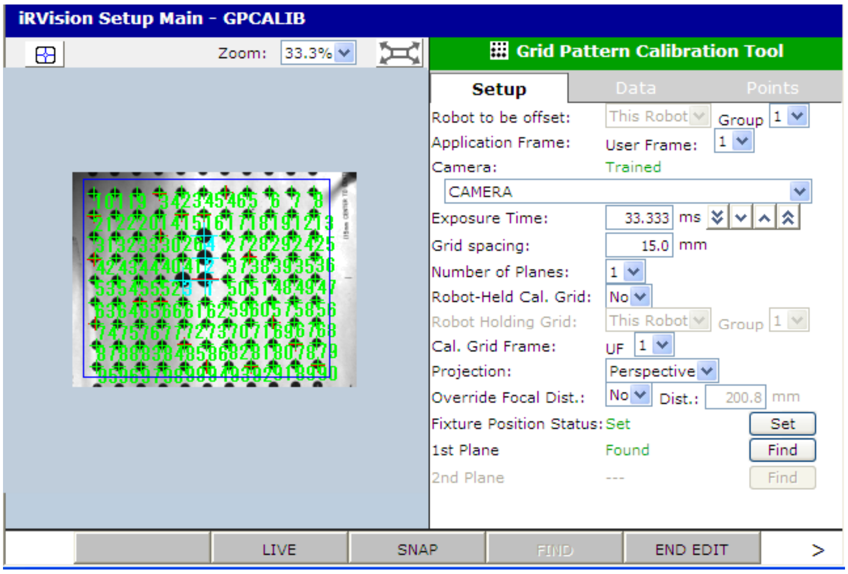
1. To capture the image of the calibration grid, press F3 SNAP.

> ⚠ **CAUTION**
> The calibration grid does not have to fill the field of view, but the calibration will be less accurate if circles of the grid pattern appear only a part in the image. Make sure that the image is filled with circles of the grid pattern; do not care about some of the circles appearing outside the image.

2. Tap the [Find] button of [1st Plane].
3. Specify the grid range with the displayed red rectangle.



4. Press F4 OK.
5. When the grid pattern is found successfully, crosshairs (+) appear at the center of each of the found circles.



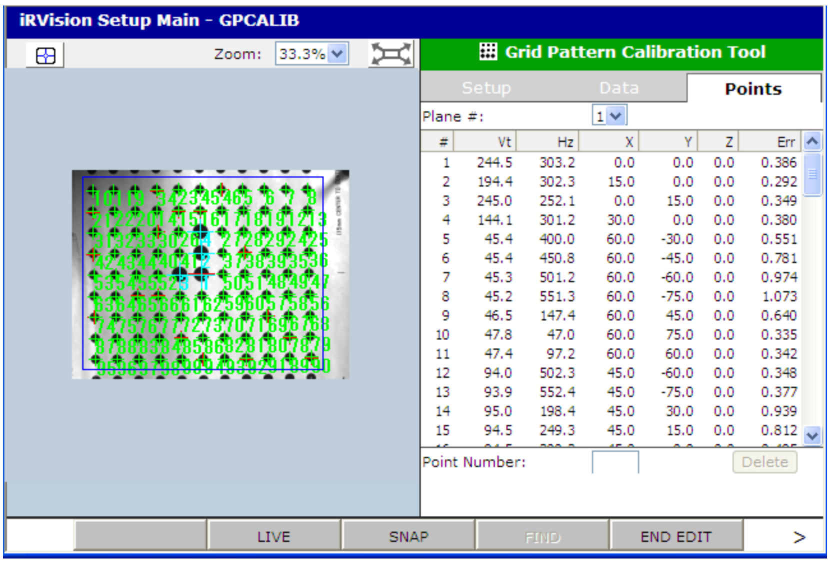
6. Check that blue crosshairs (+) appear in the four large circles. Also, check that green crosshairs (+) appear in small circles. There might be one or two undetected small circles.

For 1-plane calibration, this completes the procedure for calibration.

For 2-plane calibration, jog the robot that has the camera or the robot that has the calibration grid to change the distance between the camera and calibration grid. Generally, move the robot by about 150 mm, then repeat the above steps for the 2^{nd} plane.

5.1.2 Checking Calibration Points

Check the calibration points that have been found.
If you tap the [Points] tab, a page like the one shown below appears.



The image has a green and a red crosshair at the center of each circle that has been found. The green cross hair shows where the calibration point was found in the image, the red cross hairs shows the calculated position of where the calibration point should be. Since green crosshairs are plotted after red crosshairs, only a green crosshair is visible if a green and a red crosshair are plotted at the same position.

Plane
Display the calibration points of the previous or next calibration plane. Use these items in the case of 2-plane calibration.

Vt, Hz
The coordinate values of the found calibration points on the image are displayed.

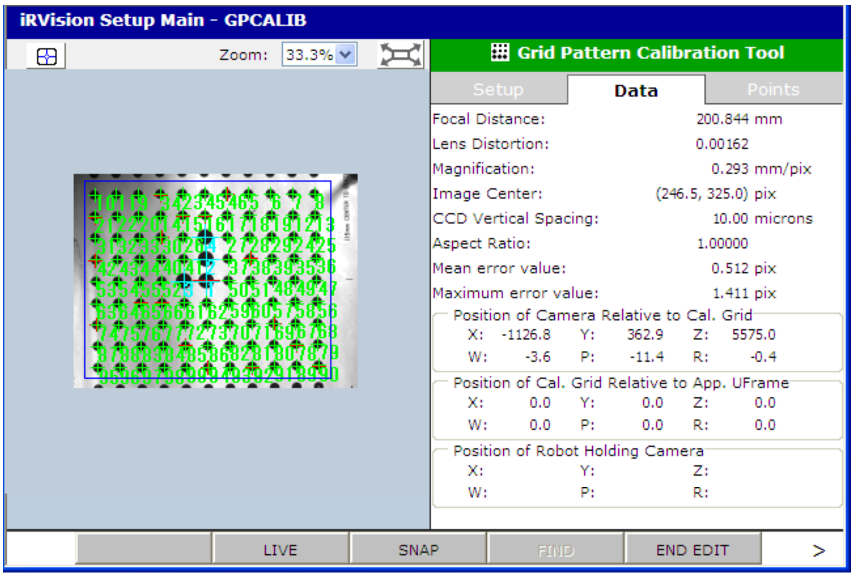
X, Y, Z
The coordinate values of the grid points on the calibration grid frame are displayed.

Error
The distance between the centers of the green crosshairs and red crosshairs plotted on the image is displayed. A smaller value indicates more accurate calibration.

Deleting a calibration point
If a crosshair is displayed at a location where no grid point is present, enter the index number of that point in the text box to the left of the [Delete] button and then tap the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated.

5.1.3 Checking Calibration Data

Check the calculated calibration data. Tap the [Data] tab.



Focal Distance
The calculated focal distance of the lens is displayed. Check that the value is appropriate for the lens in use. The focal length is a label on the lens. In the case of 1-plane calibration, if the W and P values in the [Position of Camera Relative to Calibration Grid] section are both less than several ± degrees, the focal distance cannot be measured accurately. Therefore, in the [Setup] tab, set [Override Focal Distance] to [Yes] and enter the nominal focal distance of the lens in use. If you enter the focal distance, the calibration data is automatically recalculated. Note the user can compare the Z value in Position of

Camera relative to Cal Grid with the measured distance of camera lens to grid (Z value). Please modify focal distance until the two Z values are close.

Lens Distortion

The calculated lens distortion coefficient is displayed. A larger absolute value indicates greater lens distortion. Generally, lenses with shorter focal distances are said to have greater distortion. Grid pattern calibration returns accurate coordinates by using this calculated lens distortion when accurately converting the image frame to the robot frame.

Magnification

The size of a pixel in millimeters on the grid pattern plane (1st plane in the case of 2-plane calibration) is displayed. The value indicates how many millimeters are equivalent to a pixel. If the grid pattern plane is not vertical to the optical axis of the camera, the magnification near the center of the image is displayed.

Image Center

The coordinates of the center of the image are displayed.

CCD Vertical Spacing

The physical size of a pixel of the light receiving element of the camera in use is displayed.

Aspect Ratio

The aspect ratio of a pixel of the image is displayed.

Maximum / Mean Error

The average and maximum errors of all the calibration points shown in the [Points] tab table are displayed.

Position of Camera Relative to Cal. Grid

The position of the camera relative to the calibration grid frame is displayed. For grid frame setting, see Chapter 11, "CALIBRATION GRID".

Position of Cal. Grid Relative to App UFrame

The position of the calibration grid relative to the user frame selected in [Application Frame:] of the [Setup] tab is displayed. It indicates the position where the calibration grid was located when the camera was calibrated. In the case of 2-plane calibration, the calibration grid position on the 1st plane is displayed.

Position of Robot Holding Camera

The position of the robot that was holding the camera at the time of calibration is displayed. It indicates the position of the mechanical interface frame (the wrist flange) of the robot relative to the user frame selected in [Application Frame:] of the [Setup] tab. The value is displayed only for a robot-mounted camera.

5.1.4 Automatic Re-Calibration

If the position of the camera is changed or the camera is replaced for some reason after the system is put into operation, the camera needs to be re-calibrated. In such a case, the use of automatic re-calibration allows you to restore the camera to its proper position with ease. Since no manual operation is involved in re-calibrating the camera, automatic re-calibration prevents the operator's mistakes and other human errors.

Performing automatic re-calibration requires that a robot program for automatic re-calibration be taught in advance. Shown below is a program example for carrying out 2-plane calibration with a robot mounted camera. In P[1], the position of the robot to detect calibration plane 1 is specified. Calibration plane 2 is 100 mm higher in the Z direction than calibration plane 1. In the case of 1-plane calibration, the 21st and subsequent lines are unnecessary.

```
 1:   UFRAME_NUM=1
 2:   UTOOL_NUM=1
 3:J P[1] 100% FINE
 4:
 5:   PR[99]=LPOS
 6:   PR[99,1]=0
 7:   PR[99,2]=0
 8:   PR[99,4]=0
 9:   PR[99,5]=0
10:   PR[99,6]=0
11:
12:! Compensate backlash
13:   PR[99,3]=(-5)
14:J P[1] 100% FINE OFFSET,PR[99]
15:
16:! Find plane-1
17:   PR[99,3]=0
18:J P[1] 100% FINE OFFSET,PR[99]
19:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1
20:
21:! Find plane-2
22:   PR[99,3]=100
23:J P[1] 100% FINE OFFSET,PR[99]
24:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
25:   END
```

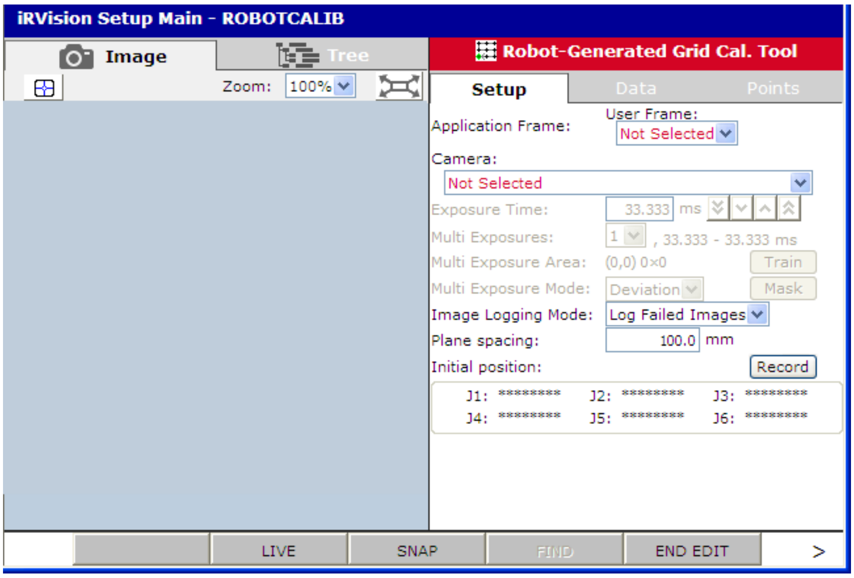
To perform automatic re-calibration, execute the created robot program.

⚠ CAUTION

1. Automatic re-calibration does not reset the calibration grid frame. Make sure that the calibration grid is securely fixed at the position where it was initially calibrated and is not moved.
2. If the calibration grid is robot mounted, do not change the values of the tool frame containing the calibration grid frame. The values of the tool frame are referenced when the position of the calibration grid is calculated from the robot position.

5.2 ROBOT-GENERATED GRID CALIBRATION

Robot-generated grid calibration is a general-purpose camera calibration function suitable for the calibration of a wide-view-angle camera. Selecting [Robot-Generated Grid Calibration] displays a page like the one shown below.



Tip
In Robot-generated grid calibration, the preconfiguration is executed in setup page and the calibration is executed in *i*RVision Utility menu. For details of the calibration step in *i*RVision Utility menu, please refer to the Section 10.1 "Robot-Generated Grid Calibration".

5.2.1 Camera Calibration Tools

If you select [Robot-Generated Grid Calibration] in the tree view, and tap [Setup] tab, a setting screen will be displayed.

Application Frame

Specify the robot's user frame to be used for camera calibration. Measurement results are converted to values in the set this frame before output.

In many cases, the base frame of the Robot is set up in [Application Frame].
In the following case, the user frame is set up and is set up in [Application Frame].

- The direction of the user frame is different from the direction of the base frame.

⚠ CAUTION
The application frame must be set in the robot controller before the camera calibration is performed. If the application frame is changed after calibrating the camera, calibrate the camera again.

Camera

From the drop-down box, choose the camera to be calibrated. When you select a camera name, the corresponding camera positioning state is displayed to the left of the drop-down box.

The aperture and the focus of the lens need to be adjusted to be optimal for the detection of the work before calibrating. The robot target should be set mid way between the two planes and in the middle on the camera view.

If the aperture and the focus of the lens haven't been adjusted yet, adjust them here. Temporary, fully open the aperture of the lens and adjust the exposure time to a good brightness. Focus the lens. Set Exposure time to 33.0 milliseconds and close the aperture of the lens to a good brightness. When the calibration is executed, execute the target detection by not changing configuration of the camera but the exposure time. The first aperture adjustment is performed to reduce the camera depth of field to a minimum range, this provides the highest tuning ratio for the focus ring. The second aperture adjustment is performed to allow the greatest brightness range at the Vision Process level for the Exposure Time.

Exposure Time of Camera

Set the exposure time to make sure that the target is detected easily. This exposure time setting is used only for calibration. For details of the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Image Logging Mode

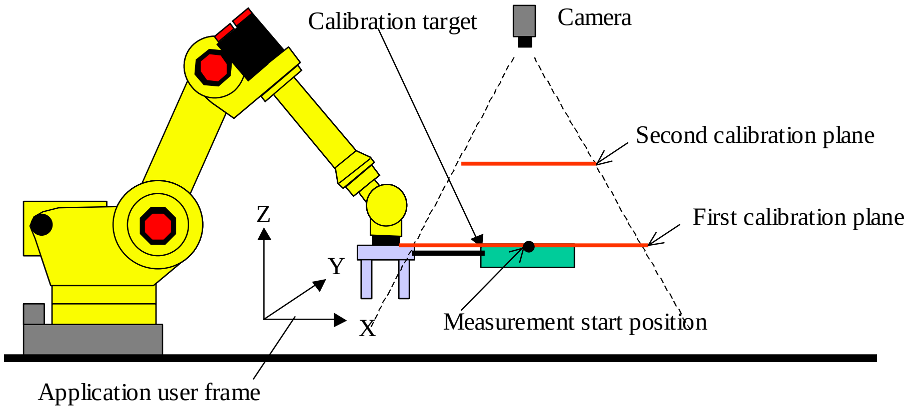
From the drop-down box, select whether to save images in the vision log.

Plane spacing

Specify the spacing between calibration planes 1 and 2. An optimal calibration plane spacing is 10% of the spacing between the camera and calibration plane 1. If you enter a positive value when the Z-axis of the application user frame is directed toward the camera, or if you enter a negative value when the Z-axis is in the opposite direction, calibration plane 2 is located closer to the camera relative to calibration plane 1. This reduces the risk of the robot interfering with peripheral equipment when moving.

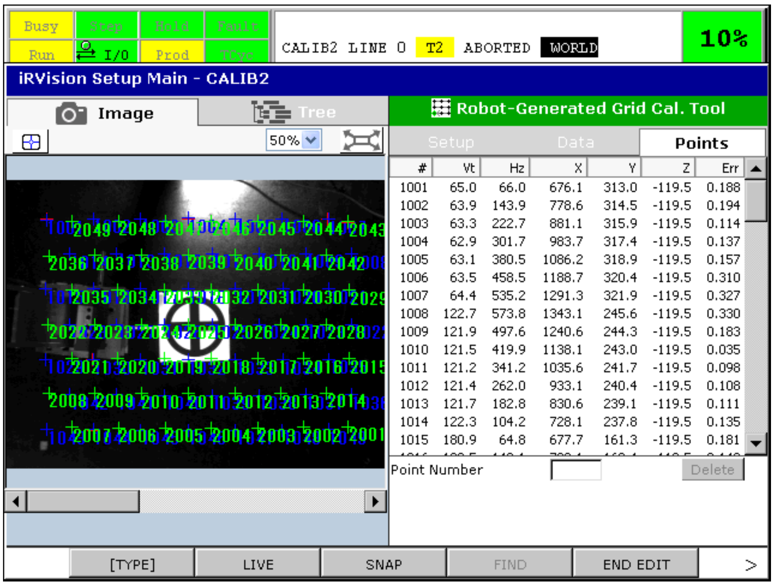
Initial position

Specify the measurement start position. This start position should be set so that the target mounted on the robot end of arm tooling comes roughly at the center of the camera's field of view. The height of the start position is equal to that of the calibration plane 1. During camera calibration, the robot moves in parallel to the XY plane of the application frame, while maintaining the posture of the start position. Jog the robot to a place that is appropriate as the start position, and tap the RECORD button.



5.2.2 Checking Calibration Points

If you select [Robot-Generated Grid Calibration] in the tree view, and tap [Points] tab, a page like the one shown below appears.



The image has a blue crosshair plotted on each calibration point in calibration plane 1 and a green crosshair plotted on each calibration point in calibration plane 2, at the center of each circle that has been found. A calibration point number is shown at the lower right of each crosshair. A red crosshair shows the 3D position of an individual circle that is obtained by projecting the circle onto the image by means of the calculated calibration data. Since blue and green crosshairs are plotted after red crosshairs, a red crosshair is not visible if a blue or green crosshair and a red crosshair are plotted at the same position.

Vt, Hz

The coordinate values of the found calibration points on the image are displayed.

X, Y, Z

The coordinate values of the grid points on the user frame to be offset are displayed.

Error

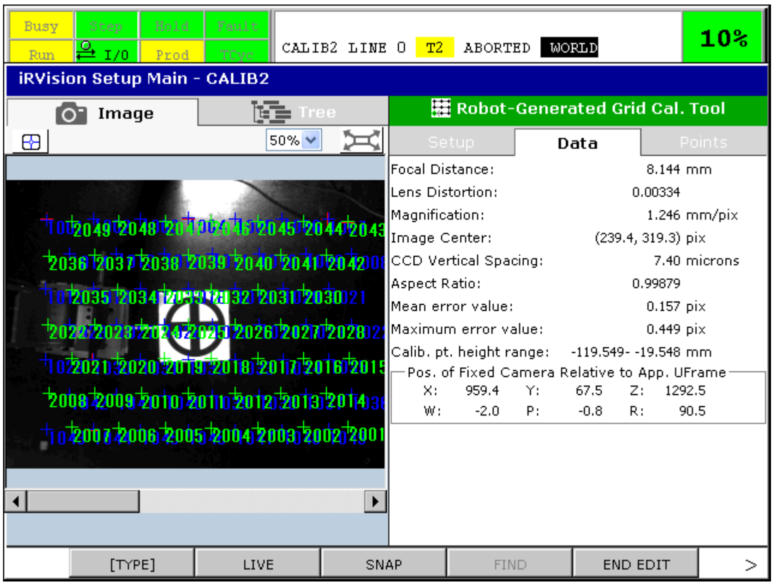
The distance between the centers of the blue and green crosshairs and the centers of the red crosshairs plotted on the image is displayed. A smaller value indicates more accurate calibration.

Deleting a calibration point

If a crosshair is displayed at a location where no calibration point is present, select that point by tapping it in the list or enter the index number of the point in the text box to the left of the [Delete] button, and then tap the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated.

5.2.3 Checking Calibration Data

If you select the [Robot-Generated Grid Calibration] in the tree view, and tap the [Data] tab, a page like the one shown below appears.



Focal Distance

The calculated focal distance of the lens is displayed. Check that the focal distance is within ±5% of the nominal focal distance of the lens (the value indicated in the spec sheet).

Lens Distortion

The calculated lens distortion coefficient is displayed. A larger absolute value indicates greater lens distortion. Generally, lenses with shorter focal distances are said to have greater distortion. Robot-generated grid calibration returns accurate coordinates by using this calculated lens distortion when accurately converting the image frame to the robot frame.

Magnification

The size of a pixel in millimeters on calibration plane 1 is displayed. The value indicates how many millimeters are equivalent to a pixel on the image.

Image Center

The position where the light passing through the center of the lens is projected is displayed. A typical lens is designed so that the light passing through the center of the lens is projected at the center of the image. Check that the image center is set to be near the center of the image.

CCD Vertical Spacing

The physical size of a pixel of the light receiving element of the camera in use is displayed.

Aspect Ratio

The aspect ratio of a pixel of the image is displayed.

Maximum / Mean Error

The average and maximum errors of all the calibration points shown in the [Points] tab table are displayed.

Pos. of Fixed Camera Relative to App UFrame

The position of the fixed camera relative to the user frame to be offset is displayed.

5.2.4 Automatic Re-Calibration

If the position of the camera is changed or the camera is replaced for some reason after the system is put into operation, the camera needs to be re-calibrated. In such a case, the use of automatic re-calibration allows you to restore the camera to its proper position with ease. Since no manual operation is involved in re-calibrating the camera, automatic re-calibration prevents the operator's mistakes and other human errors. Robot-generated grid calibration automatically generates a calibration program. By executing this program from the first line, you can perform re-calibration.

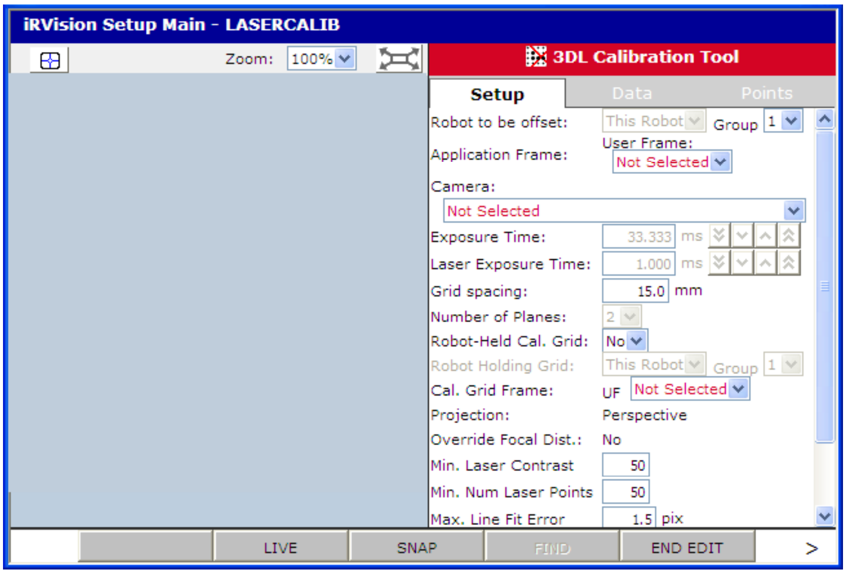
> ⚠ **CAUTION**
> Automatic re-calibration does not reset the target positioning information. Make sure that the target is securely fixed at the position where it was initially calibrated and is not moved.

5.3 3D LASER VISION CALIBRATION

The 3DL Calibration is the method to calibrate the 3D laser vision sensor.

When 3DL calibration setup window is opened, the following is displayed.

When you use the camera in the 3D laser vision sensor for 2D application, the 3DL calibration can be used for the 2D application. However, in such a case, the XY plane of the application frame must be parallel to the workpiece plane. See Section 5.1 "GRID PATTERN CALIBRATION" for details.



5.3.1 Calibrating Camera

Calibrate the camera.

Robot to be offset

Specify the target robot position offset by setting its controller and group number.

Application Frame

Specify the number of the user frame to be used for robot position offset. Measurement results are converted to values in the set this frame before output.

In many cases, the base frame of the Robot is set up in [Application Frame].
In the following cases, the user frame is set up and is set up in [Application Frame].

- The camera is mounted in other robot which is not the robot for compensation .
- The calibration grid is mounted in other robot which is not the robot for compensation.

> ⚠ **CAUTION**
> The application frame must be set in the robot controller before the camera calibration is performed. If the application frame is changed after calibrating the camera, calibrate the camera again.

Camera

Select the camera you want to calibrate.

Exposure Time

Set the exposure time to be applied when the grid pattern is found in this window, with a value ranging from 0.04 to 250. The unit is ms.

Laser Exposure Time

Set the exposure time to be applied when laser slits are found in this window, with a value ranging from 0.04 to 250. The unit is ms.

Grid Spacing

Enter the spacing between grid points on the calibration grid used. The unit is mm.

Number of Planes

Show the number of planes to be calibrated. Two planes are selected. This setting cannot be changed.

Robot-Held Cal. Grid

Select the installation status of the calibration grid. Select [No] if the calibration grid is not moved with respect to the user frame, or select [Yes] if the calibration grid is mounted on the robot.

Robot Holding Grid

This item is set only when [Yes] is selected in [Calib. Grid Held by Robot]. Select the robot that has the calibration plate. In [Group], set the group number of the robot.

Cal. Grid Frame

Calibration grid frame indicates the position and orientation of the calibration grid when the camera calibration was performed.

When the calibration grid is in a fixed location, its position relative to the robot base frame should be set in a user frame area. On this screen, you select the user frame number in which the calibration grid frame information has been set.

When the calibration grid is attached to the robot end of arm tooling, its position relative to the robot mechanical interface frame (the robot wrist flange) should be set in a user tool area. On this screen, you select the user tool number in which the calibration grid frame information has been set.

Detailed information on how to set the calibration grid frame is described in Section 10.2, "GRID FRAME SETTING".

Projection

[Perspective] is selected. This setting cannot be changed.

Override Focal Length

The focal distance of the lens used. [No] is selected. This setting cannot be changed.

Min. Laser Contrast

Set the threshold of contrast applicable when a laser point sequence is to be found. Set a value ranging from 1 to 254. The default value is 50.

Min. Num. Laser Points

Set the minimum number of laser points required for calibration with a value ranging from 1 to 479. The default value is 50.

Max Line Fit Error

Set the margin to be applied when a laser point sequence is regarded as being on a calculated straight line, with a value ranging from 0 to 10. The unit is mm and the default value is 3 mm.

Fixture Position Status

The current setting is indicated. This item can be set only when [No] is selected in [Calib. Grid Held by Robot]. When the [Set] button is tapped, the values in the application user frame specified in [Application Frame] are registered as the position of the calibration grid.

> ⚠ **CAUTION**
> If the position of the calibration grid is changed, e.g., when re-calibrating the camera, it is necessary to recalculate the position of the calibration grid by setting the application user frame again that contains the calibration grid frame and tapping the [Set] button for the position of the calibration grid.

This button is disabled when the calibration grid is robot mounted. The position information of the calibration grid is automatically calculated and saved when the grid pattern is found.

1st Plane, 2nd Plane

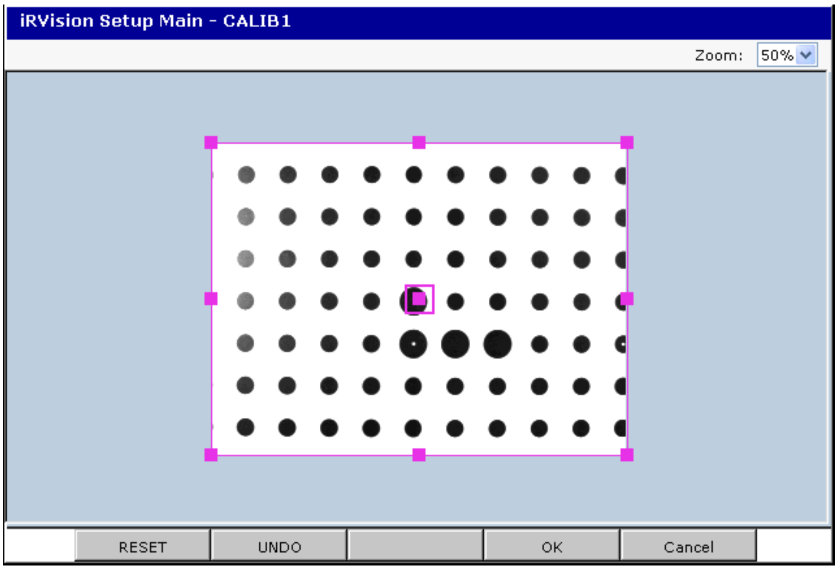
The current calibration plane status is indicated. To find the grid pattern, perform the following steps with the calibration grid mounted or fixed in the frame specified in [Calib. Grid Held by Robot].

1. Place the calibration grid at a distance of about 350 mm (550 mm when the stand off of your 3D laser sensor is 600 mm) from the 3D laser sensor so that they face each other.

> ⚠ **CAUTION**
> The calibration grid does not have to fill the field of view, but the calibration will be less accurate if circles of the grid pattern appear only a part in the image. Make sure that the image is filled with circles of the grid pattern; do not care about some of the circles appearing outside the image.

2. Tap the [Snap and Find] button of [1st Plane].

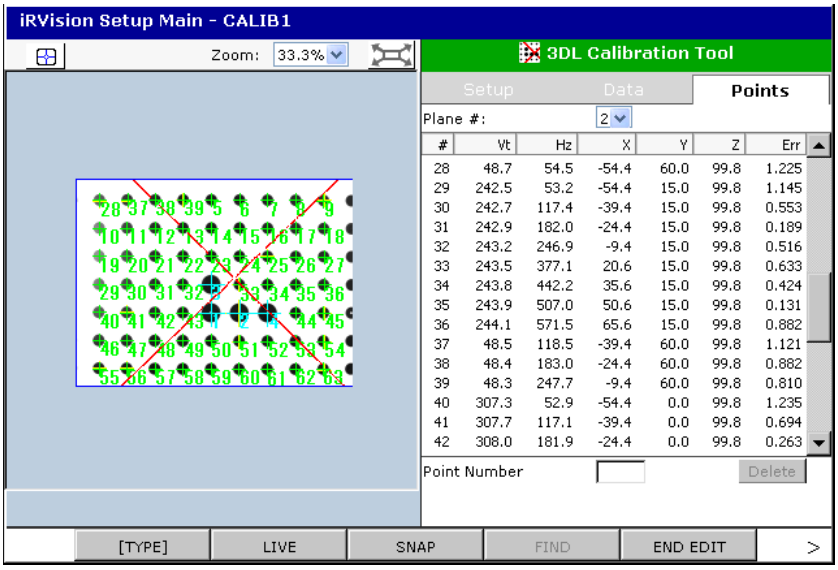
3. Teach the search window for the grid pattern and laser point sequence so that only the grid pattern is fit in the search window, and press F4 OK.



4. Check that almost all circles are found and the laser slits are found clearly. If the location is successful, [Found] is indicated in [1st Plane].
5. Place the calibration grid at a distance of about 450 mm (650 mm when the stand off of your 3D laser sensor is 600 mm) from the 3D laser sensor so that they face each other.
6. Tap the [Snap and Find] button of [2nd Plane].
7. Teach the search window for the grid pattern and laser point sequence so that only the grid pattern is fit in the search window, and press F4 OK.
8. Check that almost all circles are found and the laser slits are found clearly. If the location is successful, [Found] is indicated in [2nd Plane].

5.3.2 Checking Calibration Points

Check the calibration points that have been found.
When the [Points] tab is tapped, a screen like the one shown below appears.



#	Vt	Hz	X	Y	Z	Err
28	48.7	54.5	-54.4	60.0	99.8	1.225
29	242.5	53.2	-54.4	15.0	99.8	1.145
30	242.7	117.4	-39.4	15.0	99.8	0.553
31	242.9	182.0	-24.4	15.0	99.8	0.189
32	243.2	246.9	-9.4	15.0	99.8	0.516
33	243.5	377.1	20.6	15.0	99.8	0.633
34	243.8	442.2	35.6	15.0	99.8	0.424
35	243.9	507.0	50.6	15.0	99.8	0.131
36	244.1	571.5	65.6	15.0	99.8	0.882
37	48.5	118.5	-39.4	60.0	99.8	1.121
38	48.4	183.0	-24.4	60.0	99.8	0.882
39	48.3	247.7	-9.4	60.0	99.8	0.810
40	307.3	52.9	-54.4	0.0	99.8	1.235
41	307.7	117.1	-39.4	0.0	99.8	0.694
42	308.0	181.9	-24.4	0.0	99.8	0.263

1. Check for any crosshairs that appear in a place other than the grid points.

2. If there is an incorrect point, enter the number of that point in the text box on the right of [Point Number], then tap [Delete] button.

The image has a green and a yellow crosshair at the center of each circle that has been found. The green cross hair shows where the calibration point was found in the image, the yellow cross hairs shows the calculated position of where the calibration point should be. Since green crosshairs are plotted after yellow crosshairs, only a green crosshair is visible if a green and a yellow crosshair are plotted at the same position.

Plane
Display the calibration points of the previous or next calibration plane. Use these items in the case of 2-plane calibration.

Vt, Hz
The coordinate values of the found calibration points on the image are displayed.

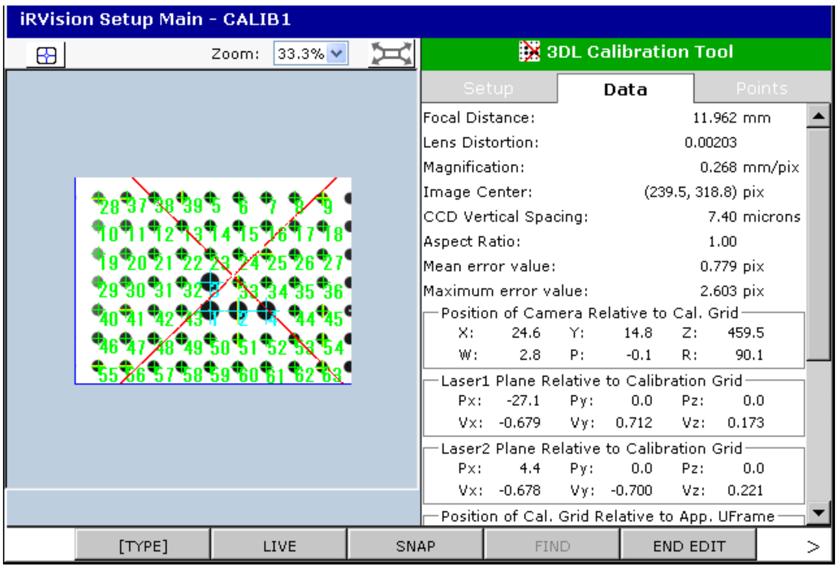
X, Y, Z
The coordinate values of the grid points on the calibration grid frame are displayed.

Error
The distance between the centers of the green crosshairs and yellow crosshairs plotted on the image is displayed. A smaller value indicates more accurate calibration.

Deleting a calibration point
If a crosshair is displayed at a location where no grid point is present, enter the index number of that point in the text box to the left of the [Delete] button and then tap the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated.

5.3.3 Checking Calibration Data

Tap the [Data] tab.



Focal Distance
The calculated focal distance of the lens is displayed. Check that the value is appropriate for the lens in use.

Lens Distortion

The calculated lens distortion coefficient is displayed. A larger absolute value indicates greater lens distortion. Generally, lenses with shorter focal distances are said to have greater distortion. Grid pattern calibration returns accurate coordinates by using this calculated lens distortion when accurately converting the image frame to the robot frame.

Magnification

The size of a pixel in millimeters on the grid pattern plane is displayed. The value indicates how many millimeters are equivalent to a pixel. If the grid pattern plane is not vertical to the optical axis of the camera, the magnification near the center of the image is displayed.

Image Center

The coordinates of the center of the image are displayed.

CCD Vertical Spacing

The physical size of a pixel of the light receiving element of the camera in use is displayed.

Aspect Ratio

The aspect ratio of a pixel of the image is displayed.

Maximum / Mean Error

The average and maximum errors of each calibration point shown in the [Points] tab table are displayed.

Position of Camera relative to Cal. Grid

The position of the camera relative to the calibration grid frame is displayed.
For grid frame setting, see Chapter 11, "CALIBRATION GRID".

Laser1 Plane Relative to Calibration Grid

The laser 1 plane relative to the calibration grid frame.

Laser2 Plane Relative to Calibration Grid

The laser 2 plane relative to the calibration grid frame.

Position of Cal. Grid relative to App UFrame

The position of the calibration grid relative to the user frame selected in [Application Frame:] of the [Setup] tab is displayed. It indicates the position where the calibration grid was located when the camera was calibrated.

Position of Robot Holding Camera

The position of the robot that was holding the camera at the time of calibration is displayed. It indicates the position of the mechanical interface frame (the wrist flange) of the robot relative to the user frame selected in [Application Frame:] of the [Setup] tab. The value is displayed only for a robot-mounted camera.

Camera Frame Relative to Robot

[Camera frame relative to the robot] on the [Data] tab indicates the position of the frame which shows the shooting direction of the camera relative to the mechanical interface frame of the robot (the wrist flange of the robot) when the 3D laser sensor is robot mounted. The camera frame is defined so that the origin is located 400 mm (or 600mm; depending on the standoff of the 3D laser sensor) from the camera unit window on the optical axis of the camera and the Z-axis is located parallel to the optical axis of the camera. If this value is set for the user tool of the robot and a jog is performed on the basis of the user tool, it is possible to jog the robot without changing the camera distance or to rotate the camera about the optical axis.

Laser Frame Relative to Robot

[Laser frame relative to the robot] on the [Data] tab indicates the position of the frame which shows the laser emitting direction relative to the mechanical interface frame of the robot (the wrist flange of the robot) when the 3D laser sensor is robot mounted. This frame is defined so that the origin is located 400 mm (or 600mm; depending on the standoff of the 3D laser sensor) from the camera unit window of the camera on the line of intersection of two slit laser beams and the Z-axis is located parallel to the line of intersection of the two slit laser beams. If this value is set for the user tool of the robot and a jog is performed on the basis of the user tool, it is possible to move the robot in parallel with the two slit laser beams or to rotate the camera about the laser beams.

5.3.4 Automatic Re-Calibration

If the position of the 3D laser sensor is changed or the sensor is replaced for some reason after the system is put into operation, the 3D laser sensor needs to be re-calibrated. In such a case, the use of automatic re-calibration allows you to restore the sensor to its proper position with ease. Since no manual operation is involved in re-calibrating the sensor, automatic re-calibration prevents the operator's mistakes and other human errors. Performing automatic re-calibration requires that a robot program for automatic re-calibration be taught in advance. A program example is shown below. In P[1], the position of the robot to detect calibration plane 1 is specified. Calibration plane 2 is 100 mm higher in the Z direction than calibration plane 1.

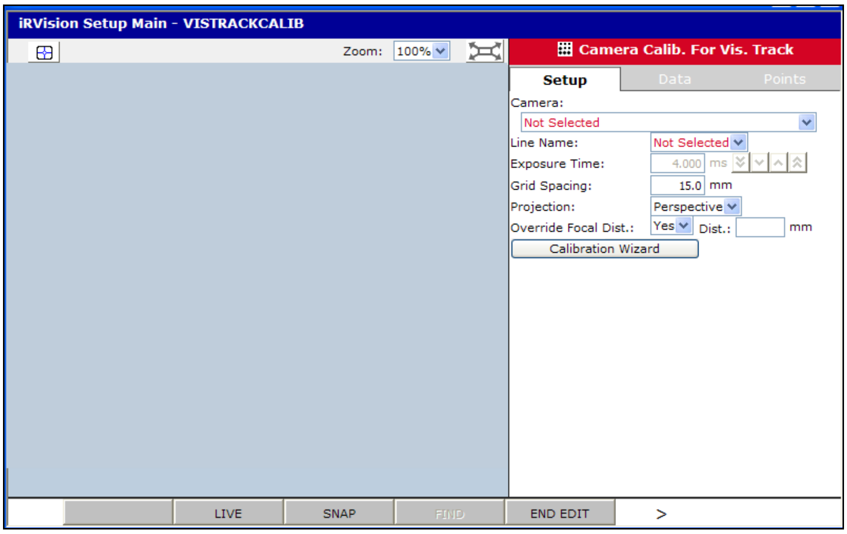
```
  1:   UFRAME_NUM=1
  2:   UTOOL_NUM=1
  3:J P[1] 100% FINE
  4:
  5:   PR[99]=LPOS
  6:   PR[99,1]=0
  7:   PR[99,2]=0
  8:   PR[99,4]=0
  9:   PR[99,5]=0
 10:   PR[99,6]=0
 11:
 12:! Compensate backlash
 13:   PR[99,3]=(-5)
 14:J P[1] 100% FINE OFFSET,PR[99]
 15:
 16:! Find plane-1
 17:   PR[99,3]=0
 18:J P[1] 100% FINE OFFSET,PR[99]
 19:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1
 20:
 21:! Find plane-2
 22:   PR[99,3]=100
 23:J P[1] 100% FINE OFFSET,PR[99]
 24:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
 25:   END
```

To perform automatic re-calibration, execute the created robot program.

> ⚠ **CAUTION**
>
> 1 Automatic re-calibration does not reset the calibration grid frame. Make sure that the calibration grid is securely fixed at the position where it was initially calibrated and is not moved.
>
> 2 If the calibration grid is robot mounted, do not change the values of the tool frame containing the calibration grid frame. The values of the tool frame are referenced when the position of the calibration grid is calculated from the robot position.

5.4 VISUAL TRACKING CALIBRATION

The visual tracking calibration is the camera calibration method dedicated to the visual tracking application. When camera calibration of visual tracking is selected, the following is displayed:



5.4.1 Calibrating Camera

Calibrate the camera.

Camera

Select a camera to be used.

Line Name

Select a Line of visual tracking to be used.

About the Lines, please refer to "R-30*i*B CONTROLLER *i*RVision Visual Tracking Application OPERATOR'S MANUAL".

Exposure Time

Enter the shutter speed of the camera.

Grid Spacing

Enter the spacing between grid points on the calibration grid used.

Projection

Select [Perspective].

Override Focal Length

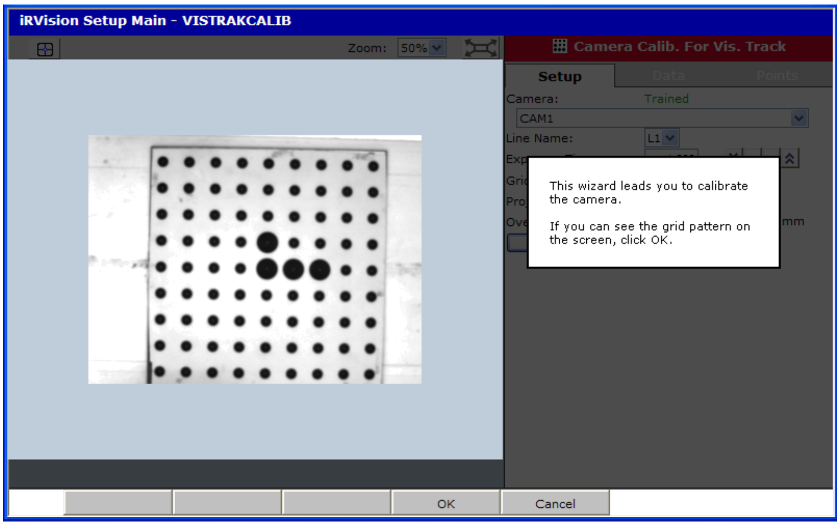
Select [Yes], and enter the focal distance of the lens used in the text box to the right.

Calibration Wizard

Perform the following steps in the wizard to perform camera calibration:

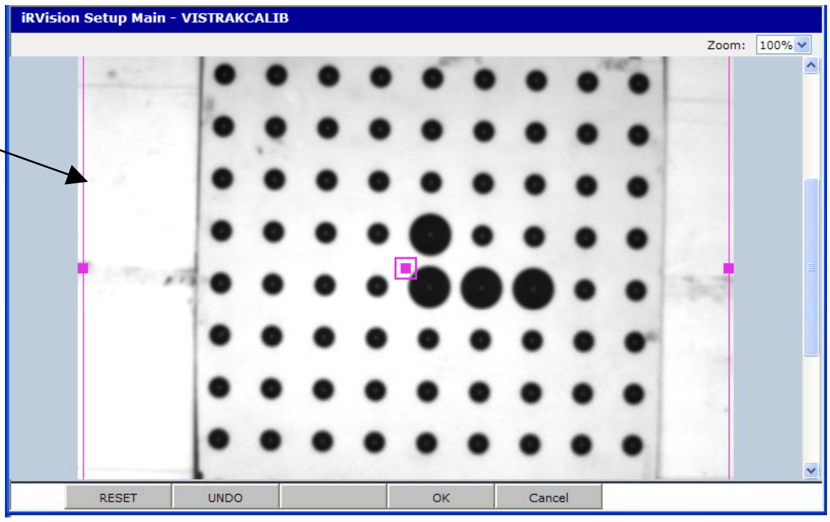
> ⚠ **CAUTION**
> Make sure that the tracking frame has been set before camera calibration is performed. If the tracking frame is changed after camera calibration is performed, camera calibration must be performed again.

1. Tap the [Calibration Wizard] button with the calibration grid placed within the camera field of view.



2. Check that the grid pattern on the calibration grid is displayed on the screen, then press F4 OK. The Image will expand with the search area set to enclose a large area. Adjust the anchor points as necessary.

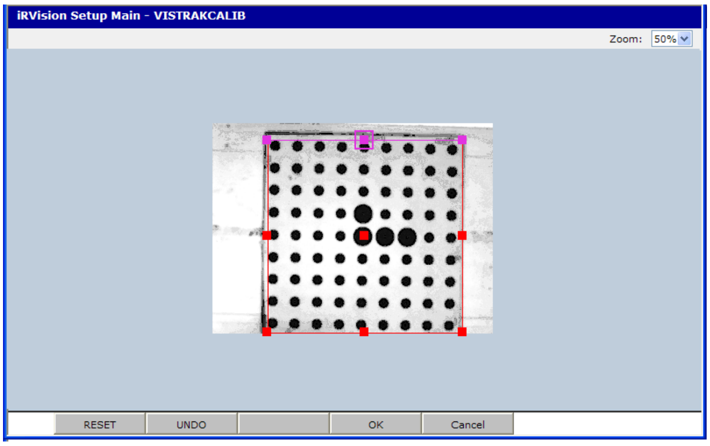
Purple Rectangular Window



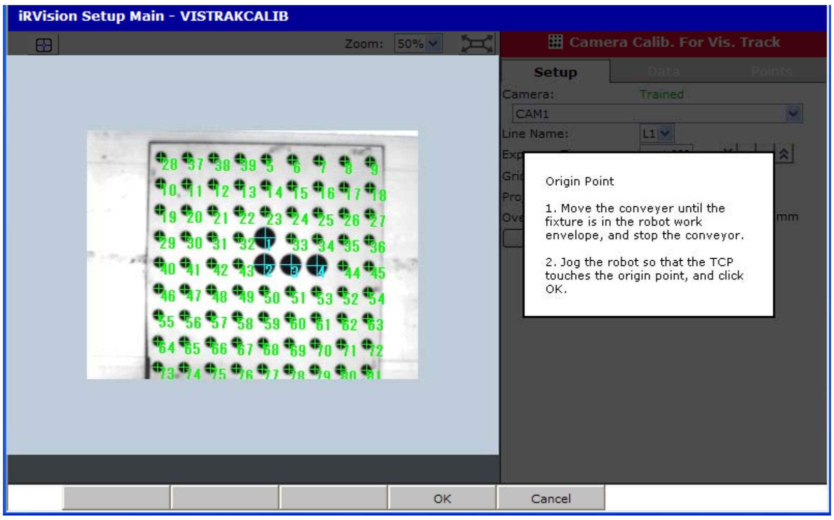
⚠ CAUTION

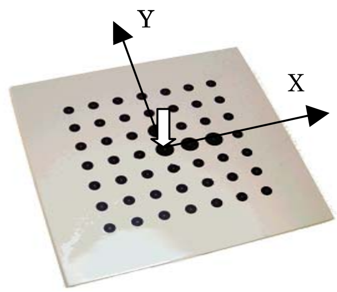
The calibration grid does not have to fill the field of view, but the calibration will be less accurate if circles of the grid pattern appear only a part in the image. Make sure that the image is filled with circles of the grid pattern; do not care about some of the circles appearing outside the image.

3. Enclose the grid pattern with a purple rectangular window, then press F4 OK. As many full circles as possible should be enclosed.



4. Upon completion of grid pattern location, the screen shown below is displayed.



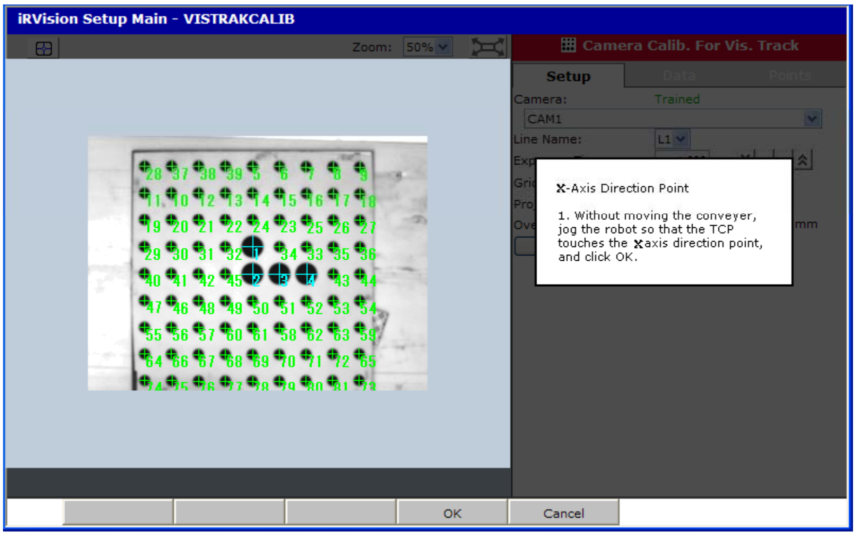


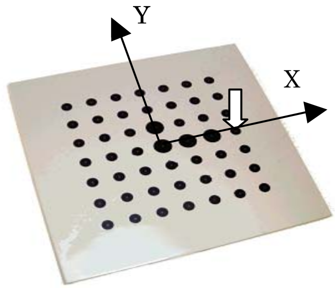
5. Move the conveyor so that the calibration grid is placed in front of the robot that includes *i*RVision.

⚠ CAUTION

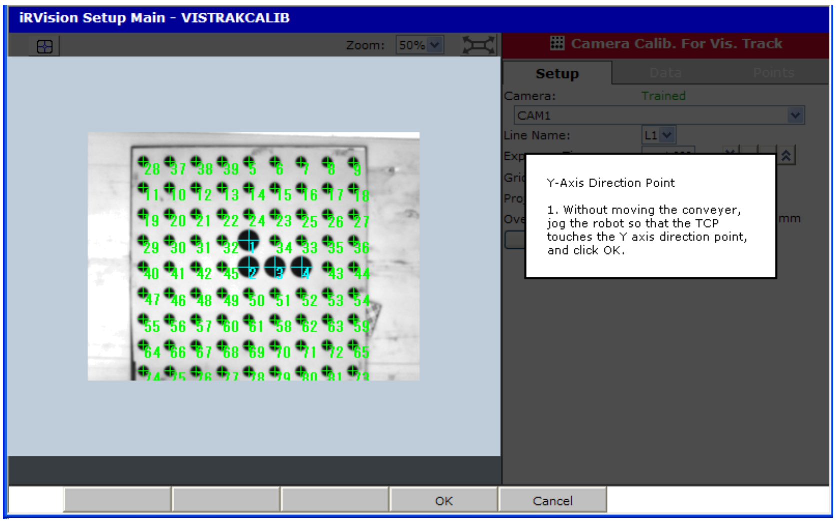
Be careful not to move the calibration plate.

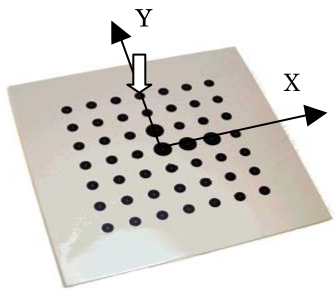
6. Jog the robot so the TCP is on the origin of the calibration grid, and press F4 OK.



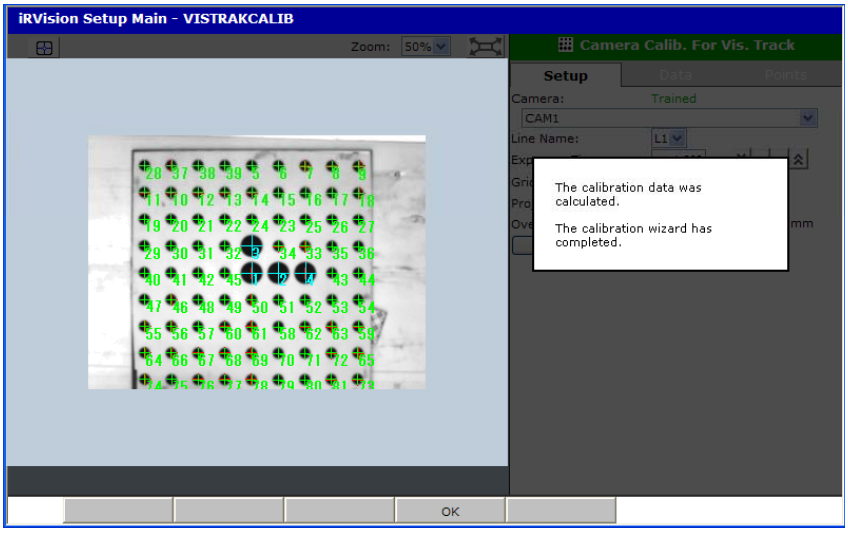


7. Jog the robot so the TCP is on a point on the positive X-axis of the calibration grid, then press F4 OK.





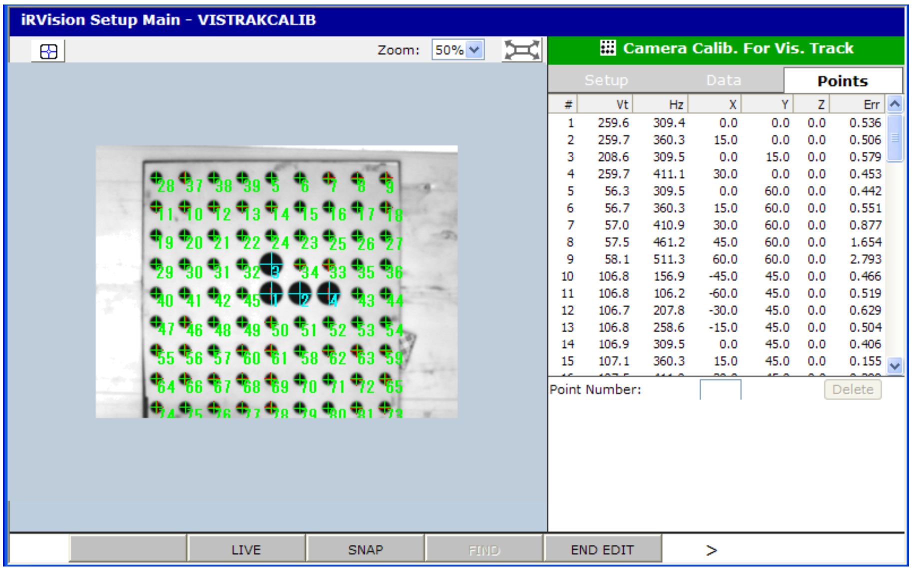
8. Jog the robot so that the TCP is on a point on the positive Y-axis of the calibration grid, then press F4 OK.



9. Press F4 OK.

5.4.2 Checking Calibration Points

Check the calibration points that have been found.
When the [Points] tab is tapped, a screen like the one shown below appears.



The image has a green and a red crosshair at the center of each circle that has been found. A green crosshair shows the position of a calibration point detected from the image, and a red crosshair the 3D position of an individual circle. These represent the positions obtained by projecting the points onto the image by means of the calculated calibration data. Since green crosshairs are plotted after red crosshairs, only a green crosshair is visible if a green and a red crosshair are plotted at the same position.

Vt, Hz

The coordinate values of the found calibration points on the image are displayed.

X, Y, Z

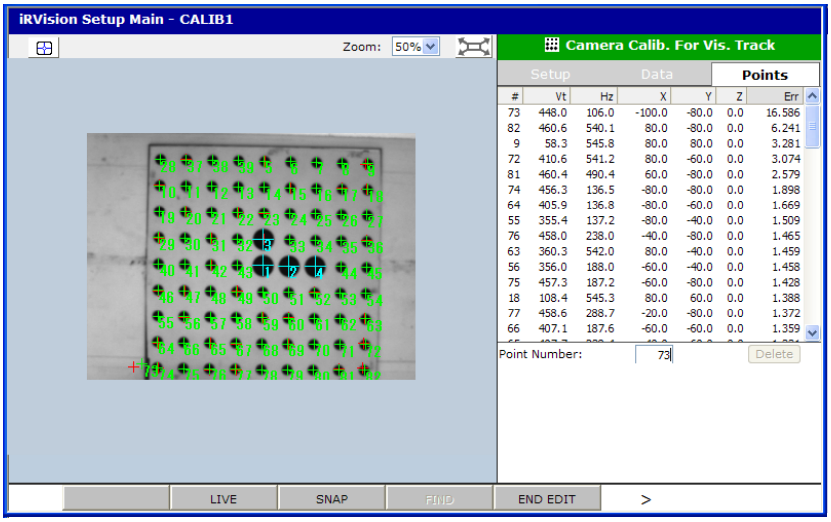
The coordinate values of the grid points on the calibration grid frame are displayed.

Error

The distance between the centers of the green crosshairs and red crosshairs plotted on the image is displayed. A smaller value indicates more accurate calibration.

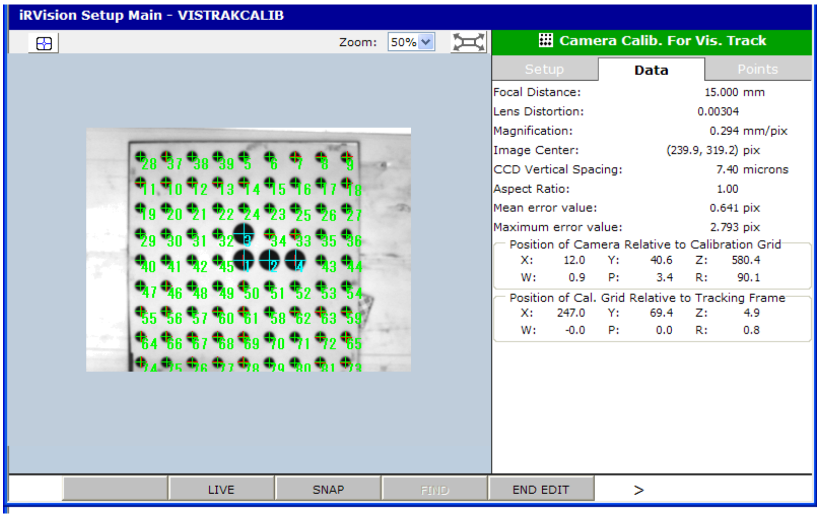
Deleting a calibration point

If a crosshair is displayed at a location where no grid point is present, enter the index number of that point in the text box to the left of the [Delete] button and then tap the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated. The user can Double tap the Err header to sort the column. In the example below #73 has a large error. Tap on 73 and point in the image is highlighted. In this case 73 is a false circle. Enter 73 as the Point Number and tap the [Delete] button. The point is removed and a new calculation is performed.



5.4.3 Checking Calibration Data

Check the calculated calibration data. Tap the [Data] tab.



Focal Distance

The calculated focal distance of the lens is displayed. Check that the value is appropriate for the lens in use.

If the W and P values in the [Position of Camera Relative to Calibration Grid] section are both less than several ± degrees, the focal distance cannot be measured accurately. Therefore, in the [Setup] tab, set [Override Focal Distance] to [Yes] and enter the nominal focal distance of the lens in use. If you enter the focal distance, the calibration data is automatically recalculated.

Lens Distortion

The calculated lens distortion coefficient is displayed. A larger absolute value indicates greater lens distortion. Generally, lenses with shorter focal distances are said to have greater distortion. Grid pattern calibration returns accurate coordinates by using this calculated lens distortion when accurately converting the image frame to the robot frame.

Magnification

The size of a pixel in millimeters on the grid pattern plane is displayed. The value indicates how many millimeters are equivalent to a pixel. If the grid pattern plane is not vertical to the optical axis of the camera, the magnification near the center of the image is displayed.

Image Center

The coordinates of the center of the image are displayed.

CCD Vertical Spacing

The physical size of a pixel of the light receiving element of the camera in use is displayed.

Aspect Ratio

The aspect ratio of a pixel of the image is displayed.

Maximum / Mean Error

The average and maximum errors of each calibration point shown in the [Points] tab table are displayed.

Position of Camera relative to Calibration Grid

The position of the camera relative to the calibration grid frame is displayed.
For grid frame setting, see Chapter 11, "CALIBRATION GRID".

Position of Cal. Grid Relative to Tracking Frame

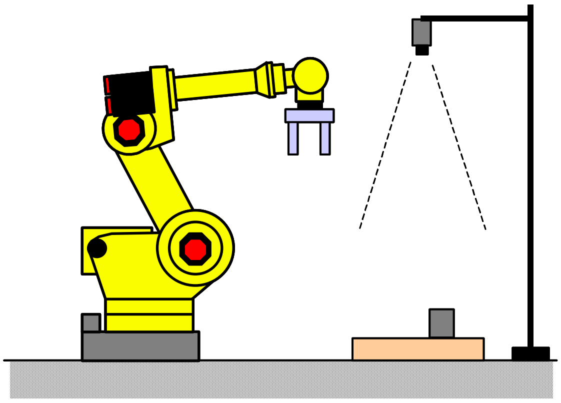
The position of the calibration grid relative to the tracking frame when the grid pattern is detected. For tracking frame, please refer to "R-30*i*B CONTROLLER *i*RVision Visual Tracking Application OPERATOR'S MANUAL".

6 VISION PROCESSES

This chapter explains how to set up vision processes.

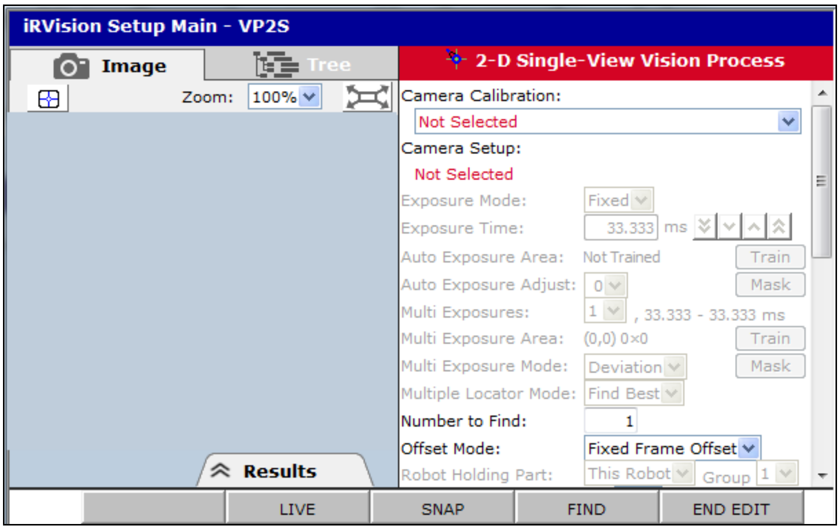
6.1 2D SINGLE VIEW VISION PROCESS

This is a vision process that detects the two-dimensional position of the workpiece with a single camera, and offsets the robot position.

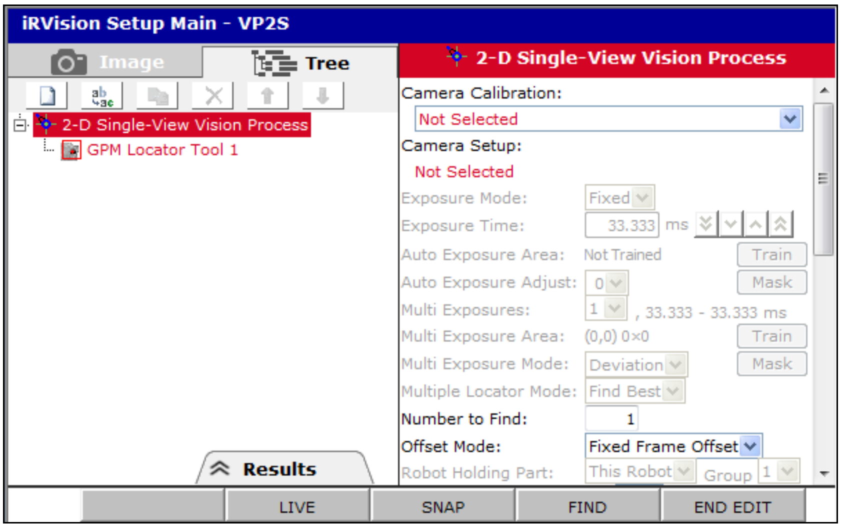


6.1.1 Setting up a Vision Process

If you open the setup page of [2D Single-view Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration
Select the camera calibration you want to use.

Camera Setup
The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time
Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting the Exposure".

Multiple Locator Find Mode
If you have created more than one locator tool, select how to execute those tools.

Find Best
All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

Find First
The locator tools will be executed sequentially from the top. The location process will stop as soon as the specified number of workpieces have been found. The subsequent locator tools will not be executed. When the results are sorted by score, even if the score of a workpiece found by the locator tool executed first is lower than that of a workpiece found by a locator tool executed subsequently, the result of the locator tool executed first is selected.

Number to Find
Enter the maximum number of workpieces to be found per measurement. The specifiable range is 1 to 100.

Offset Mode
Select the robot position offset mode.

Fixed Frame Offset
The fixed frame offset data will be calculated.

Tool Offset

The tool offset data will be calculated.

Found Position

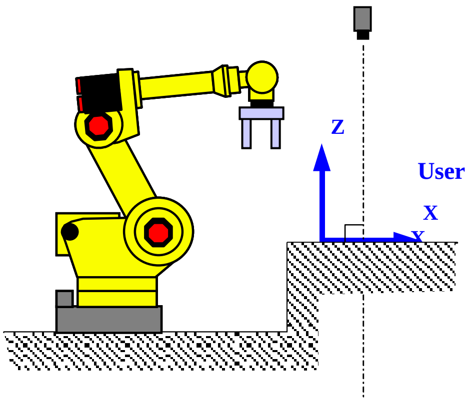
The found position will be output as is, instead of the offset data. This option is provided for any required special offset mode. Do not select it under normal conditions.

Robot Holding the Part

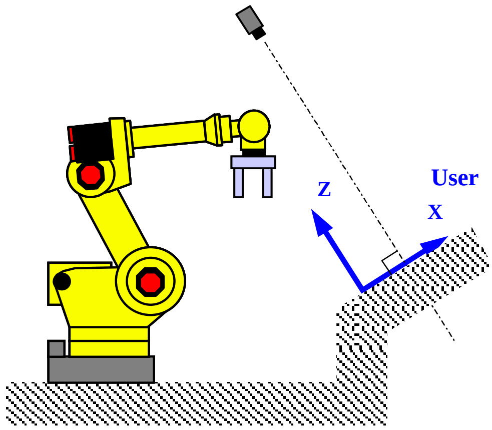
If you have chosen [Tool Offset] for [Offset Mode], specify the robot that is holding the workpiece.

Offset Frame

A 2D vision process measures displacement of a workpiece on a plane. The plane is called the offset plane. The offset plane is defined as a plane parallel to the XY plane of the offset frame. Here, specify the offset frame. If you have chosen [Fixed Frame Offset] for [Offset Mode], specify a user frame as the offset frame. If you have chosen [Tool Offset] for [Offset Mode], specify a user tool. The following are examples of the offset frame in the case of Fixed Frame Offset.



When the workpiece is moved horizontally



When the workpiece is moved on an inclined plane:

> **Tip**
> The Z height of the offset plane is specified as [Part Z height] discussed below. Here, you determine the gradient of the offset plane.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds.

Setting the Sorting Parameters

Set the sorting parameters to be applied when more than one workpieces have been found. For details, see Subsection 3.7.12, "Sorting".

Delete Duplicates If <

The position and angle of each found result are checked to see whether the result is the same as another result. If there are multiple found results within the specified pixels and angle, the results are assumed to indicate the same workpiece and only the found result with the highest score is output.

Ref. Data To Use

The reference data is used to calculate offset data from the found result. The reference data mainly consists of two types of data described below.

Part Z Height

Height of the found part of the workpiece as seen from the offset frame.

Ref. Pos. Status

Position of the workpiece found when the robot position is taught. The offset data is the difference between the actual workpiece position found when running the vision process and the reference position.

A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used. However, for example, if there are two types of workpiece, each having a different height, the vision process uses two sets of reference data because it needs to set a different part Z height for each of the workpieces.

Ref. Data Index To Use

Choose one of the following to specify how to determine the reference data to use.

This Index

The same reference data is used to calculate the offset data.

Model ID

Different reference data is used depending on the model ID of the found workpiece. Choose this in such cases as when there are two or more types of workpieces having different heights.

ID

If [This Index] is selected in [Ref.Data Index To Use], enter the reference data ID to use.

Measurements in mm

If this is checked, child command tools will output length measurement values after converting them to millimeters. This function is available only when this vision process has only a single reference data.

Adding reference data

You can add reference data as follows.

1. Tap button.
2. In [Model ID], enter the model ID for which to use the reference data.

Deleting reference data

You can delete reference data as follows, if there is more than one set.

1. Select the reference data you want to delete using the index drop-down list
2. Tap button.

Part Z Height

Enter the height of the trained features on the workpiece above or below the offset frame.

Ref. Pos. Status

If the reference position is set, [Set] is displayed in green; otherwise, [Not Set] is displayed in red.

Reference Position X,Y,R

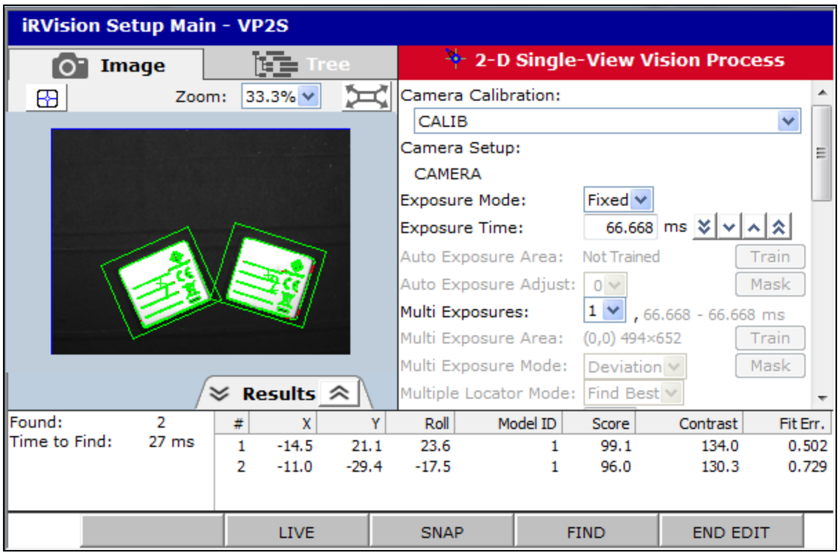
The coordinate values of the set reference position are displayed.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.1.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found

The number of found workpieces is displayed.

Time to Find

The time the vision process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y

Coordinate values of the model origin of the found workpiece (units: mm).

R

Rotation angle of the found workpiece around the Z axis (units: degrees).

Model ID

Model ID of the found workpiece.

Score

Score of the found workpiece.

Contrast

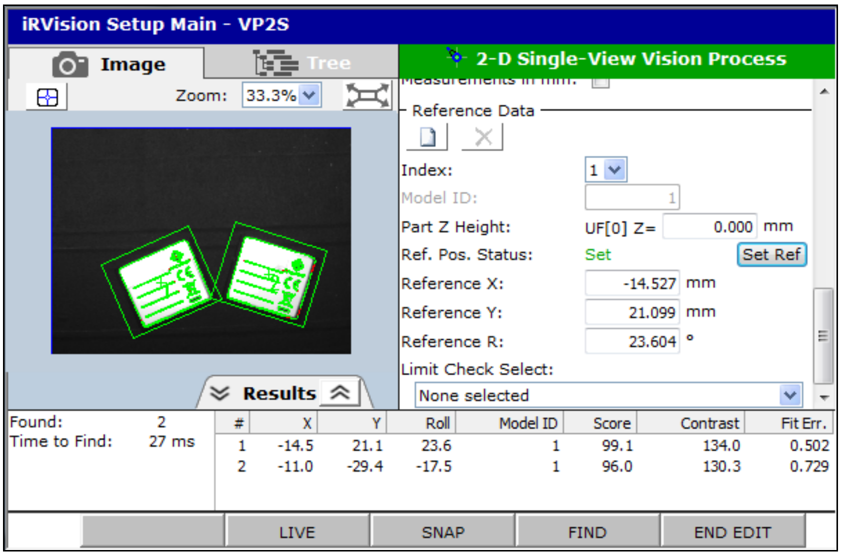
Contrast of the found workpiece.

Fit Err.

Elasticity of the found workpiece (units: pixels).

6.1.3 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.



1. Open the vision process Setup Page.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Enter the proper Part Z Height, the height of the found edges above or below the application user frame.
4. Press F3 SNAP and then press F4 FIND to find the workpiece.
5. Tap the [Set Ref] button.
6. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.1.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

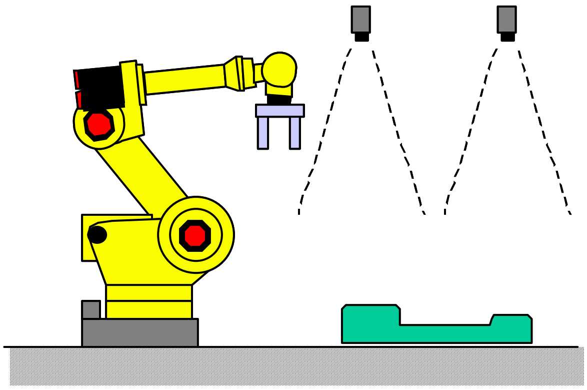
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

6.2 2D MULTI-VIEW VISION PROCESS

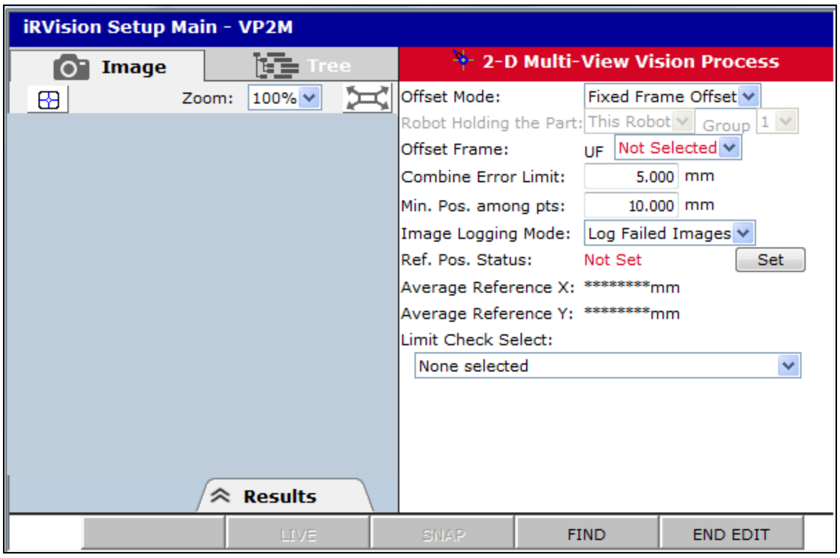
This is a vision process that detects the two-dimensional position of the workpiece by finding multiple features on different parts of it, and then offsets the robot position. It is effective when the workpiece is too large for the camera to capture its entire image.



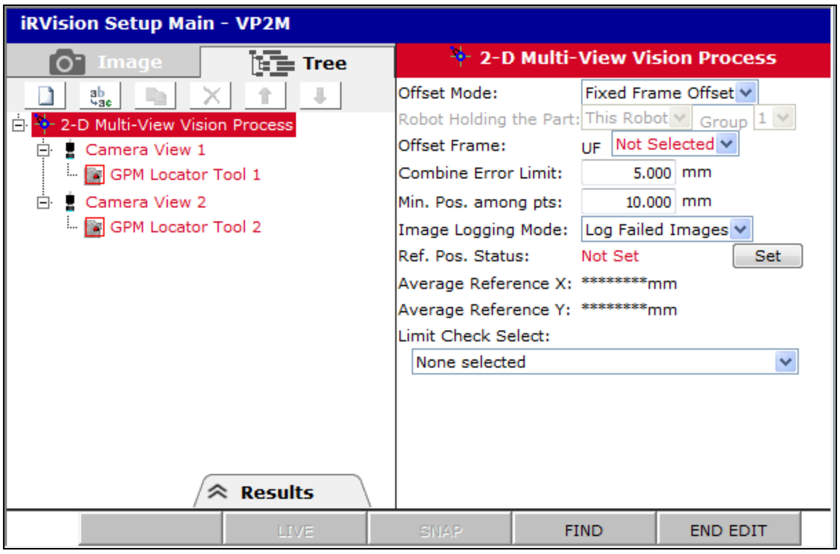
In this process, a tool called Camera View is located under the vision process. One camera view corresponds to one measurement point. While the standard number of camera views is two, this number can be increased to a maximum of four.

6.2.1 Setting up a Vision Process

If you open the setup page of [2D Multi-View Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Offset Mode

Select the robot position offset mode.

Fixed Frame Offset

The fixed frame offset data will be calculated.

Tool Offset

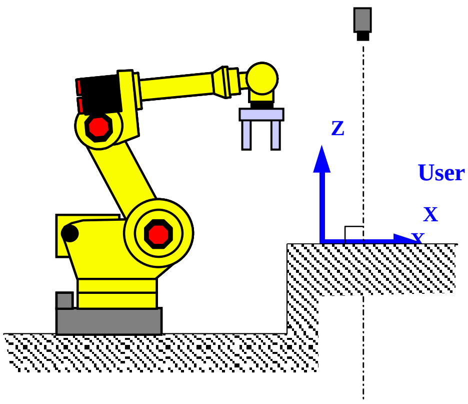
The tool offset data will be calculated.

Robot Holding the Part

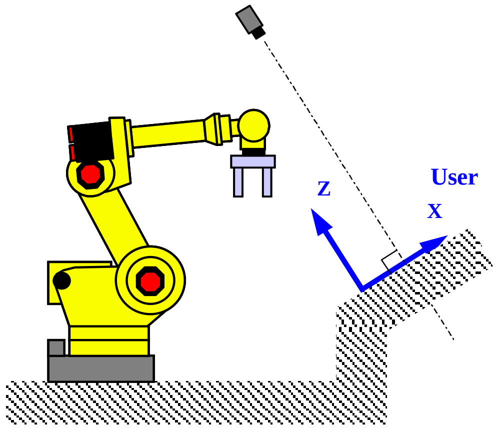
If you have chosen [Tool Offset] in [Offset Mode], specify the robot holding the workpiece.

Offset Frame

A 2D vision process measures the displacement of a workpiece on a plane. The plane is called the offset plane. The offset plane is defined as a plane parallel to the XY plane of the offset frame. Here, specify the offset frame. If you have chosen [Fixed Frame Offset] for [Offset Mode], specify a user frame as the offset frame. If you have chosen [Tool Offset] for [Offset Mode], specify a user tool. The following are examples of the offset frame in the case of Fixed Frame Offset.



When the workpiece is moved horizontally



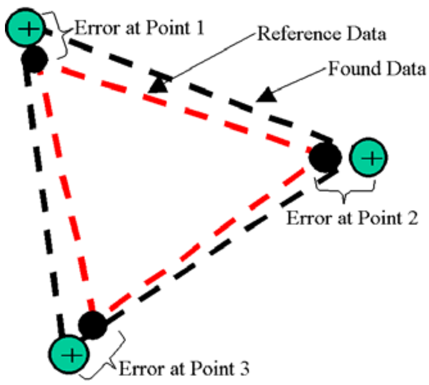
When the workpiece is moved on an inclined plane:

> **Tip**
> The Z height of the offset plane is specified as [Part Z height] discussed below. Here, you determine the gradient of the offset plane.

Combine Error Limit

The combine error limit is the distance the found targets for each camera view move independently of each other. The figure below shows the original found location for each of the three views as the small black targets, and it shows the current found location for each view as the larger target. In the example below there is a combine error, since the relationship between the three targets changed from the original reference position find to the current find, as seen by the size and shape of the triangle changing.

If the calculated combine error limit is greater than the user specified limit, the workpiece will not be found. Typically a sudden increase in the combine error is due to incorrect calibration of one or more of the camera views, or physical changes in the workpiece.



Min. Pos. among pts

Specify allowable minimum distance between measurement points. If the distance between measurement points is shorter than the distance you specify here, an alarm is generated. This item is intended to prevent the robot from receiving an incorrect position offset in case the same workpiece feature is incorrectly found in multiple camera views. Under the normal conditions, the value does not need to be changed.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds per camera view.

Ref. Pos. Status

If the reference position is set, [Set] is displayed in green; otherwise, [Not Set] is displayed in red.

Average Reference X, Y

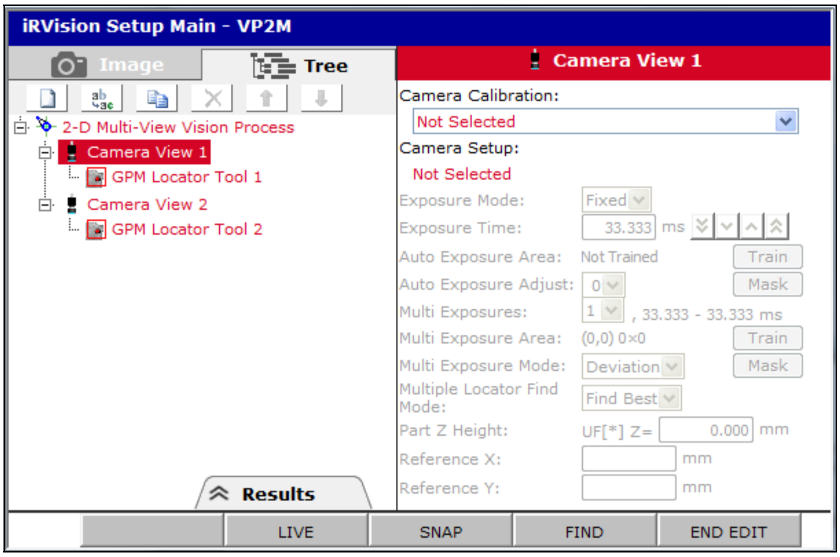
The average reference position of each camera view is displayed. The [Offset Limit] described next is to check the location or travel distance of this reference position.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.2.2 Setting up a Camera View

If you select [Camera View 1] in the tree view, a screen like the one shown below appears.



Camera Calibration
Select the camera calibration you want to use.

Camera Setup
The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time
Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, “Setting Exposure mode”.

Multiple Locator Find Mode
If you have created more than one locator tool, select one of the following to specify how to execute those tools.

Find Best
All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

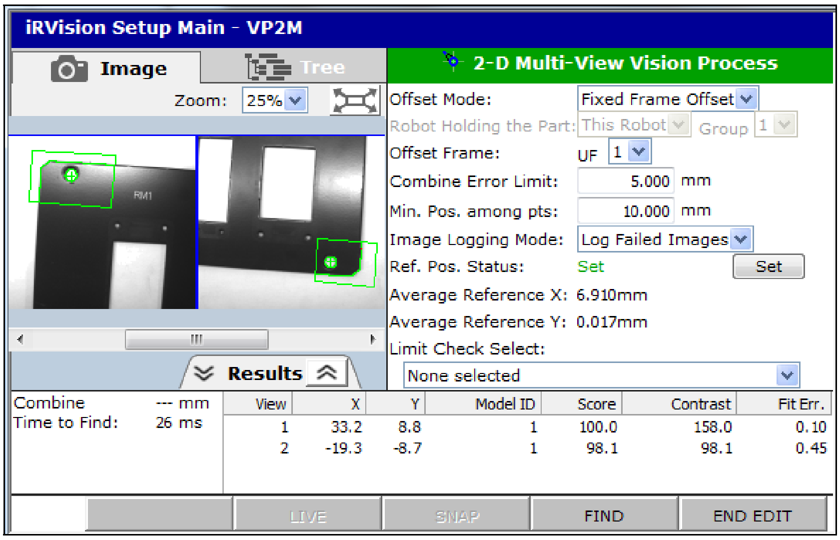
Find First
The locator tools will be executed sequentially in the order they are listed in the tree view, and the first result that is found will be output. Because the location process will stop as soon as a workpiece is found and the subsequent locator tools will not be executed, this is effective when you place priority on processing time.

Part Z Height
Enter the height of the trained features on the workpiece above or below the offset frame.

Reference Position X,Y
The coordinate values of the set reference position are displayed.

6.2.3 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected. There are two ways to run a test. One is to test the entire vision process, and the other is to test each camera view individually. If you intend to perform position offset using a fixed camera, testing the entire vision process at one time is easier. In the case of a robot-mounted camera or tool offset, where the robot position in camera view 1 differs from that in camera view 2, test each camera view individually.



Combine

Alignment deviation between the point found when the reference position is set and the point found when the test is run (units: mm). This value becomes nearly 0 if there are no differences between workpieces and no location error.

Time to Find

The time the vision process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y

Coordinate values of the model origin of the found workpiece (units: mm).

Model ID

Model ID of the found workpiece.

Score

Score of the found workpiece.

Contrast

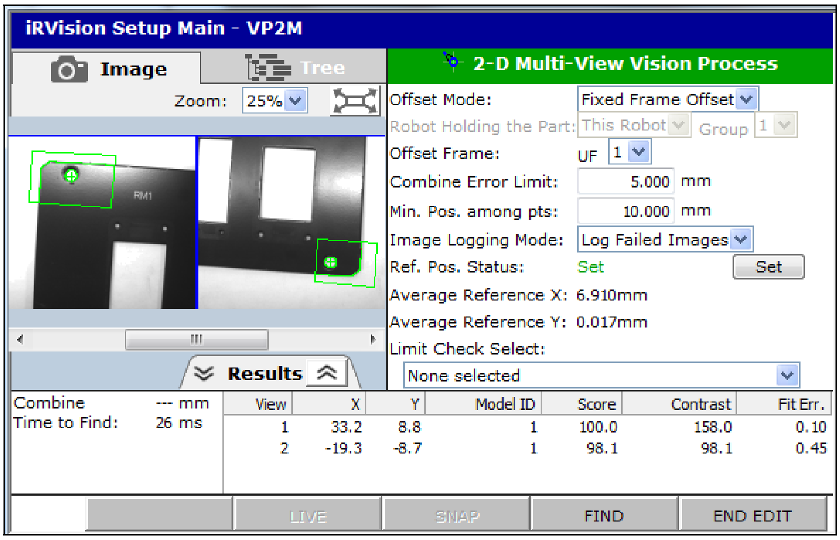
Contrast of the found workpiece.

Fit Err.

Elasticity of the found workpiece (units: pixels).

6.2.4 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.



1. Open the Setup Page for the vision process.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Make sure to enter the proper Part Z Height of the locators in each camera view.
   The Part Z Height is the height of the found edges, above or below the application user frame.
4. Press F3 SNAP and then press F4 FIND to find the workpiece.
5. Tap the [Set] button.
6. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.2.5 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

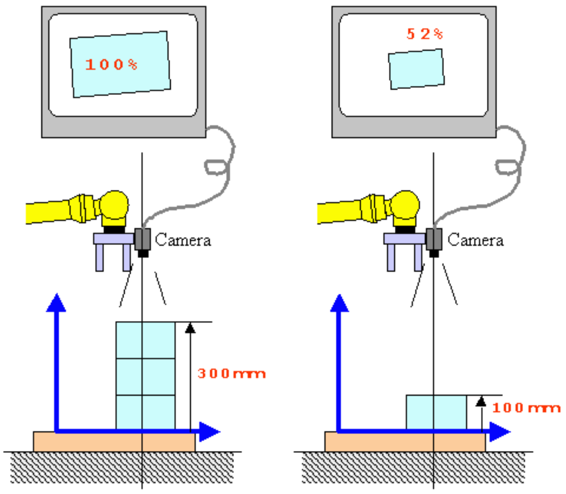
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

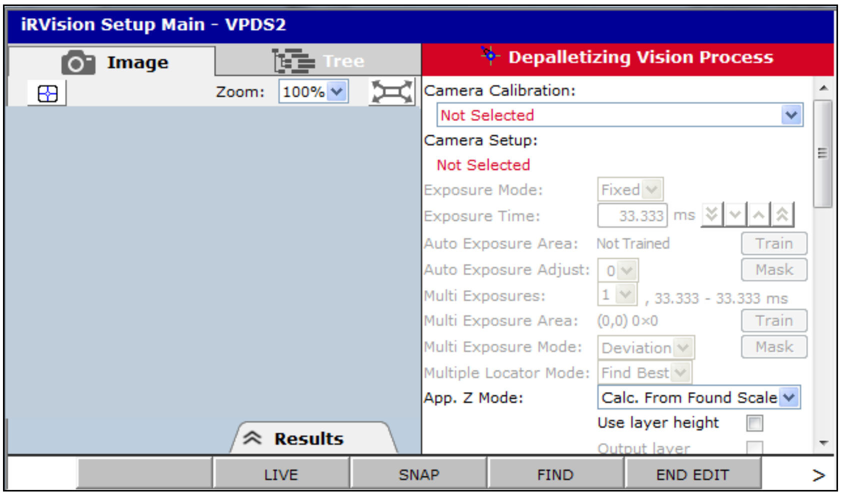
6.3 DEPALLETIZING VISION PROCESS

The Depalletizing Vision Process is a vision process that performs vertical-direction position offset in addition to the regular two-dimensional position offset. The height of the workpiece is measured based on the apparent size of the workpiece captured by the camera.

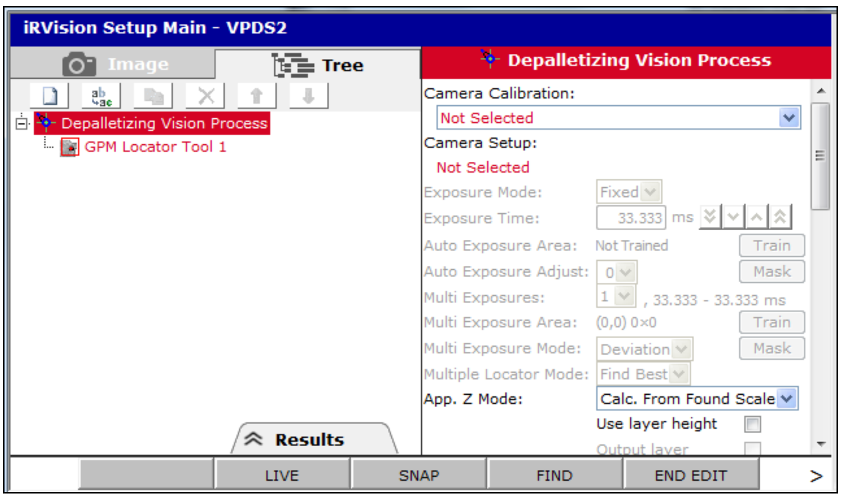


6.3.1 Setting up a Vision Process

If you open the setup page of [Depalletizing Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use.

Camera Setup
The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time
Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, “Setting Exposure Mode”.

Multiple Locator Find Mode
If you have created more than one locator tool, select how to execute those tools.

Find Best
All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

Find First
The locator tools will be executed sequentially from the top. The location process will stop as soon as the specified number of workpieces have been found. The subsequent locator tools will not be executed. When the results are sorted by score, even if the score of a workpiece found by the locator tool executed first is lower than that of a workpiece found by another locator tool executed subsequently, the result of the locator tool executed first is output.

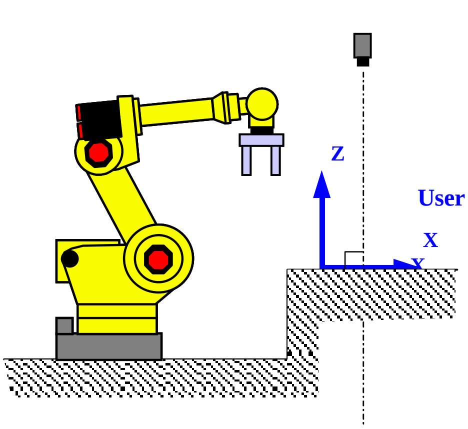
App. Z Mode
Specify how to calculate the height of the workpiece.

Calc. From Found Scale
The Z-direction height of the workpiece will be calculated from the found workpiece size.
When [Use layer height] is checked, the number of the layer at which the workpiece is placed is determined from the size of the workpiece found by the vision process. The position of the workpiece is calculated based on the height information corresponding to the layer. The height can be calculated stably even when there is a little size measurement error because the same height information is used for each individual layer.
When [Output layer] is checked, the determined layer of the workpiece can be output to the vision register as a measurement value. Specify the number of the measurement value to which to output the tier in [No.].

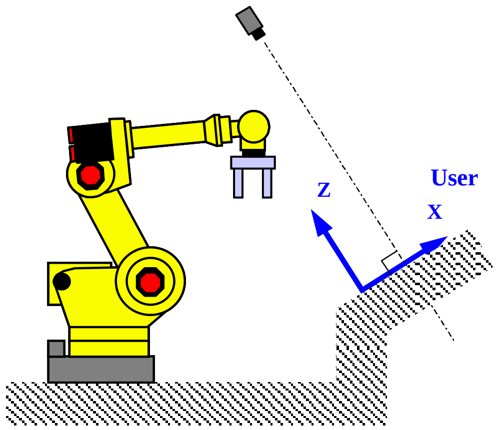
Use Register Value
The value stored in the specified register of the robot controller will be used as the Z-direction height.

Number to Find
Enter the maximum number of workpieces to be found per measurement. The specifiable range is 1 to 100.

Offset Frame
A 2D vision process measures the displacement of a workpiece on a plane. The plane is called offset plane. The offset plane is defined as a plane parallel to the XY plane of the offset frame. Here, specify the offset frame. If you have chosen [Fixed Frame Offset] for [Offset Mode], specify a user frame as the offset frame. If you have chosen [Tool Offset] for [Offset Mode], specify a user tool. The following are examples of the offset frame in the case of Fixed Frame Offset.



When the workpiece is moved horizontally



When the workpiece is moved on an inclined plane:

> **Tip**
> The Z height of the offset plane is specified as [Reference Height] discussed below. Here, you determine the gradient of the offset plane.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Image

Save images only when the vision operation fails.

Log All Image

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds.

Setting the Sorting Parameters

Set the sorting parameters to be applied when more than one workpiece has been found. For details, see Subsection 3.7.12, "Sorting".

Delete Duplicates If <

The position and angle of each found result is checked to see whether the result is the same as another result. If there are multiple found results within the specified pixels and angle, the results are assumed to indicate the same workpiece and only the found result with the highest score is output.

Reference Data

The reference data is used to calculate offset data from the found result. The reference data mainly consists of two types of data described below.

App. Z Coordinate

This item is used to determine the Z-direction height of the workpiece. If you have chosen [Use Register Value] in [App Z Mode], specify the number of the register of the robot controller that stores the Z-direction height. If you have chosen [Calculate From Found Size] in [App Z Mode], specify two sets of Z-direction height and size data used as the reference.

Reference Position

Position of the workpiece found when the robot position is taught. The offset data is the difference between the actual workpiece position found when running the vision process and the reference position.

A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used. However, for example, if there are two types of workpiece, the vision process uses two sets of reference data because it needs to set the parameters and reference position to determine the Z-direction height for each workpiece.

Adding reference data

You can add or delete reference data as follows.

1. Tap button.
2. In [Model ID], enter the model ID for which to use the reference data.

Register Number

Use this item when [Use Register Value] is chosen in [App. Z Mode]. Specify the number of the register that stores the workpiece height.

Layer error threshold

The layer at which the workpiece is placed is automatically determined based on information of the found size and height corresponding to the reference layer taught in advance. The calculated layer may have a margin of error depending on the found size. Set a value between 1% and 50% as the permissible calculation error in [Layer error threshold]. For example, assume that a value of 20% is specified. When the height of the workpiece calculated from the found size is within a range between ±20% of the reference height for the layer, the layer is determined. If the height is outside the range, an alarm is issued because the layer cannot be determined.

Setting the Reference Height and Size

Use this item when [Calculate From Found Scale] is chosen in [App. Z Mode]. Set the relationship between the actual Z-direction height of the workpiece and the apparent size of the workpiece captured by the camera.

1. Place one workpiece, and touch up the workpiece surface using touch-up pins. Enter this height data in [Reference Height 1].
2. Press F3 SNAP and then press F4 FIND to find the workpiece. Then, tap the [Set Scale] button and set [Reference Scale 1].
3. Place n workpieces, and touch up the workpiece surface using touch-up pins. Enter this height data in [Reference Height 2].
4. Press F3 SNAP and then press F4 FIND to find the workpiece. Then, tap the [Set Scale] button and set [Reference Scale 2].

Setting the Reference Layer

Use this option when [Use layer height] is checked in [App. Z Mode]. Enter the number of the tier containing the workpiece with which the reference height and size are set.

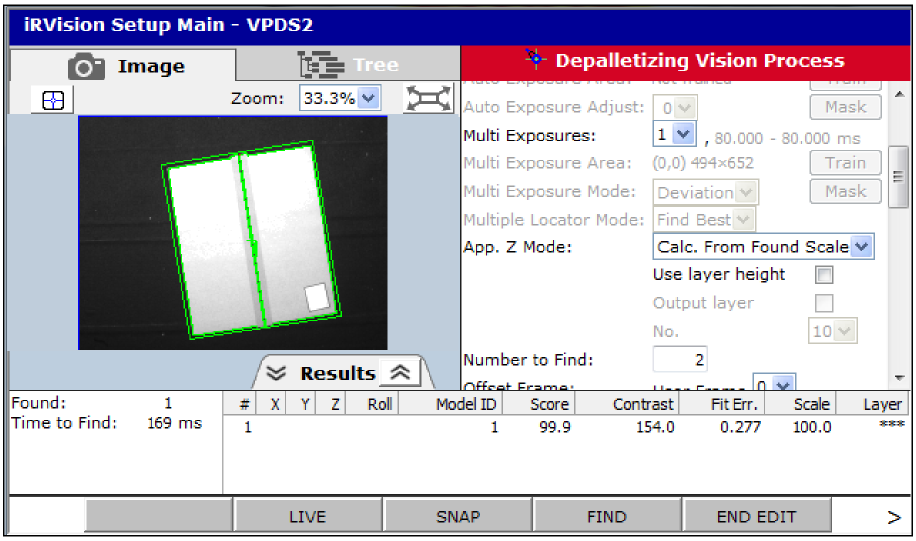
Reference Position Status
If the reference position is set, [Trained] is displayed in green; otherwise, [Not Trained] is displayed in red.

Reference Position X,Y,Z,R
The coordinates of the set reference position are displayed.

Offset Limit
Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.3.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found
The number of found workpieces is displayed.

Time to Find
The time the vision process took is displayed in milliseconds.

Found Result Table
The following values are displayed.

X,Y,Z
Coordinate values of the model origin of the found workpiece (units: mm).

Roll
Rotation angle of the found workpiece around the Z axis (units: degrees).

Model ID
Model ID of the found workpiece.

Score

Score of the found workpiece.

Size

Size of the found workpiece

Contrast

Contrast of the found workpiece.

Fit Err.

Elasticity of the found workpiece (units: pixels).

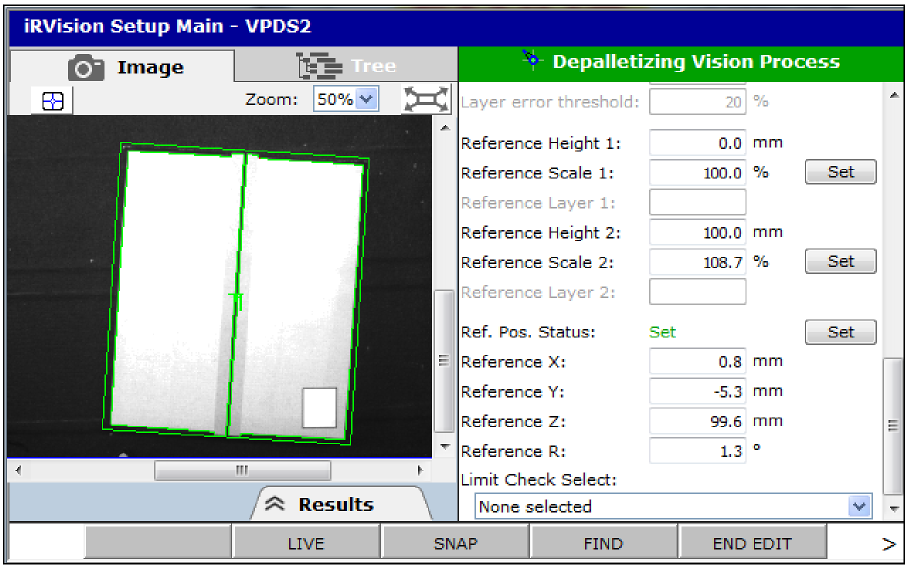
Layer

Number of the layer containing the workpiece that is calculated from the found size.

> **NOTE**
> If you run a find test without setting the reference Z-direction height or size when [Calculate From Found Scale] is chosen in [App. Z Mode], ******** is displayed for X, Y, Z, and R because these values cannot be calculated.

6.3.3 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.



1. Open the vision process setup page.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Press F3 SNAP and then press F4 FIND to find the workpiece.
4. Tap the [Set] button.
5. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.3.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

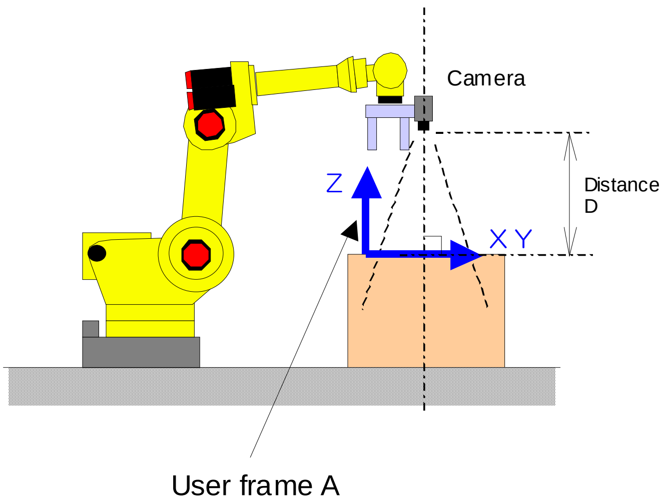
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

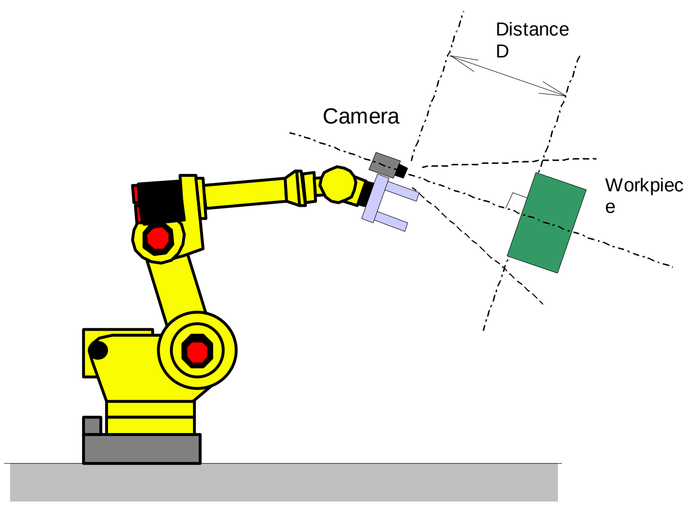
Number of Exposure

Specify a number between 1 and 6.

6.4 FLOATING FRAME VISION PROCESS

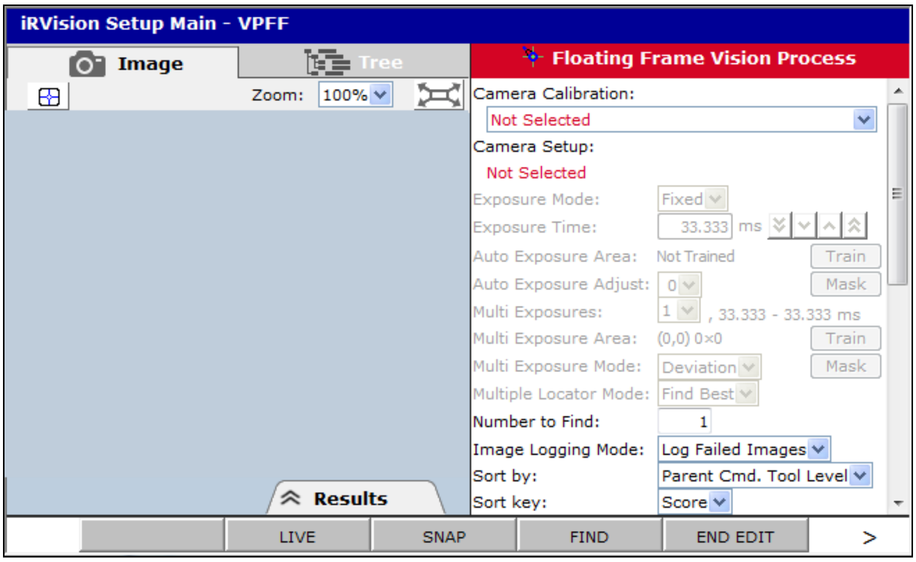
The Floating Frame Vision Process is a vision process that detects the two-dimensional position of the workpiece and offsets the robot position. Specifically, it is possible to measure the workpiece at various robot positions with one set of camera calibration using the camera attached to the robot end of arm tooling.



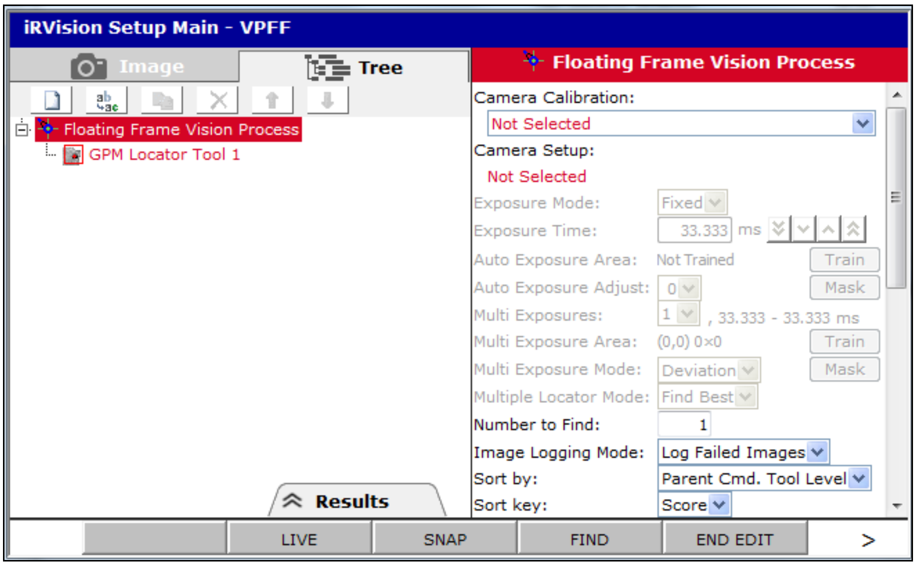


6.4.1 Setting up a Vision Process

If you open the setup page of [Floating Frame Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Multiple Locator Find Mode

If you have created more than one locator tool, select how to execute those tools.

Find Best

All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools will be executed sequentially from the top. The location process will stop as soon as the specified number of workpieces have been found. The subsequent locator tools will not be executed. When the results are sorted by score, even if the score of a workpiece found by the location tool executed first is lower than that of a workpiece found by a locator tool executed subsequently, the result of the locator tool executed first is output.

Number to Find

Enter the maximum number of workpieces to be found per measurement. The specifiable range is 1 to 150.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds.

Ref. Data Index To Use

Choose one of the following to specify how to determine the reference data to use.

This Index

The same reference data is used to calculate the offset data.

Model ID

Different reference data is used depending on the model ID of the found workpiece. Choose this in such cases as when there are two types of workpieces having different heights.

ID

If [This Index] is selected in [Ref.Data Index To Use], enter the reference data ID to use.

Setting the Sorting Parameters

Set the sorting parameters to be applied when more than one workpiece has been found. For details, see Subsection 3.7.12, “Sorting”.

Delete Duplicates If <

The position and angle of each found result are checked to see whether the result is the same as another result. If there are multiple found results within the specified pixels and angle, the results are assumed to indicate the same workpiece and only the found result with the highest score is output.

Reference Data

The reference data is used to calculate offset data from the found result. The reference data mainly consists of two types of data described below.

Part Z Height

Enter the height of the trained features on the workpiece above or below the application user frame.

Reference Position

Position of the workpiece found when the robot position is taught. The offset data is the difference between the actual workpiece position found when running the vision process and the reference position.

A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used. However, for example, if there are two types of workpieces, each having a different height, the vision process uses two sets of reference data because it needs to set a different part Z height for each of the workpieces.

Adding reference data

You can add or delete reference data as follows.

1. Tap button.
2. In [Model ID], enter the model ID for which to use the reference data.

Part Z Height

Enter the height of the trained features on the workpiece above or below the application user frame. This is the height of part in the reference position. The reference position part must be in the X/Y plane of the application frame.

Reference Position Status

If the reference position is set, [Set] is displayed in green; otherwise, [Not Set] is displayed in red.

Reference X, Y, Z, W, P, R

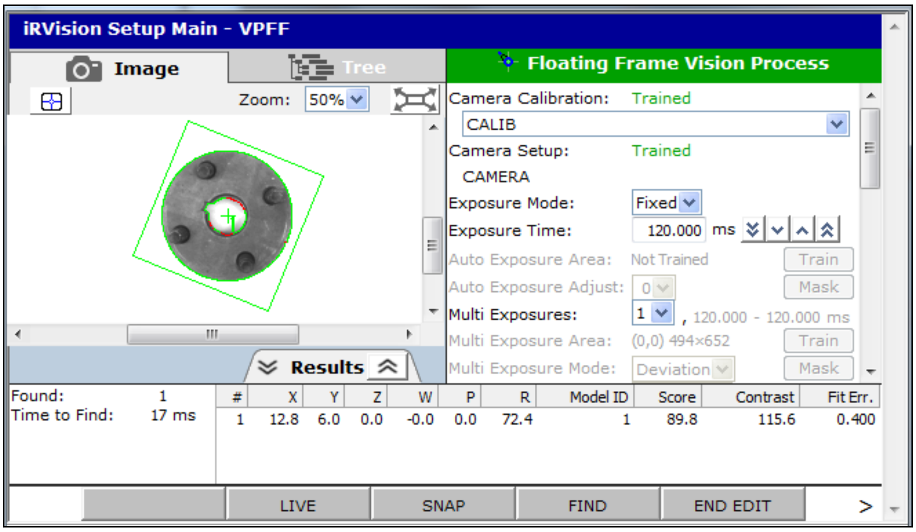
The coordinates of the set reference position are displayed.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.4.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found
The number of found workpieces is displayed.

Time to Find
The time the vision process took is displayed in milliseconds.

Found Results table
The following values are displayed.

X, Y
Coordinates of the model origin of the found workpiece (units: mm).

Z, W, P
Values to which the amount of travel from the robot position during calibration to that during measurement of the workpiece is added (units; mm, degrees).

R
Rotation angle of the found workpiece around the Z-axis (units: degrees).

Model ID
Model ID of the found workpiece.

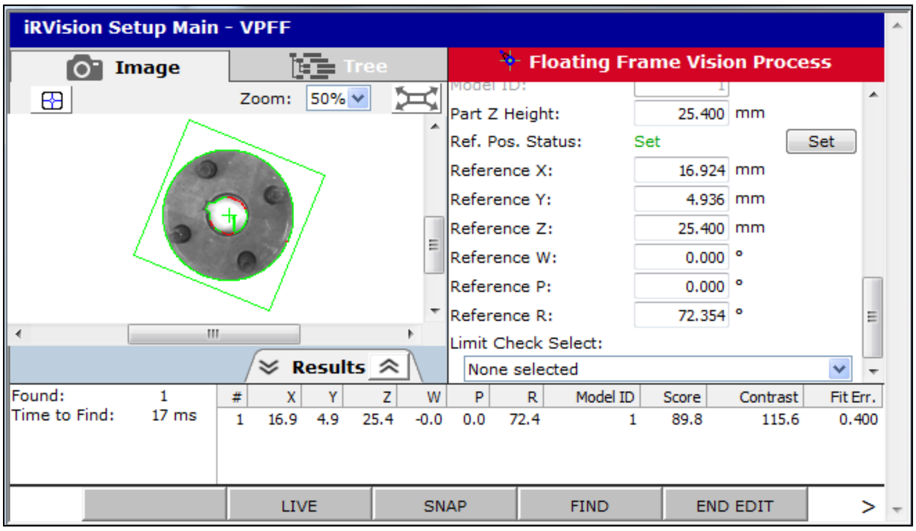
Score
Score of the found workpiece.

Contrast
Contrast of the found workpiece.

Fit Err.
Elasticity of the found workpiece (units: pixels).

6.4.3 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.



1. Open the vision process Setup Page.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Enter the height of the reference part above or below the application user frame in the Part Z Height field
4. Press F3 SNAP and then press F4 FIND to find the workpiece.
5. Tap the [Set] button.
6. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.4.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

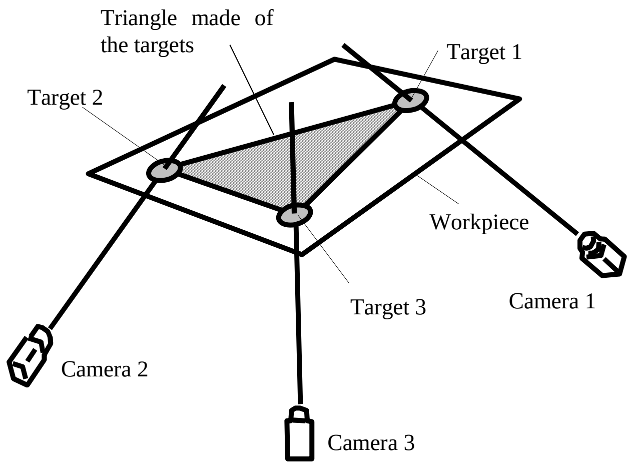
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

6.5 3D TRI-VIEW VISION PROCESS

This vision process detects three parts of a large workpiece, such as a vehicle, by using three cameras respectively, and offsets the robot based on the calculated 3D position of the workpiece. Upon detection of a part, the three cameras respectively measure a gaze line from the camera to the detection target. By applying a triangle whose shape is known to these three gaze lines, the vision process determines where each detection target is located on the gaze line and obtains the 3D position and posture data of the workpiece.



There is a tool called "Camera View" beneath this vision process. One camera view handles one measurement point. The number of camera views is three and cannot be changed.

6.5.1 Application Consideration

This subsection describes the detection targets, camera position, and other factors to consider.

6.5.1.1 What to consider

In determining the detection targets, note the following:

- The accurate relative positional relationship among the three detection targets must be able to be calculated from a drawing or other information.
- There must be no difference in relative relationship among the positions of the three detection targets or the positions where the work is done.
- Three detection targets must be available that are sufficiently apart from each other to cover the entire workpiece.
- The triangle whose vertexes are the three detection target points must not be extremely long lengthwise.
- The detection targets must not appear different in shape.
- The detection targets must not have any part near them that is similar in shape.

In the case of a vehicle, the reference holes are suitable as the detection targets.

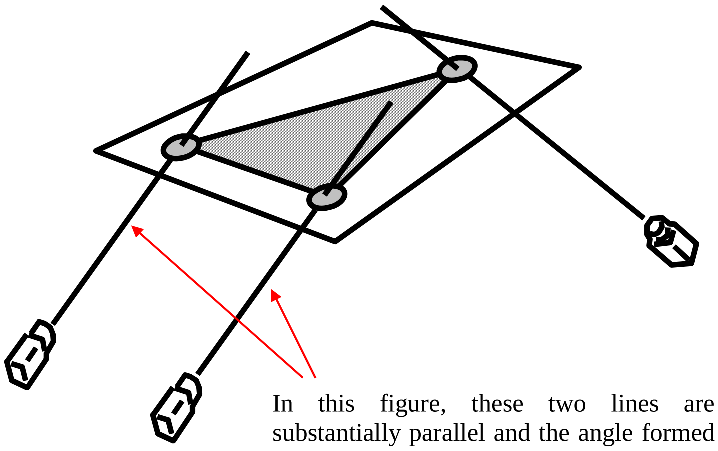
6.5.1.2 Camera position

Determining the camera view

Determine the size of the camera view so that the detection targets stay in the view even if they maximally deviate. Making the camera view extremely large may make it impossible to ensure the required offset accuracy.

Determining the camera position

The vision process finds detection targets and measures three gaze lines. Position the camera so that any two gaze lines are not close to being parallel and that the angle formed by any two gaze lines is sufficiently wide (preferably 60 degrees or more).



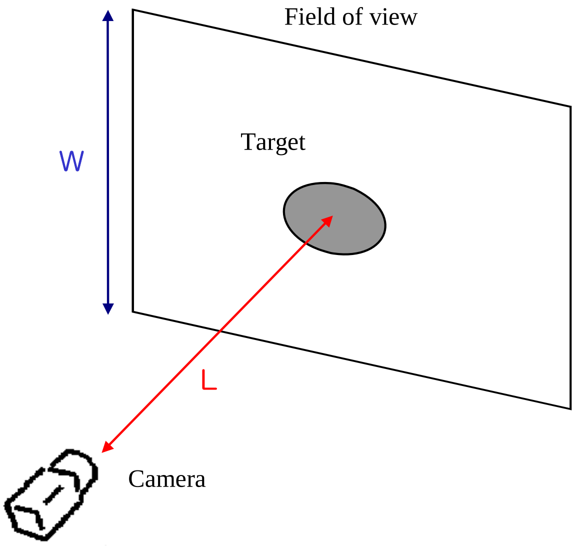
In this figure, these two lines are substantially parallel and the angle formed by gaze lines is small.

Determining the lens focal distance

The focal distance of the lens to be used is determined by the size of the camera view and the distance between the camera and detection target. In the case of the XC-56 camera, the focal distance f (mm) is roughly calculated by the following equation:

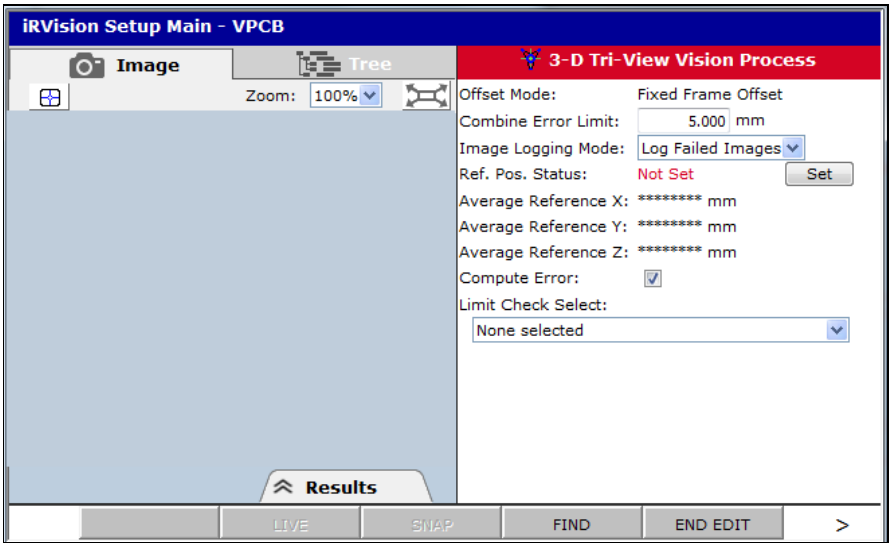
$f=3.55\times L\div W$

L: Distance between the camera and detection target (mm)
W: Size of the camera view (mm)

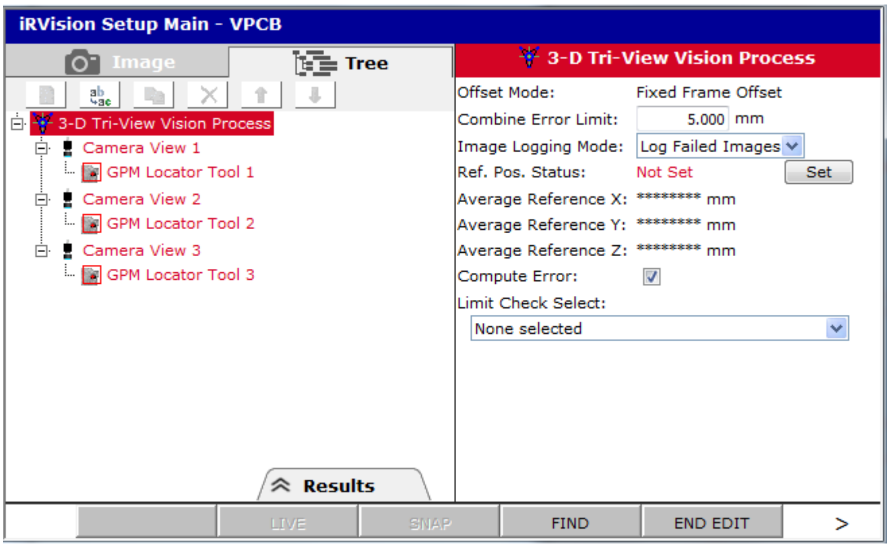


6.5.2 Setting up a Vision Process

If you open the setup page of [3D Tri-View Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Offset Mode

In the 3D tri-view vision process, only the fixed frame offset is available. The offset data for the fixed frame offset is calculated.

Combine Error Limit

The combine error limit is the distance the found targets for each camera view move independently of each other. The figure below shows the original found location for each of the three views as the small black targets, and it shows the current found location for each view as the larger target. In the example below there is a combine error, since the relationship between the three targets changed from the original reference position find to the current find, as seen by the size and shape of the triangle changing.

If the calculated combine error limit is greater than the user specified limit, the workpiece will not be found. Typically a sudden increase in the combine error is due to incorrect calibration of one or more of the camera views, or physical changes in the workpiece.

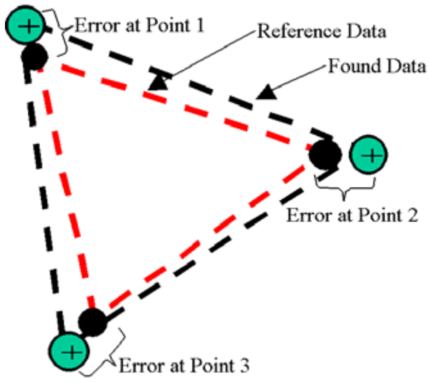


Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process is execution completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds per camera view.

Setting the Reference Position

If the reference position is set, [Set] is displayed in green. Otherwise, [Not Set] is displayed in red.

Average Reference X,Y,Z

The average reference position of each camera view is displayed. The [Offset Limit] described next is to check the location or travel distance of this reference position.

Compute Error Estimation

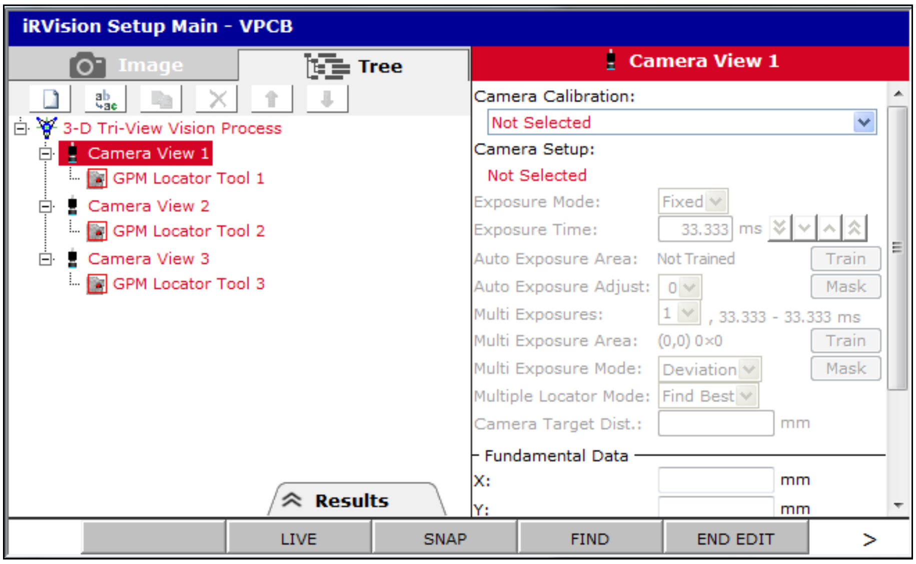
If you check this box, the error estimation is computed when the vision process succeeds in finding a workpiece.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.5.3 Setting up a Camera View

If you select [Camera View 1] in the tree view, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use. The camera calibration must be the grid pattern calibration, and the projection method must be [Perspective]. To prevent the location accuracy from deteriorating, it is recommended to select "2" as the number of calibration planes when performing the calibration. Note also that all the camera calibration must have the same application user frame selected.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time

Set the camera’s exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Multiple Locator Find Mode

If you have created more than one locator tool, select how to execute those tools from the following:

Find Best

All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools in the tree view will be executed sequentially from the top, and the result that is located first will be output. The location process will stop as soon as a workpiece is found, leaving the subsequent locator tools unexecuted. This is effective when greater emphasis is put on the processing time.

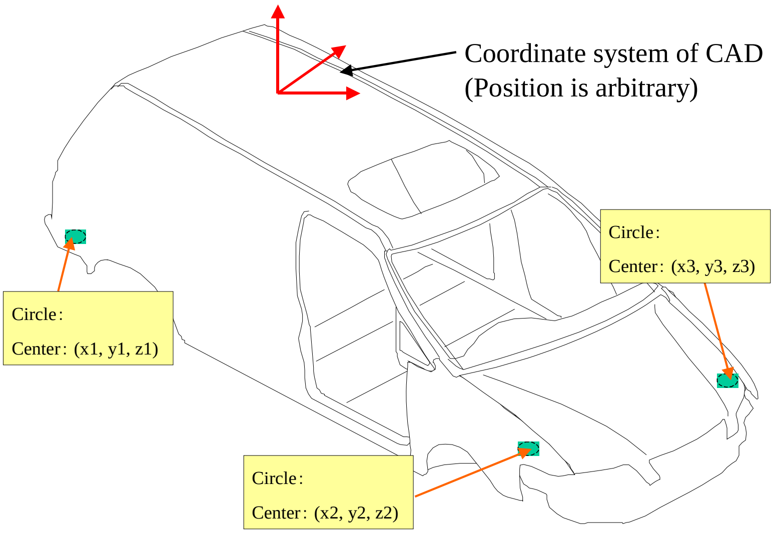
Camera Target Dist.

Enter an approximate distance between the camera and the target to find. If you select calibration data, the distance between the camera at the time of calibration and the origin of the calibration grid is set as the default. Also, when the reference position is set, this value is overwritten by the camera-to-target distance resulting from the location process of the vision process.

Fundamental Data X, Y, Z

Enter the position of the target to find in a given frame. For example, you may enter the coordinates of the target on the drawing.

Fundamental data input example: The following figure shows an example of fundamental data input using the CAD data of the workpiece. The coordinates of the target shown in CAD data are input as the fundamental data.



Reference Position X, Y, Z

The coordinates of the set reference position are displayed.

Compute Error

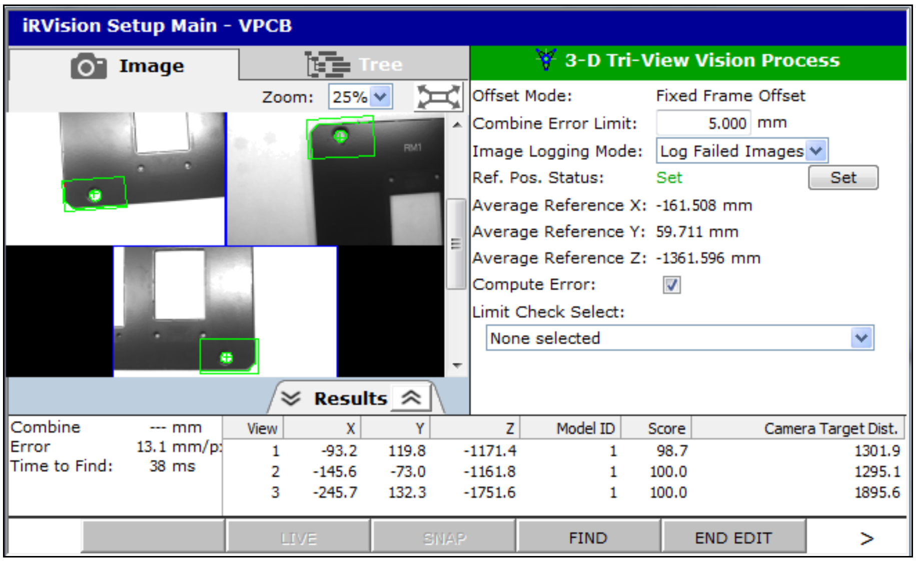
If this checkbox is checked and the detection of the vision process became successful, the detection error in the locator tool on the image is calclated.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.5.4 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected. There are two ways to run a test. One is to test the entire vision process, and the other is to test each camera view individually. In the case of a fixed camera, testing the entire vision process at one time is easier. In the case of a robot-mounted camera, where the robot position differs for each camera view, test each camera view individually.



Combine

Alignment deviation between the point found when the reference position is set and the point found when the test is run (units: mm). This value becomes nearly 0 if there are no differences between targets to find and no location error.

Error

This estimation indicates how much the detection error in the locator tool on the image affects the calculated 3D position of the workpiece. For example, when this value is 8.0 mm/pix, 0.1 pix of detection error can cause $8.0 \times 0.1 = 0.8$ mm of variable of the measured 3D position. You cannot estimate total compensation accuracy only from this value, but if this value is too large for your application, reconsider changing camera layout.

Time to Find

The time the vision process took is displayed in milliseconds.

Found results table

The following values are displayed.

X,Y,Z

Coordinates of the model origin of the found target (units: mm).

Model ID

Model ID of the found workpiece.

Score

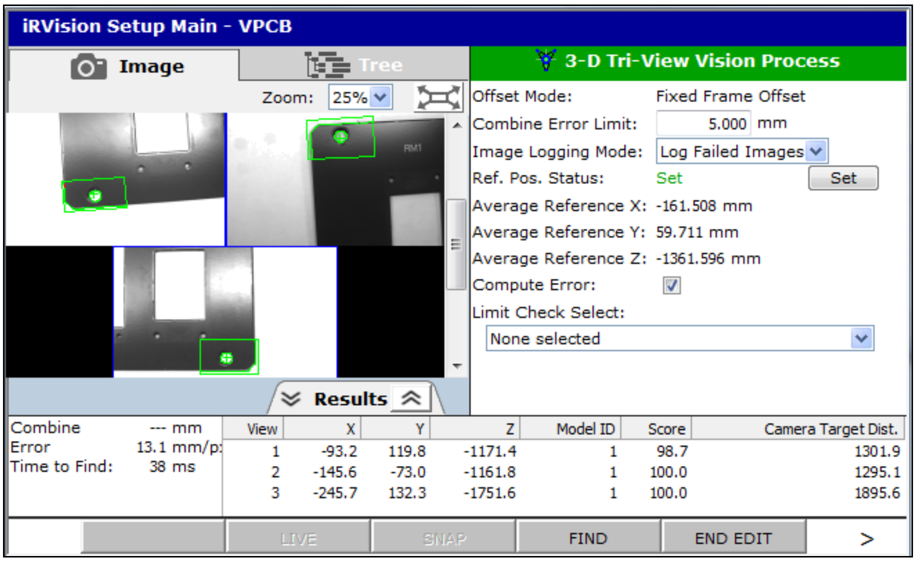
Score of the found workpiece.

Camera Target Dist.

Distance between the camera and the model origin of the found target (unit: mm).

6.5.5 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.



1. Open the vision process setup page.
2. In the view of each camera, place a workpiece for which you want to set the reference position.
3. Snap the image with each camera view ready for finding the workpiece, and then press F4 FIND to find the workpiece.
4. Tap the [Set] button.
5. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.5.6 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

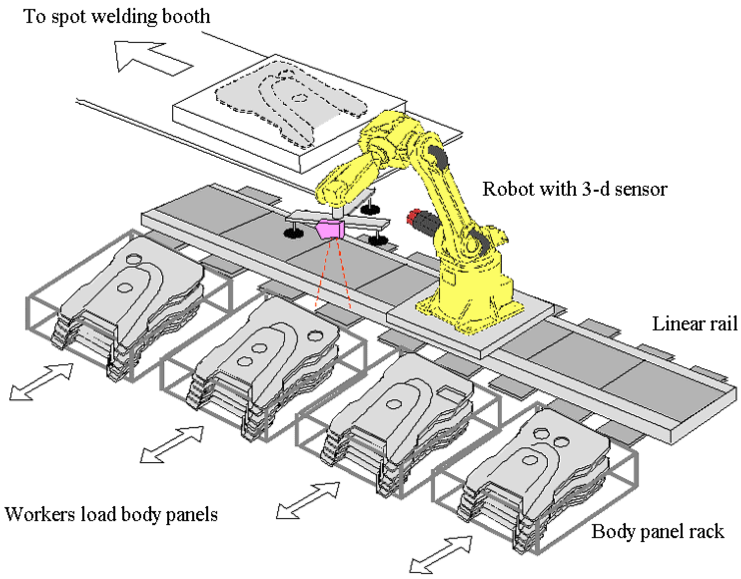
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

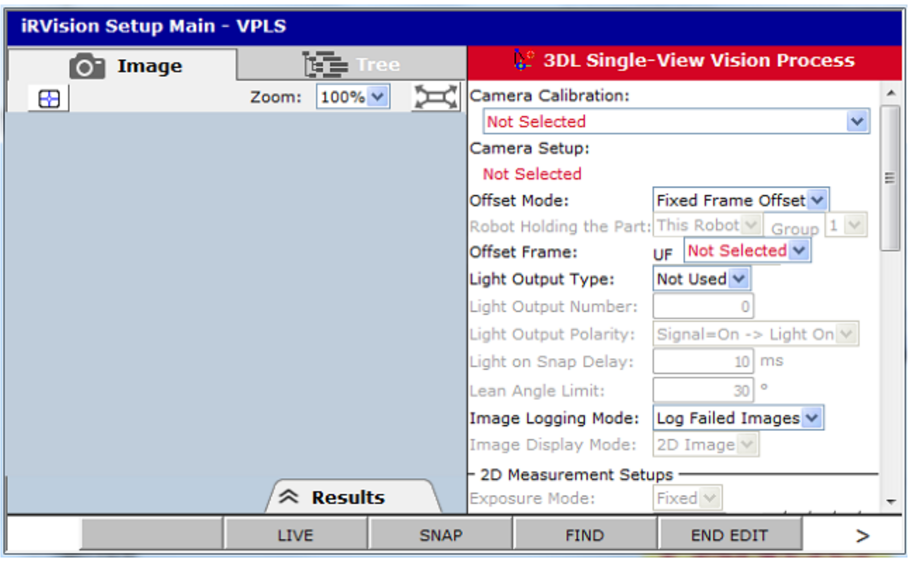
6.6 3DL SINGLE VIEW VISION PROCESS

The 3DL Single-View Vision Process measures the three-dimensional position and posture of the workpiece and adjusts the handling of the workpiece by the robot.

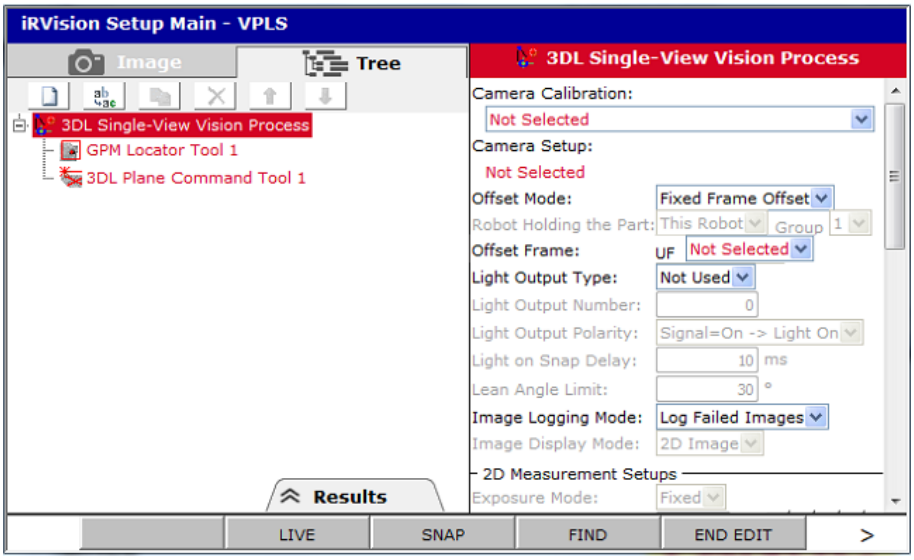


6.6.1 Setting up a Vision Process

If you open the setup page of [3DL Single View Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Offset Mode

Select the robot position offset mode.

Fixed Frame Offset

The fixed frame offset data will be calculated.

Tool Offset

The tool offset data will be calculated.

Found Position (User)

The found position will be output as is, instead of the offset data. This option is provided for any required specified offset mode. Do not select it under normal conditions. The found position is relative to the application user frame.

Found Position (Tool)

The found position will be output, instead of the offset data, after being converted to a value as seen from the tool frame. This option is provided for any required specified offset mode. Do not select it under normal conditions

Robot Holding Part

If you have chosen [Tool Offset] or [Found Position (Tool)] for [Offset Type], specify the robot holding the workpiece.

Offset Frame

A 3DL single view vision process measures the offset data with respect to the plane which is selected in this item. If you have chosen [Fixed Frame Offset] for [Offset Mode], specify a user frame as the offset frame. If you have chosen [Tool Offset] for [Offset Mode], specify a user tool. The following are examples of the offset frame in the case of Fixed Frame Offset.

Setting the Light

Use this function to have an external light turned on or off as appropriate for the vision process executed with the 3D laser sensor. By using this function, you can have the light turned on, for example, when finding two-dimensional features during one three-dimensional measurement, or have it turned off when finding the two laser lines. It is common to have an LED ring light mounted to the 3D laser sensor to provide controlled lighting.

Set the function as follows.

1. In [Light Output Signal Type], specify the type of signal - DO or RO - that turns on or off the light.
2. In [Light Output Signal Number], enter the number of the output point to which the ON/OFF signal is connected. For example, when connecting the signal to RO[1], enter 1.
3. In [Light Output Signal Polarity], set the relationship between the signal output and turning on or off the light. To turn on the light when the signal is ON, set [Signal=ON->Light=ON]. To turn it off when the signal is ON, set [Signal=OFF->Light=ON].
4. In [Light ON snap delay], set the wait time when you want to snap just after the light ON. Under normal conditions, set 0.

Lean Angle Limit

Any workpiece found with an angle greater than the lean angle limit from the reference position is treated as not being found.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 600 and 1200 milliseconds.

Image Display Mode

Change the image to be displayed in the Setup Page.

2D Image

The camera-captured image is displayed.

Laser Slit Image 1

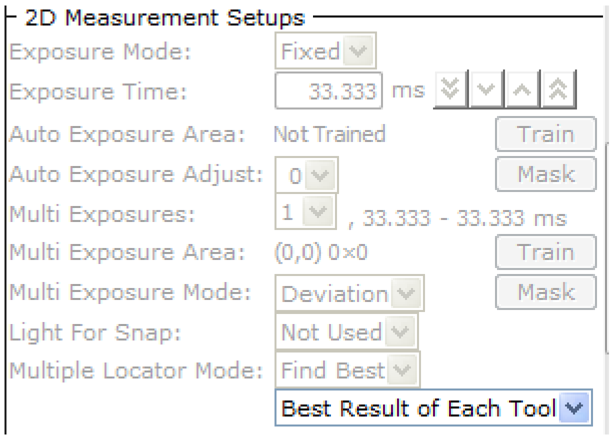
The image of laser slit 1 is displayed.

Laser Slit Image 2

The image of laser slit 2 is displayed.

6.6.1.1 2D Measurement setups

Perform the 2D measurement setups.



Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Light for Snap

Set whether to turn on or off the light when snapping an image for two-dimensional measurement.

Multiple Locator Find Mode

From the upper drop-down box, select which locator tools to execute in the case that multiple locator tools have been made.

Find Best

All the locator tools are executed. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools are executed sequentially from the top. The location process stops as soon as a locator tool detects workpieces. The subsequent locator tools are not executed.

From the lower drop-down box, select which results of each locator tool to use in the case that the tool has multiple results.

Best Result of Each Loc. Tool

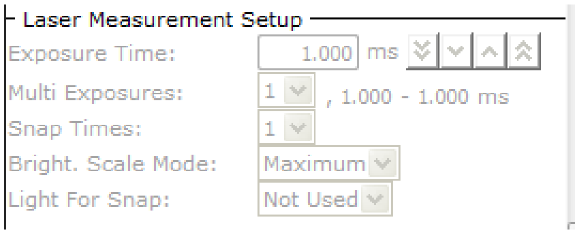
The result having the highest score is selected for each locator tool. The measurement uses only the selected results.

All Result of Each Loc. Tool

All the results are used in descending order of scores until the measurement succeeds. This is effective when you want to eliminate measurement failure caused by misdetection of a locator tool.

6.6.1.2 Laser measurement setups

Perform the laser measurement setups.



Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, “Setting an Exposure Mode”.

Snap Times

Use this item when you want to snap multiple images during one exposure time and to obtain an average image. This setting is valid only when 1 is set in [Multi Exposure].

Bright. Scale Mode

Specify a method for coordinating the brightness for multi-exposure.

Maximum

After all laser images are summed up, the brightness of the whole image is scaled so that the brightness in the photometric area is lower than 256. If halation occurs at even one point in the photometric area, the image becomes relatively dark as a whole.

Summation

After all laser images are summed up, the brightness of the pixel, brightness of which is higher than 256, is clipped. The brightness of whole image is kept and the brightness of pixels in which halation occurs is only suppressed to the maximum displayable brightness.

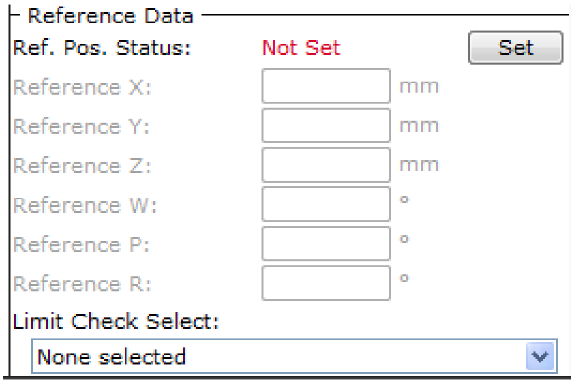
Light for Snap

Set whether to turn on or off the light when snapping an image for laser measurement.

TIP

If more than one laser measurement tool, such as 3DL plane command tool or 3DL displacement command tool, has been created, the tools will be executed sequentially from the top, and the measurement process will stop as soon as a measurement succeeds, leaving the subsequent tools unexecuted.

6.6.1.3 Reference data



Reference Position Status

If the reference position is set, [Set] is displayed in green; otherwise, [Not Set] is displayed in red.

Reference Position X,Y,Z,W,P,R

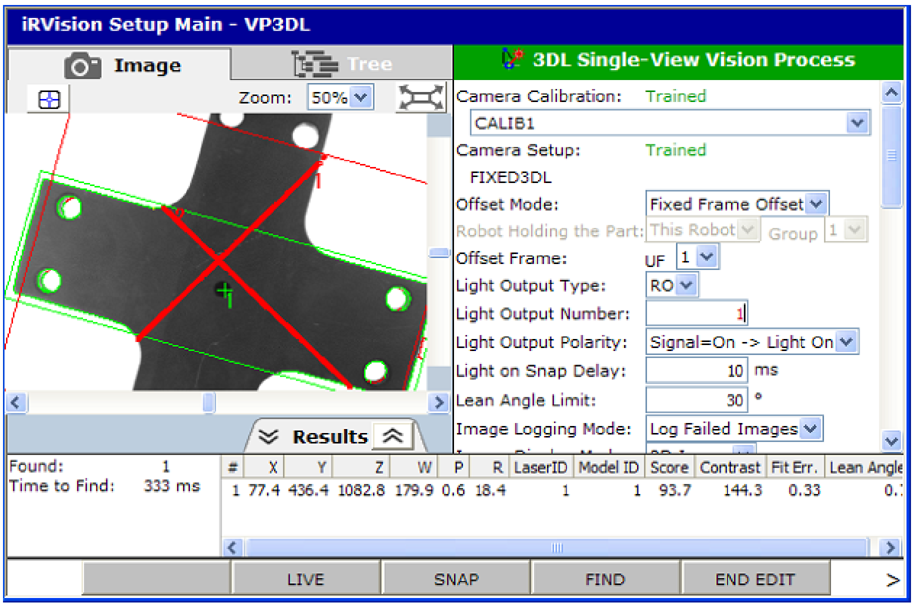
The coordinate values of the set reference position are displayed.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.6.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found

The number of found workpieces is displayed.

Time to Find

The time the vision process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y,Z

Coordinate values of the model origin of the found workpiece (units: mm).

W,P,R

Rotation angle of the found workpiece around the X, Y, and Z axis (units: degrees).

Laser ID

Laser measurement ID of the found workpiece.

Model ID

Model ID of the found workpiece.

Score

Score of the found workpiece.

Contrast

Contrast of the found workpiece.

Fit Err.

Elasticity of the found workpiece (units: pixels).

Lean Angle

Inclination angle of the found workpiece (units: degrees).

6.6.3 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.

1. Open the Setup Page for the vision process.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Press F3 SNAP and then press F4 FIND to find the workpiece.
4. Tap the [Set] button.
5. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.6.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

Laser Exposure Time

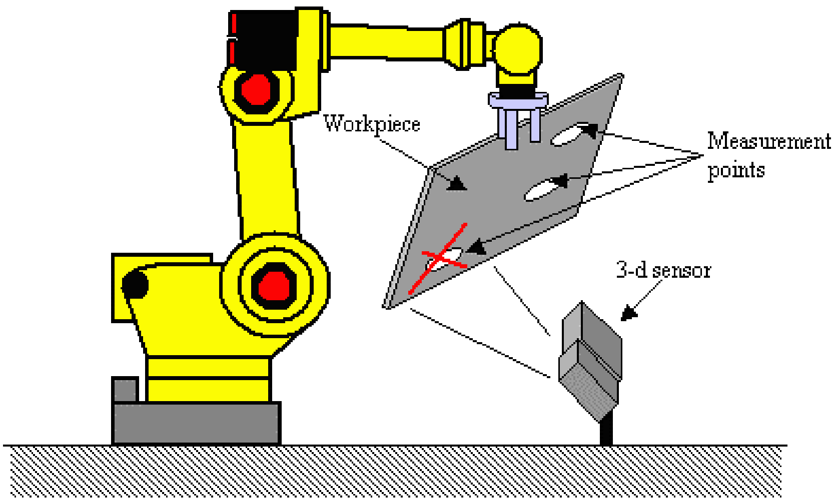
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Laser Exposure

Specify a number between 1 and 6.

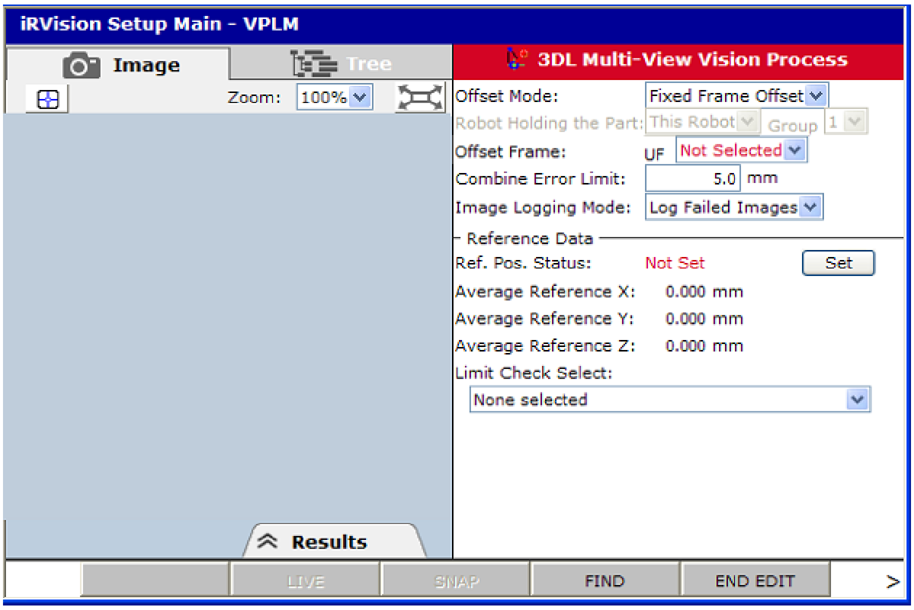
6.7 3DL MULTI-VIEW VISION PROCESS

The 3DL multi-view vision process is used to find the position of the workpiece by finding multiple parts of it. It is effective when the workpiece is too large for the camera to capture its entire image and when the orientation of the workpiece is tilted.

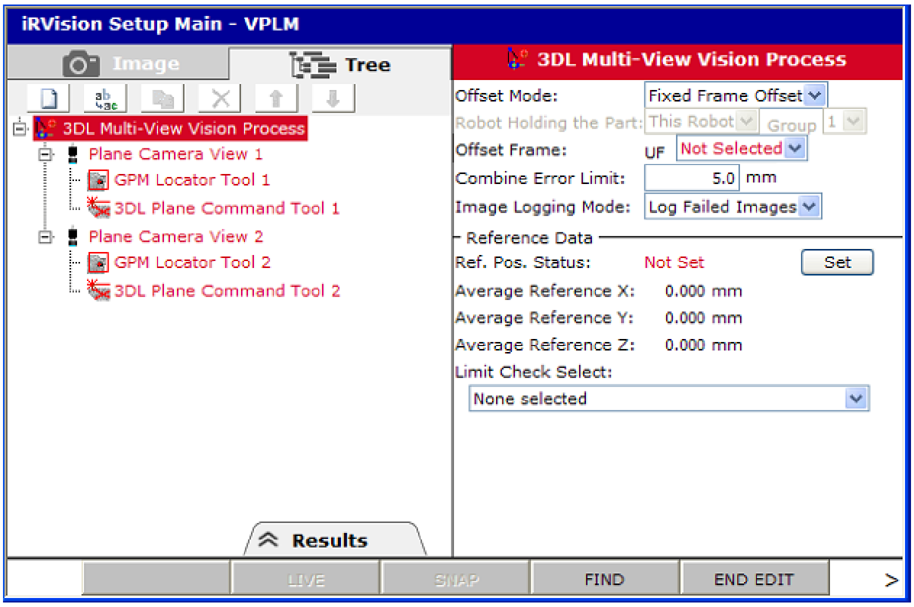


6.7.1 Setting up a Vision Process

If you open the setup page of [3DL Multi View Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Offset Mode

Select the robot position offset mode.

Fixed Frame Offset

The fixed frame offset data will be calculated.

Tool Offset

The tool offset data will be calculated.

Robot Holding Part

If you have chosen [Tool Offset] in [Offset Mode], specify the robot holding the workpiece.

Offset Frame

A 3DL multi-view vision process measures the offset data with respect to the plane which is selected in this item. If you have chosen [Fixed Frame Offset] for [Offset Mode], specify a user frame as the offset frame. If you have chosen [Tool Offset] for [Offset Mode], specify a user tool. The following are examples of the offset frame in the case of Fixed Frame Offset.

Combine Error Limit

The combine error limit is the distance the found targets for each camera view move independently of each other. The figure below shows the original found location for each of the three views as the small black targets, and it shows the current found location for each view as the larger target. In the example below there is a combine error, since the relationship between the three targets changed from the original reference position find to the current find, as seen by the size and shape of the triangle changing.

If the calculated combine error limit is greater than the user specified limit, the workpiece will not be found. Typically a sudden increase in the combine error is due to incorrect calibration of one or more of the camera views, or physical changes in the workpiece.

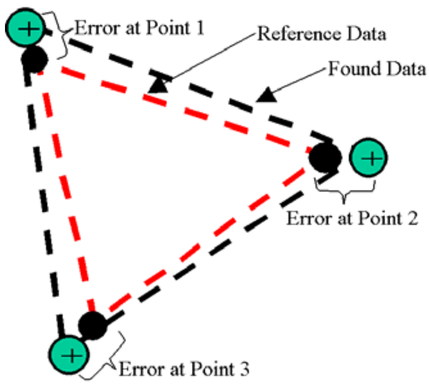


Image Logging Mode

Specify whether to save log images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 600 and 1200 milliseconds per camera view.

Reference Position Status

If the reference position is set, [Trained] is displayed in green; otherwise, [Not Trained] is displayed in red.

Average Reference X, Y, Z

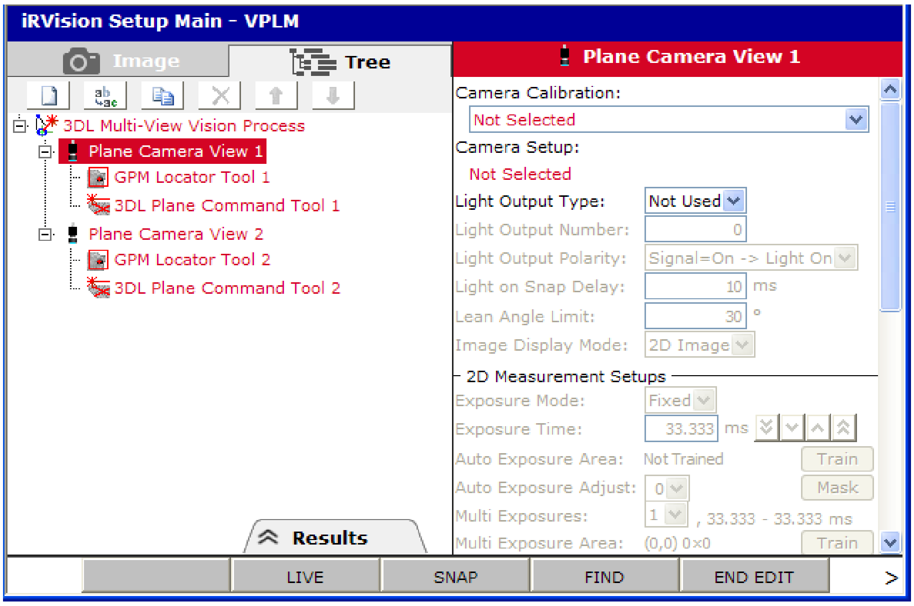
The average reference position of each camera view is displayed. The offset limit check described next is to check the location or travel distance of this reference position.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.7.2 Setting up a Camera View

If you select [Plane Camera View 1] in the tree view, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Setting the Light

Use this function to have an external light turned on or off as appropriate for the vision process executed with the 3D laser sensor. By using this function, you can have the light turned on, for example, when finding two-dimensional features during one three-dimensional measurement, or have it turned off when finding the two laser lines. It is common to have an LED ring light mounted to the 3D laser sensor to provide controlled lighting.

Set the function as follows.

1. In [Light Output Signal Type], specify the type of signal - DO or RO - that turns on or off the light.
2. In [Light Signal Number], enter the number of the output point to which the ON/OFF signal is connected. For example, when connecting the signal to RO[1], enter 1.

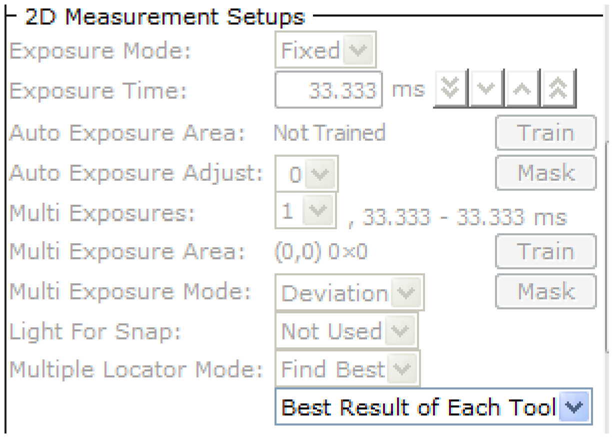
3. In [Light Output Signal Polarity], set the relationship between the signal output and turning on or off the light. To turn on the light when the signal is ON, set [Signal=ON->Light=ON]. To turn it off when the signal is ON, set [Signal=OFF->Light=ON].
4. In [Light on snap delay], set the wait time from the output of the light ON signal until an image is snapped. Under normal conditions, set 0.

Lean Angle Limit

Any workpiece found with an angle greater than the lean angle limit from the reference position is treated as not being found.

6.7.2.1 2D measurement setups

Perform the 2D measurement setups.



Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, “Setting an Exposure Mode”.

Light for Snap

Set whether to turn on or off the light when snapping an image for two-dimensional measurement.

Multiple Locator Find Mode

From the upper drop-down box, select which locator tools to execute in the case that multiple locator tools have been made.

Find Best

All the locator tools are executed. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools are executed sequentially from the top. The location process stops as soon as a locator tool detects workpieces. The subsequent locator tools are not executed.

From the lower drop-down box, select which results of each locator tool to use in the case that the tool has multiple results.

Best Result of Each Loc. Tool

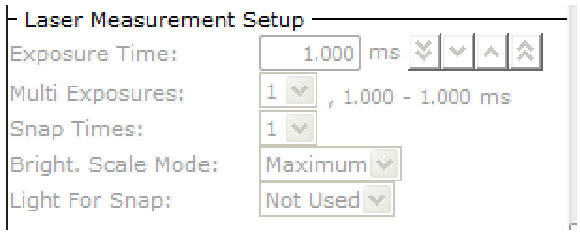
The result having the highest score is selected for each locator tool. The measurement uses only the selected results.

All Result of Each Loc. Tool

All the results are used in descending order of scores until the measurement succeeds. This is effective when you want to eliminate measurement failure caused by misdetection of a locator tool.

6.7.2.2 Laser measurement setups

Perform the laser measurement setups.



Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Snap Times

Use this item when you want to snap multiple images during one exposure time and to obtain an average image. This setting is valid only when 1 is set in [Multi Exposure].

Bright. Scale Mode

Specify a method for coordinating the brightness at the time of laser image synthesis in multi-exposure.

Maximum

After all laser images are summed up, the brightness of the whole image is scaled so that the brightness in the photometric area is lower than 256. If halation occurs at even one point in the photometric area, the image becomes relatively dark as a whole.

Summation

After all laser images are summed up, the brightness of the pixel , brightness of which is higher than 256, is clipped. The brightness of whole image is kept and the brightness of pixels in which halation occurs is only suppressed to the maximum displayable brightness.

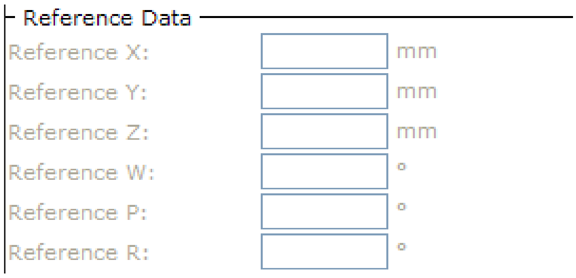
Light for Snap

Set whether to turn on or off the light when snapping an image for laser measurement.

TIP

If more than one laser measurement tool, such as 3DL plane command tool, has been created, the tools will be executed sequentially from the top, and the measurement process will stop as soon as a measurement succeeds, leaving the subsequent tools unexecuted.

6.7.2.3 Reference data

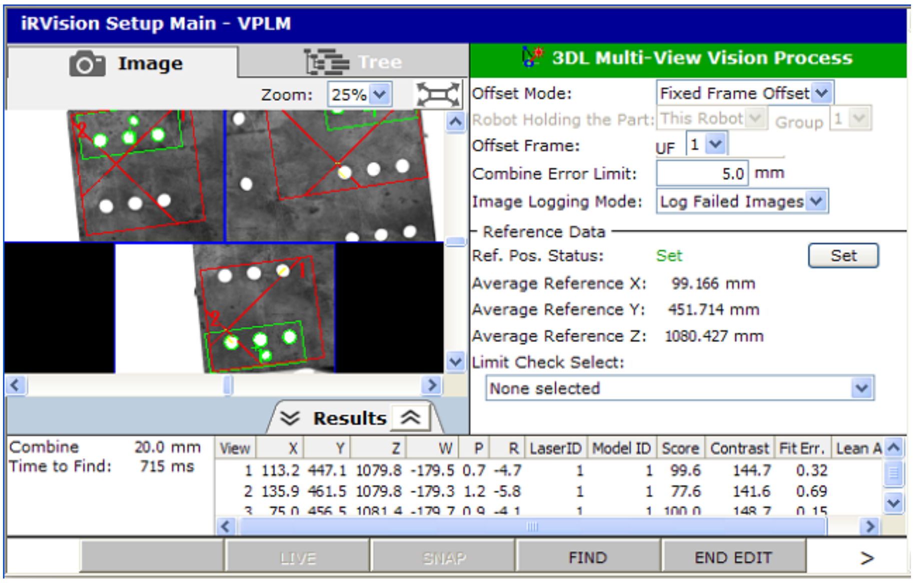


Reference X,Y,Z,W,P,R

The coordinate values of the set reference position are displayed.

6.7.3 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Combine

Alignment deviation between the point found when the reference position is set and the point found when the test is run (units: mm). This value becomes nearly 0 if there are no differences between targets to find and no location error.

Time to Find

The time the vision process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y,Z

Coordinate values of the model origin of the found workpiece (units: mm).

W,P,R

Rotation angle of the found workpiece around the X, Y, and Z axes (units: degrees).

Laser ID

Laser measurement ID of the found workpiece.

Model ID
Model ID of the found workpiece.

Score
Score of the found workpiece.

Contrast
Contrast of the found workpiece.

Fit Err.
Elasticity of the found workpiece (units: pixels).

Lean Angle
Inclination angle of the found workpiece (units: degrees).

6.7.4 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.

1. Open the vision process Setup Page.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Press F3 SNAP and then press F4 FIND to find the workpiece.
4. Tap the [Set] button.
5. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.7.5 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure
Specify a number between 1 and 6.

Laser Exposure Time
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

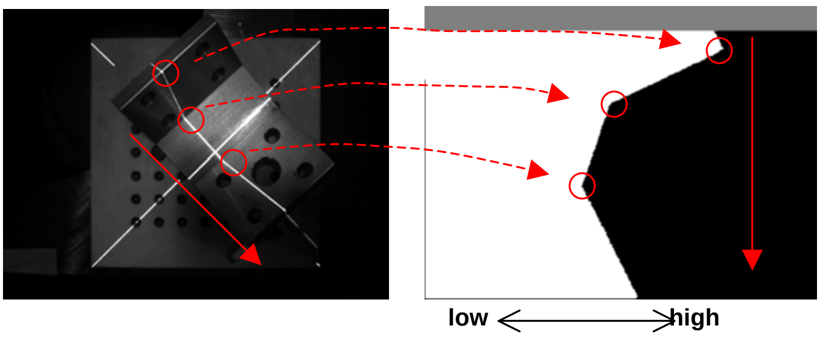
Number of Laser Exposure
Specify a number between 1 and 6.

6.8 3DL CROSS-SECTION VISION PROCESS

This function is typically used for a workpiece to which a “3DL vision process” cannot be applied. It illuminates the workpiece with the laser, collects height information of the illuminated part, and generates a cross-sectional image of the workpiece. Then, it executes a GPM locator tool on the generated cross-sectional image and calculates the three-dimensional position of the target section.

> ⚠ **CAUTION**
> This function performs only measurement. To adjust the handling of the workpiece by the robot, offset data must be calculated using a robot program.

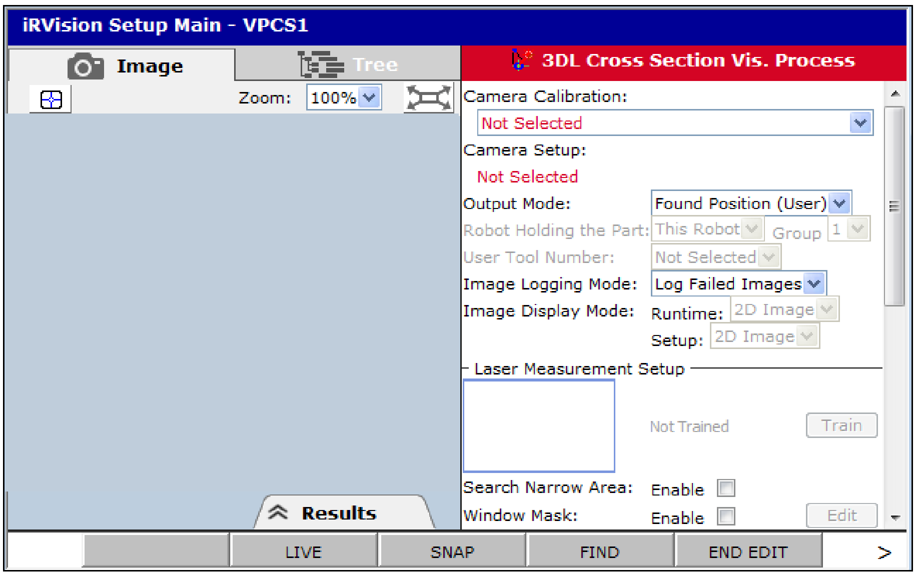
The lower right image shows the cross section image. The arrow direction of a laser slit indicates the vertical direction and the height indicates the horizontal direction as shown at lower left. In the following images, ○ and ○ connected with a line with an arrow indicate the same section.



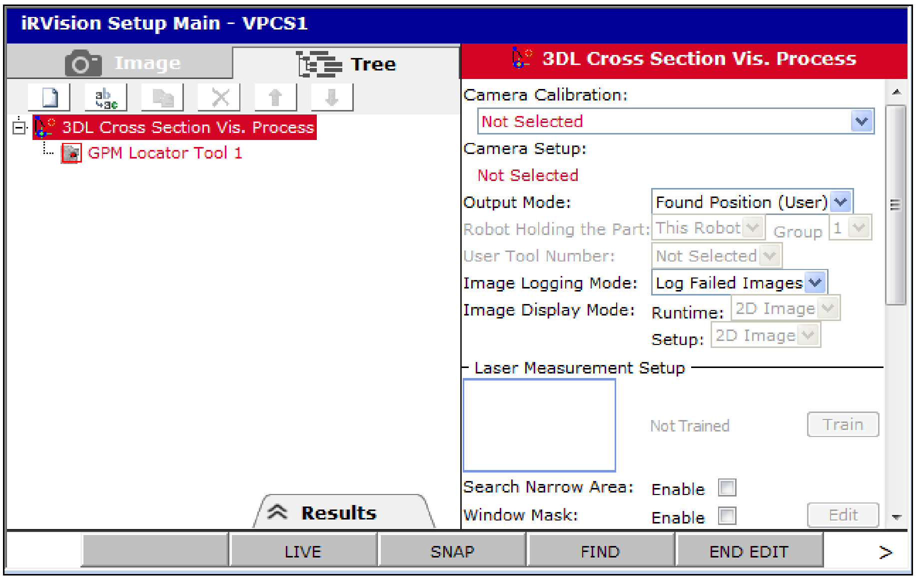
(2D image) (Cross-sectional image)

6.8.1 Setting up a vision process

If you open the setup page of [3DL Cross-Section Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration
Select the camera calibration you want to use.

Camera Setup
The name of the camera specified for the selected camera calibration is displayed.

Output Mode
Select the mode in which to output measurement results.

Found Position (User)
The found position in the application user frame will be output as is.

Found Position (Tool)
The found position will be output after being converted to a value in the specified user tool. It is mainly used to measure the error of the workpiece grasped by robot when 3D-sensor is secured.

Robot Holding the Part
If you have chosen [Found Position (Tool)] in [Output Mode], specify the robot that is holding the workpiece.

User Tool Number
If you have chosen [Found Position (Tool): in [Output Mode], specify the user tool from which you want to convert the found position to a value as seen.

Image Logging Mode
Specify whether to save images to the vision log when running the vision process.

Do Not Log
Do not save any images to the vision log.

Log Failed Images
Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds.

Image Display Mode

Change the image to be displayed. The setting in [Runtime] is used when the image is displayed on the runtime monitor; the setting in [Setup] is used when it is displayed on the Setup Page.

2D Image

The camera-captured image is displayed.

Laser Slit Image

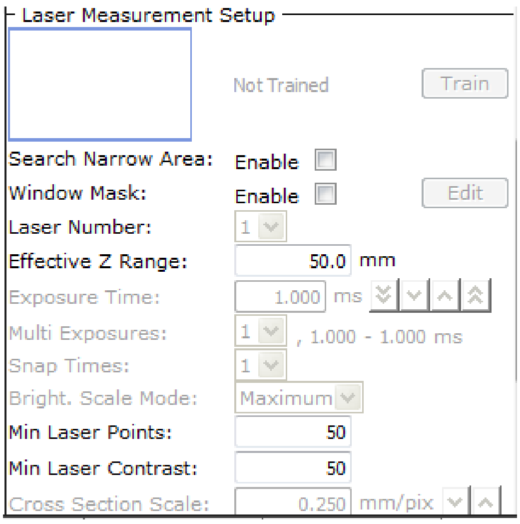
The laser slit image is displayed.

Cross-sectional Image

The cross-sectional image of the workpiece is displayed.

6.8.1.1 Laser measurement setup

Perform the laser measurement setups.



Setting the measurement area

Set the measurement area as follows.

1. Press F6 Laser ON to turn on the laser
2. Press F2 LIVE to change to the live image display.
3. Jog the robot so that the section to be measured is at the center of the image. You can make positioning easier to do by tapping button, which displays the center line of the window.
4. Adjust the distance between the 3D laser sensor and workpiece so that the laser intersection point comes around the center of the measurement section. In this case, the distance between the 3D laser sensor camera and measurement section is about 400 mm.

5. Press F2 STOP to stop the live image, then press F6 Laser OFF to turn off the laser.
6. Tap the [Train] button.
7. Enclose the workpiece to be taught within the displayed red rectangle, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.

Search Narrow Area

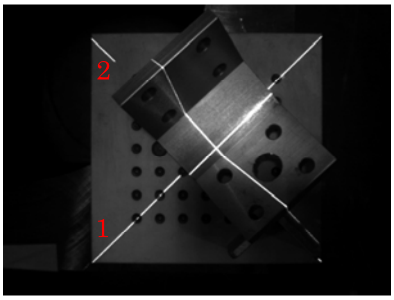
If the area to be measured is small and the available points are few, enable [Search Narrow Area], which lets you increase the number of points to be used for the measurement. Note that this increases the processing time as well. Therefore, enable this item only when necessary.

Window Mask

If there is a region you want to remove from the measurement area, set a mask. To create a mask in the measurement area, tap the [Edit Mask] button. Even when you have edited a mask, the tool will ignore the mask if you uncheck the [Enable] check box. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.

Laser Number

Specify one of the two laser slits that you want to use to generate the cross-sectional image.



1: Laser slit with which the workpiece is illuminated from the lower left to the upper right on the image.
2: Laser slit with which the workpiece is illuminated from the upper left to the lower right on the image.

Effective Z Range

Specify the range within which points are to be used as a Z value when the cross-sectional image is generated. Set a range which actually contains the measurement section as much as possible.

Setting the Exposure Time

Set the camera’s exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, “Setting an Exposure Mode”.

Snap Times

Use this item when you want to snap multiple images during one exposure time to obtain an average image. This setting is valid only when a value of 1 is set in [Multi Exposure].

Bright. Scale Mode

This item is valid only when a value of 2 or greater is set in [Snap Times]. Select the pixel output mode when the maximum value obtained by the sum of the brightness values of pixels exceeds 255.

Maximum

Each pixel in the area is adjusted with the same ratio so that the brightness of the brightest pixel is set to 255 and output them.

Summation

Pixels output as is unless the brightness of any pixel does not exceed 255 regardless of the brightness of the brightest pixel. This item is effective when the workpiece has a very bright part such as a mirror finished surface and an appropriate image cannot be obtained with the maximum brightness.

Min Laser Points

If the number of effective points found in the measurement area, excluding the mask area, is below this threshold, the measurement result is invalid. If the laser point found result varies because of a small measurement area or change in image brightness, lowering the minimum number of laser points might make location possible. Note that, because the inclination of the workpiece plane is calculated from the found points, measurement accuracy can degrade as the number of points decreases. The number of effective laser points to be found depends on the [Min. Laser Contrast] shown below.

Min Laser Contrast

This is the threshold for finding points of the laser applied to the measurement area, excluding the mask area.

[Min. Num. Laser Points] and [Min. Laser Contrast] above should be confined to those cases where adjusting other settings never yields accurate found results. Forcing the tool to find laser points or changing the values inadvertently might result in inaccurate calculation of the detection position.

> ⚠ **CAUTION**
> Before changing location parameters [Min. Num. Laser Points] and [Min. Laser Contrast], check that the laser measurement exposure time in the vision process has been adjusted so that an image is captured adequately.

Cross Section Scale

Set the resolution (mm/pixel) of the generated cross-sectional image.

Multi-Locator Mode

If you have created more than one locator tool, select how to execute those tools.

Find Best

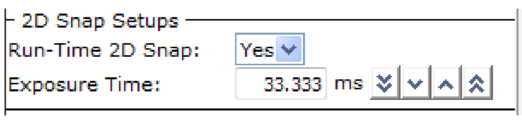
All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools will be executed sequentially from the top. The location process will stop as soon as the specified number of workpieces have been found. The subsequent locator tools will not be executed.

6.8.1.2 2D measurement setups

Perform the 2D measurement setups.



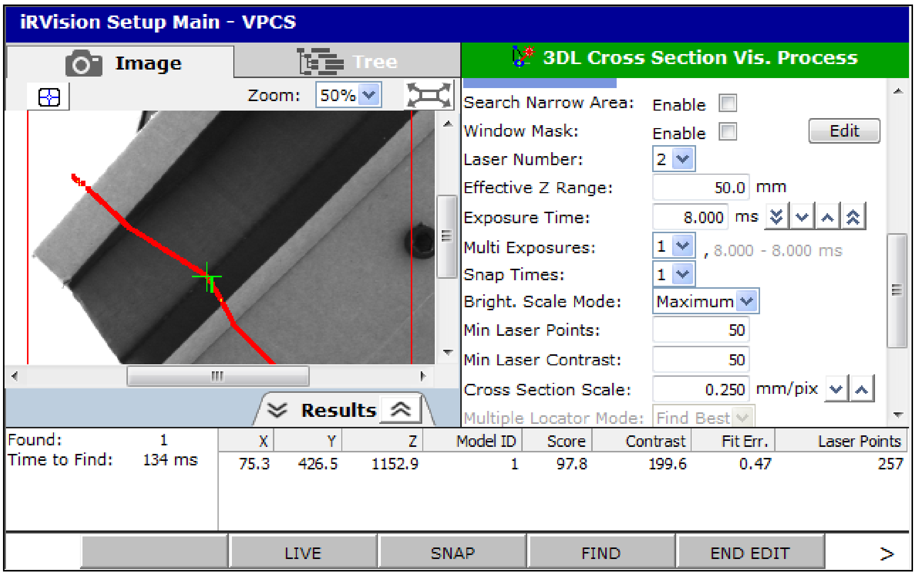
Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

The exposure time specified here is used only setup mode only. In runtime the 3DL cross-section vision process, finds the workpiece by using the cross-section image generated from the laser image, so the 2D image is not snapped. Therefore the exposure time specified here is not used during runtime.

6.8.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found
The number of found workpieces is displayed.

Time to Find
The time the vision process took is displayed in milliseconds.

Found Results table
The following values are displayed.

X, Y, Z
Coordinates of the model origin of the found workpiece using the cross-sectional image (units: mm).

W, P, R
These values are all 0 (units: degrees).

Model ID
Model ID of the found workpiece using the cross-sectional image.

Score
Score of the found workpiece using the cross-sectional image.

Contrast
Contrast of the found workpiece using the cross-sectional image.

Fit Err.

Elasticity of the found workpiece using the cross-sectional image (units: pixels).

Laser Points

Number of laser points used to generate the cross-sectional image.

6.8.3 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Laser Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Laser Exposure

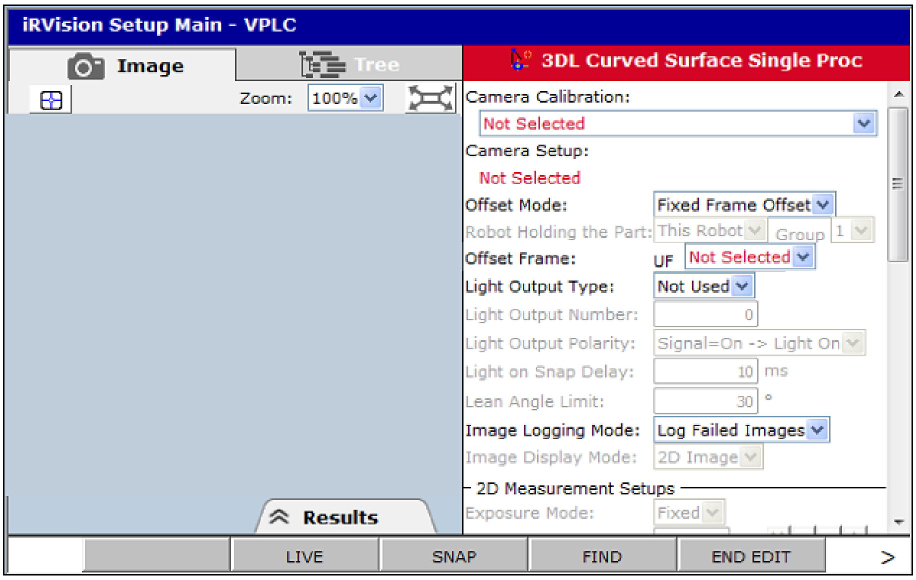
Specify a number between 1 and 6.

6.9 3DL CURVED SURFACE SINGLE VIEW VISION PROCESS

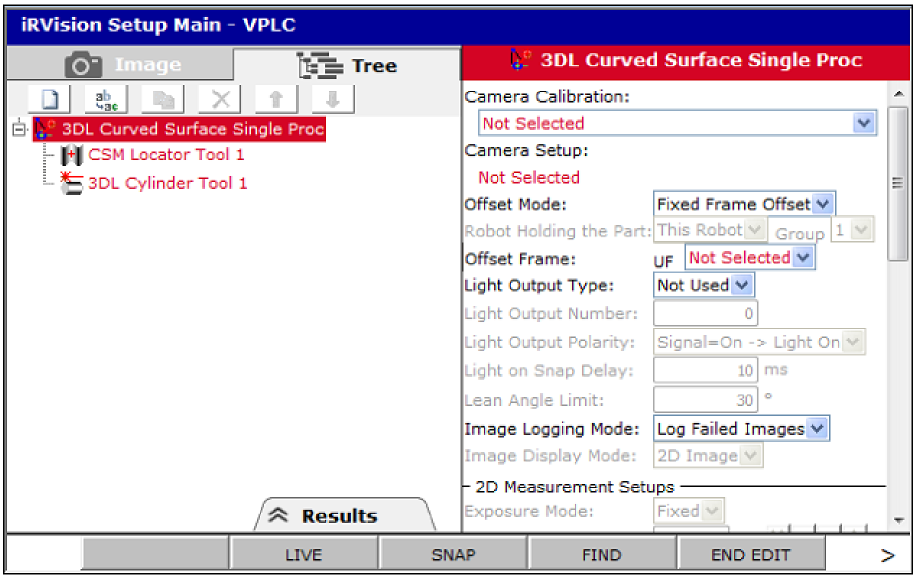
Of the 3DL vision processes, this one measures the three-dimensional position and posture of a workpiece - particularly a circular cylinder having a curved surface - and adjusts the handling of the workpiece by the robot. The curved surface locator tool and cylinder command tool can be used.

6.9.1 Setting up a Vision Process

If you select [3DL Curved Surface Single Proc], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

From the dropdown box, select the camera calibration you want to use.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Offset Mode

From the dropdown box, select one of the following robot position offset modes:

Fixed Frame Offset

The fixed frame offset data will be calculated.

Tool Offset

The tool offset data will be calculated.

Found Position (User)

The found position will be output as is, instead of the offset data. This option is provided for any required specified offset mode. Do not select it under normal conditions.

Found Position (Tool)

The found position will be output, instead of the offset data, after being converted to a value as seen from the tool frame. This option is provided for any required specified offset mode. Do not select it under normal conditions

Robot Holding Part

If you have chosen [Tool Offset] or [Found Position (Tool)] for [Offset Mode], specify the robot holding the workpiece.

Offset Frame

A 3DL curved surface single vision process measures the offset data with respect to the plane which is selected in this item. If you have chosen [Fixed Frame Offset] for [Offset Mode], specify a user frame as the offset frame. If you have chosen [Tool Offset] for [Offset Mode], specify a user tool. The following are examples of the offset frame in the case of Fixed Frame Offset.

Setting the Light

Use this function to have an external light turned on or off as appropriate for the vision process executed with the 3D laser sensor. By using this function, you can have the light turned on, for example, when finding two-dimensional features during one three-dimensional measurement, or have it turned off when finding the laser lines. Set the function as follows.

1. In [Light Output Signal Type], specify the type of signal - DO or RO - that turns on or off the light.
2. In [Light Output Signal Number], enter the number of the output point to which the ON/OFF signal is connected. For example, when connecting the signal to RO[1], enter 1.
3. In [Light Output Signal Polarity], set the relationship between the signal output and turning on or off the light. To turn on the light when the signal is ON, set [Signal=On->Light On]. To turn it off when the signal is ON, set [Signal=Off->Light On].
4. In [Light on Snap Delay], set the wait time from the output of the light ON signal until an image is snapped. Under normal conditions, set 0.

Lean Angle Limit

Any workpiece found with an angle greater than the lean angle limit from the reference position is treated as not being found.

Image Logging Mode

From the drop down box, select one of the following image logging modes:

Do Not Log

Do not save any images to the vision log. This mode enables the fastest logging and consumes the least amount of memory card space.

Log Failed Images

Save images only when the vision operation fails. This mode is effective when you want to analyze failed images later for corrective action.

Log All Images

Save all images. This mode is effective when you want to obtain a large amount of image data for adjusting the location parameters.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 600 and 1200 milliseconds per camera view.

Image Display Mode

Select the items to be displayed in the vision image display area.

2D Image

The 2D image and location result are displayed.

Laser Slit Image 1

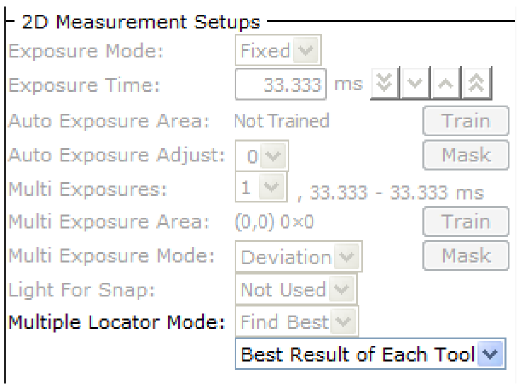
The slit image of laser 1 is displayed.

Laser Slit Image 2

The slit image of laser 2 is displayed.

6.9.1.1 2D measurement setups

Perform the 2D measurement setups.



Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Light For Snap

Set whether to turn on or off the light when snapping an image for 2D measurement.

Multiple Locator Find Mode

From the upper drop-down box, select which locator tools to execute in the case that multiple locator tools have been made.

Find Best

All the locator tools are executed. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools are executed sequentially from the top. The location process stops as soon as a locator tool detects workpieces. The subsequent locator tools are not executed.

From the lower drop-down box, select which results of each locator tool to use in the case that the tool has multiple results.

Best Result of Each Loc. Tool

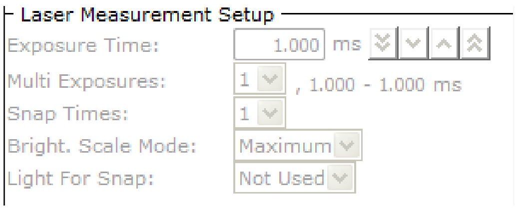
The result having the highest score is selected for each locator tool. The measurement uses only the selected results.

All Result of Each Loc. Tool

All the results are used in descending order of scores until the measurement succeeds. This is effective when you want to eliminate measurement failure caused by misdetection of a locator tool.

6.9.1.2 Laser measurement setup

Perform the laser measurement setups.



Setting the Exposure Time

Set the camera’s exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Snap Times

Use this item when you want to snap multiple images during one exposure time and to obtain an average image. This setting is valid only when 1 is set in [Multi Exposures].

Bright. Scale Mode

Specify a method for coordinating the brightness when laser images obtained by multi-exposure are combined.

Maximum

After all laser images are summed up, the brightness of the whole image is scaled so that the brightness in the photometric area is lower than 256. If halation occurs at even one point in the photometric area, the image becomes relatively dark as a whole.

Summation

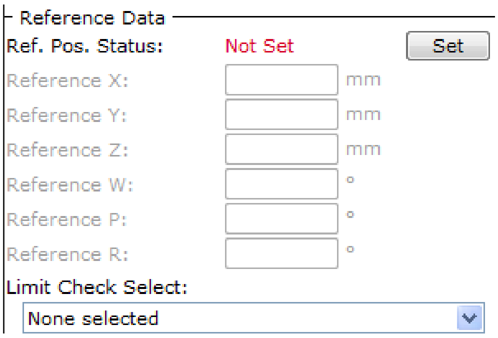
After all laser images are summed up, the brightness of the pixel, brightness of which is higher than 256, is clipped. The brightness of whole image is kept and the brightness of pixels in which halation occurs is only suppressed to 255.

Light For Snap

Set whether to turn on or off the light when snapping an image for laser measurement.

> **TIP**
>
> If more than one laser measurement tool, such as cylinder command tool or 3DL displ. command tool, has been created, the tools will be executed sequentially from the top, and the measurement process will stop as soon as a measurement succeeds, leaving the subsequent tools unexecuted.

6.9.1.3 Reference data



Setting the Reference Position

If the reference position is set, [Set] is displayed in green. Otherwise, [Not Set] is displayed in red.

Reference X, Y, Z, W, P, R

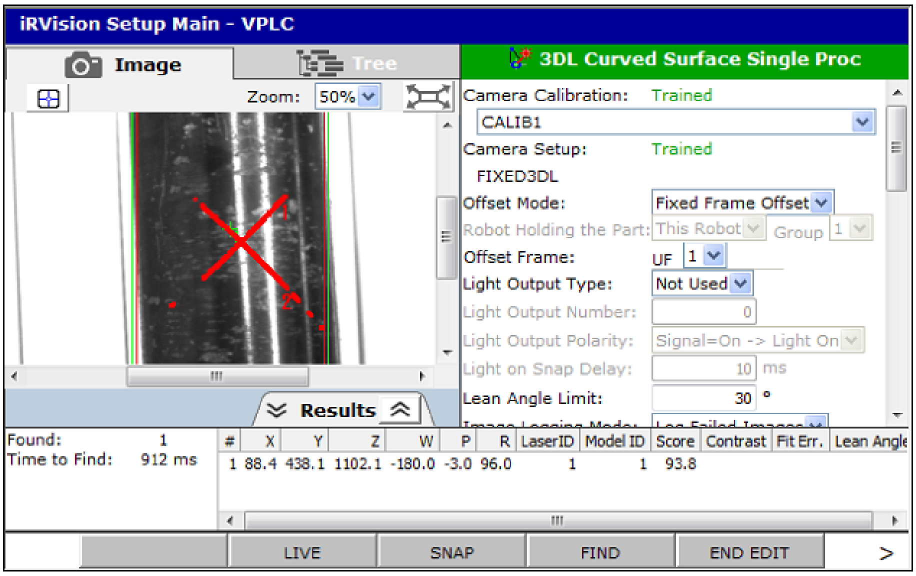
The coordinates of the set reference position are displayed.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.9.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found
The number of found workpieces is displayed.

Time to Find
The time the vision process took is displayed in milliseconds.

Found Result Table
The following values are displayed.

X, Y, Z
Coordinates of the model origin of the found workpiece (unit: mm).

W, P, R
Rotation angle of the found workpiece around the X, Y, and Z axis (unit: degrees).

Laser ID
Laser measurement ID of the found workpiece.

Model ID
Model ID of the found workpiece.

Score
Score of the found workpiece.

Contrast
Contrast of the found workpiece.

Fit Err.
Elasticity of the found workpiece (unit: pixels).

Lean Angle

Inclination angle of the found workpiece in the normal direction at the reference position (unit: degrees).

6.9.3 Setting the Reference Position

Set the reference position.
The offset value is calculated based on the relationship between the reference position you set here and the found position.

1. Open the vision process Setup Page.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Press F3 SNAP and then press F4 FIND to find the workpiece.
4. Tap the [Set] button.
5. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set.
Teach the position to the robot without moving the workpiece.

6.9.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

Specify a number between 1 and 6.

Laser Exposure Time

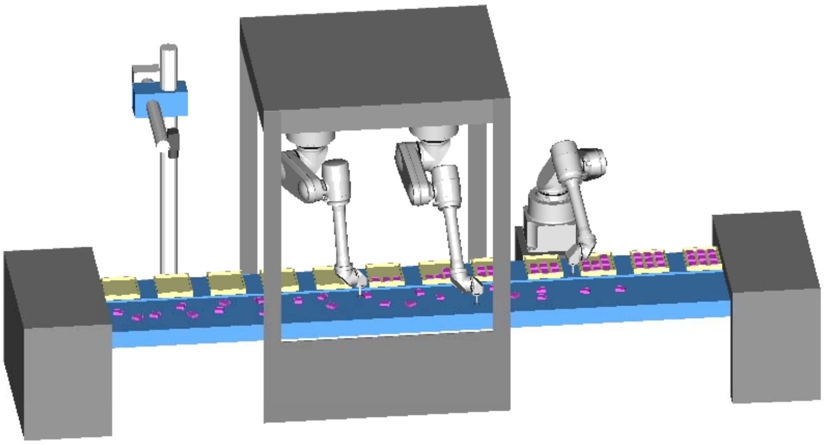
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Laser Exposure

Specify a number between 1 and 6.

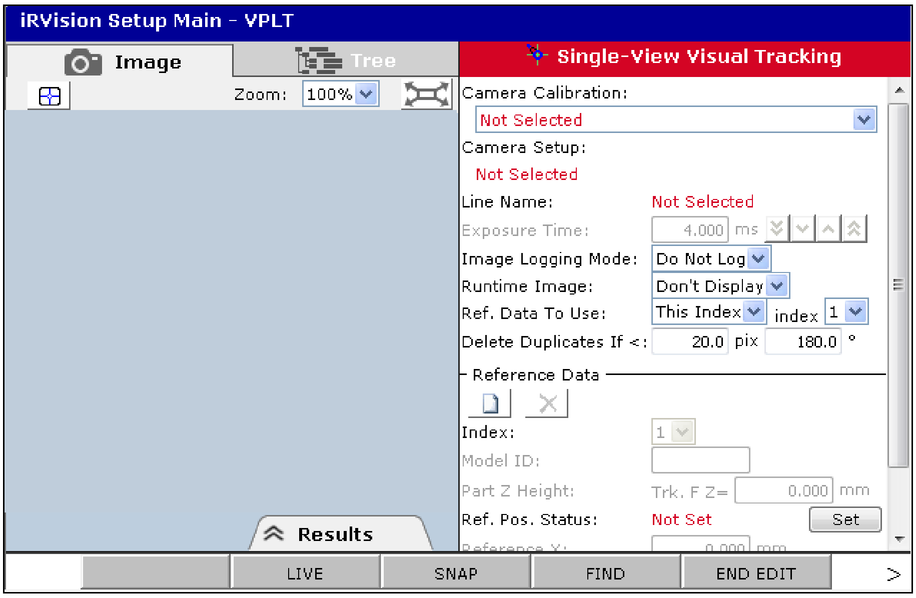
6.10 SINGLE VIEW VISUAL TRACKING

This is a vision process for a two-dimensional application that finds a workpiece being carried on a conveyor with a single camera and picks up the workpiece without stopping the conveyor.

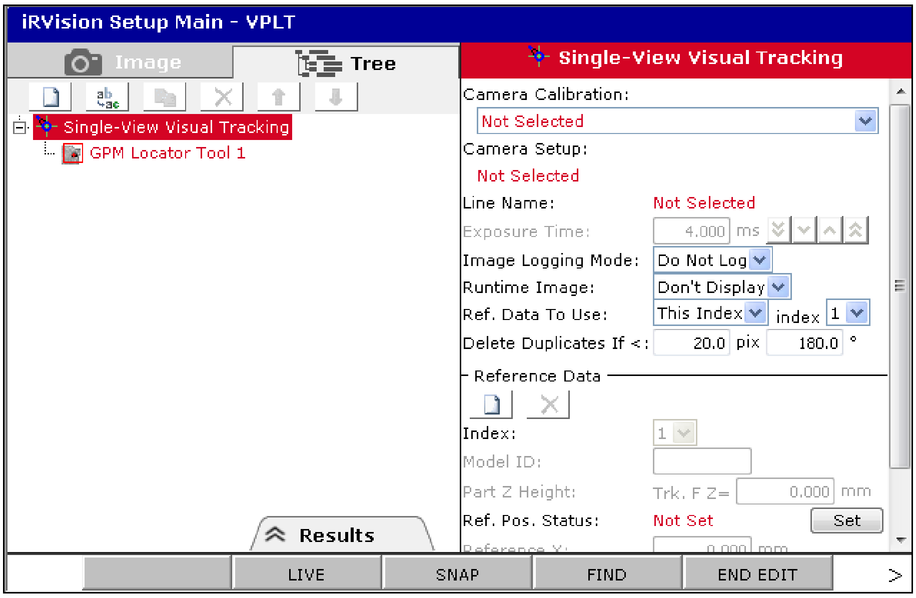


6.10.1 Setting up a Vision Process

If you open the setup page of [Single View Visual Tracking], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use.
The selectable camera calibrations are only those for visual tracking.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Line Name

The name of the Line specified for the selected camera calibration is displayed. For detailed information about the Line, please refer to "R-30*i*B CONTROLLER *i*RVision Visual Tracking Application OPERATOR'S MANUAL".

Exposure Time

Specify the exposure time for the camera to capture an image.
As the exposure time, specify the smallest possible value that does not cause the image of the moving conveyor to blur. As a guide, the value should be so small that the conveyor travels no more than 0.5 pixels during the exposure time.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process. While the options shown below are available, choose [Do Not Log] for visual tracking under normal conditions, because the image saving processing takes time.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. In case of this vision process, the time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds.

Runtime Image

Specify how to display an image on the runtime monitor.

Display With 100%

The image will be displayed at a magnification of 100% on the runtime monitor.

Display With 50%

The image will be displayed at a magnification of 50% on the runtime monitor.

Don't Display

No image will be displayed on the runtime monitor.

Since displaying an image on the runtime monitor takes time, choose an option as appropriate for the system's tracking time requirement. If you choose [Don't Display], no image will be displayed on the runtime monitor, allowing the vision process to run fastest. While [Display with 50%] takes more time than [Don't Display], it is faster than [Display with 100%].

Ref. Data Index To Use

Choose one of the following to specify how to determine the reference data to use.

This Index

The same reference data is used to calculate the offset data.

Model ID

Different reference data is used depending on the model ID of the found workpiece. Choose this in such cases as when there are two types of workpiece having different heights.

Delete Duplicates if <

The position and angle of each found result is checked to see whether the result is the same as another result. If there are multiple found results within the specified pixels and angle, the results are assumed to the same workpiece and only the found result with the highest score is output.

Reference Data

The reference data is used to calculate offset data from the found result. The reference data mainly consists of two types of data described below.

Part Z Height

Height of the found part of the workpiece as seen from the tracking frame.

Reference Position

Position of the workpiece found when the robot position is taught. The offset data is the difference between the actual workpiece position found when running the vision process and the reference position.

A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used. However, for example, if there are two types of workpieces being carried on the conveyor, each having a different height, the vision process uses two sets of reference data because it needs to set a different "Z-direction height" for each of the workpieces.

ID

If [This Index] is selected in [Ref. Data To Use], enter the reference data ID to use.

Adding reference data

You can add reference data as follows.

1. Tap button.
2. In [Model ID], enter the model ID for which to use the reference data.

Deleting reference data

You can delete reference data as follows, if there is more than one set.

1. Select the reference data you want to delete using the index drop-down list
2. Tap button.

Part Z Height

Enter the height of the found part of the workpiece as seen from the tracking frame.

> ⚠ **CAUTION**
> This is not the height from the surface of the conveyor. For example, if a thick calibration grid is used to set up the tracking frame, then the value to be set is obtained by subtracting the thickness of the calibration grid from the height of the workpiece.

Ref. Pos. Status

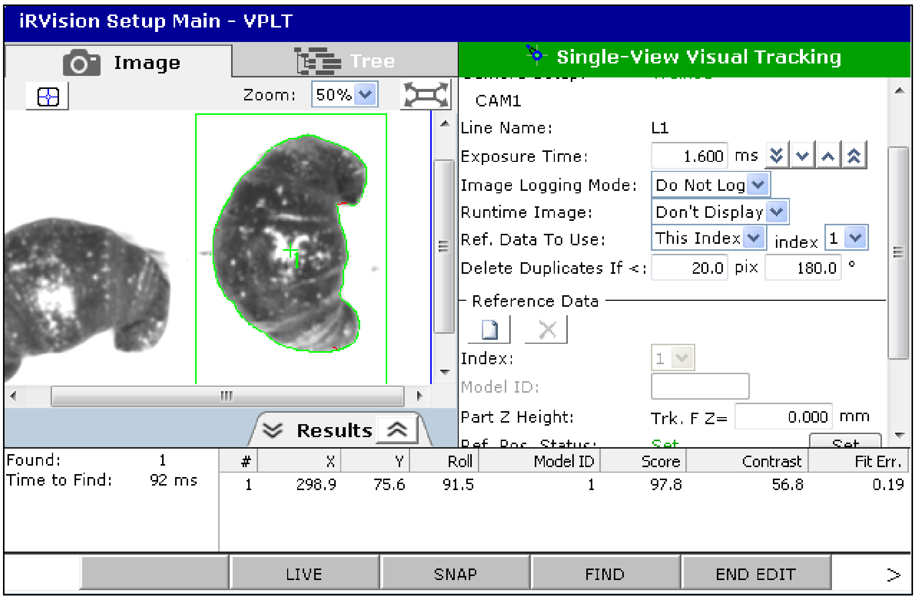
If the reference position is set, [Set] is displayed in green; otherwise, [Not Set] is displayed in red.

Reference Position X,Y,R

The coordinates of the set reference position are displayed.

6.10.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found

The number of found workpieces is displayed.

Time to Find

The time the vision process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y

Coordinate values of the model origin of the found workpiece (units: mm).

Roll

Rotation angle of the found workpiece around the Z axis (units: degrees).

Model ID

Model ID of the found workpiece.

Score

Score of the found workpiece.

Contrast

Contrast of the found workpiece.

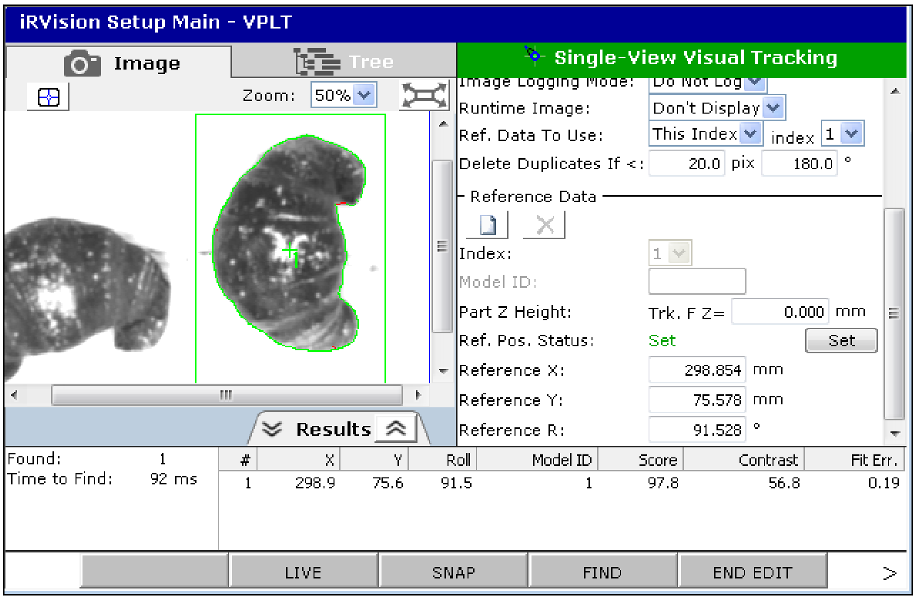
Fit Err.

Elasticity of the found workpiece (units: pixels).

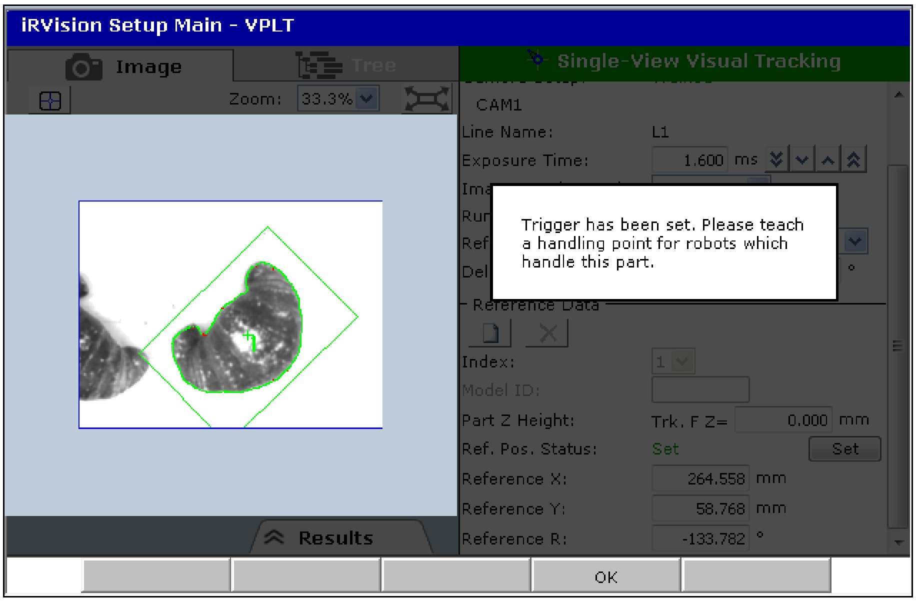
6.10.3 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.

1. Open the vision process Setup Page.



2. In [ID] in [Reference Data], choose the reference data for which to set the reference position.
3. Place a workpiece in the camera view.
4. Press F3 SNAP and then press F4 FIND to find the workpiece.
5. Check that the workpiece has been found correctly, and tap the [Set] button.
6. When the reference position is set, the following message appears.



7. Check the message, and press F4 OK.

The encoder value of the conveyor at the time of the reference position setting is set as the trigger for each robot. Run the conveyor without moving the workpiece on it until the workpiece comes in front of a robot, and teach the robot position.

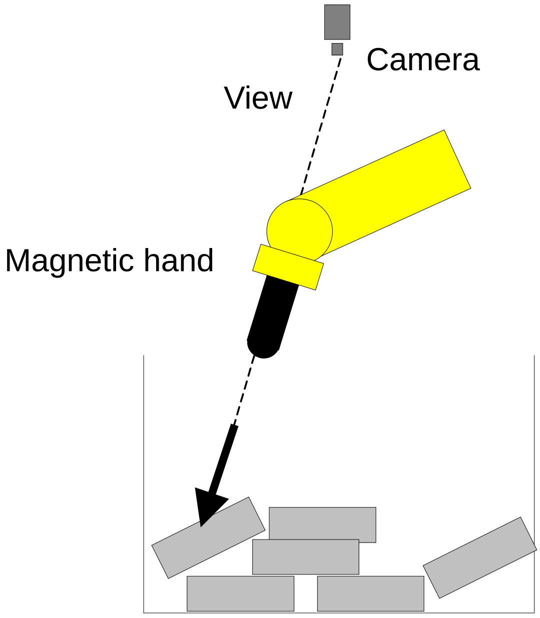
6.10.4 Overridable Parameters

This vision process has no overridable parameters that can be overridden with Vision Override.

6.11 BIN-PICK SEARCH VISION PROCESS

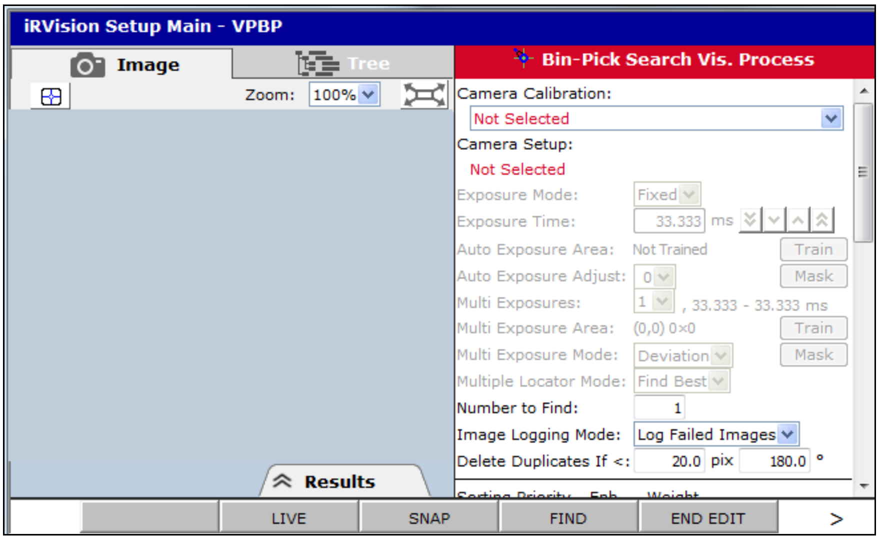
This vision process determines the location, X, Y, Z, and R of the workpiece and it also determines the yaw and pitch based on where the part is in the field of view. The height, or Z, is estimated based on the found scale of the workpiece.

The yaw and pitch are not the actual orientation of the workpiece but its position relative to the camera. This allows a simple bolt item pick-up system with a magnetic gripper to pick-up the workpiece without coming into contact with exterior walls.

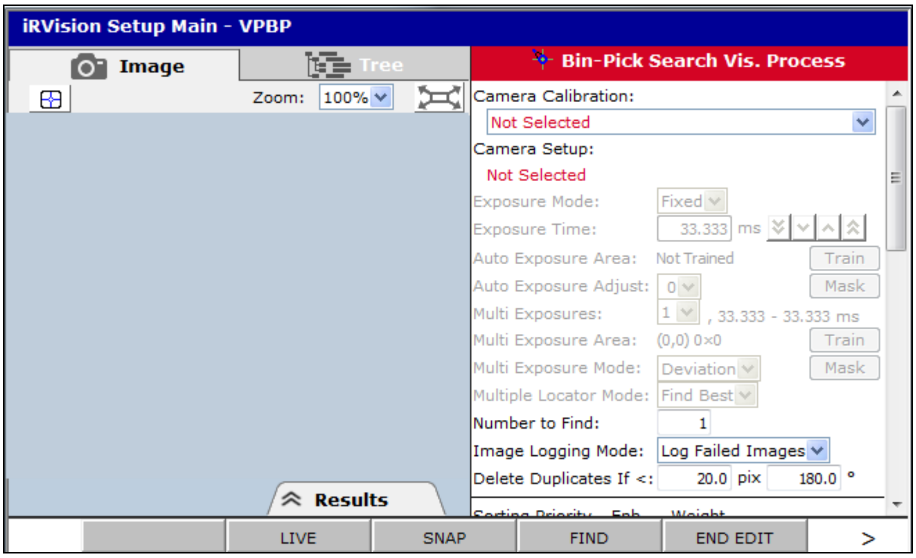


6.11.1 Setting up a Vision Process

If you open the setup page of [Bin-Pick Search Vis.Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use.

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Multiple Locator Find Mode

If you have created more than one locator tool, select how to execute those tools.

Find Best

All the locator tools will be executed, and the best result will be chosen. This is effective when you want to identify the type or put location accuracy before processing time.

Find First

The locator tools will be executed sequentially from the top. The location process will stop as soon as the specified number of workpieces have been found. The subsequent locator tools will not be executed.

Number to Find

Enter the maximum number of workpieces to be found per measurement. The specifiable range is 1 to 100.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds per camera view.

Delete Duplicates If <

The position and angle of each found result are checked to see whether the result is duplicated with another result. If there are multiple found results within the specified pixels and angle, the results are assumed to indicate the same workpiece and only the found result with the highest score is output.

Sorting Priority

Specify the priority to determine the pick-up order to be applied when more than one workpiece has been found. The [Bin-Pick Search Vis.Process] calculates the priority using the results of the following five items and sorts the results unlike other vision processes. You can specify which items are used for priority calculation and how much these items reflect the calculation by checking [Enabled] for each required item and setting weight for them. Priorities calculated according to these settings are relative values for comparing workpieces with each other. The same priority is not always given to a found workpiece with the same size and score because calculation is performed so that the average priority of all workpieces found at a time is almost 50.

Height

Priority is given to a workpiece with the largest Z value in the application user frame.

Score

Priority is given to a workpiece with a high score in the found result.

Aspect

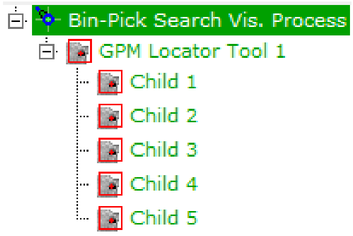
Priority is given to a workpiece with a high ellipticity, that is, a small inclination.

Diff.Height

Priority is given to a workpiece with a height closest to the height (Z value in the application user frame) of the workpiece last picked out.

Child N Found

As a pattern match model, the entire workpiece is taught to the parent pattern match tool. Then, as a child tool of the parent pattern match, part of the workpiece is taught. Priority is given to a workpiece with the maximum number of child tools. Use this item when you want to give priority to a workpiece with a small section hidden by another workpiece.



Reference Data

The reference data is used to calculate offset data from the found results. The vision processes can have more than one reference data. Typically, the vision process only has one reference data. However, in such a case two types of workpieces are mixed, it is required to set the parameter which used to determine the Z-direction height of the workpiece, the reference data and so on for each types of workpieces, so two reference data are used.

Adding reference data

You can add reference data as follows.

1. Tap button.
2. In [Model ID], enter the model ID for which to use the reference data.

Deleting reference data

You can delete reference data as follows, if there is more than one set.

1. Select the reference data you want to delete using the index drop-down list
2. Tap button.

Setting the Reference Height and Size

Use this item when [Calculate From Found Scale] is chosen in [App. Z Mode]. Set the relationship between the actual Z-direction height of the workpiece and the apparent size of the workpiece captured by the camera.

1. Place one workpiece in the field of view. Determine the height of the workpiece above or below the application user frame, this can be done using the robot with a pointer tool if desired. Enter this height data in [Reference Height 1].
2. Press F3 SNAP and then press F4 FIND to find the workpiece. Then, tap the [Set] button and set [Reference Scale 1].
3. Place a second workpiece in the field of view at a different height than the first. Determine the height of the workpiece above or below the application user frame, enter this height data in [Reference Height 2].
4. Press F3 SNAP and then press F4 FIND to find the workpiece. Then, tap the [Set] button and set [Reference Scale 2].

Ref. Pos. Status

If the reference position is set, [Set] is displayed in green; otherwise, [Not Set] is displayed in red.

Reference X, Y, Z, W, P, R

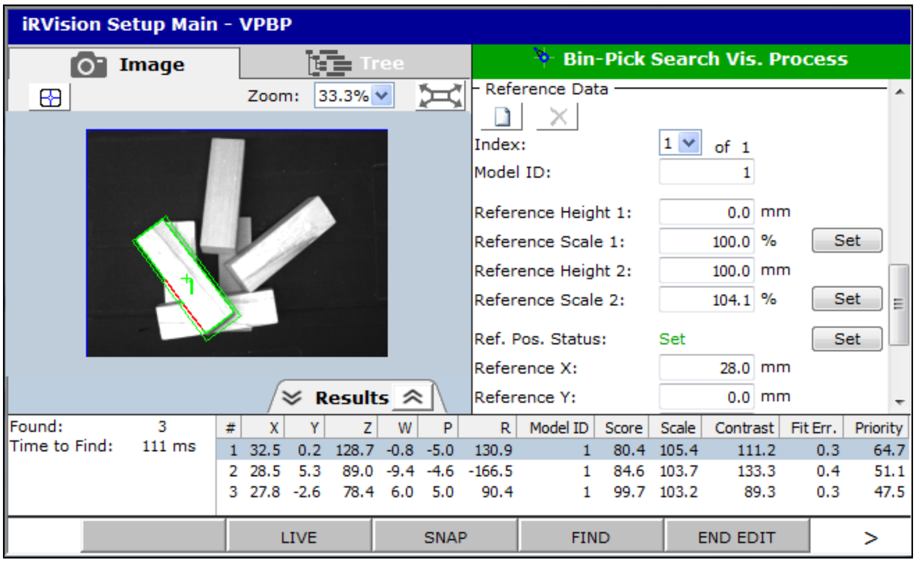
The coordinates of the set reference position are displayed.

Offset Limit

Specify the condition used to check whether the calculated offset value is within the specified range. By default, [None selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, see Section 8.2, "OFFSET LIMIT".

6.11.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found

The number of found workpieces is displayed.

Time to Find

The time the vision process took is displayed in milliseconds.

Found Results table

The following values are displayed.

X, Y, Z

Coordinates of the model origin of the found workpiece (units: mm).

W, P

Inclination of the gaze line connecting the camera and found workpiece (units: degrees).

R

Rotation angle of the found workpiece around the Z-axis (units: degrees).

Model ID

Model ID of the found workpiece.

Score
Score of the found workpiece.

Size
Size of the found workpiece.

Contrast
Contrast of the found workpiece.

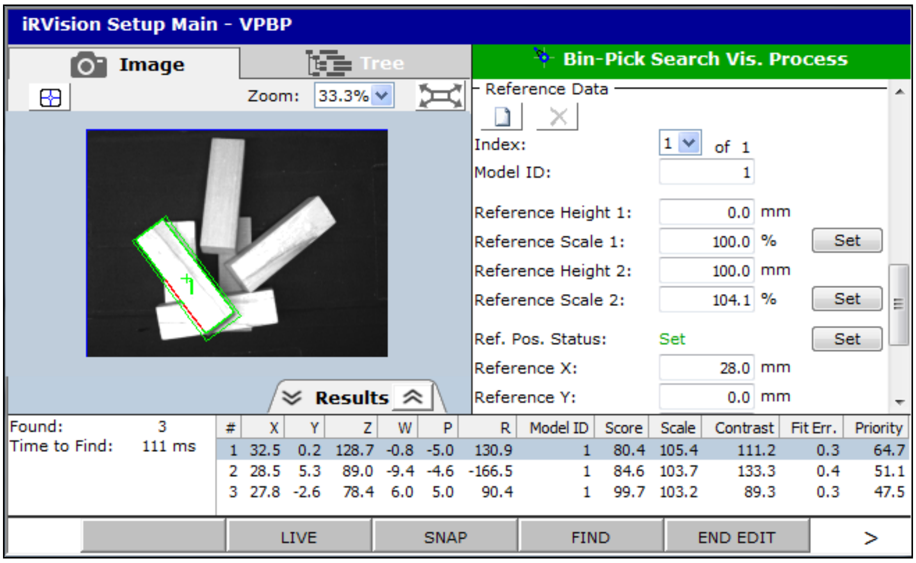
Fit Err.
Elasticity of the found workpiece (units: pixels).

Priority
Pick-up priority given to the found workpiece.

> **NOTE**
> If you run a find test without setting the reference Z-direction height or size, ******** is displayed for X, Y, Z, W, P, and R because these values cannot be calculated.

6.11.3 Setting the Reference Position

Set the reference position. The offset value is calculated based on the relationship between the reference position you set here and the found position.



1. Open the vision process Setup Page.
2. Place a workpiece in the camera view for which you want to set the reference position.
3. Press F3 SNAP and then press F4 FIND to find the workpiece.
4. Tap the [Set] button.
5. Check that [Ref. Pos. Status] is set to [Set] and that a value is displayed for each reference position element.

Teach the robot the position where the workpiece is when the reference position is set. Teach the position to the robot without moving the workpiece.

6.11.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

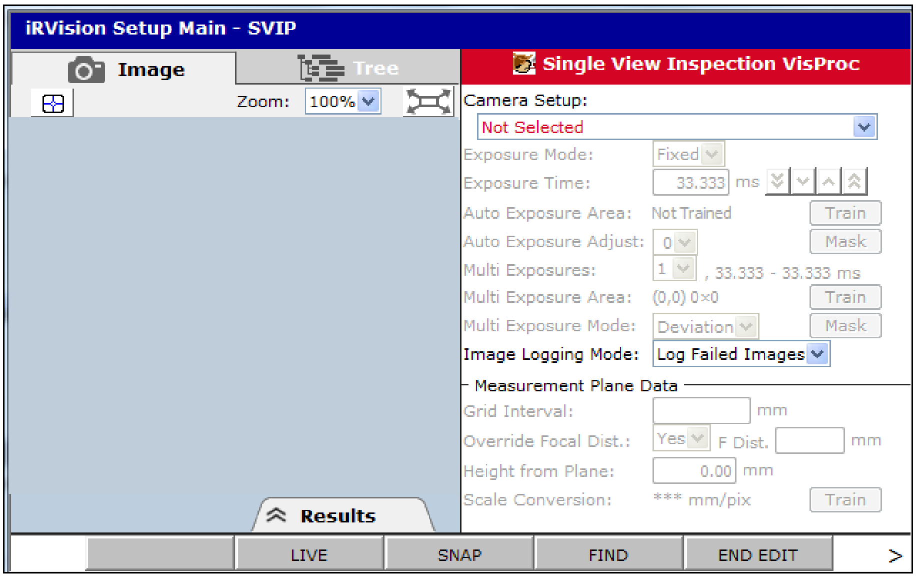
Specify a number between 1 and 6.

6.12 SINGLE VIEW INSPECTION VISION PROCESS

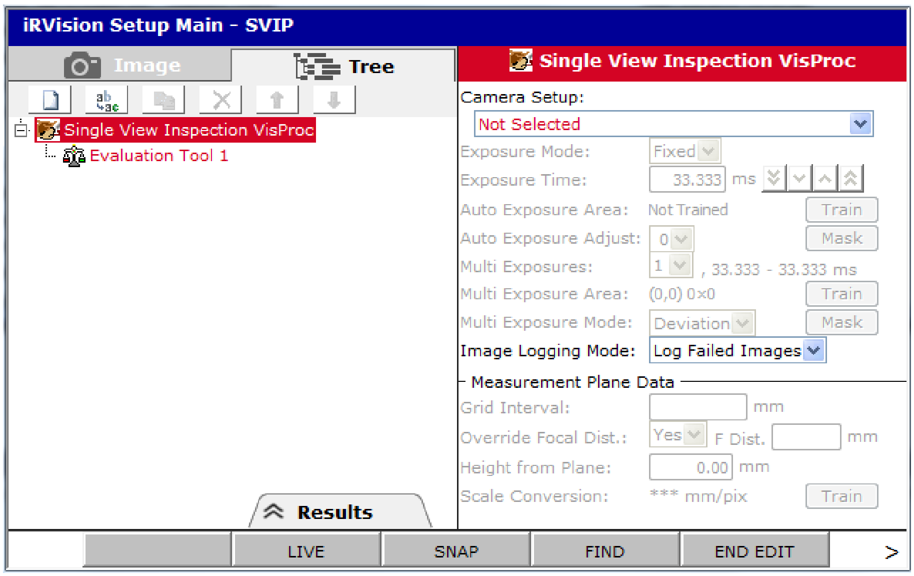
The single view inspection vision process, unlike ordinary vision processes intended for robot position offsetting, makes "pass or fail" judgment as to inspection results.

6.12.1 Setting up a Vision Process

If you open the setup page of [Single-View Inspection], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Setup
Select the camera to be used.

Setting the Exposure Time
Set the exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Image Logging Mode
Specify whether to save images to the vision log when running the vision process.

Do Not Log
Do not save any images to the vision log.

Log Failed Images
Save images only when the inspection result is "fail" or when judgment cannot be made.

Log All Images
Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds per camera view.

6.12.2 Setting a Measurement Plane

In a single view inspection vision process, measure length is either evaluated as the number of pixels on the image or as a value converted into millimeters. To convert length into millimeters, mount the calibration grid at the same height as the measurement plane, snap the grid pattern with the camera, and set the measurement plane information. In this tutorial, the measurement plane is set because the width of the connector needs to be evaluated in millimeters.

Grid Interval

Input the grid interval of the calibration grid in millimeters.

Override Focal Dist.

Select [Yes] and input the nominal focal distance of the lens in millimeters.

It is possible to select [No] to calculate the focal distance automatically. However, when the camera optical axis is perpendicular with the calibration grid, the focal distance cannot be calculated correctly. If the focal distance calculated automatically deviates from the nominal focal distance by ±10% or more, select [Yes] and input the nominal focal distance of the lens used.

Height from Plane

The measurement plane offset value needs to be specified when the height of the measurement plane to be set (height of the target to be measured) differs from the height of the grid pattern plane of the placed calibration grid. Input a positive value in millimeters when the measurement plane to be set is closer to the camera than the grid pattern plane or a negative value when the measurement plane is farther from the camera than the grid pattern plane.

Teaching a Measurement Plane

Snap an image of the calibration grid and set the measurement plane. Press F3 SNAP to capture the image and tap the [Train] button.
Adjust the red rectangle so that the grid is included in the frame. Since the calibration grid is generally placed so that the grid is displayed over the entire field of view, the purple rectangle is set to the full screen mode. When the F4 OK is pressed, the calibration grid is detected and the measurement plane is set.

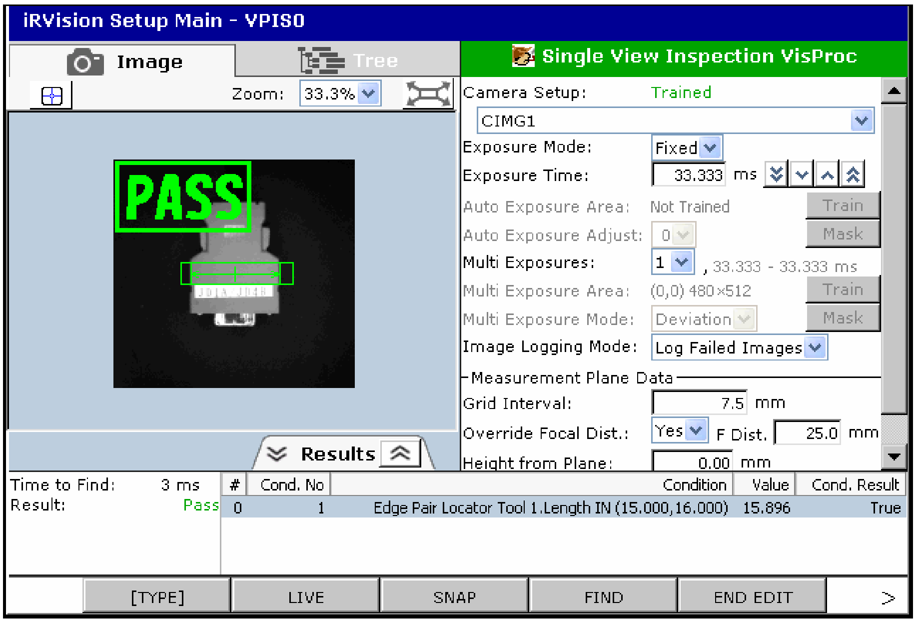
When the measurement plane is set, the average scale on the set measurement plane is displayed in [Scale Conversion]. The scale indicates the conversion factor between one pixel on the image and the length in millimeters on the measurement plane, and its unit is mm/pix. When there is lens distortion or the camera optical axis is not perpendicular to the measurement plane, the scale is not even in the image. So the shown scale is the average value.

When the [Train] button is tapped and the measurement plane has already been taught, a message would appear asking whether the measurement plane information should be changed or the change should be canceled. If there are command tools that had already been taught, a change in the measurement plane may change their measurement results. If the measurement plane is re-taught, these command tools may need to be taught again as necessary.

> ⚠ **CAUTION**
> When the measurement plane is taught after command tools had been taught, it is recommended to re-train those command tools that have measurement values subjected to millimeter conversion.

6.12.3 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Time to Find

The time the vision process took is displayed in milliseconds.

Result

The result of the single view inspection is displayed.

Found Result Table

These evaluation results are displayed.

Cond. No

Number of the conditional expression.

Condition

Conditional expression that is set.

Value

Evaluation target value evaluated with the conditional expression.

Cond. Result

Evaluation result of the conditional expression

6.12.4 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

Number of Exposure

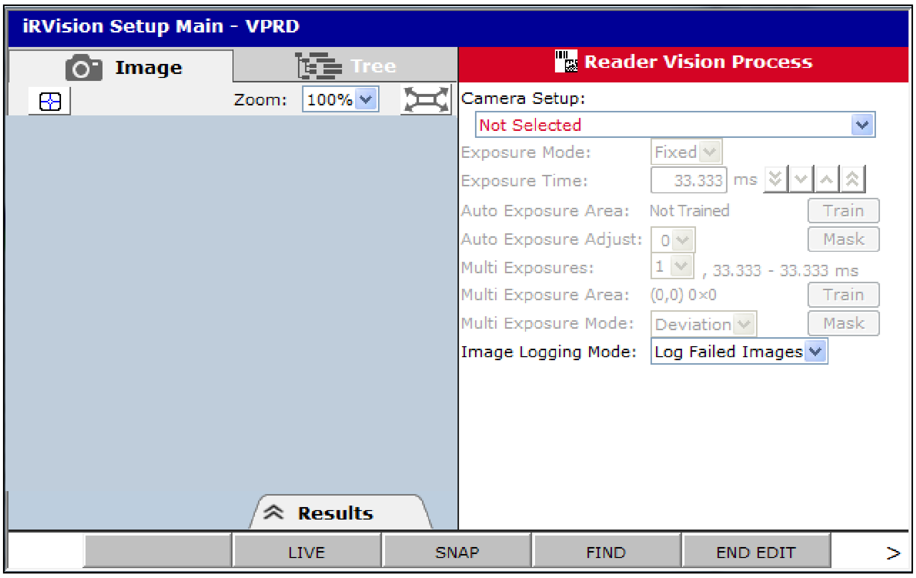
Specify a number between 1 and 6.

6.13 READER VISION PROCESS

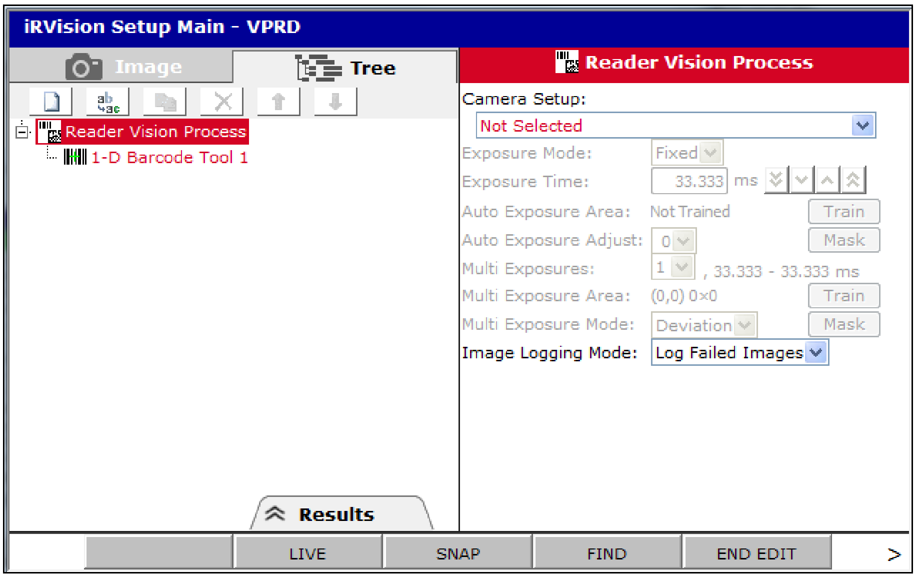
Reader vision process, unlike ordinary vision processes that returns vision offset to compensate robot positions, reads the barcode and returns a result string.

6.13.1 Setting up a Vision Process

If you open the setup page of [Reader Vision Process], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera
Select a camera to be used.

Setting the Exposure Time
Set the exposure time to be applied when running the vision process. For detailed information about the individual items to be set, see Subsection 3.7.11, "Setting an Exposure Mode".

Image Logging Mode
Specify whether to save images to the vision log when running the vision process.

Do Not Log
Do not save any images to the vision log.

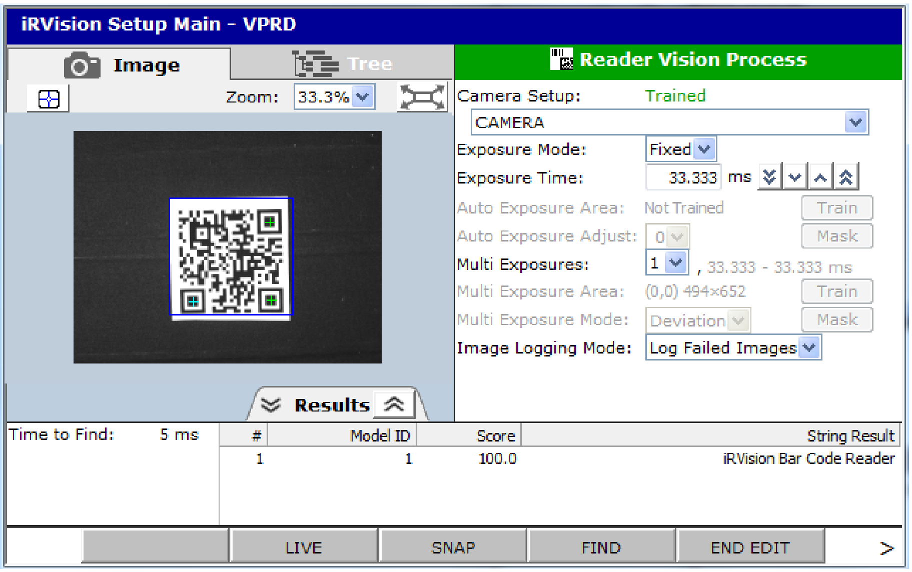
Log Failed Images
Save images only when the vision operation fails.

Log All Images
Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds per camera view.

6.13.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Time to Find
The time the vision process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

Model ID

Model ID of the found barcode.

Score

Score of the found barcode

String Result

String of the found barcode.

6.13.3 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time

Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

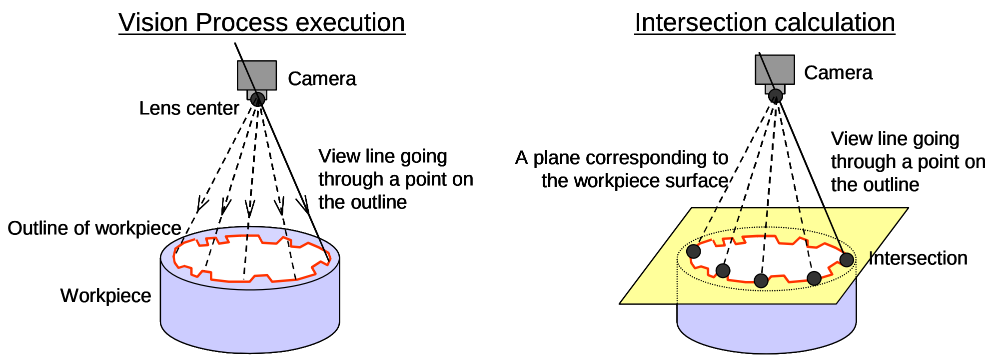
Number of Exposure

Specify a number between 1 and 6.

6.14 IMAGE TO POINTS VISION PROCESS

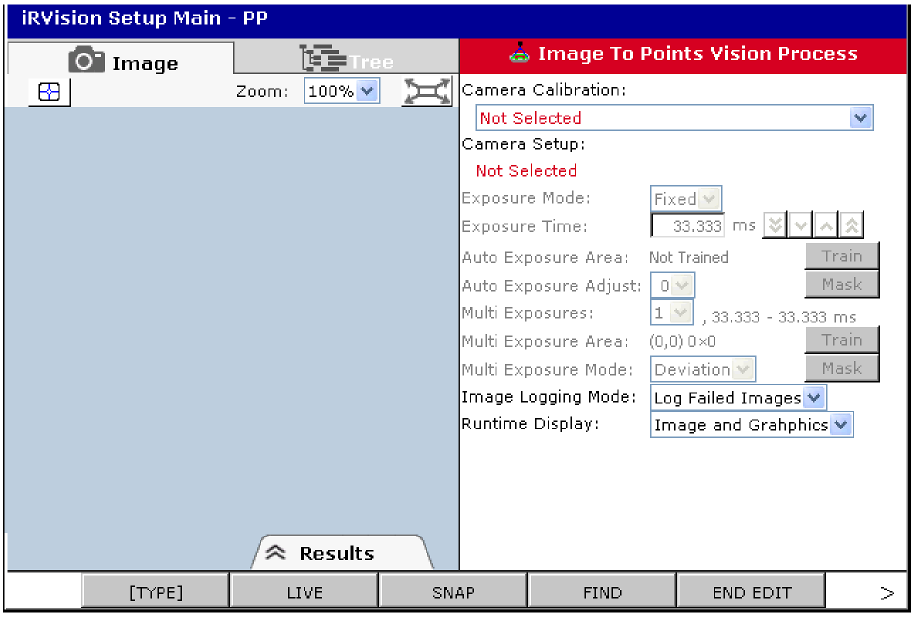
This vision process extracts points on the outline of a workpiece and output view lines data which go through the points. The 3-D positions of extracted points can be obtained by calculating the points of intersection of the view lines and the plane corresponding to the workpiece surface. The 3-D positions can be used to generate a robot motion path automatically.

> ⚠ **CAUTION**
> This vision process does not use program commands for *i*RVision because specific applications use this vision process and each application provides KAREL programs to execute this vision process.

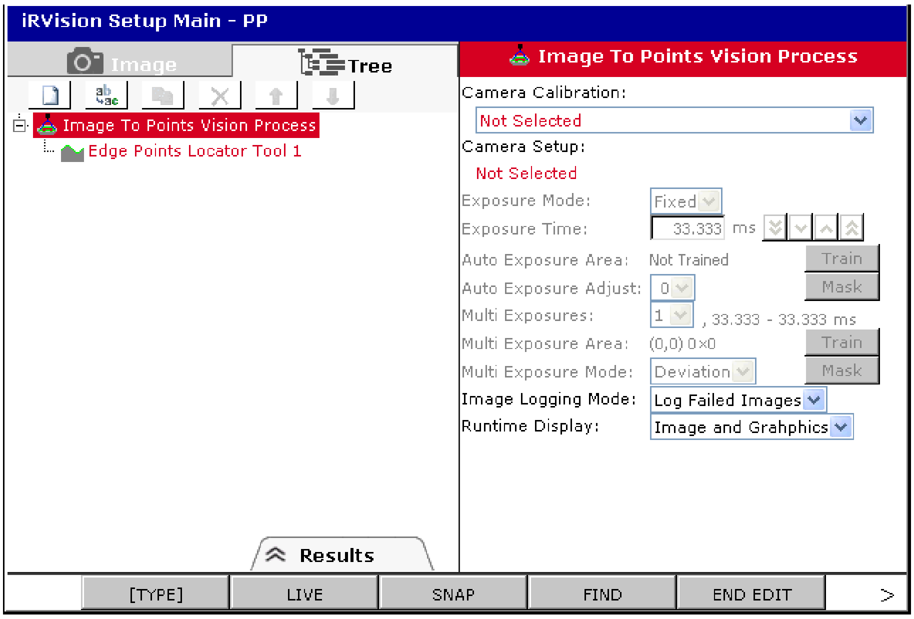


6.14.1 Setting up a Vision Process

If you open the setup page of [Image To Points], a screen like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Camera Calibration

Select the camera calibration you want to use. You can use the following types of camera calibrations.

- Grid Pattern Calibration
- Robot-Generated Grid Calibration
- 3D Laser Vision Calibration

Camera Setup

The name of the camera specified for the selected camera calibration is displayed.

Setting the Exposure Time

Set the camera's exposure time to be applied when running the vision process.

Image Logging Mode

Specify whether to save images to the vision log when running the vision process.

Do Not Log

Do not save any images to the vision log.

Log Failed Images

Save images only when the vision operation fails.

Log All Images

Save all images.

> ⚠ **CAUTION**
> The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to save images depends on the type of memory card in use and is typically between 200 and 400 milliseconds per camera view.

Runtime Display:

Select what will be displayed on the runtime monitor.

Image and Graphics

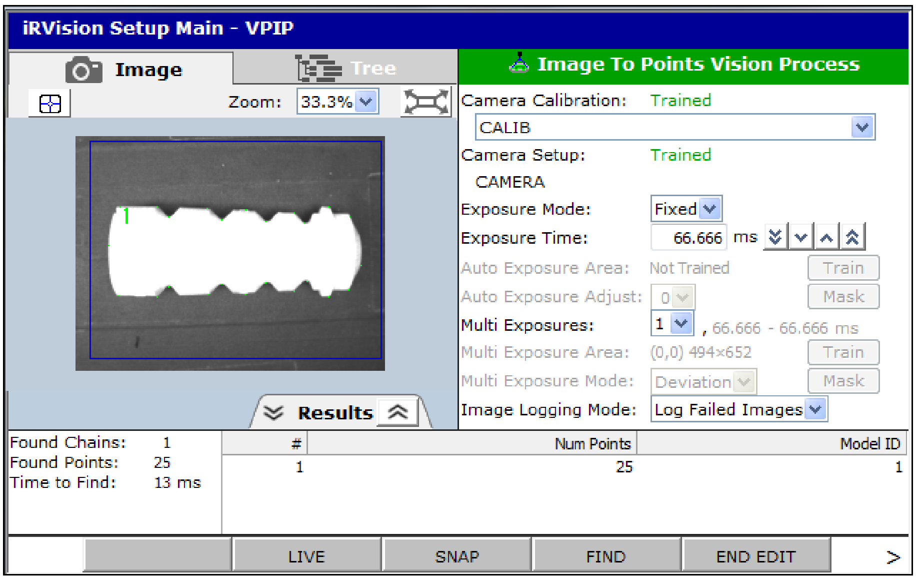
The camera image and found results will be displayed.

Image Only

Only the camera image will be displayed. When [Image Only] is selected, the process time is faster than [Image and Graphics] at runtime.

6.14.2 Running a Test

Press F4 SNAP to run a test and check whether the tool behaves as expected.



Found Chains
The number of found chains is displayed.

Found Points
The total number of the points extracted from found chains is displayed.

Time to Find
The time the vision process took is displayed in milliseconds.

Found Result Table
The following values are displayed.

Model ID
Model ID of each found chain.

Num Points
The number of points extracted from each found chain.

6.14.3 Overridable Parameters

This vision process has the following overridable parameters that can be overridden with Vision Override. See 8.1 “VISION OVERRIDE” and 9.2.2.13 “OVERRIDE” for details.

Exposure Time
Specify a number in milliseconds. If [Exposure Mode] of the vision process is set to [Auto], [Exposure Mode] is temporarily changed to [Fixed] to use the specified exposure time when you override the exposure time of the vision process.

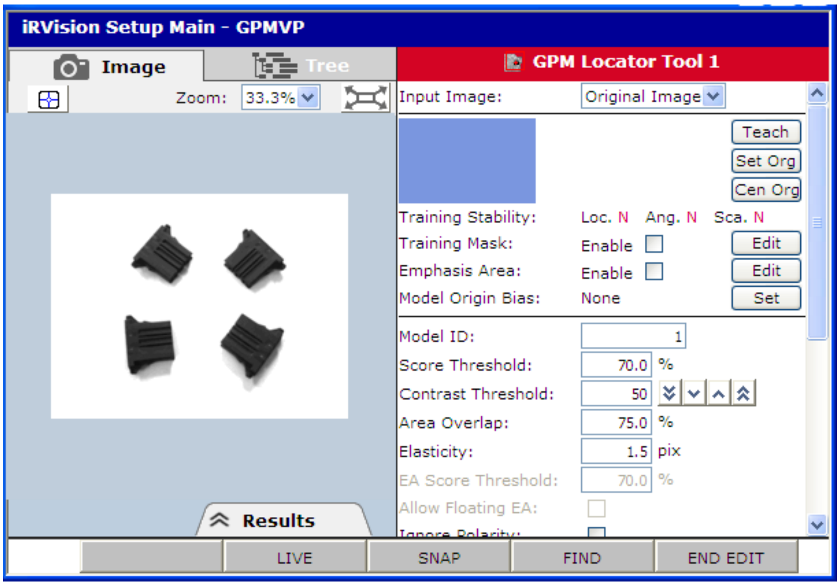
Number of Exposure
Specify a number between 1 and 6.

7 COMMAND TOOLS

This chapter explains how to set the command tools.

7.1 GPM LOCATOR TOOL

The GPM Locator tool employs the image processing tool that is the core of *i*RVision. It checks a camera-captured image for the same pattern as a model pattern taught in advance and outputs its location. If you select the GPM Locator tool in the tree view of the setup page for the vision process, a setup page like the one shown below appears.



Input Image

Select the image which is used for training model and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this GPM Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.1.1 Setting up a Model

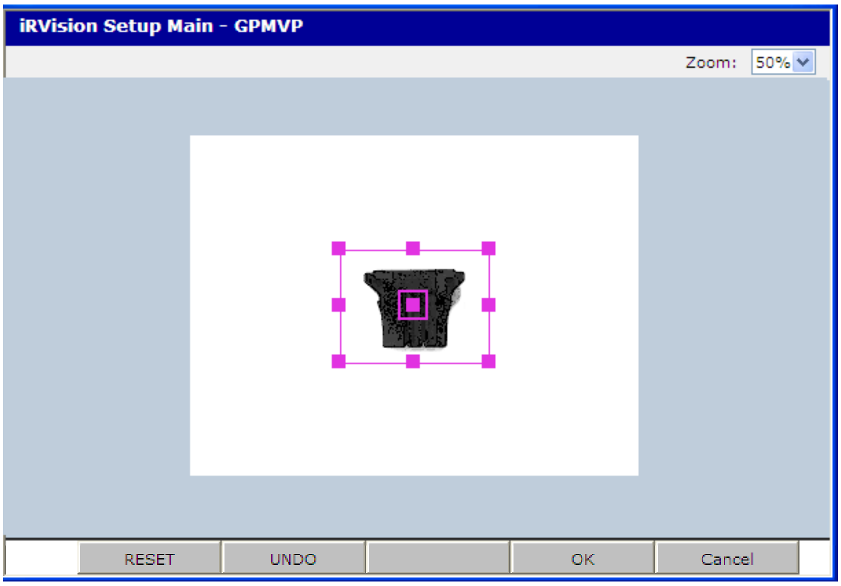
Teach the model pattern of the workpiece you want to find.

Teaching the model pattern

Teach the model pattern as follows.

1. Press F2 LIVE to change to the live image display.
2. Place the workpiece near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4. Tap the [Teach Pattern] button.

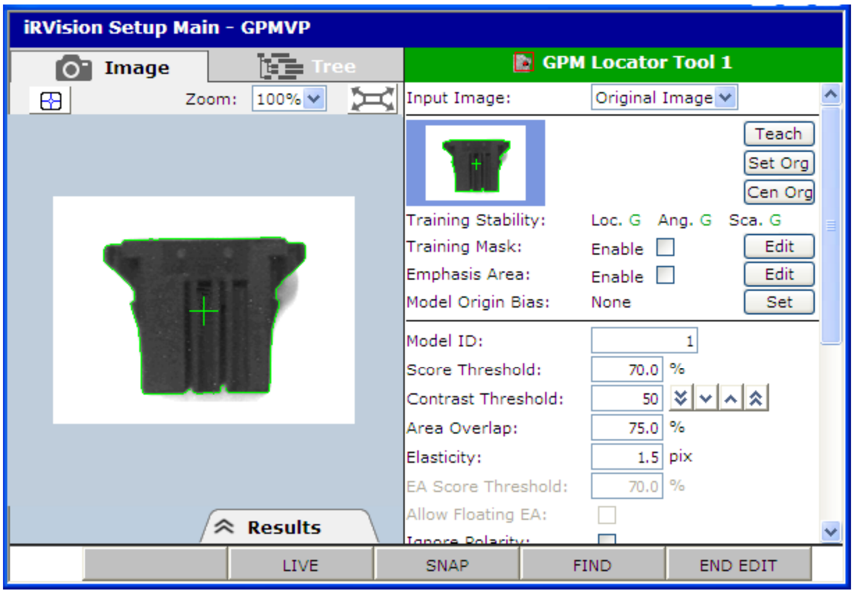
5. Enclose the workpiece within the red rectangle that appears, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, "Setting Window".



Training Stability

The evaluation results for items [Location], [Orientation], and [Scale] of the taught model pattern are displayed as one of the following three levels:

Good: Can be determined stably.
Poor: Cannot be determined very stably.
None: Cannot be determined.



If Poor or None is displayed for an item, perform the relevant operation as follows.

Location:

Poor: Use the emphasis area or change the part to be taught as a model pattern.
None: Change the part to be taught as a model.

Orientation:

Poor: Use the emphasis area or change the part to be taught as a model pattern.
None: Uncheck the [Orientation] check box.

Scale:

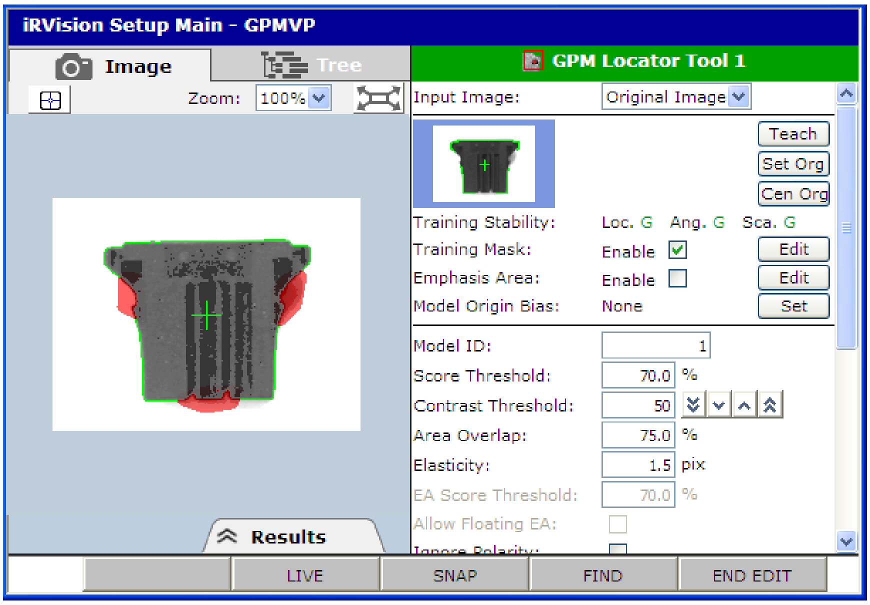
Poor: Use an emphasis area or change the part to be taught as a model pattern.
None: Uncheck the [Scale] check box.

> **NOTE**
> For detailed information about items such as a model pattern, which can be found stably, see Subsection 7.1.5.2, “Model Pattern” in Subsection 7.1.5, “Setup Guidelines".

Training Mask

If the taught model pattern has any unnecessary items in the background, any unwanted or incorrect features not found in all other parts, or any blemishes, you can remove them from the pattern by filling that part with the color of red.

To edit a training mask, tap the [Edit] button on the [Training Mask] line. When an enlarged view of the model pattern appears on the image display control, fill the unnecessary part of the model pattern with the color of red. For detailed information about the operation method, see Subsection 3.7.10, “Editing Mask”.



Model Origin

The "model origin" is the point that numerically represents the location of the found pattern. The coordinate values (Row, Column) of the location of the found pattern indicate the location of the model origin. When the found result is displayed on the image, a appears at the model origin.

To move the model origin manually, tap the [Set Org] button. An enlarged view of the model pattern appears on the image display control, and appears at the current position of the model origin. Move the with the mouse to move the model origin. For detailed information about the operation method, see Subsection 3.7.8, “Setting a Point”.

If the taught model pattern is rotatable, you can calculate the rotation center and set the model origin there. For example, when the taught model pattern is a circular hole, the model origin can be set at the center of the circle. To set the model origin at the rotation center, tap the [Cen Org] button. If the model pattern is rotatable, the rotation center is calculated and the model origin is set at the rotation center. If the model pattern is not rotatable and the rotation center cannot be calculated, a message to that effect appears.

Emphasis Area

Use an emphasis area when the position of the workpiece cannot be determined correctly unless attention is paid to a small characteristic part of that workpiece.

To set an emphasis area in the model pattern, tap the [Edit] button on the [Emphasis Area] line. When an enlarged view of the model pattern appears on the image display control, fill the part where you want to set an emphasis area with the color of blue. For detailed information about the operation method, see Subsection 3.7.10, “Editing Mask”.

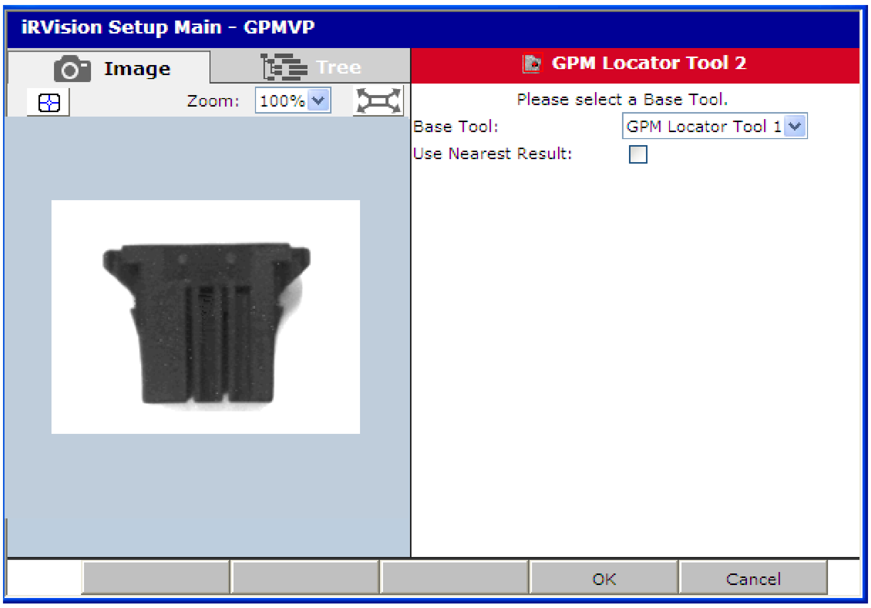
When an emphasis area is used to stabilize orientation calculation or prevent incorrect location, the target object fails to be found if the emphasis area cannot be found. In other words, if the emphasis area cannot be found, the target object goes undetected even when the object itself is detectable.

Bias

The bias function adds bias to the found pose of this GPM Locator Tool so that the tool outputs the same found position data as another GPM Locator Tool that has already been taught when a same workpiece is detected. When this function is used, the same position data is output for a workpieces as far as placed at the same position regardless of whether the workpiece is found by this GPM Locator Tool or another existing GPM Locator Tool, which allows position offset using the same reference position data.

Set the bias as follows:

1. Open the window for setting the GPM Locator Tool you want to set the bias.
2. Tap the [Set] button in [Model Origin Bias].
3. The following page appears. Select the GPM Locator Tool which is already trained as the [Base Tool].



4. Press F4 OK. The tool attempts to find the workpiece using the model image of the reference tool. When the tool finds the workpiece successfully, the bias is set. When the bias is set properly, the model origin is changed so that the tool outputs the same found position as the reference tool.

Usually, the [Use Nearest Result] check box should be unchecked. Then, when the tool finds two or more workpieces in the image, the bias is calculated on the basis of the found workpiece which has the highest score.

In case you want the tool to calculate the bias on the basis of another workpiece in the image, move the model origin of the tool near the model origin of the reference tool manually and check this box. Then, the bias is calculated on the basis of the found workpiece of the model origin of which is the nearest from the model origin the reference tool.

Model ID

When you have taught two or more GPM Locator tools and want to identify which tool was used to detect the workpiece, assign a distinct model ID to each tool. The model ID of the tool, which found the workpieces, is reported to the robot controller along with offset data. This enables the robot program to identify the type of the found workpieces.

7.1.2 Adjusting the Location Parameters

Adjust the location parameters.

Score Threshold

The accuracy of the found result is expressed by a score, with the highest score being 100. The target object is successfully found if its score is equal to or higher than this threshold value. If the score is lower, the target object is not found. Set a value between 10 and 100. The default value is 70. Setting a small value might lead to inaccurate location.

Contrast Threshold

Specify the contrast threshold for the search. The default value is 50. If you set a small value, the tool will be able to find the target in obscure images as well but take longer to complete the location process. The minimum value is 1. If the tool is prone to inadequately find blemishes and other unwanted edges with low contrast, try setting a larger value. Those image features whose contrast is lower than the threshold are ignored. Selecting the [Image+Edges] in [Image Display Mode] lets you check the image features extracted based on the current threshold.

Area Overlap

If the ratio of overlap of the found objects is higher than the ratio specified here, then the found result for the workpiece with the lower score is deleted, leaving only the one with the higher score. The ratio of overlap is determined by the area where the models' external rectangular frames overlap. If you specify 100% as the limit value, the found results will not be deleted even if the workpieces overlap.

Elasticity

Specify a pixel value to indicate how much the pattern in the image is allowed to be deviated (distorted) in geometry from the taught model. Setting a large value enables the tool to find the target in images that are greatly deviated in geometry. However, the larger the value is, the more likely inaccurate location becomes.

EA Score Threshold

Besides the score threshold for the entire model, specify the score threshold for the emphasis area alone indicating how high the score must be for the object to be found. The default value is 70 points.

Allow Floating EA

This can be specified to allow the tool to find an object even if the position of the emphasis area is deviated by two to three pixels relative to the position of the entire model pattern.

Search Window

Specify the range of the area of the image to be searched. The narrower the range is, the faster the location process ends. The default value is the entire image. To change the search window, tap the [Set] button. When a rectangle appears on the image, adjust its geometry, as when teaching a model. For detailed information about the operation method, see Subsection 3.7.9, “Setting a Window”.

Run-Time Mask

Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle- or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, “Editing a Mask”.

DOF - Orientation

Specify the range of orientation subject to be searched. The tool searches for a model rotated in the range specified by [Minimum] and [Maximum], with the orientation of the taught model being 0 degrees. The specifiable value range is from −360 to +360 degrees for both [Minimum] and [Maximum]. The narrower the orientation range is, the faster the search process ends. If a range wider than 360 degrees is specified, the range is automatically corrected to the range of −180 to +180 degrees when the vision process runs.

If you uncheck this box, the orientation is ignored and the tool searches only for a model having the orientation specified in [Nominal].

By default, the orientation search is enabled and the range is from −180 to +180 degrees.

DOF - Scale

Specify the range of scale to be searched. With the size of the taught model being 100%, the tool searches for a model expanded or reduced by the ratio specified in [Minimum] and [Maximum]. The specifiable value range is from 25% to 400% for both [Minimum] and [Maximum]. The narrower the size range is, the faster the search process ends.

If you uncheck this box, the scale is ignored and the tool searches only for a model having the scale specified in [Nominal].

By default, the scale search is disabled.

DOF - Aspect

Specify the range of aspect ratios to be searched. With the ratio of the taught model being 100%, the tool searches for a model flattened by the ratio specified in [Minimum] and [Maximum]. The specifiable value range is from 50% to 100% for both [Minimum] and [Maximum]. The narrower the aspect ratio range is, the faster the search process ends.

If you uncheck this box, the aspect ratio is ignored and the tool searches only for a model having the aspect ratio specified in [Nominal].

By default, the aspect ratio search is disabled.

Time-out

If the location process takes longer than the time specified here, the tool ends the process without finding all of the workpieces.

Result Plotting Mode

Select how the found results are to be displayed on the image after the process is run.

Plot Everything

The origin, features, and rectangle of the model will be displayed.

Plot Edges

Only the origin and features of the model will be displayed.

Plot Bounding Box

Only the origin and rectangle of the model will be displayed.

Plot Only Origin

Only the origin of the model will be displayed.

Plot Nothing

Nothing will be displayed.

Image Display Mode

Select the image display mode for the Setup Page.

Image

Only the camera image will be displayed.

Image+Results

The camera image and found results will be displayed.

Image+Edges

The camera image and features of the image will be displayed.

Pattern

The taught model pattern will be displayed. The features will be indicated in green, and the emphasis area in blue.

Pattern+Mask+EA

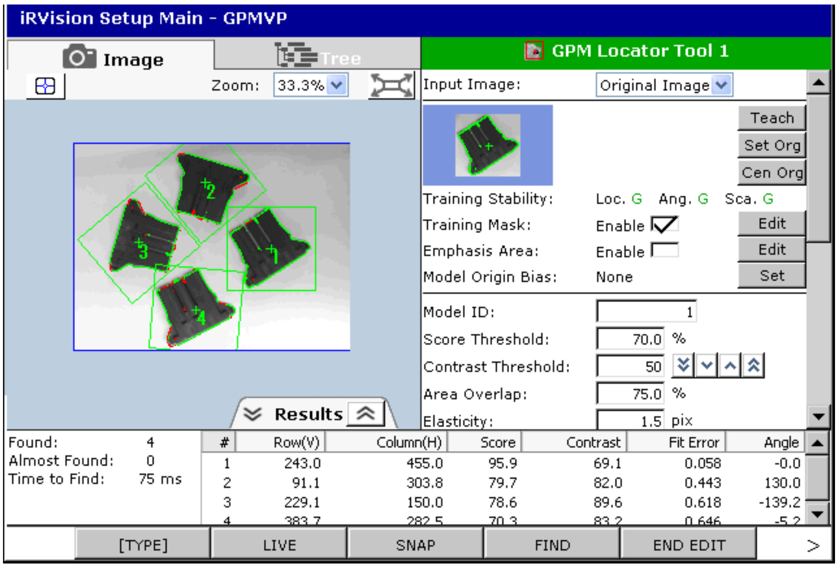
The taught model pattern, with an area overlaid that is masked as the emphasis area, will be displayed.

Show Almost Found

If there is any workpiece that failed to be found because it fell just short of meeting the score, contrast, orientation, scale, and/or other conditions, its test result is displayed. The result appears in a red rectangle on the image.

7.1.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Found
The number of found workpieces is displayed.

Almost Found
The number of workpieces that failed to be found because they were slightly outside the specified range is displayed. "0" is displayed if the [Show Almost Found] check box is not checked.

Time to Find
The time the location process took is displayed in milliseconds.

Found Result Table
The following values are displayed.

Row, Column
Coordinate values of the model origin of the found pattern (units: pixels).

Score
Score of the found pattern.

EA Score
Score for the emphasis area only. This is displayed only when the box for the emphasis area is checked.

Contrast
Contrast of the found pattern.

Fit Error
Deviation of the found pattern from the model pattern (units: pixels).

Angle

Orientation of the found pattern (units: degrees). This is displayed only when the box for the orientation search is checked.

Scale

Scale of the found pattern (units: %). This is displayed only when the box for the scale search is checked.

Aspect

Aspect ratio of the found pattern (units: %). This is displayed only when the box for the aspect ratio search is checked.

Skew

Skew angle of the found pattern (units:degrees). This is displayed only when the box for the aspect ratio search is checked.

7.1.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. See 8.1 "VISION OVERRIDE" and 9.2.2.13 "OVERRIDE" for details.

Score Threshold

Specify a number between 10 and 100.

Contrast Threshold

Specify a number between 1 and 250.

Elasticity

Specify a number between 1 and 5.

DOF Angle

Enable/disable selection, minimum angle, maximum angle and nominal angle can be specified. Specify 0 for disable or 1 for enabled. Specify a number between –360 and 360 for the minimum, maximum and nominal angles.

DOF Scale

Enable/disable selection, minimum scale, maximum scale and nominal scale can be specified. Specify 0 for disable or 1 for enabled. Specify a number between 25 and 400 for the minimum, maximum and nominal scales.

DOF Aspect Ratio

Enable/disable selection, minimum aspect ratio, maximum aspect ratio and nominal aspect ratio can be specified. Specify 0 for disable or 1 for enabled. Specify a number between 50 and 100 for the minimum, maximum and nominal aspect ratios.

7.1.5 Setup Guidelines

Read these guidelines for a deeper understanding of how the GPM Locator tool works.

7.1.5.1 Overview and functions

This section provides an overview of the GPM Locator tool, describing what you can do and how you see objects with this tool.

What you can do with the GPM locator tool

The GPM Locator Tool offers image processing capabilities to process images captured by the camera, find the same pattern in an image as the pattern taught in advance, and output the position and orientation of the found pattern. The pattern taught in advance is called a model pattern, or simply a model.

As the position and orientation of the object placed within the camera view change, the position and orientation of the figure of that object captured through the camera also change accordingly. The GPM Locator Tool finds where the same pattern as the model pattern is in the image fed from the camera.

If the figure of the object in the image has same pattern as the model pattern, the Locator Tool can find it, regardless of differences of the following kinds:

- Linear movement: The position of the figure in the image is different than in the model pattern.
- Rotation: The apparent orientation of the figure in the image is different than in the model pattern.
- Expansion/reduction: The apparent size of the figure in the image is different than in the model pattern.

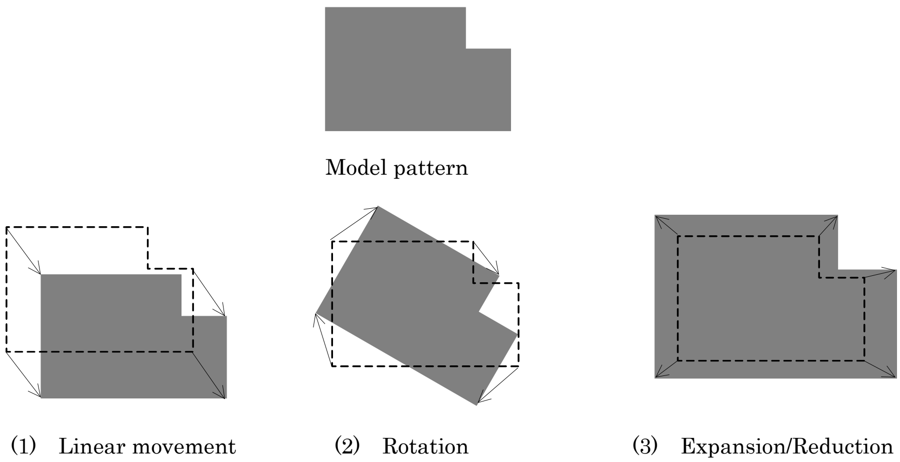


Fig 7.1.5.1 (a) Pattern movement

What is the same pattern?

What does the GPM Locator Tool consider the "same pattern" as the model pattern? The GPM Locator Tool has two criteria to judge whether a pattern is the "same pattern" as the model pattern. When the pattern meets both of the criteria, the GPM Locator Tool regards it as the "same pattern".

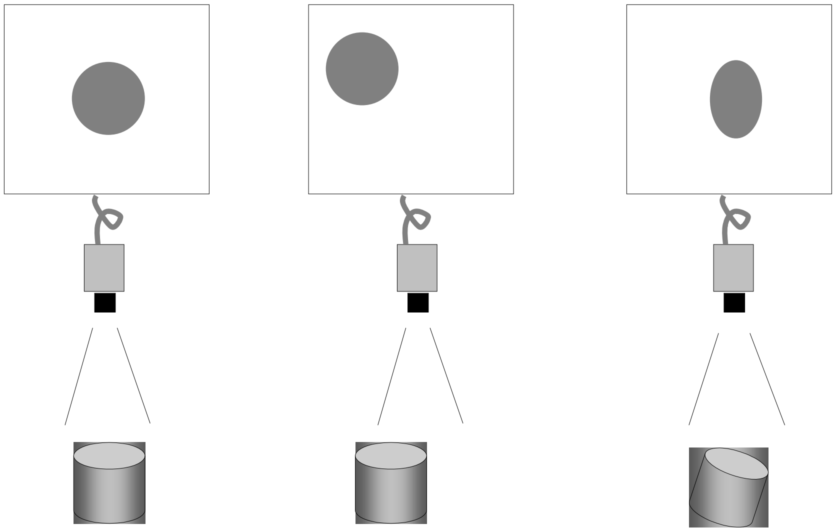
- The figure has the same geometry.
- The figure has the same dark/light polarity.

An understanding of what the GPM Locator Tool considers the same pattern helps you make the tool find eligible patterns with increased stability.

Figure having the same geometry

First, we will discuss about a "figure having the same geometry".

For example, suppose that you look at circular cylinders via a camera, as in Fig. 7.1.5.1(b). While the figures in Fig. 7.1.5.1(b) (i) and Fig. 7.1.5.1(b) (ii) differ in position in the image, they are considered to have the "same geometry" because both appear to be a perfect circle. The figure in Fig. 7.1.5.1(b) (iii), on the other hand, appears to be an ellipse in the image because the object is seen obliquely from the camera, whereas it is in fact a circular cylinder like the objects in Fig. 7.1.5.1(b) (i) and Fig.7.1.5.1(b) (ii). Therefore, the tool considers the figure in the image in Fig. 7.1.5.1(b) (iii) to have a "different geometry" from those in Fig. 7.1.5.1(b) (i) and Fig. 7.1.5.1(b) (ii).



(i) (ii) (iii)

Fig 7.1.5.1 (b) When seen from the

Conversely, if the actual objects differ in geometry but their figures captured by the camera happen to be geometrically identical, the GPM Locator Tool judges them to have the "same geometry".

Image distortion

There is another factor to consider when determining whether the figure in the image is geometrically identical. It is "image distortion".

No image captured via a camera is immune to distortion. Distortion occurs for a variety of reasons including distortion of the camera lens itself, lack of parallelism between the lens and the light receiving element surface, digitizing error, and improper lighting on the workpiece. Because of distortions resulting from these problems, for example, the figure of a square workpiece captured by the camera can be distorted in various ways, thus making the figure not exactly square. Also, when you snap an image of the same object several times, each resultant image might be distorted in a slightly different way due to a minor change in lighting or another factor.

One obstacle to the GPM Locator Tool finding the same pattern as the model pattern in the image is the "differences in distortion between the model pattern and the pattern in the image" stemming from these image distortions. The model pattern is distorted, and so is the pattern in the image. The problem is that the two models are distorted differently.

The GPM Locator Tool is designed to allow a "certain degree of geometric deviation" between two patterns. Fig. 7.1.5.1(c) shows a little exaggerated example where the dotted line represents the pattern taught as the model with the solid line representing the pattern found in the image. If the deviation between these two patterns is within the allowable range, the GPM Locator Tool judges them to be geometrically identical.

If there is any part where the deviation is greater than the allowable range, the GPM Locator Tool regards the part as "missing from the pattern in the image", judging that its geometry is different only in that particular part.

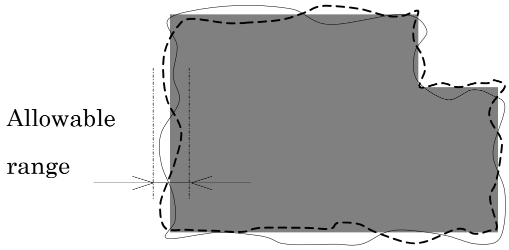


Fig 7.1.5.1(c) Geometric deviation

Also, the phenomenon of a circular cylinder being presented as an ellipse, as in Fig. 7.1.5.1(b), might be due to an image distortion occurring because the camera's optical axis is not perpendicular to the surface of the circular cylinder. Therefore, even when the object is slightly slanted, it is judged to have the same geometry if the resulting distortion is within the allowable range.

Figure having the same dark/light polarity

Next, we will discuss about a "figure having the same dark/light polarity".

Suppose you have two images as shown in Fig. 7.1.5.1(d) (i) and Fig.7.1.5.1(d) (ii). The figures in Fig. 7.1.5.1(d) (i) and Fig. 7.1.5.1(d) (ii) have the same geometry because both are squares of the same size. However, Fig. 7.1.5.1(d) (i) has a dark square on a light background, while Fig. 7.1.5.1(d) (ii) has a light square on a dark background. The difference between these two concerns "which is light, workpiece (square) or background", i.e. the difference in dark/light polarity. If the patterns differ in dark/light polarity, the Locator Tool judges them different even when they are geometrically identical.

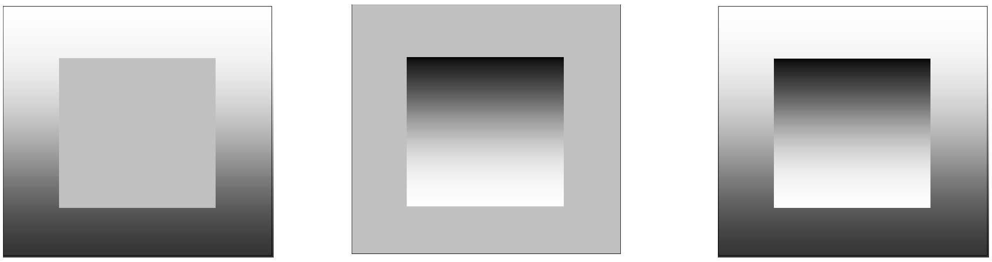
Therefore, if you teach a model pattern like the one in Fig. 7.1.5.1(d) (i), the tool cannot find a pattern like the one in Fig. 7.1.5.1(d) (b).

(i) **(ii)**

Fig 7.1.5.1 (d) Dark/light polarity

Next, suppose that you teach the pattern in Fig. 7.1.5.1(d) (i) as the model pattern and then obtain images with the patterns shown in Fig. 7.1.5.1(e). The image in Fig. 7.1.5.1(e) (i) has uneven brightness in the background, and the image in Fig. 7.1.5.1(e) (ii) has uneven brightness in the workpiece (square). The image in Fig. 7.1.5.1(e) (iii) has uneven brightness in both the background and the workpiece.

These three patterns all have the same dark/light polarity as Fig. 7.1.5.1(d) (i) in the upper half of the square and as Fig. 7.1.5.1(d) (ii) in the lower half of the square. This means that the dark/light polarity is the same as the model pattern only for half of the pattern. Therefore, the tool judges the patterns to be half identical and half different.



(i) (ii) (iii)

Fig 7.1.5.1 (e) Dark/light polarity

One thing to note is that "the human eye is quite insensible to dark/light polarity". What are shown in Fig. 7.1.5.1(d) and Fig. 7.1.5.1(e) are mere examples where the dark/light polarity is very easy to discern. In most actual images, "telling which is lighter and which is darker" requires a considerable amount of attention. If the tool fails to find a pattern, it might be necessary to check whether the "dark/light polarity is in the reverse direction".

Missing or extra feature

Next, suppose that you teach the pattern in Fig. 7.1.5.1(f) (i) as the model pattern and then have an image captured by the camera with the pattern shown in Fig. 7.1.5.1(f) (ii). The pattern in Fig. 7.1.5.1(f) (b) does not contain a white circle, which is found in the model pattern in Fig. 7.1.5.1(f) (i).

If a feature found in the model pattern is missing from the pattern in the image, the Locator Tool judges that the pattern is different by as much as that missing feature. In this case, the pattern in Fig. 7.1.5.1(f) (ii) is considered to be different from the model pattern in Fig. 7.1.5.1(f) (i) in that "it is missing the white circle".

Conversely, what happens if you teach the pattern in Fig. 7.1.5.1(f) (ii) as the model pattern and then have an image captured by the camera with the pattern shown in Fig. 7.1.5.1(f) (i)?

The GPM Locator Tool judges that the pattern in the image has the "same geometry", even if it contains an extra feature not found in the model pattern. Therefore, the pattern in Fig. 7.1.5.1(f) (i) is considered to have the "same geometry" as the model pattern in Fig. 7.1.5.1(f) (ii).

(i) (ii)

Fig 7.1.5.1 (f) Missing extra feature

Pattern similarity

We have discussed the criteria concerning a number of factors such as geometry, image distortion, dark/light polarity, and missing feature. However, not all these criteria need to be satisfied fully. It is virtually impossible to eliminate the influence of the discussed factors completely. The GPM Locator Tool is designed to allow the influence of these factors to a certain degree. In other words, the tool is meant to find "similar patterns", rather than "the same patterns".

One measure of similarity is by evaluating how similar the pattern found in the image is to the model pattern. While this is generally called the "degree of similarity", the Locator Tool refers to this value as a "score". The score is a numerical value ranging from 0 to 100 points. If the pattern fully matches, it gets a score of 100 points. If it does not match at all, the score is 0. If the pattern in the image has any part that is "distorted because of the lens distortion", that is "distorted due to parallax", that has a "different dark/light polarity", that is "missing a feature", or that does not match for any other reason, the score is reduced from 100 points accordingly. If such parts account for 30% of the model pattern, the score is 70 points.

When you have the GPM Locator Tool find a matching pattern in an image, you specify a score threshold so that the tool "finds patterns whose score is higher than the specified threshold".

7.1.5.2 Model pattern

The first thing you do when using the GPM Locator Tool is to teach the object you want the tool to find as a model pattern. This section provides the guidelines on teaching a model pattern.

Teaching a model pattern

Teach the geometry of the workpiece as seen via the camera as a model pattern. To teach a model pattern, read the image of the workpiece from the camera and enclose the part of the image you want to register as a model pattern within a rectangle. It is important to place the workpiece so that it comes to the center of the image. An image seen via the camera is subject to various kinds of distortion such as the distortion of the camera lens. Such distortions become minimal near the center of the image. When teaching a model pattern, therefore, make sure that the workpiece is placed so that it comes as near to the center of the image as possible.

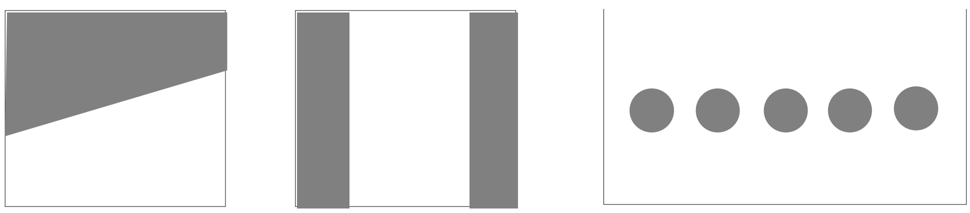
Geometries whose position cannot be determined

There are some types of geometries whose position, orientation, or other attributes cannot be determined. If the position or orientation of the geometry taught as the model pattern cannot be determined, the GPM Locator Tool cannot find the pattern properly. Examples of such geometries are given below.

<1> Geometries whose position cannot be determined

With the geometries shown in Fig. 7.1.5.2(a) (i) and Fig. 7.1.5.2(a) (ii), the position cannot be determined in the direction parallel to the line. Avoid using these patterns as a model pattern unless "you do not mind which part of the pattern the tool finds as long as the tool finds the pattern".

In these cases, the images captured by the camera look perfectly identical to the human eye, whereas the position found by the GPM Locator Tool differs for each pattern. This is because images are subject to distortion, as earlier described. Although humans see the pattern as a straight line, both the model pattern and the pattern in the image are in fact distorted, uneven curved lines. The tool searches for the position where the two uneven curved lines best match each other. Even if you snap multiple images consecutively with the workpiece fixed to the same place, the position where the unevenness matches varies for each image, since all the images are distorted in slightly different ways.



(i) Straightline **(ii) Parallel lines** **(iii) Equally spaced identical features**

Fig 7.1.5.2 (a) Geometries whose position cannot be

Care must be exercised as well when identical features are equally spaced, as shown in Fig. 7.1.5.2(a) (iii). For example, if you teach three of the five black circles as the model pattern, the tool cannot discern which three black circles to find. Therefore, you should avoid using such a geometry as the model pattern.

Even if you teach all the five black circles as the model pattern, a pattern gets a score as high as 80 points when it matches four of the black circles. This makes the found result unreliable when the score is lower than 90 points.

<2> Geometries whose orientation cannot be determined

The orientation of the circle shown in Fig. 7.1.5.2(b) (i) cannot be determined, because the orientation of the pattern in the image matches that of the model pattern no matter how the model pattern is rotated. In this case, specify that the orientation is to be ignored in the search.

Since the orientation of the rectangle shown in Fig. 7.1.5.2(b) (ii) perfectly matches at both 0 and 180 degrees, it is unknown which orientation the tool will find. In this case, limit the search range of orientation, as in –90 degrees to +90 degrees. The same is true with regular triangles and polygons.

(i) Circle **(ii) Rectangle**

Fig 7.1.5.2 (b) Geometry whose orientation cannot be determined

<3> Geometries whose scale cannot be determined

As for a corner like the one shown in Fig. 7.1.5.2(c), the scale cannot be determined because the pattern in the image fully matches the model pattern no matter how many times its size is expanded. In this case, specify that the scale is to be ignored in the search.

Fig 7.1.5.2 (c) Geometry whose scale cannot be determined

Masking the model pattern

As described earlier in "Missing or extra feature", if a feature found in the model pattern is missing from the pattern in the image, the GPM Locator Tool judges that the pattern is different by as much as that missing feature. On the other hand, however, the tool ignores extra features. Therefore, if there is any extra feature that happens to exist in the image when the model pattern is taught, it is desirable not to include that feature in the model pattern.

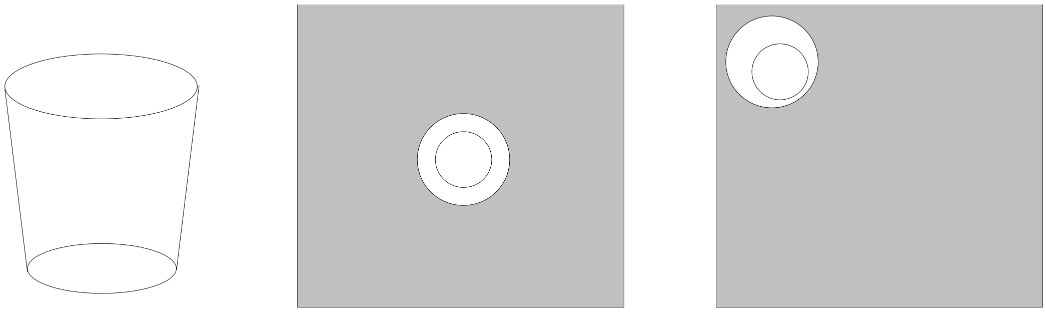
The GPM Locator Tool allows you to mask a specific part of the image and to remove that part from the model pattern after the model pattern teaching operation. This process is called "masking the model pattern". If the image taught as a model pattern includes any of the parts described below, mask those parts and remove them from the model pattern.

<1> Part where the distance from the camera differs

When you see an object through a camera, what is known as "parallax" occurs. Even when an object is moved linearly by the same amount in the actual space, the amount of travel in the image seen via the camera varies, if the distance from the camera to the object is different. This difference in the amount of travel is called parallax.

When you move an object having a certain height, the distance from the camera differs for the top and bottom of the object and the amount of travel seen via the camera varies due to parallax. This means that moving the object results in changes not only in position but also in geometry in the image.

For example, consider a glass like the one shown in Fig. 7.1.5.2(d) (i). If you place the glass so that it comes near the center of the image, the camera views the glass from right above and the resultant pattern is a concentric double circle as shown in Fig. 7.1.5.2(d) (ii). If you place the glass so that it comes to a corner of the image, however, the resultant pattern is an eccentric double circle due to the parallax effect as shown in Fig. 7.1.5.2(d) (iii). Since the patterns in Fig. 7.1.5.2(d) (ii) and Fig. 7.1.5.2(d) (iii) differ in geometry, the pattern in Fig. 7.1.5.2(d) (iii) cannot be found even if the pattern in Fig. 7.1.5.2(d) (ii) is taught as the model pattern.



(i) (ii) (iii)

Fig 7.1.5.2 (d) Effect of parallax

To avoid this problem, any part where the distance from the camera is different must be masked and removed from the model pattern. In the case of the glass, mask either the outer or inner circle.

As described earlier, the GPM Locator Tool allows distortion between the model pattern and the pattern in the image as long as the distortion is within the allowable range. If the difference in geometry caused by parallax is within the allowable range of distortion, the GPM Locator Tool can find the pattern.
Also, widening the distance between the camera and the workpiece helps alleviate the effect of parallax.

<2> Part that looks differently for each workpiece

When you capture an image of a workpiece via the camera, the image sometimes might contain a feature, such as a blemish, that looks different for each workpiece or each time the position of the workpiece is changed. The GPM Locator Tool pays attention to such features as well when searching the image for a pattern identical to the taught model pattern. Therefore, removing these features from the model pattern helps the tool find matching patterns more accurately.

Mask the following parts to remove them from the model pattern.
- Blemish on the workpiece
- Unevenness on the workpiece surface (e.g. casting surface)
- Part that happens to appear aglow
- Shadow
- Hand-written letters and marks
- Label

<3> Part where dark/light polarity is irregular

When the position or orientation of an object is changed, the way the object is illuminated and how shadows are cast on it might change as well, thus altering the dark/light polarity of the figure in the image. As described earlier, the GPM Locator Tool considers a pattern different if its dark/light polarity is different.

When you snap images of actual workpieces, it is often the case that the dark/light polarity appears reversed in some parts of the pattern although the overall dark/light polarity of the pattern remains unchanged. These parts look different for each workpiece, as described in <2>, and removing them from the model pattern helps the tool find matching patterns more accurately.

Other points to note

Basically, the more complex the geometry you teach as the model pattern is, the more stable the found result becomes. For example, a small circle is often difficult to be distinguished from a blemish. When the model pattern has a complex geometry, it is very unlikely that an unintended object happens to look like it.

Masking the model pattern excessively might draw you into the pitfall described above. If you mask too many parts of the model pattern, you can end up with a pattern having a very simple geometry, causing the tool to find an "unintended object" that happens to be included in the image. Or, the model pattern you teach might have a "geometry whose position or orientation cannot be determined".

7.1.5.3 Found Pattern

This section explains about the pattern found by the Locator Tool.

Position of the found pattern

When the GPM Locator Tool finds a pattern identical to the model pattern in the image, it outputs the coordinates of the "model origin" of that found pattern as the "position of the pattern".

You can set the position of the model origin anywhere you like. When you initially teach the model pattern, the model origin is positioned in the center of the rectangle you use for teaching the model pattern. No matter where you set the model origin, the probability of finding and the location accuracy of the GPM Locator Tool will not be affected.

If you change the position of the model origin, the tool outputs different coordinates even when it finds a pattern at the same position in the image. Changing the position of the model origin after setting the reference position makes it impossible to perform robot position offset normally. Note that, after you change the position of the model origin, you need to change the reference position and the taught robot position accordingly.

Orientation and scale of the found pattern

When the GPM Locator Tool finds a pattern identical to the model pattern in the image, it outputs the orientation and scale of the found pattern relative to the model pattern as "Orientation" and "Scale".

The orientation of the found pattern indicates by how many degrees it is rotated with respect to the model pattern. The scale of the found pattern shows how many times it is expanded with respect to the model pattern.

Score of the found pattern

The GPM Locator Tool represents how similar the pattern found in the image is to the model pattern, by using an evaluation value called score. The score is a numerical value ranging from 0 to 100 points. If the pattern fully matches, it gets a score of 100 points. If it does not match at all, the score is 0.

For example, a score of 70 points indicates that the pattern in the image is 30% different from the model pattern because it has parts that are "hidden beneath other objects", that are "invisible due to halation", that are "distorted because of the lens distortion", that are "distorted due to parallax", that have a "different dark/light polarity", etc.

To judge whether proper values are obtained, repeat the find test while changing the position and orientation of the workpiece in the image. The desirable situation is where you constantly get a score of over 70 points, preferably 80 points or more.

If this is not the case, check the following:

- Whether the lens is dirty
- Whether the lens is in focus
- Whether the lens diaphragm is properly adjusted
- Whether the type of lighting is adequate
- Whether the brightness of lighting is properly adjusted
- Whether the points described in "Masking the model pattern" are followed

Elasticity of the found pattern

The GPM Locator Tool represents how much the pattern found in the image is distorted with relation to the model pattern, by using an evaluation value called "elasticity". The elasticity is 0 pixels if the found pattern fully matches the model pattern. The value will be 0.4 pixels if "some parts of the found pattern fully match and some parts are deviated by 1 pixel with an average deviation of 0.4 pixels". The smaller the value is, the less distorted the found pattern is with relation to the model pattern.

To judge whether proper values are obtained, repeat the find test while changing the position and orientation of the workpiece in the image. The desirable situation is where you constantly get an elasticity value of below 1.0 pixel, preferably 0.5 pixels or less.

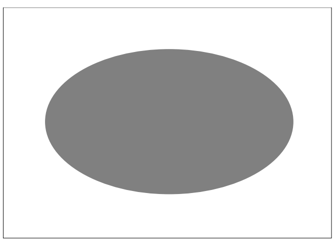
If this is not the case, check the following:

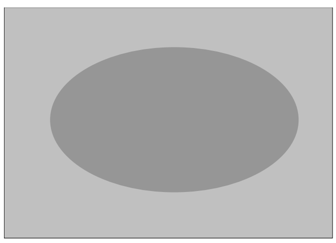
- Whether the lens is in focus
- Whether the lens diaphragm is properly adjusted
- Whether the type of lighting is adequate
- Whether the brightness of lighting is properly adjusted
- Whether the points described in "Masking the model pattern" are followed

Contrast of the found pattern

In addition to score and elasticity, there is one more evaluation value that the GPM Locator Tool finds - "contrast". This value represents "how clearly the pattern found in the image can be seen". The value of contrast ranges from 1 to 255. The larger the value, the clearer the pattern.

Contrast is irrelevant to "whether the pattern is identical to the model pattern". For example, take the ellipses shown in Fig. 7.1.5.3 (i) and Fig. 7.1.5.3 (ii). Since the ellipse in Fig. 7.1.5.3 (i) is seen clearly, it has a higher contrast value than the one in Fig. 7.1.5.3 (ii). Still, these ellipses get the same score because their geometry and dark/light polarity are the same. However, if any part of the ellipse in Fig. 7.1.5.3 (ii) is invisible because of low contrast, the pattern's score is reduced as much.





(i) High contrast **(ii) Low contrast**

Fig 7.1.5.3 Contrast

To judge whether proper values are obtained, repeat the find test while changing the position and orientation of the workpiece in the image. The desirable situation is where you constantly get a contrast value of 50 or higher. Also, the contrast of an image widely varies depending on the weather condition and the time of the day. Make sure that contrast values of 50 or higher are obtained in different time zones of the day.

If this is not the case, check the following:

- Whether the lens is dirty
- Whether the lens is in focus
- Whether the lens diaphragm is properly adjusted
- Whether the type of lighting is adequate
- Whether the brightness of lighting is properly adjusted
- Whether ambient light is present

7.1.5.4 Location parameters

This section provides the guidelines on adjusting the parameters of the GPM Locator Tool.

Search Window

Specify the range of the area of the image captured from the camera that is searched for the pattern. The default value is the entire image.

The size of the search window is determined based on the application that uses the GPM Locator Tool. For example, if the workpiece is likely to appear anywhere in the image, select the entire image. If the workpiece is considered to appear at almost the same position in every shot, the search window can be narrowed.

The narrower the search window is, the faster the location process runs.

If you choose a type of lens that offers a wider camera view, you can narrow the search window. This approach is not recommended, however, since it will degrade the location accuracy. Determine the scale of the camera view according to the amount of deviation of the found workpiece, and then specify the size of the search window in the image based on that scale.

Run-Time Mask

You can set masks within the range that is specified as the search window.
Use this function when you want to specify a circular or other non-rectangular geometry as the search range.

Orientation range

Choose whether to ignore orientation in the search.

<1> Ignore orientation in the search
<2> Do an orientation search within the range specified by the upper and lower limits

For example, suppose that you teach the geometry shown in Fig. 7.1.5.4(a) (i) and that the image captured by the camera shows the workpiece having the same geometry but rotated at 5 degrees.

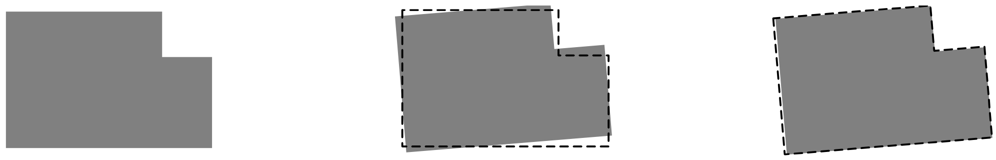
If you specify <1>, orientation is ignored in the search. The tool pays attention only to the orientation specified by the reference value and finds those patterns that are not rotated like the one shown in Fig.

7.1.5.4(a) (ii). Any deviation in orientation is regarded as geometrical distortion, and the score is reduced as much.

If you specify <2>, an orientation search is done within the range specified by the upper and lower limits. Therefore, a pattern like the one shown in Fig. 7.1.5.4(a) (iii) can also be found as a fully matching pattern.

In the case of <2>, care must be taken because a pattern is not found if its orientation is outside the orientation range specified by the upper and lower limits, regardless of how slightly. For example, when you have taught a regular triangle as the model pattern, the tool will mathematically be able to find any triangle if you specify the orientation range as from −60 degrees to +60 degrees. In actuality, however, the orientation of some triangles might not fit into this range, like −60.3 degrees and +60.2 degrees. To avoid this problem, set the orientation range with small margins, as from −63 degrees to +63 degrees.

The time the location process takes is shorter in the case of <1> than <2>. If you specify <2>, the location process takes less time when the orientation range is narrower.



(i) Model pattern **(ii) Reference orientation 0°** **(iii) Orientation range±180°**

Fig 7.1.5.4 (a) Orientation range

Scale range

Choose whether to ignore scale in the search.

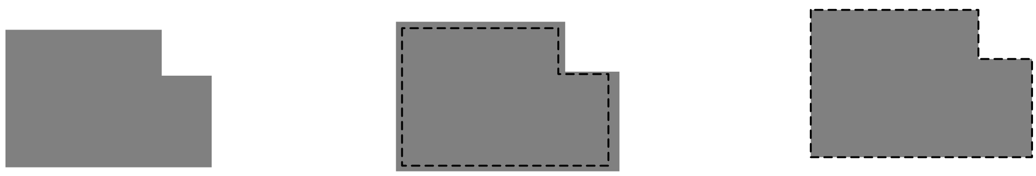
<1> Ignore scale in the search
<2> Do a scale search within the range specified by the upper and lower limits

For example, suppose that you teach the geometry shown in Fig. 7.1.5.4(b) (i) and that the image captured by the camera shows the workpiece having the same geometry but expanded by 3%.

If you specify <1>, scale is ignored in the search. The tool pays attention only to the scale specified by the reference value and finds those patterns that are not expanded like the one shown in Fig. 7.1.5.4(b) (ii). Any deviation in scale is regarded as geometrical distortion, and the score is reduced as much.

If you specify <2>, a scale search is done within the range specified by the upper and lower limits. Therefore, a pattern like the one shown in Fig. 7.1.5.4(b) (iii) can also be found as a fully matching pattern. In the case of <2>, care must be taken because a pattern is not found if its scale is outside the range specified by the upper and lower limits, regardless of how slightly.

The time the location process takes is shorter in the case of <1> than <2>. If you specify <2>, the location process takes less time when the scale range is narrower.



(i) Model pattern **(ii) Reference scale 100%** **(iii) Scale range±10%**

Fig 7.1.5.4 (b) Scale range

Note on the scale

A change in the scale, or a change in the size of the figure in the image captured by the camera, means that "the distance between the camera and the workpiece has changed". As described with relation to parallax, if the distance between the camera and the workpiece changes, the actual travel amount of the object becomes different even if the apparent travel amount in the image remains unchanged. Therefore, a change in the distance between the camera and the workpiece makes the tool unable to calculate the actual travel amount of the object correctly from the travel amount of the object in the image. This can impede the accurate offset of the robot position.

If the apparent scale has changed even though the distance between the camera and the workpiece has not changed, you might have altered the lens zoom or focus. In this case, by letting the GPM Locator Tool do a scale search as well, you can have the location process itself accomplished. Doing so, however, makes the tool unable to calculate the actual travel amount of the object correctly from the travel amount of the object in the image, thereby impeding the accurate offset of the robot position.

When using the scale search, make sure that not only the GPM Locator Tool but also the entire application, including robot position offset, are prepared for cases when patterns having different scales are found.

Score threshold

Specify the score threshold for a pattern to be found. A pattern in the image is not found if its score is lower than the specified threshold. The default value is 70 points.

To determine the threshold, repeat the find test while changing the position and orientation of the workpiece in the image. Identify the worst score, and set the value obtained by subtracting 5 to 10 points from that worst score.

Lowering the score threshold forces the GPM Locator Tool to examine many parts of the image where a pattern can potentially be found, thus resulting in a longer location process. Conversely, raising the score threshold lets the tool narrow down the parts to examine, leading to a shorter location time.

If you need to set the score threshold to lower than 60, the lens setup or lighting is often inadequate. Before setting a low threshold, check the following:

- Whether the lens is dirty
- Whether the lens is in focus
- Whether the lens diaphragm is properly adjusted
- Whether the type of lighting is adequate
- Whether the brightness of lighting is properly adjusted
- Whether the points described in "Masking the model pattern" are followed
- Whether the lens setup has not been changed since teaching the model pattern
- Whether the distance between the camera and the workpiece has not been changed since teaching the model pattern

Contrast threshold

Specify the contrast threshold for a pattern to be found. A pattern in the image is not found if its average contrast is lower than the specified threshold. The specifiable contrast threshold value range is 10 to 255. The default value is 50.

To determine the threshold, repeat the find test while changing the position and orientation of the workpiece in the image. Identify the lowest contrast, and set the value obtained by subtracting 10 or so from that lowest contrast. The contrast widely varies depending on the time of the day, the weather conditions, and so on. Conduct tests in different time zones on different days to confirm the validity of the threshold.

A higher contrast threshold leads to a shorter location process.
If you need to set the contrast threshold to lower than 20, the lens setup or lighting is often inadequate. Before setting a low threshold, check the following:

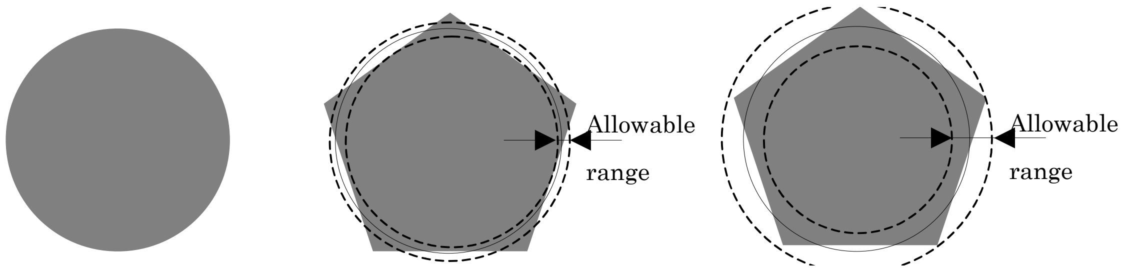
- Whether the lens is dirty
- Whether the lens is in focus
- Whether the lens diaphragm is properly adjusted
- Whether the type of lighting is adequate
- Whether the brightness of lighting is properly adjusted
- Whether the points described in "Masking the model pattern" are followed

Allowable elasticity

Specify the upper limit of elasticity with relation to the model pattern for a pattern to be found. The allowable elasticity must be specified in pixels. The default value is 1.5 pixels.

This default value rarely needs to be changed. It is not recommended to set a large value for the allowable elasticity, except in the case of a "bag-like workpiece whose geometry is subject to change".

What differs between when a small value is set for the allowable elasticity and when a large value is set is explained below, using a rather extreme example. Suppose that you have taught a circle, like the one shown in Fig. 7.1.5.4(c) (i), as the model pattern, and you have a pentagon in the image, as shown in Fig. 7.1.5.4(c) (ii). When a small value is set for the allowable elasticity, the pattern in Fig. 7.1.5.4(c) (ii) is not found because its geometry is judged different. When a large value is set for the allowable elasticity, however, even the pattern in Fig. 7.1.5.4(c) (iii) is considered to have the same geometry and is found.



(i) Model pattern **(ii) Allowable range ±1.5 pixels** **(iii) Allowable range ±4.0 pixels**

Fig 7.1.5.4 (c) Allowable elasticity range

When a large value is set for the allowable elasticity, the GPM Locator Tool needs to take many distorted geometries into consideration and takes longer to find a pattern. Conversely, setting a small value leads to a shorter location time.

When a large value is set for the allowable elasticity, it appears that patterns can be found with high scores. However, this setting is often prone to incorrect location or failure to find a matching pattern. This can also be inferred from the example in Fig. 7.1.5.4(c) (iii). Keep in mind that setting a large value for the allowable elasticity can generally result in frequent incorrect locations.

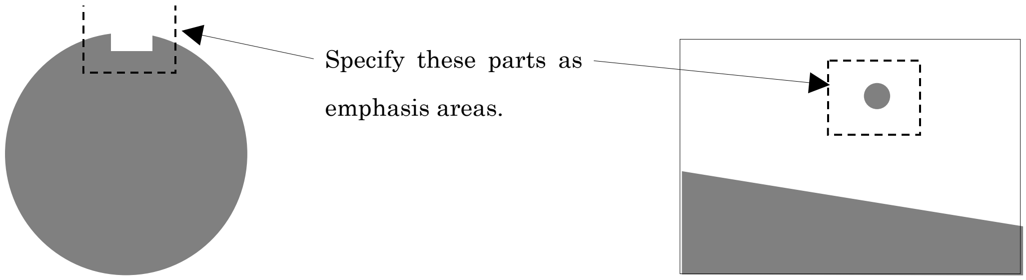
Using an emphasis area

After teaching a model pattern, you can specify that attention is to be paid to a specific part of the model pattern. Such a part is called an emphasis area. In the cases described below, specifying an emphasis area enables stable pattern location.

<1> When the position cannot be determined without paying attention to a small part

The position and orientation of both of the patterns shown in Fig. 7.1.5.4(d) can be uniquely determined. Without the parts enclosed within the dotted-line boxes, however, they will end up being "geometries whose position or orientation cannot be determined". What is distinctive of these parts enclosed within the dotted-line boxes is that they are relatively small in comparison with the entire model pattern.

In such cases, the tool often finds the orientation or position incorrectly, because the pattern as a whole appears to match well, even though the part enclosed within the dotted-line box cannot be seen.



(i) Key groove in a circle **(ii) Line and small circle**

Fig 7.1.5.4 (d) Emphasis area

Humans unconsciously pay attention to these small parts, while the GPM Locator Tool needs to be taught to do so. Such small parts that require special attention are called "emphasis areas". Teaching emphasis areas to the GPM Locator Tool makes it able to find position and orientation more accurately.

If the part specified as an emphasis area cannot be seen in the image, the pattern is not found, because the tool cannot verify that the correct pattern is found.

<2> When an incorrect pattern is found unless attention is paid to a small part

Suppose that you have two patterns of Figs. 7.1.5.4(e) (i) and (ii) mixed in the mage and want the tool to find only the pattern of Fig. 7.1.5.4(e) (ii). You teach the pattern of Fig. 7.1.5.4(e) (ii) as the model pattern. However, the pattern of Fig. 7.1.5.4(e) (i) has basically the same geometry, except for lack of the white circle, and thus gets a score of 90 points or higher, making it difficult for the tool to find only the pattern of Fig. 7.1.5.4(e) (ii). In such a case, specify the white circle, which is contained only in the pattern of Fig. 7.1.5.4(e) (ii), as an emphasis area. Doing so allows the tool to find only the pattern of Fig. 7.1.5.4(e) (ii) having the white circle more reliably.

If the part specified as an emphasis area cannot be seen in the image, the pattern is not found, because the tool cannot verify that the correct pattern is found.

Conversely, if you want only the pattern of Fig. 7.1.5.4(e) (i) to be found, it is impossible for the Locator Tool alone to make this discrimination. In that case, you can use a sub-tool such as a Blob tool to detect the white circle along with a conditional execution tool to reject the found pattern if the white circle is present.

(i) **(ii)**

Fig 7.1.5.4 (e) Emphasis area

Emphasis area threshold

In addition to the score for the entire model pattern, specify a threshold indicating how much of the emphasis area is to be matched for a pattern to be found. The default value is 70 points.

As with the "score threshold", it is not recommended to set a small value for this threshold (the value should be at least 50 points). Setting too small a value makes the use of an emphasis area meaningless.

Allowing the position deviation of the emphasis area

When you have an emphasis area to be used for location, you can specify that the tool is to allow an emphasis area even if its position is deviated by two or three pixels with respect to the position of the entire model pattern.

For example, suppose that you teach the pattern in Fig. 7.1.5.4(f) (i) as the model pattern and specify the white triangle as an emphasis area. Without the triangle, the tool can only search for the pattern as a rectangle at ±90 degrees. With the triangle, however, the tool can do the search using ±180 degrees. In other words, the triangle is used to distinguish between 0 and 180 degrees.

(i) (ii)

Fig 7.1.5.4 (f) Floating of the emphasis area

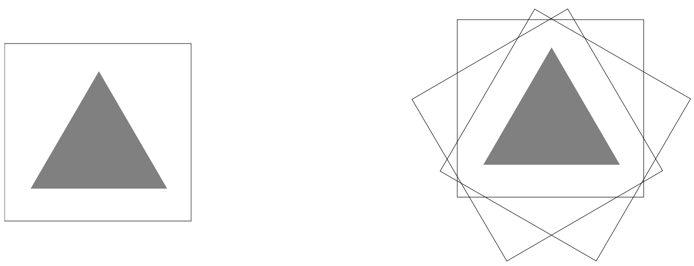
To make the situation complicated, however, the triangle is a mark on the label affixed on the cardboard package. Assume that the label is put at the same position on most packages, while it is out of position on some. In the latter case, the emphasis area in the model pattern does not match the triangle in the image, as shown by the dotted line in Fig. 7.1.5.4(f) (ii), and the tool fails to find the pattern because it considers that the emphasis area does not match. By teaching the tool to allow the position deviation of the emphasis area, you can have a pattern found even if a figure identical to the emphasis area is deviated by two to three pixels.

The use of this function causes the tool to take longer to find a pattern. Depending on the nature of the image (particularly complex images with much noise), incorrect location can occur. Before using this function, thoroughly test its effectiveness.

Area overlap

If the patterns found in an image overlap one another at more than a specified ratio, the GPM Locator Tool leaves only the pattern having the highest score and deletes the others.

For example, suppose that you teach a regular triangle, like the one shown in Fig. 7.1.5.4(g) (i), as the model pattern and specify the orientation range as from −180 degrees to +180 degrees. The GPM Locator Tool recognizes that a pattern matches at three different orientations, as shown in Fig. 7.1.5.4(f) (ii). Since these three patterns overlap one another, however, the tool leaves only one pattern having the highest score, ignoring the others.



(i) (ii)

Fig 7.1.5.4 (g) Overlap restriction

Whether two patterns overlap is determined by whether the area where the patterns' rectangular frames overlap is larger than the ratio specified for overlap restriction. If the ratio of the overlapping area is larger than the specified value, the patterns are judged to overlap. If you specify 100% for overlap restriction, the tool will not delete overlapping patterns unless they fully overlap one another (i.e. they have completely the same geometry).

Displaying almost found

You can specify that the GPM Locator Tool is to display those patterns that are almost found that barely failed to be found due to the set threshold or range. This function is available only for the test execution of the GPM Locator Tool.

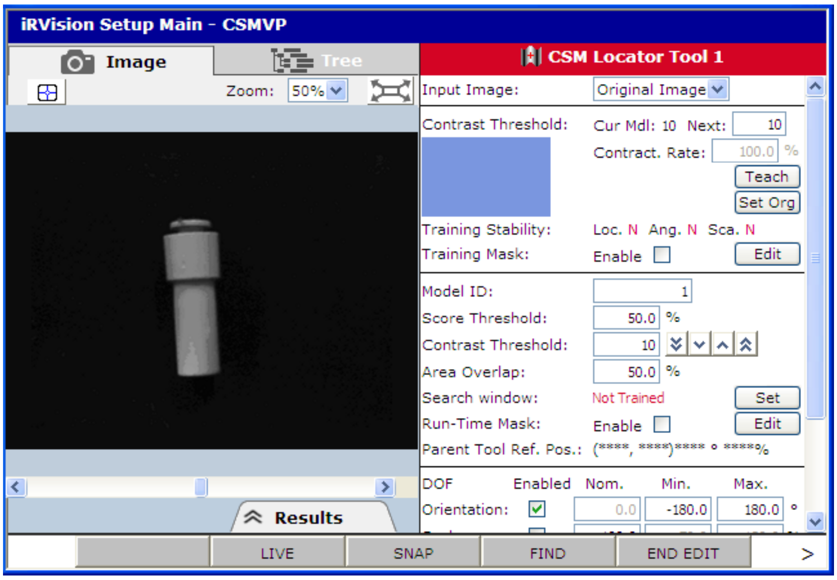
Enabling this function lets you know that there are patterns that failed to be found for the reasons listed below, which helps you adjust the location parameters.

- Pattern whose score is slightly lower than the threshold
- Pattern whose contrast is slightly lower than the threshold
- Pattern whose emphasis area is slightly lower than the threshold
- Pattern whose orientation is slightly outside the range
- Pattern whose scale is slightly outside the range

Note that this function does not guarantee that the tool will display all the patterns "whose score is a certain percentage lower than the threshold" or on any other similar principles. The function is simply intended to let the tool display patterns that it happens to find that do not satisfy the preset conditions but match the criteria listed above during the course of searching for patterns that meet the specified threshold or range.

7.2 CURVED SURFACE LOCATOR TOOL

The curved surface locator tool is an image processing tool using gradation (change from light to dark or vice versa). It checks a camera-captured image for the same pattern as a model pattern taught in advance and outputs its location. If you select the curved surface locator tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



Input Image

Select the image which is used for training model and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Curved Surface Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

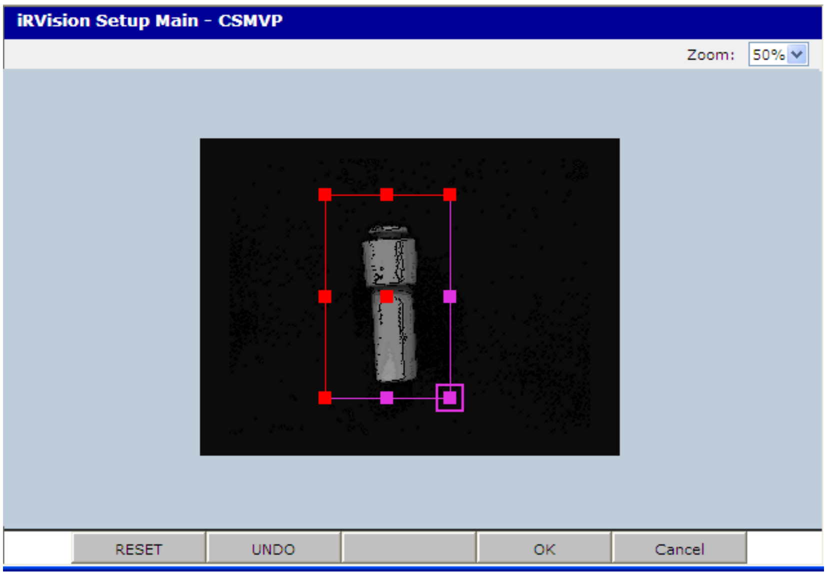
7.2.1 Setting up a Model

Teach the model pattern of the workpiece you want to find.

Teaching the model pattern

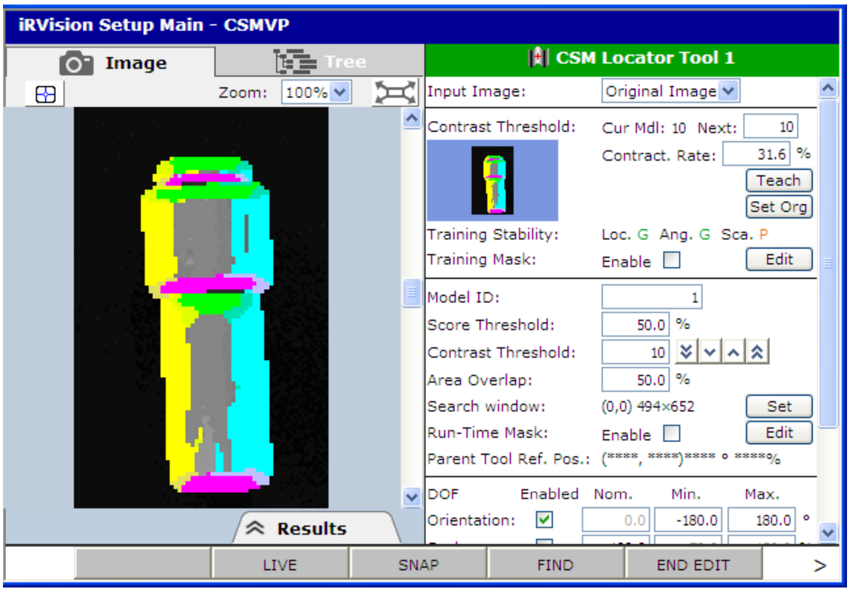
Teach the model pattern as follows.

1. Press F2 LIVE to change to the live image display.
2. Place the workpiece near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4. Select [Image + Image Feature] in [Image Display Mode], and adjust the value in [Contrast Threshold] for execution (below [Score Threshold]) to determine the contrast threshold appropriate for the model.
5. Enter the determined threshold in [Next] for [Contrast Threshold] for model teaching (above the [Teach Pattern] button), and reset [Contrast Threshold] for execution (below [Score Threshold]) to its original value.
6. Tap the [Teach] button.
7. Enclose the workpiece within the red rectangle that appears, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.



Training Stability

The evaluation results for items [Location], [Orientation], and [Scale] of the taught model are displayed as one of the following three levels.

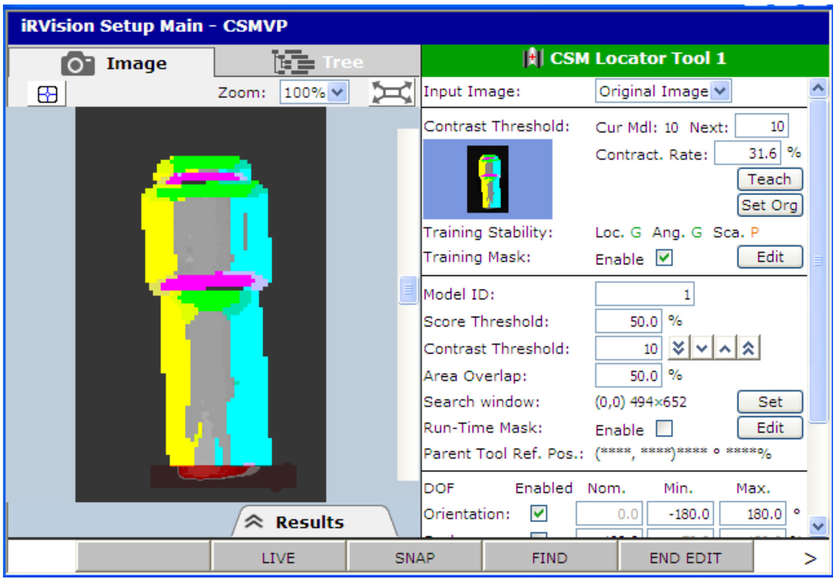


Good: Can be found stably.
Poor: Cannot be found very stably.
None: Cannot be found.

Training Mask

If the taught model pattern has any unnecessary items in the background, any unwanted or incorrect features not found in all other parts, or any blemishes, you can remove it from the pattern by filling that part with the color of red.

To edit a training mask, tap the [Edit] button on the [Training Mask] line. When an enlarged view of the model pattern appears on the image display control, fill the unnecessary parts of the model pattern with the color of red. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.



Model origin

The model origin is the point that numerically represents the location of the found pattern. The coordinates (Row, Column) of the location of the found pattern indicate the location of the model origin. When the found result is displayed on the image,  appears at the model origin.

To move the model origin manually, tap the [Set Org] button. An enlarged view of the model pattern appears on the image display control, and appears at the current position of the model origin. Move the with the mouse to move the model origin. For detailed information about the operation method, see Subsection 3.7.8, "Setting Points".

Model ID

When you want to have taught two or more curved surface locator tools and want to identify which tool the found workpiece corresponds to, you assign a distinct model ID to each tool. The model ID of the found model pattern is reported to the robot controller along with offset data. This enables the robot program to identify the type of the found model.

7.2.2 Adjusting the Location Parameters

Adjust the location parameters.

Score Threshold

The accuracy of the found result is expressed by a score, with the highest score being 100. The target object is successfully found if its score is equal to or higher than this threshold value. If the score is lower, the target object is not found. Set a value between 10 and 100. The default value is 50. Setting a small value might lead to an inaccurate location.

Contrast Threshold

Specify the contrast threshold for the search. The default value is 10. If you set a small value, the tool will be able to find the target in obscure images as well but take longer to complete the location process. The minimum value is 1. If the tool is prone to inadequately find blemishes and other unwanted edges with low contrast, try setting a larger value. Those image features whose contrast is lower than the threshold are ignored. Selecting the [Image+Image Feature] in [Image Display Mode] lets you check the image features extracted based on the current threshold.

Area Overlap

If the ratio of overlap of the found objects is higher than the ratio specified here, then the found result for the workpiece with the lower score is deleted, leaving only the one with the higher score. The ratio of overlap is determined by the area where the models' external rectangular frames overlap. If you specify 100% as the limit value, the found results will not be deleted even if the workpieces overlap.

Search Window

Specify the range of the area of the image to be searched. The smaller the search window is, the faster the location process runs. The default value is the entire image. To change the search window, tap the [Set] button. When a rectangle appears on the image, adjust its geometry, as when teaching a model. For detailed information about the operation method, see Subsection 3.7.9, "Window Setup".

Run-Time Mask

Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, "Editing Masks".

Degree of Freedom - Orientation

Specify the range of orientation subject to be searched. The tool searches for a model rotated in the range specified by [Minimum] and [Maximum], with the orientation of the taught model being 0 degrees. The specifiable value range is from -360 to +360 degrees for both [Minimum] and [Maximum]. The narrower the orientation range is, the faster the search process ends. If a range wider than 360 degrees is specified, the range is automatically corrected to 360 degrees when the vision process runs.

If you uncheck this box, the orientation is ignored and the tool searches only for a model having the orientation specified in [Nominal].

By default, the orientation search is enabled and the range is from -180 to +180 degrees.

Degree of Freedom - Scale

Specify the range of scale to be searched. With the size of the taught model being 100%, the tool searches for a model expanded or reduced by the ratio specified in [Minimum] and [Maximum]. The specifiable value range is from 30% to 160% for both [Minimum] and [Maximum]. The narrower the size range is, the faster the search process ends.

If you uncheck this box, the scale is ignored and the tool searches only for a model having the scale specified in [Nominal].

By default, the scale search is disabled.

Time-out

If the location process takes longer than the time specified here, the tool ends the process without finding all of the workpieces.

Result Plotting Mode

Select how the found results are to be displayed on the image after the process is run.

Plot Everything

The origin, features, and rectangle of the model will be displayed.

Plot Edges

Only the origin and features of the model will be displayed.

Plot Bounding Box

Only the origin and rectangle of the model will be displayed.

Plot Only Origin

Only the origin of the model will be displayed.

Plot Nothing

Nothing will be displayed.

Image Display Mode

Select the image display mode for the setup page.

Image

Only the camera image will be displayed.

Image+Results

The camera image and found results will be displayed.

Image+Gradiations

The camera image and features of the image will be displayed.

Pattern

The taught model pattern will be displayed.

Pattern+T.Mask

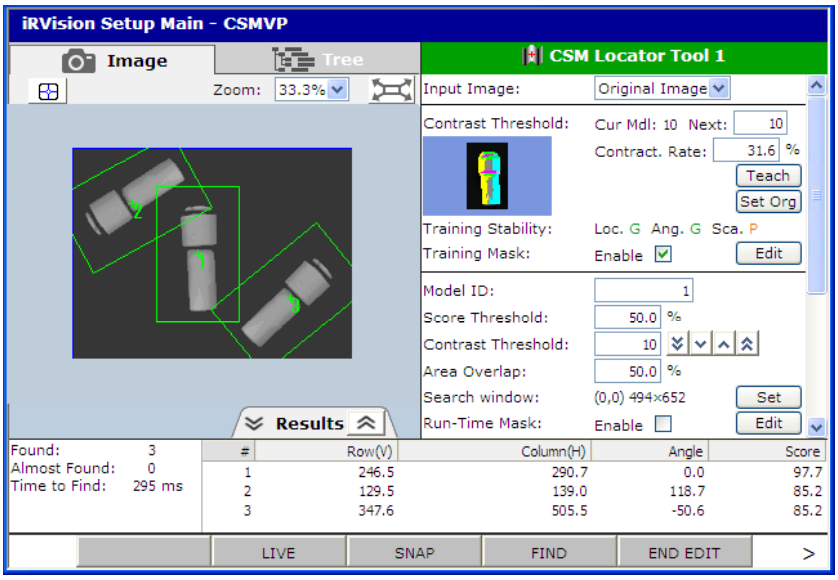
The taught model pattern, with an area overlaid that is masked as the emphasis area, will be displayed.

Show Almost Found

If there is any workpiece that failed to be found because it fell just short of meeting the score, contrast, orientation, scale, and/or other conditions, its test result is displayed. The result appears in a red rectangle on the image.

7.2.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Found

The number of found workpieces is displayed.

Almost Found

The number of workpieces that failed to be found because they were slightly outside the specified range is displayed. "0" is displayed if the [Show Almost Found] check box is not checked.

Time to Find

The time the location process took is displayed in milliseconds.

Found Results table

The following values are displayed.

Row, Column

Coordinates of the model origin of the found pattern (units: pixels).

Angle

Orientation of the found pattern (units: degrees). This is displayed only when the check box for the orientation search is checked.

Scale

Scale of the found pattern (units: %). This is displayed only when the check box for the scale search is checked.

Score

Score of the found pattern.

7.2.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. See 8.1 "VISION OVERRIDE" and 9.2.2.13 "OVERRIDE" for details.

Score Threshold

Specify a number between 10 and 100.

Contrast Threshold

Specify a number between 1 and 250.

DOF Angle

Enable/disable selection, minimum angle, maximum angle and nominal angle can be specified. Specify 0 for disable or 1 for enabled. Specify a number between –360 and 360 for the minimum, maximum and nominal angles.

DOF Scale

Enable/disable selection, minimum scale, maximum scale and nominal scale can be specified. Specify 0 for disable or 1 for enabled. Specify a number between 25 and 400 for the minimum, maximum and nominal scales.

7.2.5 Setup Guidelines

Read these guidelines for a deeper understanding of how the curved surface locator tool works.

7.2.5.1 Overview and functions

This subsection provides an overview of the curved surface locator tool, describing what you can do and how you see objects with this tool.

What you can do with the curved surface locator tool

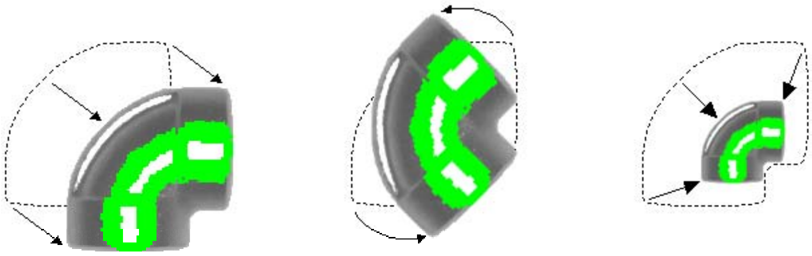
The curved surface locator tool offers image processing capabilities to process images captured by the camera, find the same pattern in an image as the pattern taught in advance, and output the position and orientation of the found pattern. The pattern taught in advance is called a model pattern, or simply a model.

As the position and orientation of the object placed within the camera view changes, the position and orientation of the figure of that object captured through the camera also changes accordingly. The curved surface locator tool finds where the same pattern as the model pattern is in the image fed from the camera.

If the figure of the object in the image has the same pattern as the model pattern, the curved surface locator tool can find it, regardless of differences of the following kinds:

- Translation : The position of the figure in the image is different than in the model pattern.
- Rotation : The apparent orientation of the figure in the image is different than in the model pattern.
- Scaling : The apparent size of the figure in the image is different than in the model pattern.

Model pattern



(1) Translation **(2) Rotation** **(3) Scaling**

What is the same pattern?

What does the curved surface locator tool consider the "same pattern" as the model pattern? The curved surface locator tool has the following two criteria to judge whether a pattern is the "same pattern" as the model pattern. When the pattern meets both of the criteria, the curved surface locator tool regards it as the "same pattern".

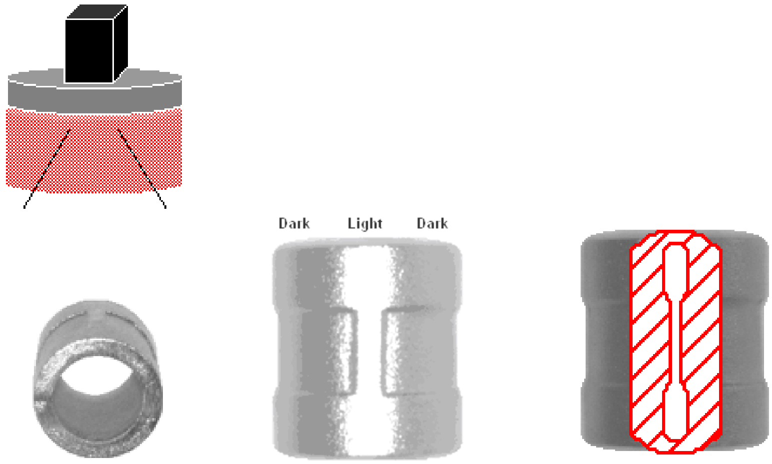
- The figure has the same geometry of distribution of gradation.
- The figure has the same orientation of gradation.

An understanding of what the curved surface locator tool considers the same pattern helps you make the tool find eligible patterns with increased stability.

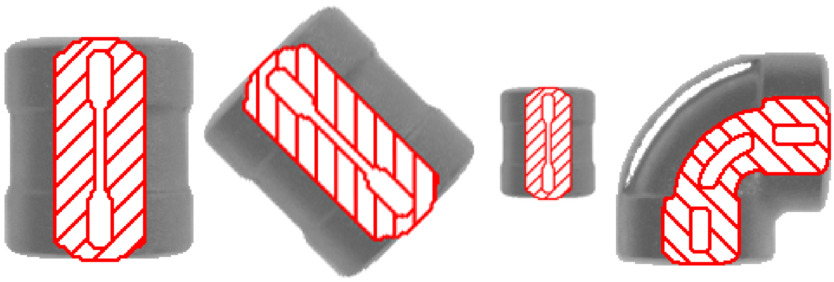
Figure having the same geometry of distribution of gradation

First, we will discuss about a "figure having the same geometry of distribution of gradation".

For example, when you look at a circular cylinder via a camera with coaxial lighting as shown in the left figure below, you can see light/dark distribution as shown in the center figure below. The curved surface locator tool focuses on the part where the tone changes from light to dark or vice versa, that is, gradation. In the right figure below, the hatched area indicates the distribution of gradation.



In the figure below, the three left figures have the same geometry of distribution of gradation, though they have different rotation angles and scales, and the rightmost figure has a different geometry. Whether figures have the same geometry of distribution of gradation depends on whether their original objects have the same geometry.

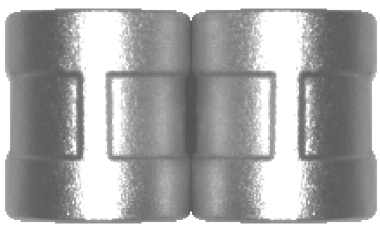


Conversely, if the original objects differ in geometry but the distributions of gradation in their figures captured by the camera happen to be geometrically identical, the curved surface locator tool judges them to have the same geometry.

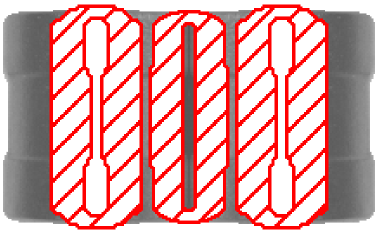
Figure having the same orientation of gradation

Next, we will discuss about a “figure having the same orientation of gradation”.

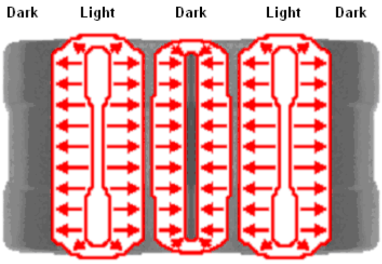
Suppose you have an image as shown in the figure below. Two circular cylinders are placed side by side and you can see distributions of gradation around the center of each circular cylinder and the valley between the circular cylinders.



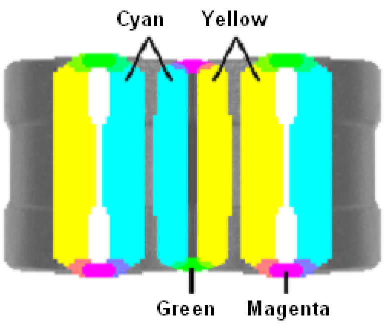
In the figure below, these distributions of gradation are indicated with hatched areas. As far as you focus on the geometry, the three distributions of gradation are similar.



When you focus on the orientation of gradation, however, you will not say that they are similar. In the figure below, the orientation of gradation from light to dark is indicated with an arrow (→). While in the right and left gradation areas, arrows are directed from within outward, in the center gradation area, they are directed inwards. Thus, when you focus on the orientation of gradation, the right and left gradation areas completely differ from the center gradation area. If the patterns differ in the orientation of gradation, the curved surface locator tool judges them different even when their distributions of gradation are geometrically identical.

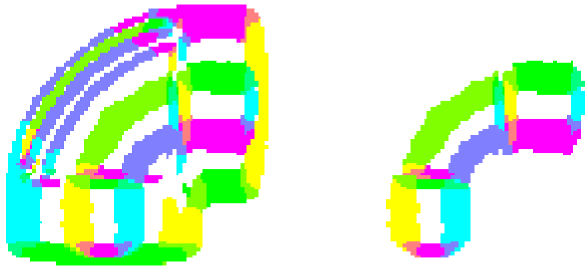


In the setup page of the curved surface locator tool, a total of eight colors, magenta, cyan, green, yellow, and colors between them, are used to make the orientation of gradation easy to check.



Missing or extra gradation area

Suppose that you have the right and left gradation images in the figure below. If you teach the left gradation image as the model pattern and make the curved surface locator tool compare it with the right gradation image, the tool judges that the right pattern is different from the model pattern because the right pattern does not have many gradation areas in the model pattern. Conversely, if you teach the right gradation image as the model pattern and make the tool compare it with the left gradation image, the tool judges that the left pattern is the same as the model pattern because the left pattern have all gradation areas in the model pattern. The curved surface locator tool does not care about extra gradation areas.



Pattern similarity

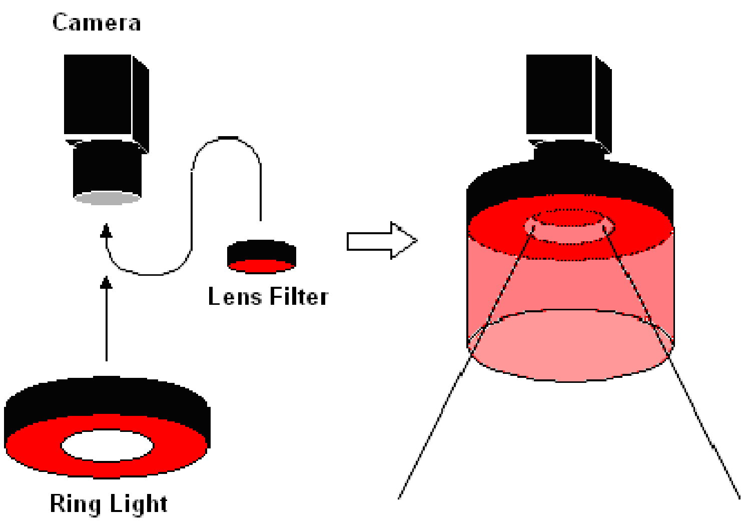
We have discussed the criteria concerning the geometry of distribution, orientation, and missing and extra areas in regard to gradation in patterns. However, not all these criteria need to be satisfied fully. It is virtually impossible to eliminate the difference between patterns. The curved surface locator tool is designed to allow the difference between patterns to a certain degree. In other words, the tool is meant to find “similar patterns”, rather than “the same patterns”.

One measure of similarity is by evaluating how similar the pattern found in the image is to the model pattern. While this is generally called the degree of similarity, the curved surface locator tool refers to this value as a “score”. The score is a numerical value ranging from 0 to 100 points. If the pattern fully matches, it gets a score of 100 points. If it does not match at all, the score is 0. If the pattern in the image has any part that is “distorted because of the lens distortion”, that is “distorted due to parallax”, that has a “different dark/light polarity”, that is “missing a feature”, or that does not match for any other reason, the score is reduced from 100 points accordingly. If such parts account for 30% of the model pattern, the score is 70 points.

When you have the curved surface locator tool find a matching pattern in an image, you specify a score threshold so that the tool “finds patterns whose score is higher than the specified threshold”.

7.2.5.2 Lighting environment

The lighting environment is important for the curved surface locator tool because the tool uses gradation generated by light on the surface of an object. It will be ideal if colored coaxial lighting and a band-pass filter which transmits only that color are used. Coaxial lighting enables the lighting and view directions to match wherever the object is placed. The combination of colored lighting and a band-pass filter enables the influence of the ambient light to be eliminated as much as possible.



7.2.5.3 Model pattern

The first thing you do when using the curved surface locator tool is to teach the object you want the tool to find as a model pattern. This subsection provides the guidelines on teaching a model pattern.

Teaching a model pattern

Teach the geometry of the workpiece as seen via the camera as a model pattern. To teach a model pattern, snap the image of the workpiece from the camera and train the part of the image you want to register as a model pattern within the rectangle. It is important to place the workpiece near the center of the image. An image seen via the camera is subject to various kinds of distortion such as the distortion of the camera lens. Such distortions become minimal near the center of the image. When teaching a model pattern, therefore, make sure that the workpiece is placed so that it comes as near to the center of the image as possible.

Masking the model pattern

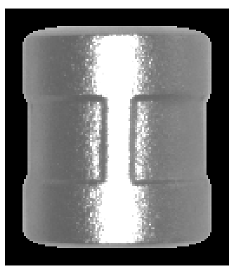
As described earlier in “Missing or extra gradation area”, if a gradation area found in the model pattern is missing from the pattern in the image, the curved surface locator tool judges that the pattern is different by as much as that missing gradation area. On the other hand, however, the tool ignores extra gradation areas. Therefore, if there is any extra feature that happens to exist in the image when the model pattern is taught, it is desirable not to include that feature in the model pattern.

The curved surface locator tool allows you to mask a specific part of the image and to remove that part from the model pattern after the model pattern teaching operation. This process is called “masking the model pattern”. If the image taught as a model pattern includes any of the parts described below, mask those parts and remove them from the model pattern.

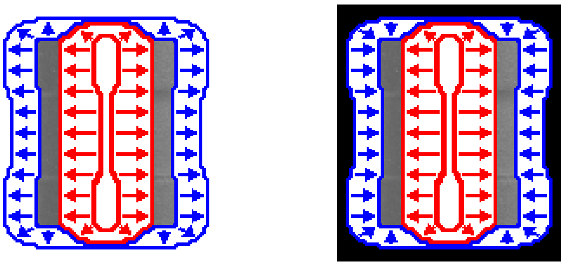
<1> Part where the orientation of gradation is irregular

When the position, orientation, or background of an object is changed, the orientation of gradation in the figure in the image might change as well. As described earlier, the curved surface locator tool considers a pattern different if its orientation of gradation is different. Therefore, masking the parts where the orientation of gradation is irregular and removing them from the model pattern helps the tool find matching patterns more accurately.

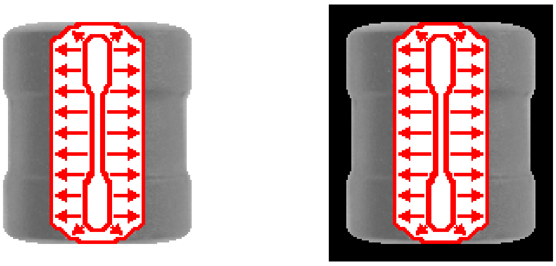
A typical example can be seen in the bulk loading state, where the brightness of the background of an object remarkably changes. For example, the background color of the left object is white and that of the right object is black in the figure below.



Then, the orientation of gradation along the periphery of the left object is opposite to that along the periphery of the right object as shown in the figure below. Therefore, if the periphery of the object is included in the model pattern, the tool will find matching patterns less accurately.



For this reason, mask the gradation area in the periphery of the object when teaching the model pattern, and only the gradation area at the center of the object that is independent of the background is left, which helps the tool find matching patterns accurately.



<2> Part that looks differently for each workpiece

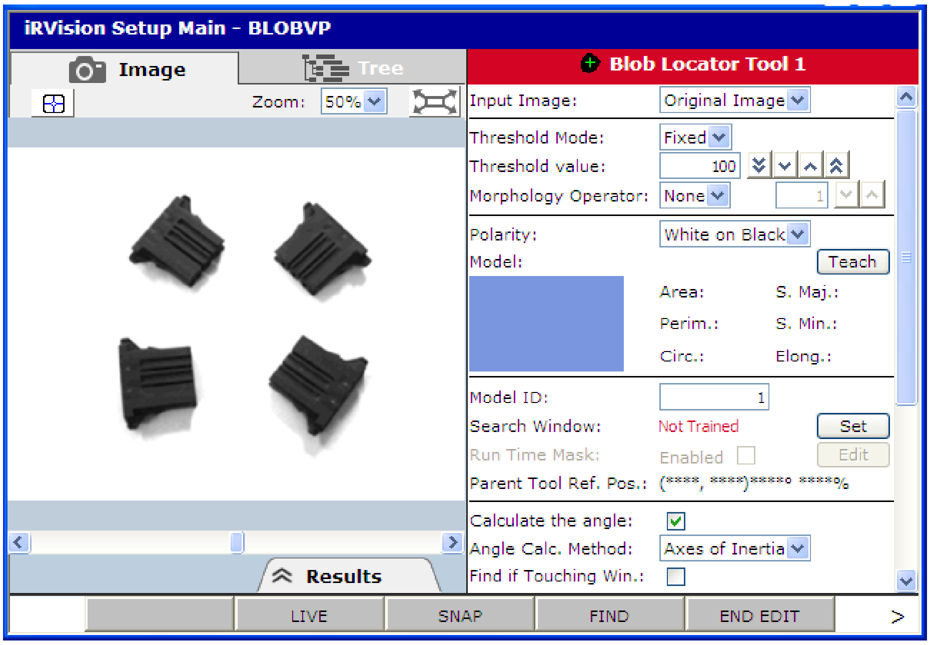
When you capture an image of a workpiece via the camera, the image sometimes might contain a feature, such as a blemish, that looks different for each workpiece or each time the position of the workpiece is changed. The curved surface locator tool pays attention to such features as well when searching the image for a pattern identical to the taught model pattern. Therefore, removing these features from the model pattern helps the tool find matching patterns more accurately.

Mask the following parts to remove them from the model pattern.

- Blemishes on the workpiece
- Areas that appear illuminated
- Shadows
- Hand-written letters and marks
- Labels

7.3 BLOB LOCATOR TOOL

The blob locator tool performs image processing that searches a binarized image for a region (hereinafter called a "blob") that has the same features, such as area and perimeter, as the specified model. If you select the blob locator tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



Input Image

Select the image which is used for training model and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Blob Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.3.1 Image Binarization

The blob locator tool converts an input gray-scale image into a binarized black-and-white image before performing image processing. First, set the conditions for the binarization of an image.

Threshold Mode

Select one of the following:

Fixed

Binarize the image using the threshold set in [Threshold value].

Auto

Calculate the threshold automatically as brightness changes.

Threshold value

Set the threshold for binarization using an integer in the range of 0 to 255. Enter a new value in the field, or change the existing value using the + or – button, so that there is a clear black-and-white distinction between the object and the background.

Morphology Operator

Select the filter to be applied to the binarized image from the options listed below, and specify the filter size in the text box on the right.

None

Do not perform morphing.

Erode

Erode the black area. Helps reduce the black pixel noise.

Dilate

Dilate the black area. Helps reduce the white pixel noise.

Open

Erode the black area and then dilate it. This will connect white blobs that are close to touching or disconnect black blobs that are slightly touching,

Close

Dilate the white area then erode it. This will connect black blobs that are close to touching or disconnect white blobs that are slightly touching.

7.3.2 Teaching a Model

Teach the workpiece to be found as the model.

Polarity

Select the color of the blob to be found from the following:

White on Black

Find a white blob.

Black on White

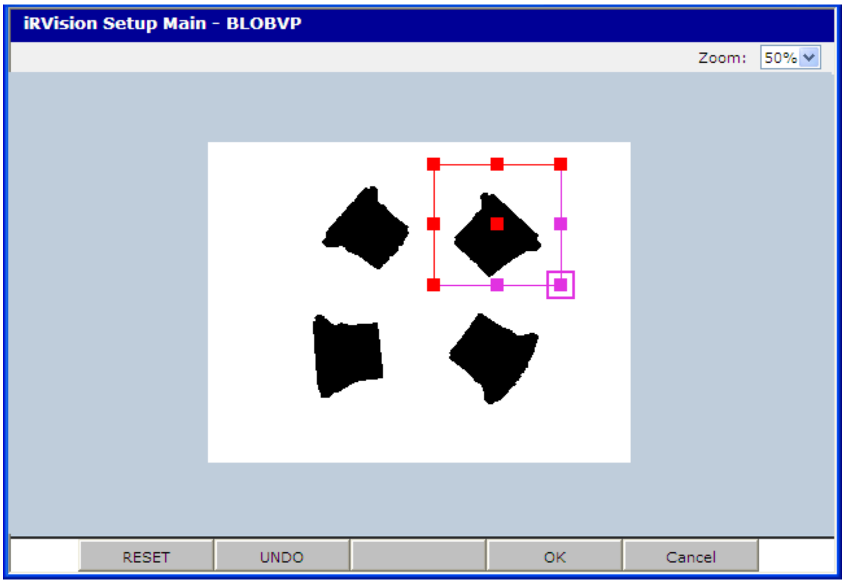
Find a black blob.

Train Model

Teach the model as follows.

1. Press F2 LIVE to change to the live image display.
2. Place the workpiece near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4 Set Polarity to [Black on White].
5. Tap the [Teach] button.

6. Enclose the workpiece within the displayed red rectangle, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.



Model ID

If you want to train more than one blob locator tool and identify which blob locator tool has found the workpiece, set a different model ID to each blob locator tool. Since the model ID of the blob locator tool that has found the workpiece is sent to a vision register along with the offset data, the robot program can identify the model ID of the found workpiece.

Trained model info.

The feature information of the trained model is displayed. Together with the image enclosed by a rectangle when training the model, the feature information of the trained blob is displayed.

7.3.3 Adjusting the Location Parameters

Adjust the location parameters.

Use Computed RT Mask

This item is available only when this blob locator tool is a child tool of another blob locator tool. When this check box is checked, a blob found by the parent blob locator tool is used as the search window and the runtime mask of this blob locator tool. Usually it is checked off.

Search Window

Specify the range of the area of the image to be searched. The narrower the range is, the faster the location process ends. The default value is the entire image. To change the search window, tap the [Set] button. When a rectangle appears on the image, adjust its geometry, as when teaching a model. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.

Runtime Mask

Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle- or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.

Calculate the angle

Specify whether to calculate the orientation of the found blob. If you check this box, the orientation of the blob will be calculated. The blob locator tool can recognize orientation in the range from –90 to +90 degrees.

If you uncheck this box, the long axis length, short axis length, and elongation of the found blob will not be calculated.

Angle Calc. Method

Specify the angle calculation method from the following:

Axis of Inertia

The axis of inertia of the found blob is calculated, and the direction of the axis is used as the angle of the found blob.

Minimum Rectangle

The minimum rectangle that circumscribes the found blob is calculated, and the direction of the rectangle is used as the angle of the found blob.

Find if Touching Win.

The blob locator tool outputs the center of mass of the blob as the found location. If the blob is in contact with the search window, it is impossible to know how much of the blob extends out of the search window, in which case the center of mass cannot be calculated accurately. By default, therefore, the blob locator tool ignores any blob touching the search window. However, checking this box causes the tool to find blobs touching the search window as well. Use this function when you want to measure the area of the black region in the image, rather than finding the location of a blob.

> ⚠ **CAUTION**
> Uncheck this box if you want to find the location of a workpiece using the blob locator tool. By default, the box is not checked.

DOF – Area

Specify the range of area values for judging the blob to match the model. If the area of the found blob is within the range specified by [minimum] and [Maximum], the location succeeds. If you uncheck the box, the area will not be checked.

DOF – Perimeter

Specify the range of perimeter values for judging the blob to match the model. If the perimeter of the found blob is within the range specified by [Minimum] and [Maximum], the location succeeds. If you uncheck the box, the perimeter will not be checked.

DOF – Circularity

The degree of circularity is calculated by dividing the 4π area by square of perimeter and represents how closely the found blob resembles a circle. If the blob is a perfect circle, this value is 1.0. The more complex the blob becomes in geometry, the smaller the value becomes.
Specify the range of degrees of circularity for judging the blob to match the model. If the degree of circularity of the found blob is within the range specified by [Minimum] and [Maximum], the location succeeds. If you uncheck the box, the degree of circularity will not be checked.

DOF – Semi Major

Specify the range of semi-major axis length values for judging the blob to match the model. If the semi-major axis length of the found blob is within the range specified by [Minimum] and [Maximum], the location succeeds. If you uncheck the box, the semi-major axis length will not be checked.

DOF – Semi Minor

Specify the range of semi-minor axis length values for judging the blob to match the model. If the semi-minor axis length of the found blob is within the range specified by [Minimum] and [Maximum], the location succeeds. If you uncheck the box, the semi-minor axis length will not be checked.

DOF – Elongation

Elongation is calculated by dividing the semi-major axis length by the semi-minor axis length and represents how slender the found blob is. The longer the blob is, the larger the value becomes. Specify the range of elongation values for judging the blob to match the model. If the elongation of the found blob is within the range specified by [Minimum] and [Maximum], the location succeeds. If you uncheck the box, the elongation will not be checked.

Display Mode

Select how the found result is to be displayed on the image after the process is run.

Found Position

Only the center of mass of the blob will be displayed.

Contour

Only the contour of the blob will be displayed.

All

Both the center of mass and contour of the blob will be displayed.

Image Display Mode

Select the image display mode for the setup page.

Grayscale Image

The camera image will be displayed as is.

Grayscale Im.+Results

The camera image and found results will be displayed.

Binary Image

The camera image will be binarized when displayed.

Binary Image+Results

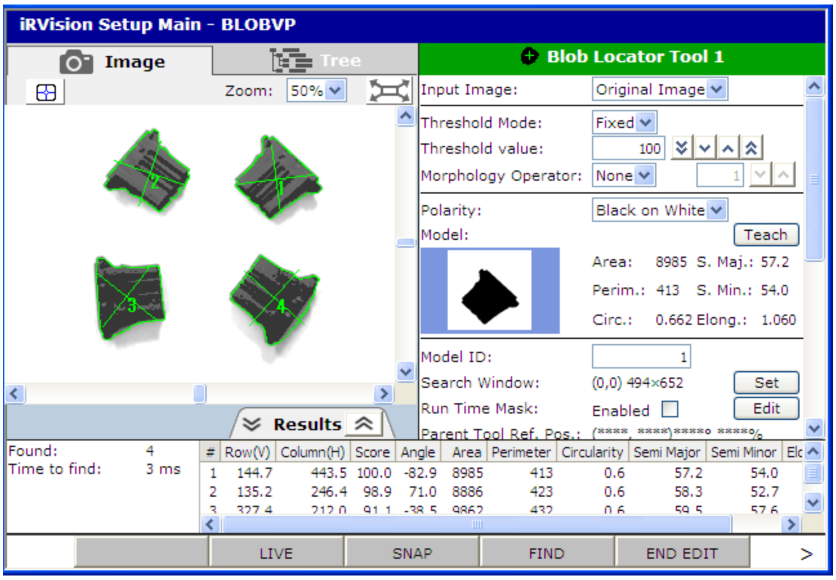
The camera image and found results will be binarized when displayed.

Model Image

The taught model pattern will be displayed.

7.3.4 Running a Test

Press F4 SNAP to run a test and see if the tool can find blobs properly.



Found

The number of found blobs is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

Row, Column

Coordinate values of the center of mass of the found blob (units: pixels).

Score

Score of the found blob.

Angle

Orientation of the found blob. This is displayed only when the [Calculate the angle] check box is checked.

Area

Area of the found blob (units: pixels).

Perimeter

Perimeter of the found blob (units: pixels).

Circularity

Degree of circularity of the found blob.

Semi-major

Long axis length of the found blob (units: pixels).

Semi-minor
Short axis length of the found blob (units: pixels).

Elongation
Elongation of the found blob.

> **NOTE**
> If the tool fails to find the object, run the find test with all the search range boxes unchecked. This slows down the process but it can identify which item causes the location to fail. With the DOF parameters unchecked, all the blobs in the image are found. Adjust the parameters to an appropriate range.until only the desired blobs are detected

7.3.5 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. See 8.1 "VISION OVERRIDE" and 9.2.2.13 "OVERRIDE" for details.

Area
Enable/disable selection for area checking, minimum area and maximum area can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum area.

Perimeter
Enable/disable selection for perimeter checking, minimum perimeter and maximum perimeter can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum perimeter.

Circularity
Enable/disable selection for circularity checking, minimum circularity and maximum circularity can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number between 0 and 1 for minimum and maximum circularity.

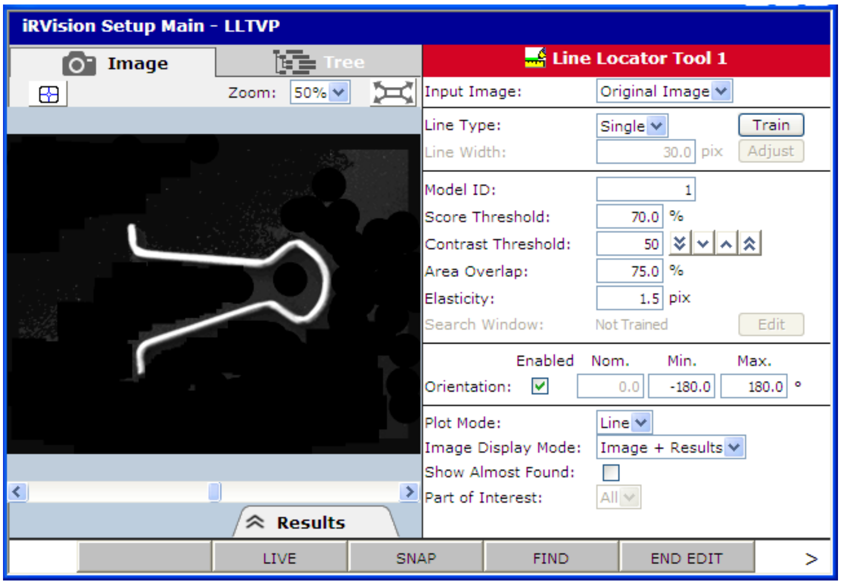
Semi Major
Enable/disable selection for semi-major axis length checking, minimum semi-major axis length and maximum semi-major axis length can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum semi-major axis length.

Semi Minor
Enable/disable selection for semi-minor axis length checking, minimum semi-minor axis length and maximum semi-minor axis length can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum semi-minor axis length.

Elongation
Enable/disable selection for elongation checking, minimum elongation and maximum elongation can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum elongation.

7.4 LINE LOCATOR TOOL

Line Locator Tool is an image processing tool that finds a line segment with the length taught in advance within a camera-captured image, and outputs the position and direction of the line. If you select a line locator tool in the tree view of the setup page for the vision process, a setup page like the one shown below appears.



Input Image

Select the image which is used for training model and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Line Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.4.1 Setting up a Model

Teach the type and the length of the line segment to find. Unlike a GPM Locator Tool, features in an image are not taught as a model.

Line Type

Select the type of line segment to find.

Single

A bordering line between a dark region and a light region is detected. A 0-degree model is generated as a vertical straight line with a dark region on the left and a light region on the right of the line.

Double (Step)

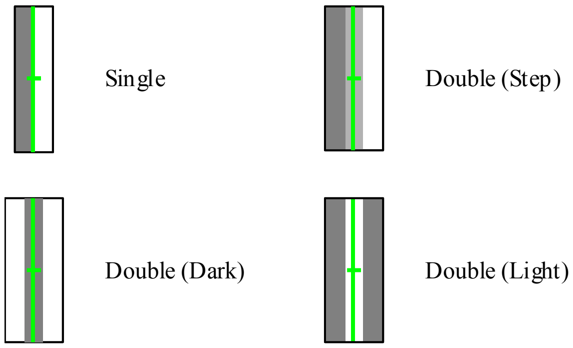
Two parallel lines are considered as a single thick line through the center of the two lines.
A 0-degree model is generated as a vertical straight line with the line having brightness between the brightness of the left and right regions, where the left region is darker and the right region is lighter than the line.

Double (Dark)

Two parallel lines are considered as a single thick line through the center of the two lines.
A straight dark line is found with this line type. A 0-degree model is generated as a vertical straight line with the line having brightness darker than the brightness of the left and right regions.

Double (Light)

Two parallel lines are considered as a single thick line through the center of the two lines.
A straight light line is found with this line type. A 0-degree model is generated as a vertical straight line with the line having brightness lighter than the brightness of the left and right regions.

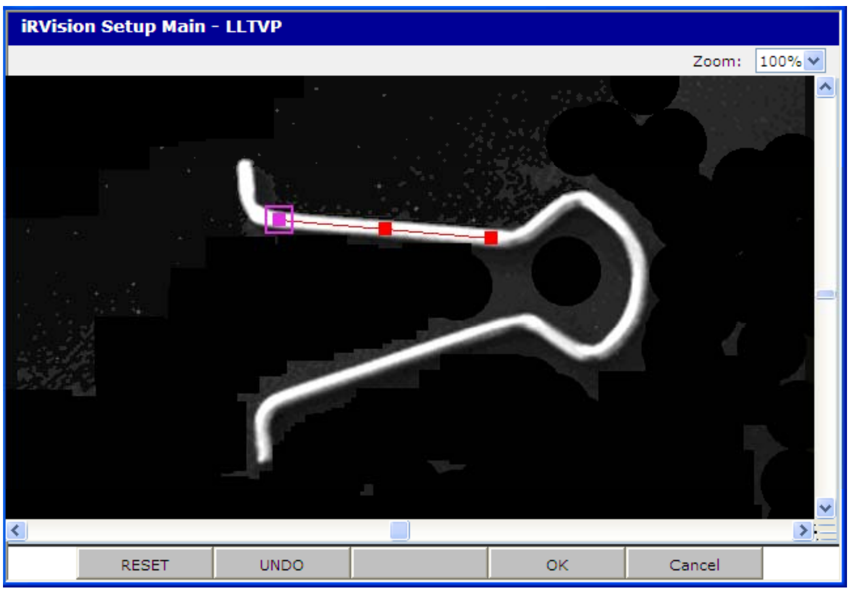


Teaching the model line length

Teach the model line length as follows.

1. Press F2 LIVE to change to the live image display.
2. Place the workpiece near the center of the camera view.
3. Press F2 STOP and then F3 SNAP to snap the image of the workpiece.
4. Tap the [Train] button.
5. Enclose the workpiece within the red rectangle that appears, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, "Setting Window".

The length of the rectangular window in the direction perpendicular to the rotation handle will be the length of the line taught as the model pattern.



Line Width

When one of the double line types is selected as the [Line Type], the width of a line to be found is specified in pixels. Set a value between 1 and 50.

Adjust Width

When one of the double line types is selected as the [Line Type], the line width is automatically adjusted to the found line width by tapping the [Adjust] button.

> **NOTE**
> The line width is automatically adjusted by finding the line internally. Specify a width close to the actual width in [Line Width] before executing.

Model Origin

The "model origin" is the point that numerically represents the location of the found line. The origin for line locator tool is automatically set at the center of the line segment, and the location cannot be changed. The coordinate values (Row, Column) of the location of the found pattern indicate the location of the model origin. When the found result is displayed on the image, a + mark appears at the model origin.

7.4.2 Adjusting the Location Parameters

Adjust the location parameters.

Score Threshold

The accuracy of the found result is expressed by a score, with the highest score being 100. The target line is successfully found if its score is equal to or higher than this threshold value. If the score is lower, the target line is not found. Set a value between 10 and 100. The default value is 70. Setting a small value might lead to inaccurate location.

Contrast Threshold

Specify the contrast threshold for the search. Set a value between 1 and 200. The default value is 50. If you set a small value, the tool will be able to find the target in obscure images as well but take longer to complete the location process. If the tool is prone to inadequately find blemishes and other unwanted edges with low contrast, try setting a larger value. Those image features whose contrast is lower than the threshold are ignored. Selecting the [Pattern] in [Image Display Mode] lets you check the image features extracted based on the current threshold.

Area Overlap

If the ratio of overlap of the found lines is higher than the ratio specified here, then the found result for the line with the lower score is deleted, leaving only the one with the higher score. The ratio of overlap is determined by the area where the models' external rectangular frames overlap. Set a value between 10 and 100. The default value is 75. If you specify 100% as the limit value, the found results will not be deleted even if the lines overlap.

Elasticity

Specify a pixel value to indicate how much the pattern in the image is allowed to be deviated (distorted) in geometry from the taught model. Set a value between 0.1 and 5.0. The default value is 1.5. Setting a large value enables the tool to find the target in images that are greatly deviated in geometry. However, the larger the value is, the more likely inaccurate location becomes.

Search Window

Specify the range of the area of the image to be searched. The narrower the range is, the faster the location process ends. When the model is taught by tapping the [Train] button, the search window is automatically set to the length of the line with the width of 100 pixels, with the center of the window at the model origin of the line. To change the search window, tap the [Edit] button. When a rectangle appears on the image, adjust its geometry, as when teaching a model. For detailed information about the operation method, see Subsection 3.7.9, “Setting a Window”.

Orientation

Specify the range of orientation subject to be searched. The tool searches for a model rotated in the range specified by [Minimum] and [Maximum], with the orientation of the taught model (vertical line in the image) being 0 degrees. The specifiable value range is from –360 to +360 degrees for both [Minimum] and [Maximum]. The narrower the orientation range is, the faster the search process ends. If a range wider than 360 degrees is specified, the range is automatically corrected to 360 degrees when the vision process runs.

If you uncheck this box, the orientation is ignored and the tool searches only for a model having the orientation specified in [Nominal].

By default, the orientation search is enabled and the range is from –180 to +180 degrees.

Result Plotting Mode

Select how the found results are to be displayed on the image after the process is run.

Line

The found line will be displayed.

Line and Model Origin

The line and the origin will be displayed.

Edges

Matched edges will be displayed in green and mismatched edges will be displayed in red.

Edges and Model Origin

The edges and the origin will be displayed.

Image Display Mode

Select the image display mode for the Setup Page.

Image

Only the camera image will be displayed.

Image+Edges

The camera image and the features within the search window will be displayed.
When the search window is not taught, the image and the features within the image will be displayed.

Image+Results

The camera image and the found results will be displayed.

Show Almost Found

If there is any line that failed to be found because it fell just short of meeting the score, contrast, orientation, and/or other conditions, its test result is displayed. The result appears in a red rectangle on the image.

Part of Interest

When the line locator tool is a child tool of another locator tool, and if the parent locator tool finds multiple found results, the result to display on the image display can be selected. If the parent locator tool has only one found result, or if the parent tool is not a locator tool, then this item is not shown.

All

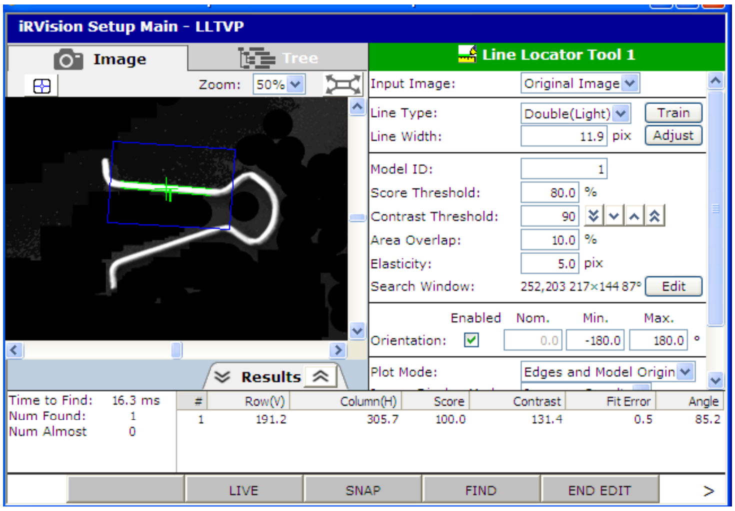
The results of all parent tool results and the corresponding line locator tool results are displayed. This option is selected by default.

Pn

Parent locator tool results in the image display are labeled with a “P” followed by an index number. The “n” represents the index number, and this option is added for how many ever parent results are found. When the parent locator tool finds multiple results, selecting this option will only display the corresponding parent result and the locator tool results based on the parent result.

7.4.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find lines properly.



Time to Find

The time the location process took is displayed in milliseconds.

Num Found

The number of found lines is displayed.

Num Almost Found

The number of lines that failed to be found because they were slightly outside the specified range is displayed. "0" is displayed if the [Show Almost Found] check box is not checked.

Found Result Table

The following values are displayed.

Row(V), Column(H)

Coordinate values of the model origin of the found line (units: pixels).

Score

Score of the found line.

Contrast

Contrast of the found line.

Fit Error

Deviation of the found line from the model line (units: pixels).

Angle

Orientation of the found line (units: degrees). This is displayed only when the box for the orientation search is checked.

7.4.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. See 8.1 "VISION OVERRIDE" and 9.2.2.13 "OVERRIDE" for details.

Score Threshold

Specify a number between 10 and 100.

Contrast Threshold

Specify a number between 1 and 250.

Elasticity

Specify a number between 1 and 5.

DOF Angle

Enable/disable selection, minimum angle, maximum angle and nominal angle can be specified. Specify 0 for disable or 1 for enabled. Specify a number between –360 and 360 for the minimum, maximum and nominal angles.

7.4.5 Guideline

Read these guidelines for a deeper understanding of how a line locator tool works.

What you can do with the line locator tool

The Line Locator Tool offers image processing capabilities to process images captured by the camera, find the line in an image as the pattern and length taught in advance (or longer), and output the position and orientation of the found line. The pattern taught in advance is called a model pattern, or simply a model. Unlike a GPM Locator Tool which generates a model pattern based on the object captured in the image, the Line Locator Tool generates and stores a model pattern internally based on the specified line type and length.

A found line is not of a finite length, but rather a segment with an infinite length in the direction of the found orientation. This feature can be utilized in such applications where the intersection of two lines or the angle formed by two lines is to be found.

Line locator tool result

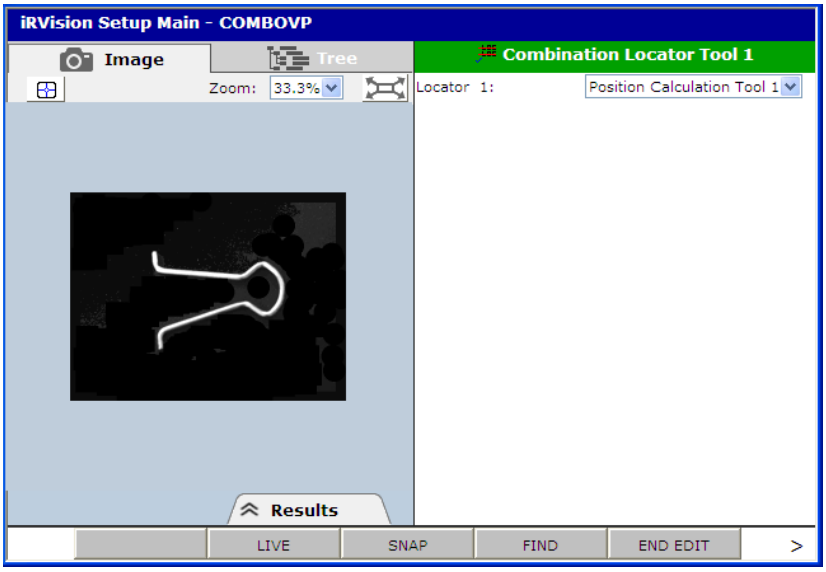
The result of a line locator tool is the position of the model origin (Vt, Hz) and the orientation of the line. However, the position of the model origin can vary along the length of the line.

The position information output by a line locator tool has a different meaning from the position information output by GPM locator tools. Where as a GPM locator tool outputs the position as a “point” in the image, the line locator tool outputs the position as a “line,” and *i*RVision differentiates them as two types of positions.

In essence, a “line” does not have definite position information. For practical purposes, the “line” position can be used to calculate the offset, or to dynamically shift the search window of a child tool. However, keep in mind that the position of a line is indeterminable and could be anywhere on a given line.

7.5 COMBINATION LOCATOR TOOL

Combination Locator Tool is a locator tool that customizes the output results by combining the results of multiple locator tools. This locator tool collaborates with the child locator tools to function as a single locator tool. The child locator tools do all the image processing, and the combination locator tool simply outputs the customized results. If you select the combination locator tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



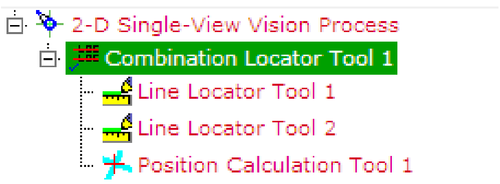
7.5.1 Setup

Setup the combination locator tool.

Adding child tools

When a combination locator tool is created, two line locator tools and a position calculation tool are added by default as its child tools. The output results can be customized by changing the combinations of child tools.

The following tree view is used when the [Line Locator 1] and [Line Locator 2] detect lines and [Position Calculation 1] calculates the intersection of the lines and [Combination Locator Tool 1] outputs the result of the calculation.



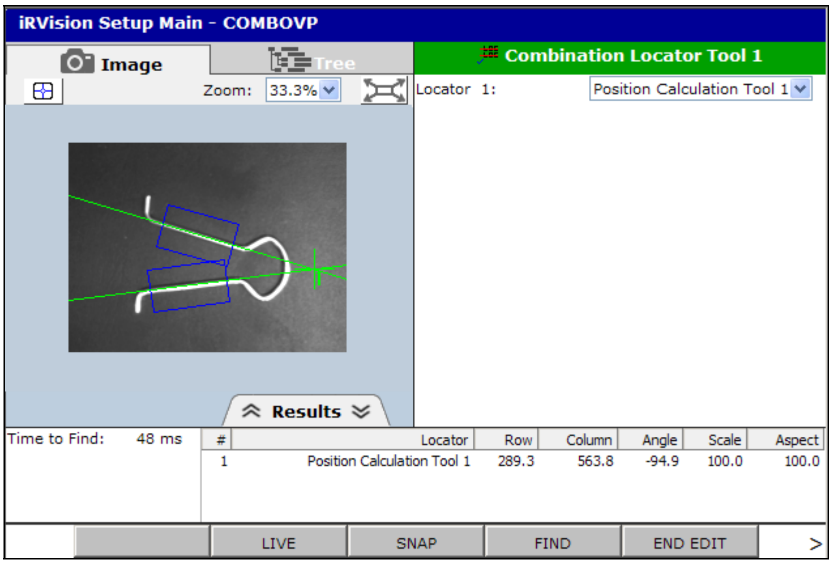
Locator 1

Select which child position calculation tool results to output as the result of the combination locator results. The found result of Locator 1 is output in that order. The results of other child tools that are not selected are not output.

For detail information of the Line Locator Tool and the Position Calculation Tool, please refer to Subsection 7.4 "Line Locator Tool" and 7.23 "Position Calculation Tool".

7.5.2 Running a Test

Press F4 SNAP to run a test and see if the tool can output the result of the selected position locator tool properly.



Time to Find

The time the location process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

Locator

Name of the locator tool that output the result.

Row, Column

Coordinate values of the model origin of the found pattern (units: pixels).

Angle

Orientation of the found pattern (units: degrees).

Scale

Scale of the found pattern (units: %).
If the selected command tool result does not have the size parameter, 100 is displayed.

Aspect Ratio

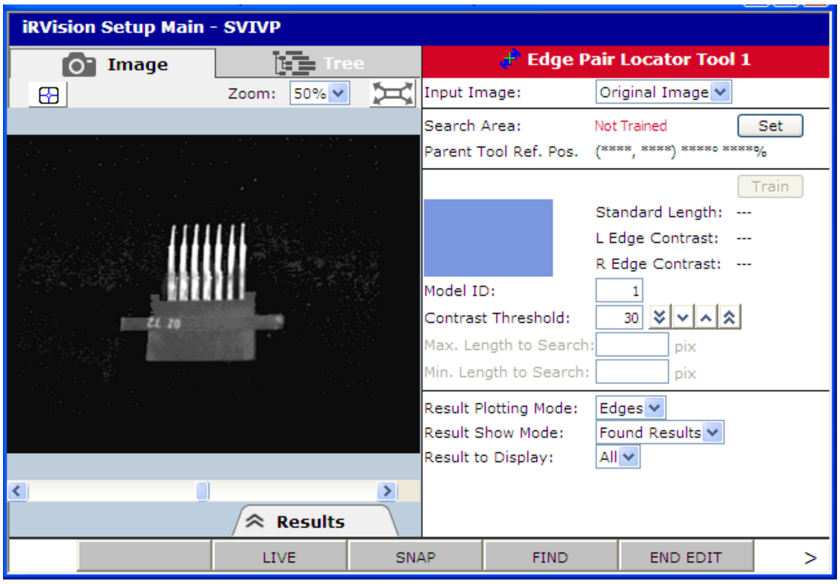
Aspect ratio of the found pattern (units: %).
If the selected command tool result does not have the aspect ratio parameter, 100 is displayed.

7.5.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.6 EDGE PAIR LOCATOR TOOL

The edge pair locator tool finds two parallel lines (edge pair) that are the same as the trained model pattern from an image and outputs the center position of the edge pair and the distance between the edges. It is mainly used for length measurement. If you select the edge pair locator tool in the tree view of the setup page for the vision process, a page like the one shown below appears.



Input Image

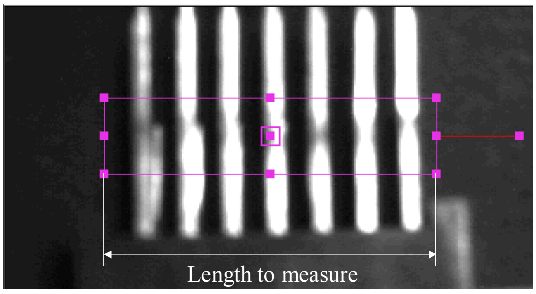
Select the image which is used for training model and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Edge Pair Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.6.1 Setting the Search Window

Set the area to be searched for an edge pair.

Search Area

Specify the range of the area of the image to be measured. The shorter the measurement area is in height, the more accurately the position of the edges is found. To change the measurement area, tap the [Set] button. When a purple rectangle appears on the image, enclose the area containing the edge pair to find with the displayed rectangle, and press F4 OK. The rectangle should be placed so that the centerline that indicates the rotation angle of the rectangle is parallel to the length to measure, as shown below. For detailed information about the operation method, see Subsection 3.7.9, "Window Setup".

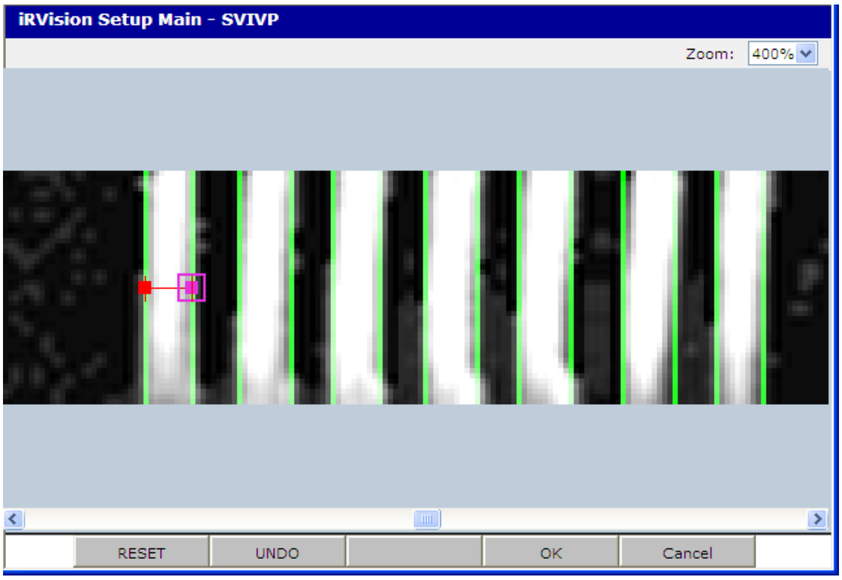


Parent Tool Reference Position

It is the reference position to be used for dynamic window shifting. This section displays the position of the workpiece found by the parent locator tool when the search area is taught.

7.6.2 Teaching a Model

Teach the edge pair to be found as the model. The procedure for teaching the model is as follows.



1. Tap the [Train] button.
2. The edge found in the measurement area is displayed in the window. First, move the left tip of the red line to the left edge of the edge pair used as the model.
3. Next, move the right tip of the red line to the right edge of the edge pair used as the model, and then press F4 OK.

When the model teaching process is completed, the information on the taught model is displayed.

Model Image

The edge pair to be found and the distance between the paired edges are displayed. The polarity of the edges to be found (from white to black or black to white) can be seen.

Standard Length

It is the distance between edges of the model edge pair. At runtime, if two or more edge pair candidates are found in the search window and they overlap each other, priority is given to the edge pair whose distance between edges is closest to the standard length.

Left/Right Edge Contrast

It is the contrast of edges of the model edge pair. At runtime, if two or more edge pair candidates are found in the search window and they overlap each other, priority is given to the edge pair whose contrast is closest to that of the model edge pair.

7.6.3 Adjusting the Location Parameters

Adjust the location parameters.

Model ID

When you want to have taught two or more edge locator tools and want to identify which tool the found workpiece corresponds to, you assign a distinct model ID to each tool. The model ID of the found model pattern is reported to the robot controller along with offset data. This enables the robot program to identify the type of the found model.

Contrast Threshold

Specify the contrast threshold for the search. The default value is 30. If you set a small value, the tool will be able to find the edges with less contrast but it will take longer to complete the location process. The minimum value is 1. If the contrast is set too low false edges may be found, if this is the case raise contrast threshold. The edges whose contrast is lower than the threshold are ignored.

Maximum Length to Search

Specify the maximum inter-edge distance of the edge pair to be found. When a model edge pair is taught, a value that is 105% of the standard length is input as the default value.

Minimum Length to Search

Specify the minimum inter-edge distance of the edge pair to be found. When a model edge pair is taught, a value that is 95% of the standard length is input as the default value.

Result Plotting Mode

Select the image display mode for the Setup Page.

Edge

The search area, the measured edge pair distance (green arrow), and the center position of the found edge pair are displayed.

Edges + Arrow

The scan direction (blue arrow), the measured edge pair distance (green arrow), and the center position of the found edge pair are displayed.

Edges + Proj. + Grad.

In addition to the information presented in the Edge mode, graphs are displayed that show changes in contrast and gradient of the search area.

Edges + Proj. + Grad.+ Arrow

In addition to the information presented in the Edges + Arrow mode, graphs are displayed that show changes in contrast and gradient of the search area.

Result Show Mode

Select the mode for displaying the result on the setup window.

Found Results

Of the found edge pairs, the one to be output as the found result is displayed.

All Edge Pairs

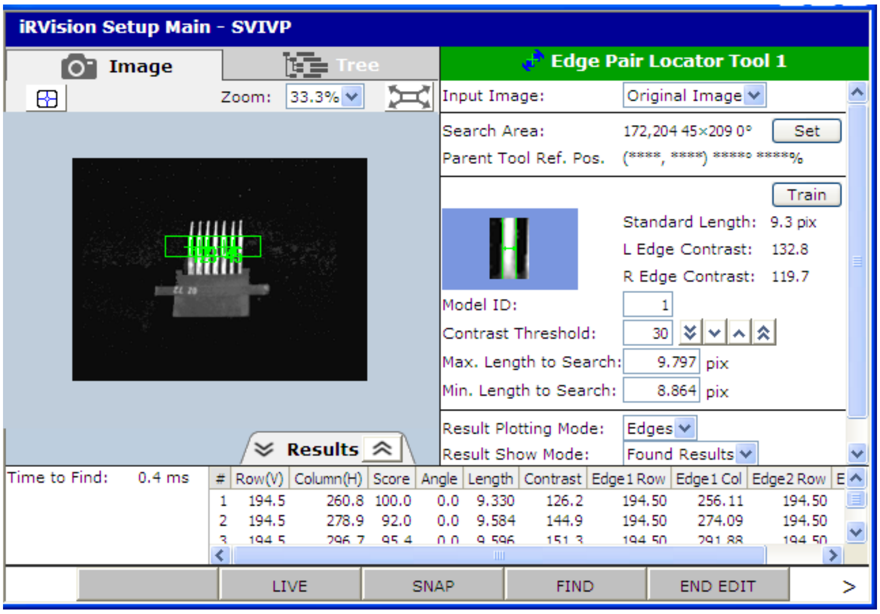
All the edge pairs whose polarity (from white to black or black to white) matches that of the model edge pair are displayed, irrespective of the length.

Result to Display

If the edge pair locator tool is inserted as a child tool of a locator tool, and if the parent locator tool outputs multiple found results, you can display the result corresponding to a specific found result of the parent tool by selecting a result number. Selecting [All] displays the results for all the found results of the parent locator tool.

7.6.4 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Time to Find

The time the location process took is displayed in milliseconds. This only represents the time it took to process the image and does not include the time it took to snap it.

Found result table - Found Results

For the edge pair locator tool, the items displayed in the found result table differ depending on the item selected in [Result Show Mode]. When [Found Results] is selected, the found edge pair to be output as the found result is displayed.

Row(V), Column(H)

Coordinates of the center of mass of the found edge pair (unit: pixel).

Score

Score of the found edge pair.

Angle
Rotation angle of the measurement area at the time when the location process is executed, relative to the measurement area at the time of setup.

Length
Inter-edge distance of the found edge pair (unit: pixel).

Contrast
Average contract of the found edge pair.

Edge 1 Row
Vertical-direction coordinate of the left edge of the found edge pair (unit: pixel).

Edge 1 Col
Horizontal-direction coordinate of the left edge of the found edge pair (unit: pixel).

Edge 2 Row
Vertical-direction coordinate of the right edge of the found edge pair (unit: pixel).

Edge 2 Col
Horizontal-direction coordinate of the right edge of the found edge pair (unit: pixel).

Found result table - All Edge Pairs
If you select [All Edge Pairs], all the edge pairs whose polarity (from white to black or black to white) matches that of the model are displayed, irrespective of the length.

Length
Distance between found edge pairs (unit: pixel).

Contrast 1
Average contrast of the left edge of the found edge pair.

Contrast 2
Average contrast of the right edge of the found edge pair.

7.6.5 Overridable Parameters

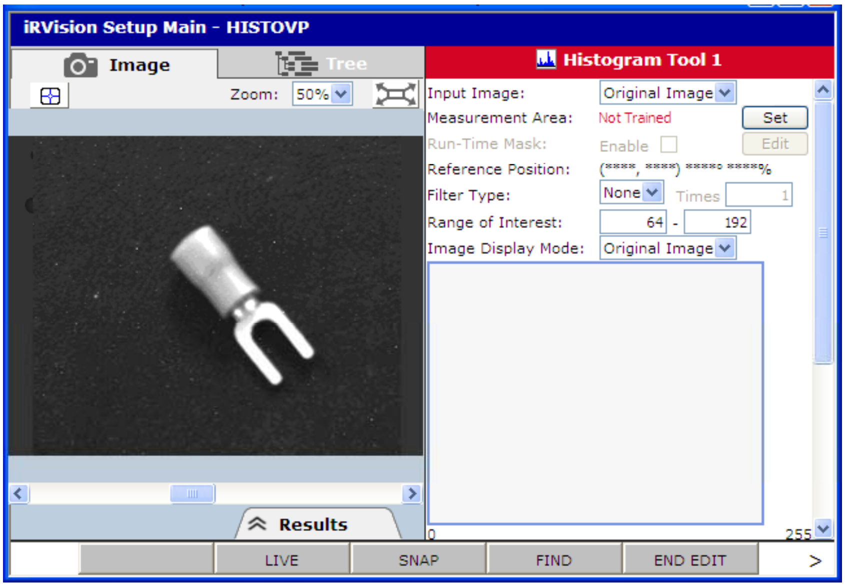
This command tool has the following overridable parameters that can be overridden with Vision Override. See 8.1 "VISION OVERRIDE" and 9.2.2.13 "OVERRIDE" for details.

Contrast Threshold
Specify a number between 1 and 250.

7.7 HISTOGRAM TOOL

The histogram tool measures the brightness of an image. When the histogram tool is located below a locator tool, such as the GPM Locator Tool, in the tree view, the measurement window of the histogram tool moves dynamically according to the found result of the parent locator tool.

If you select the histogram tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



Input Image

Select the image which is used for training area to measure brightness. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Histogram Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.7.1 Setting the Measurement Area

Use Computed RT Mask

This item is available only when this histogram tool is a child tool of a blob locator tool. When this check box is checked, a blob found by the parent blob locator tool is used as the measurement area and the runtime mask of this histogram locator tool. Usually it is unchecked.

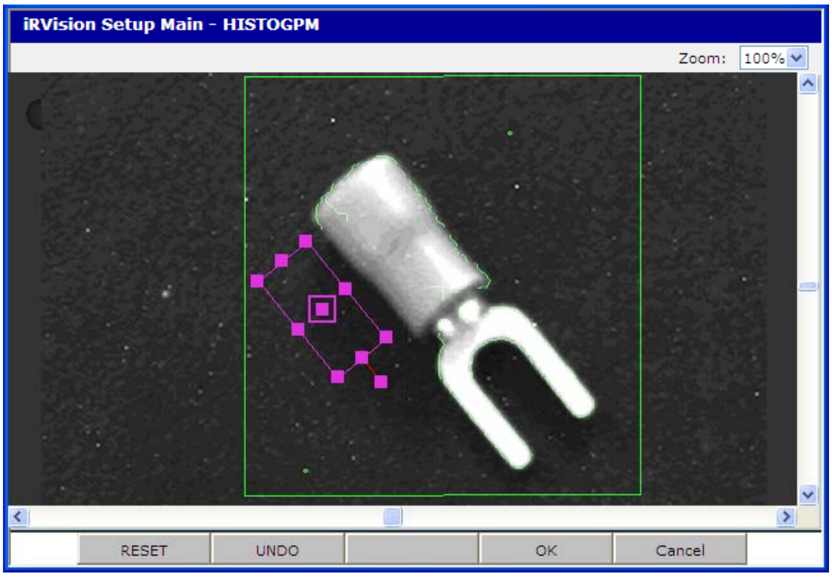
Area to measure brightness

Set the area whose brightness is to be measured, as follows.

1. Press F2 LIVE to change to the live image display.
2. Place the workpiece near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4. Tap the [Set] button for [Area to measure brightness].

The parent locator tool runs automatically, and a red + mark appears on the found object. If the location fails, an alarm message to that effect is displayed and the measurement area setting is stopped.

5. Select the area to measure, using the displayed purple rectangle, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.



The values shown in [Reference Position] indicate the position of the object that the parent locator tool found when the measurement area was specified.

Run-Time Mask

Specify an area of the measurement window that you do not want processed as an arbitrary geometry. The filled area will be masked in the rectangle specified as the measurement window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.

Filter Type

Before measuring a histogram, you can apply a filter to the image.

None

Do not use a filter.

Blur

Apply a filter to blur the image. Blurring an image obscures brightness differences in the image, thus helping alleviate the effect of noise.

Times

Specify the number of times the filter is to be applied. Currently, this item is available only when [Blur] is set in [Filter Type]. The larger the number, the stronger the blurring effect. The specifiable value range is 1 to 10.

Range of Interest

Specify the brightness range of interest from 0 (dark) to 255 (bright). [Within Range (%)], described later, indicates the percentage of pixels within the specified brightness range.

Image Display Mode

Select the type of image to be displayed in the image display frame from the following two types:

Original Image

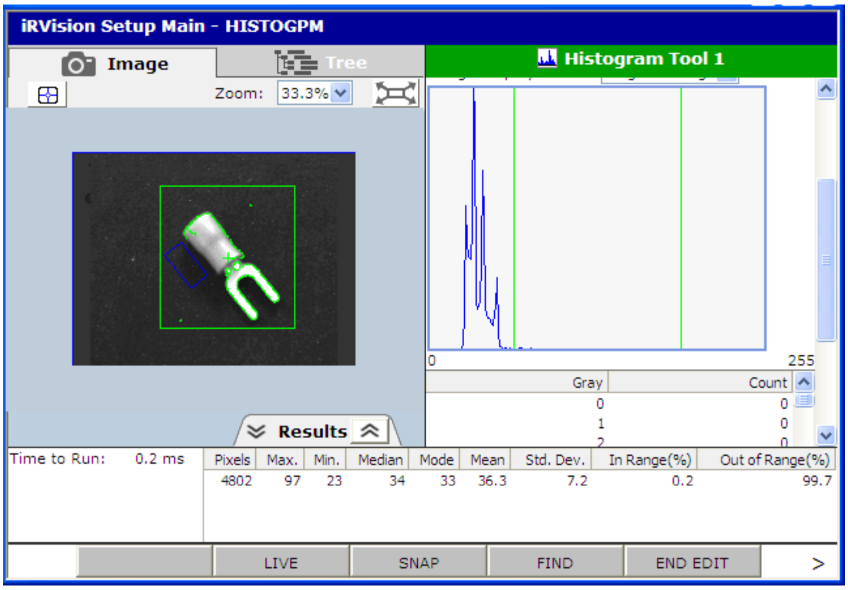
Display the image as it is captured by the camera.

Filtered Image

Display the image resulting from applying a specified filter to the original image.

7.7.2 Running a Test

Run a measurement test to see if the tool can find brightness properly.



Time to Find

The time the histogram measurement took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Pixels

Total number of pixels in the measured area.

Max.

Brightness of the brightest pixel in the measured area.

Min.

Brightness of the darkest pixel in the measured area.

Median

Median of the brightness of the measured area.

Mode

Most common brightness of pixels in the measured area.

Mean

Mean brightness of the measured area.

Std. Dev.

Standard deviation in brightness of the measured area.

In Range (%)

Ratio of the number of pixels within the brightness range specified in [Range of Interest] to the total number of pixels in the area whose brightness has been measured.

Out of Range (%)

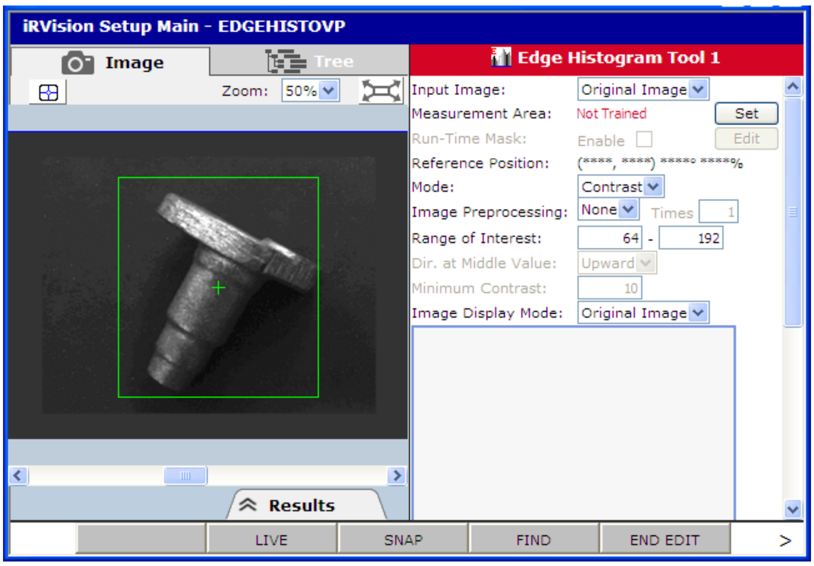
Ratio of the number of pixels outside the brightness range specified in [Range of Interest] to the total number of pixels in the area whose brightness has been measured.

7.7.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.8 EDGE HISTOGRAM TOOL

The edge histogram tool measures the changes (gradients) in brightness of an image. When the edge histogram tool is located below a locator tool, such as the GPM locator tool, in the tree view, the measurement window of the edge histogram tool shifts according to the found result of the parent locator tool. If you select the edge histogram tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



Input Image

Select the image which is used for training area to measure brightness. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Edge Histogram Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.8.1 Setting the Measurement Area

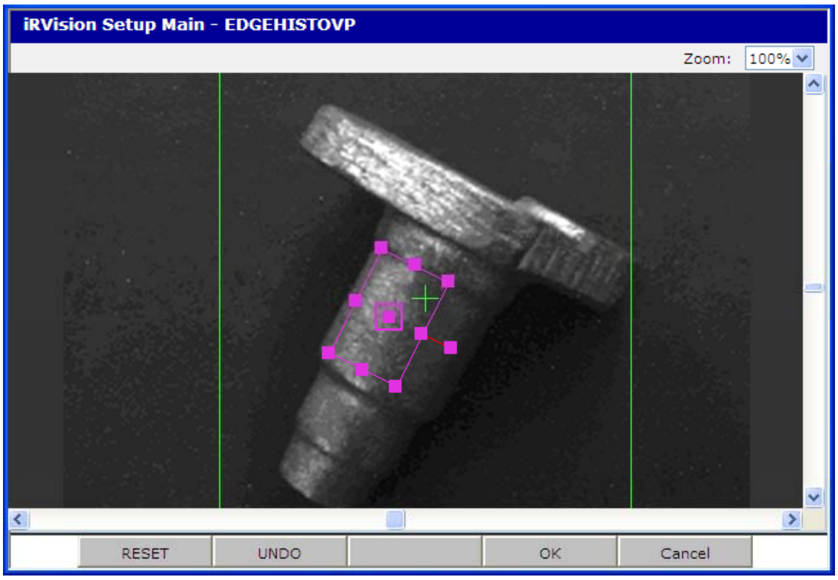
Use Computed RT Mask

This item is available only when this edge histogram tool is a child tool of a blob locator tool. When this check box is checked, a blob found by the parent blob locator tool is used as the measurement area and the runtime mask of this edge histogram locator tool. Usually it is checked off.

Measurement Area

Set the area whose gradients are to be measured, as follows.

1. Press F2 LIVE to change to the live image display.
2. Place the workpiece near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4. Tap the [Set] button for [Measurement area].
5. The parent locator tool runs automatically, and a red + mark appears on the found object.
   If the location fails, an alarm message to that effect is displayed and the measurement area setting is stopped.
6. Enclose the workpiece within the purple rectangle that appears, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Setting Window”.



The values shown in [Reference position] indicate the position of the object that the parent locator tool found when the measurement area was specified.

Run-Time Mask

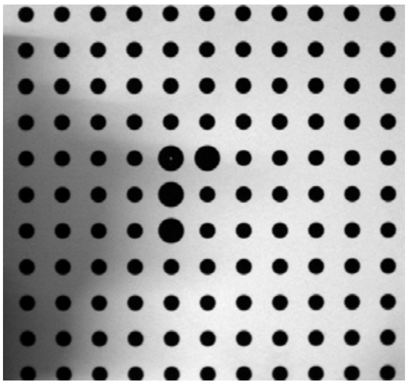
Specify an area of the measurement window that you do not want measured by the edge histogram. The masked area of the measurement window will not be subject to the image processing of the edge histogram. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, "Editing Masks".

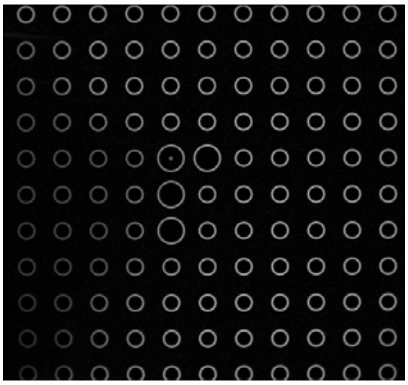
Mode

A gradient has two elements - contrast and direction. Of these, specify the element whose distribution is to be measured.

Contrast

The distribution of gradient contrasts is measured. A gradient contrast is represented by a value from 0 (weak) to 255 (strong). As shown in the example of the "gradient contrast image" in the following figure, the value becomes larger at a place where there is a greater contrast between brightness and darkness.

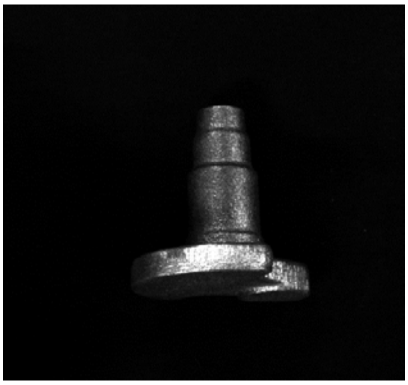


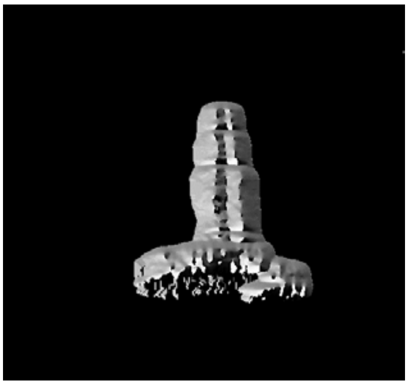


[Original Image] **[Contrast Image]**

Direction

The distribution of gradient directions is measured. A gradient direction is represented by a value from 0 to 255. Numbers become larger as they go counterclockwise on the screen. Which direction is represented by each individual value is determined by the direction of the mean 128, which is set in [Center of histogram means] described later.





[Original Image] **[Direction Image]**

Image Preprocessing

As the preprocessing before gradient distribution measurement, a filter can be applied to the image. This suppresses the disturbance of the gradient distribution due to fine noise. The following three settings are available:

None

Measure the gradient distribution with the original image without preprocessing.

Gaussian

Apply a Gaussian filter as the preprocessing. This makes it easier to save the original gradient distribution than with [Blur]. This setting is recommended when measuring a workpiece for which the original gradient distribution is relatively stable.

Blur

Apply a blurring filter to the image as the preprocessing. This produces a greater effect in averaging the original gradient distribution than does [Gaussian]. This setting is recommended in the case of an image of a casting surface or other similar material where there are many gradients that do not faithfully represent the nature of the workpiece.

Times

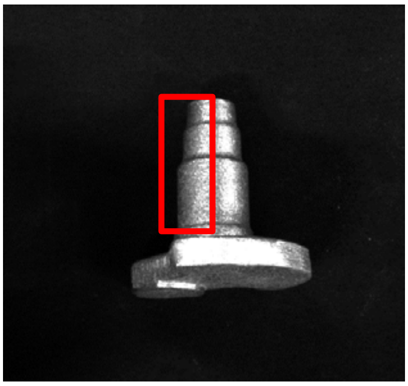
Specify the number of times the filter is to be applied as the preprocessing. Applying the filter more times produces a greater noise reduction effect but leads to a reduced gradient contrast. The specifiable value range is 1 to 10.

Range of Interest

Specify the contrast or direction range of interest in 256 steps from 0 to 255. [Within Range(%)], described later, indicates the percentage of pixels within the specified brightness range.

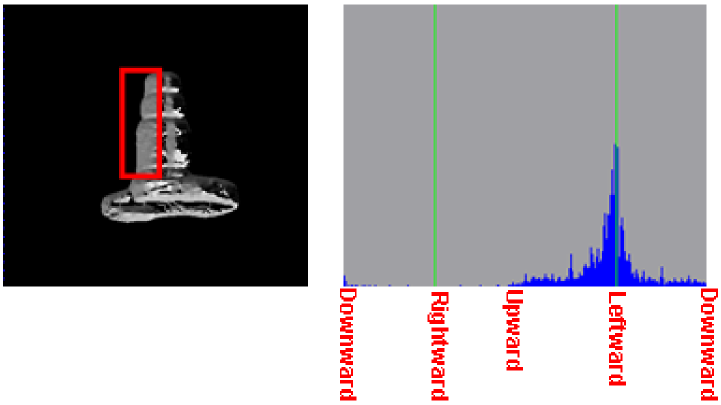
Dir. at Middle Value

This item is valid only when [Direction] is set for [Mode]. With this edge histogram tool, direction is represented in 256 steps from 0 to 255. Specify which direction to assign to these numbers 0 to 255. For example, when [Upward] is specified for [Center of histogram means], the directions of the gradient from bright to dark are assigned so that the upward direction on the screen comes to the center of the histogram (128). Set a direction that well represents the characteristics of the range to be measured. For additional information, the center of histogram means is explained for each direction of the image shown below, highlighting the area enclosed by a red rectangle where the bright-to-dark direction corresponds to the right-to-left (leftward) direction on the screen, by using the edge image and the edge histogram of that area.



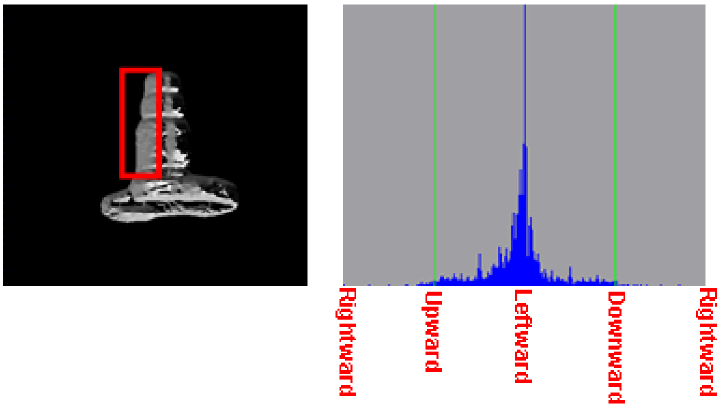
Upward

Numbers 0 to 255 are assigned to the directions of the gradient from bright to dark so that the upward direction on the screen comes to the center of the histogram. In this example, both the left and right side of the histogram show the downward direction.



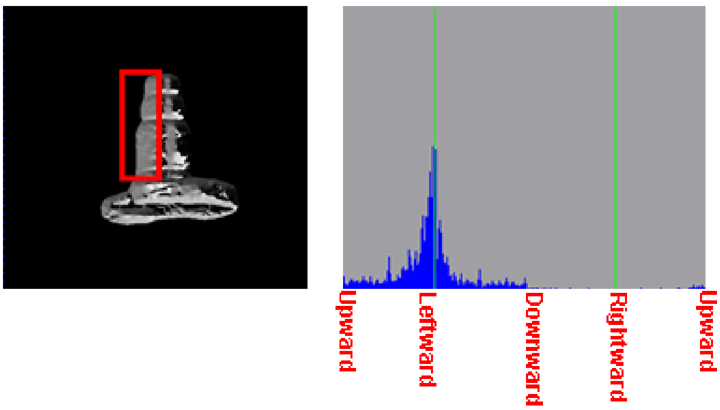
Leftward

Numbers 0 to 255 are assigned to the directions of the gradient from bright to dark so that the leftward direction on the screen comes to the center of the histogram. In this example, both the left and right side of the histogram show the rightward direction.



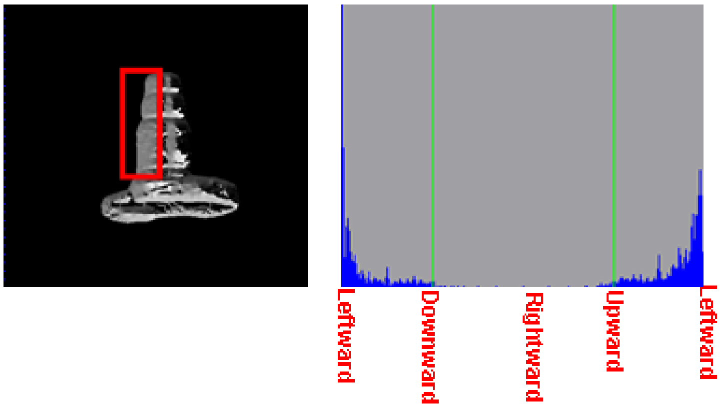
Downward

Numbers 0 to 255 are assigned to the directions of the gradient from bright to dark so that the downward direction on the screen comes to the center of the histogram. In this example, both left and right side of the histogram show the upward direction.



Rightward

Numbers 0 to 255 are assigned to the directions of the gradient from bright to dark so that the rightward direction on the screen comes to the center of the histogram. In this example, both the left and right side of the histogram show the leftward direction.



Minimum Contrast

This item is valid only when [Direction] is set for [Mode]. Pixels whose gradient contrast is lower than this value are not used for gradient direction measurement. The default value is 10, which may be adjusted as necessary.

Image Display Mode

Select the type of image to be displayed in the image display frame from the following two types:

Original Image

Display the image as it is captured by the camera.

Edge Image

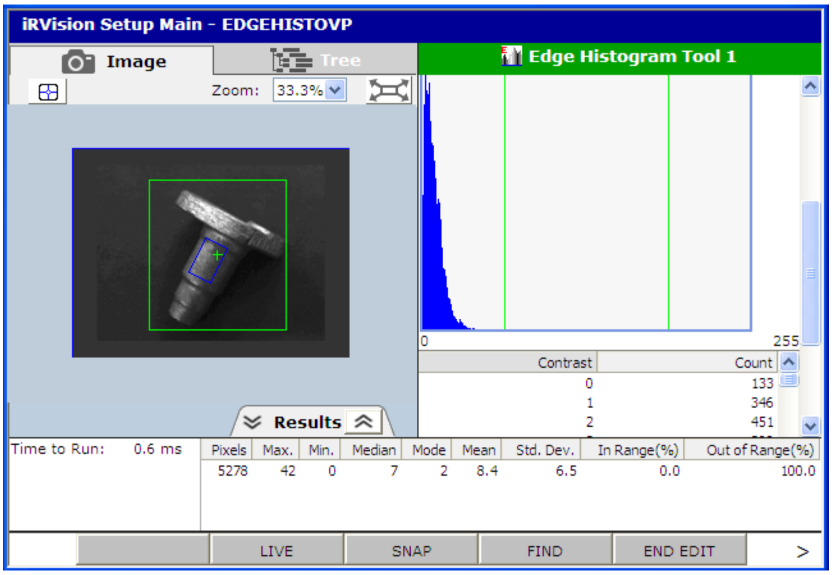
Display the image whose gradient distribution is to be measured actually. The image to be displayed differs depending on the setting of [Mode]. For information about the image to be displayed, see the description of [Mode] given earlier.

Preprocessed Image

Display the image to which the specified filter has been applied as the preprocessing.

7.8.2 Running a Test

Press F4 SNAP to run a measurement test and see if the tool can measure the gradient distribution properly.



Time to Find

The time the gradient distribution measurement took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Pixels

Total number of pixels in the area in which the gradient distribution measurement was made. The unit is the pixel. Note that pixels whose contrast is lower than the minimum contrast are excluded from the gradient distribution measurement and not included in the total number.

Max.

Maximum value in the gradient distribution measurement area.

Min.

Minimum value in the gradient distribution measurement area.

Median

Median value in the gradient distribution measurement area.

Mode

Value found the most number of times in the gradient distribution measurement area.

Mean

Mean value in the gradient distribution measurement area.

Std. Dev.

Standard deviation of the values in the gradient distribution measurement area.

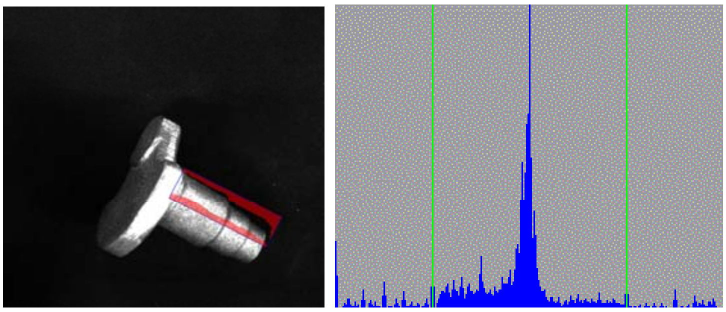
In Range (%)

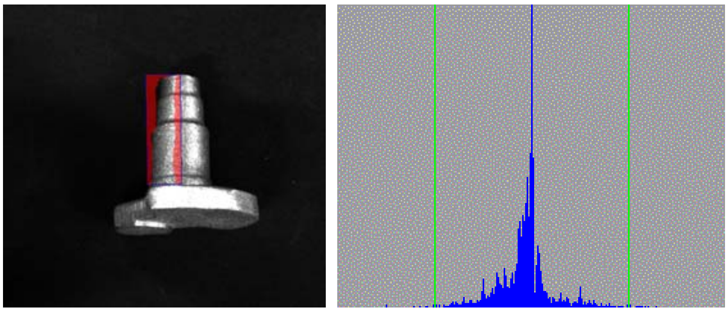
Ratio of the number of pixels within the range specified in [Range of Interest] to the total number of pixels in the gradient distribution measurement area.

Out of Range (%)

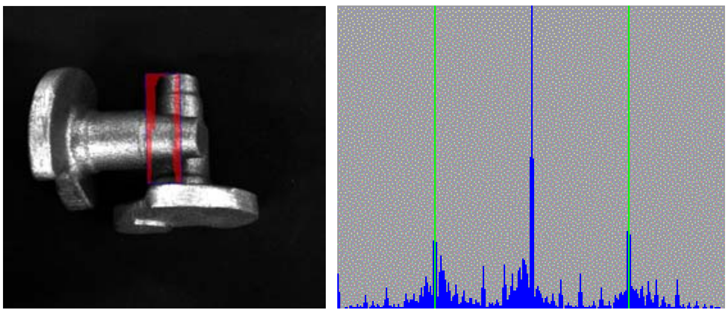
Ratio of the number of pixels outside the range specified in [Range of Interest] to the total number of pixels in the gradient distribution measurement area.

Shown below is an example of the test run using [Direction]. Since the found results of the parent tool are reflected on the direction calculation, there is no significant change in the histogram, even if the workpiece is rotated.





On the other hand, if there is any other object in the measurement area, the histogram changes as shown below. Paying attention to this change helps identify the overlap or other condition of the workpieces.



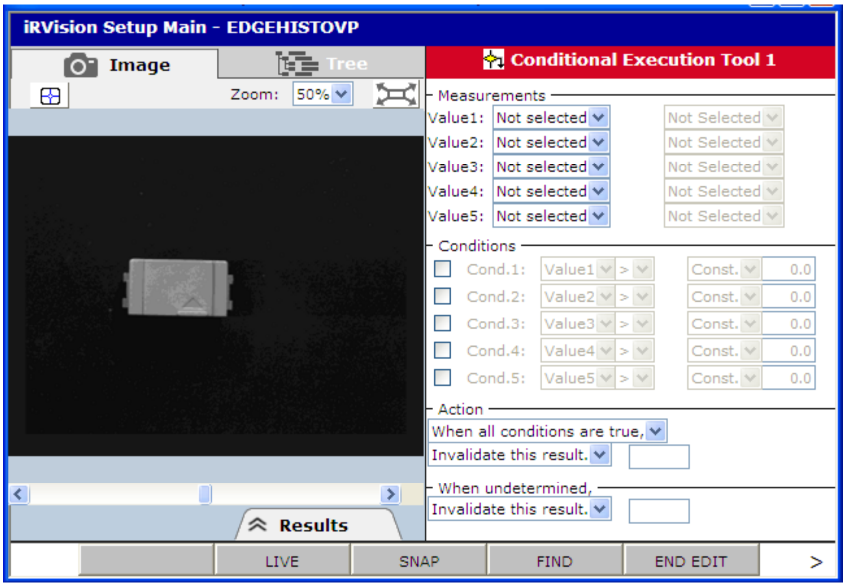
7.8.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.9 CONDITIONAL EXECUTION TOOL

The conditional execution tool evaluates the result of the histogram or other tool based on specified conditions and, only if the conditions are met, executes the specified processing.

If you select the conditional execution tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



7.9.1 Setting the Parameters

Set the conditions to evaluate and the processing to be performed when the conditions are met.

Measurements

In [Measurements], select the value or values to be evaluated with conditional statements. Up to five values can be specified.

1. From the drop-down box on the left, select a tool.
2. From the drop-down box on the right, select a measurement value.

Conditions

In [Conditions], specify the conditional statement or statements. Up to five conditions can be specified.

1. Check the box.
2. From the drop-down box on the left, select a value.
3. From the drop-down box in the middle, select an operator for evaluation.
4. From the drop-down box on the right, select [Const] or a [Value X].
5. If you select [Const], enter a constant in the text box to the right.

Action

Select the action to be performed when all the specified conditions are met.

In the first dropdown box, select the logic to perform the action.

When all conditions pass

Performs the specified action when all conditions met.

When at least one condition is true,

Perform the specified action when at least one condition met.

When all conditions are false,

Performs the specified action when all conditions does not met.

When at least one condition is false,

Performs the specified action when at least one condition not met.

In the next dropdown box, select an action to perform.

Invalidate this result

Invalidate this position.

Add the following value to model ID:

Add the specified value to the model ID.

Change the found angle by this many degrees:

Add the specified value in degrees to the found angle.

When undetermined

In [When undetermined], specify the action to be taken when whether the conditions are met cannot be determined. This can happen when there is no measurement value to evaluate - e.g., when the locator tool specified in [Value1] has failed to find the workpiece. Select one of the following options to specify the action to be taken:

Invalidate this result.

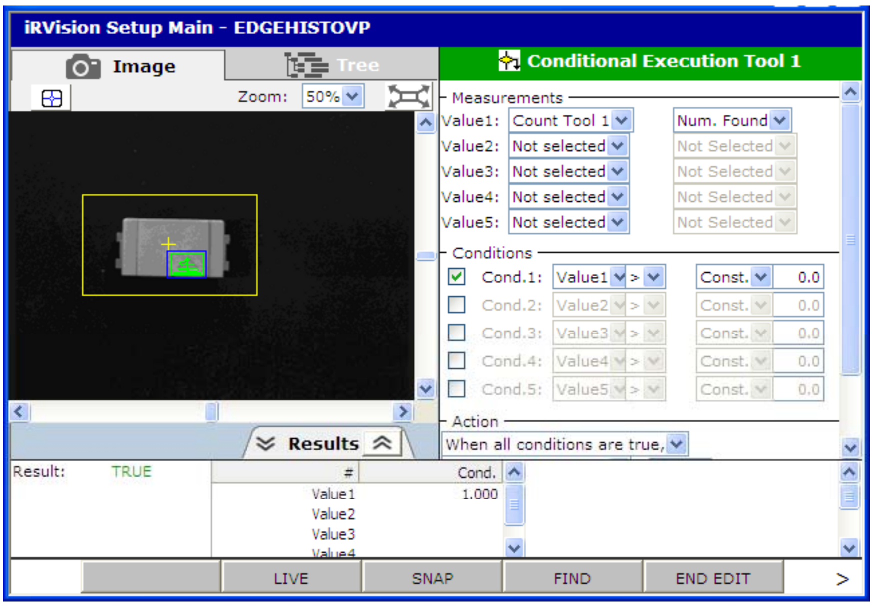
Invalidate this position.

Add the following value to model ID:

Add the specified value to the model ID.

7.9.2 Running a Test

Press F4 SNAP to run a test and see if the tool can evaluate the conditions properly.



Result

In [Result], [TRUE] is displayed if all of the specified conditions are met and [FALSE] is displayed if any of the specified conditions are not met.

Execution Result Table

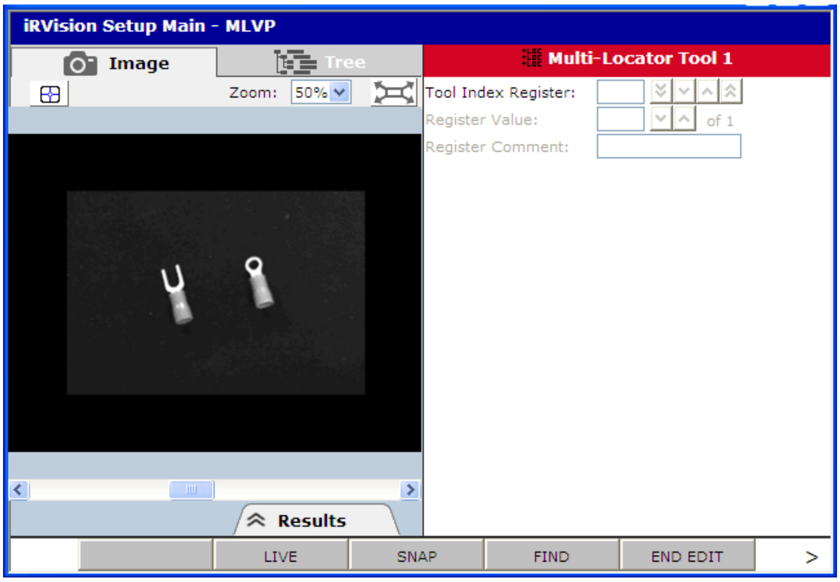
The measurement values for [Value 1] to [Value 5] and the PASS/FAIL evaluation results for [Condition 1] to [Condition 5] are displayed.

7.9.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

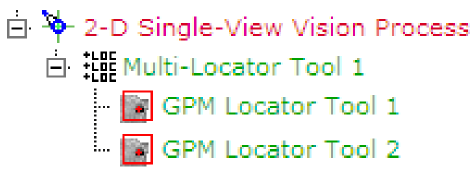
7.10 MULTI-LOCATOR TOOL

The Multi-locator tool changes the locator tool to be executed, according to the value set in a robot register. If you select the Multi-locator tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.10.1 Adding Child Tools

Add locator tools you want to use according to the value of the register as child tools of the Multi-locator tool. In the figure below, GPM Locator Tool 1 is executed when the register value is 1; GPM Locator Tool 2 is executed when it is 2.



> ⚠ **CAUTION**
> The Multi-locator tool cannot contain different types of locator tool. For example, you cannot mix a blob locator tool to a GPM Locator Tool under the multi-locator tool.

7.10.2 Setting the Register

Specify the register you want to use to change the locator tool.

Tool Index Register

Specify the number of the register you want to use to change the tool.

Register Value

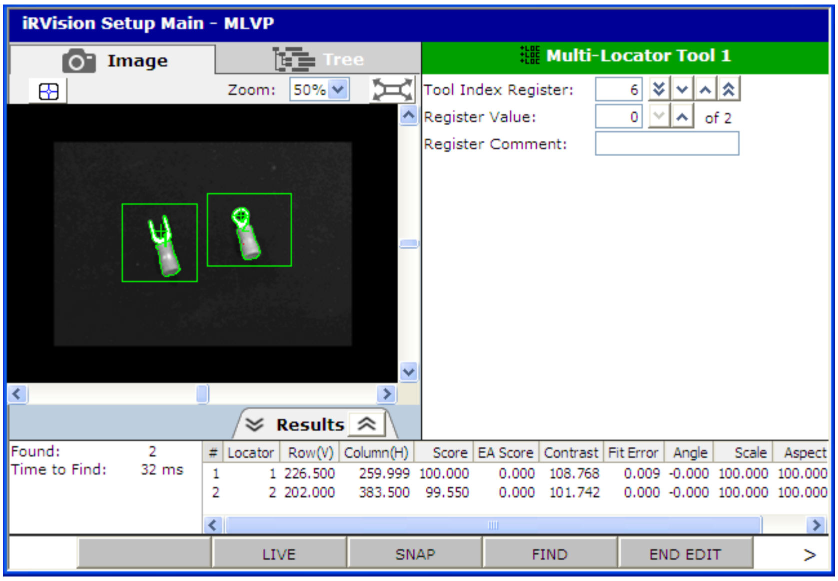
The value currently set in the register specified in [Location Tool Index Register] is displayed. When the value is changed, the value of the register of the robot controller is also updated automatically. This function is useful when you change the locator tool and run a test.

Register Comment

The comment currently set for the register specified in [Location Tool Index Register] is displayed.

7.10.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Found

The number of found workpieces is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Results table

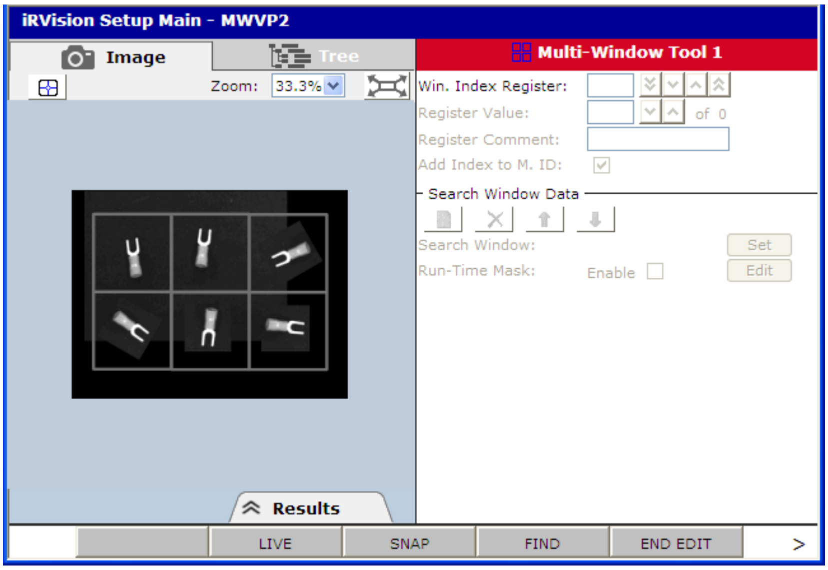
The items displayed differ depending on the tool set as child tools of the Multi-locator tool. For the explanation of each measured value, see the pages describing the set child tools.

7.10.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.11 MULTI-WINDOW TOOL

The multi-window tool changes the search window to be used, according to the value set in a robot register. If you select the multi-window tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.11.1 Setting the Register

Specify the register you want to use to change the window.

Window Index Register

Specify the number of the register you want to use to change the window.

Register Value

The value currently set in the specified register is displayed. When the value is changed, the value of the register of the robot controller is also updated automatically. This function is useful when you change the window and run a test.

Register Comment

The comment currently set for the specified register is displayed.

Add Index to M. ID

Specify whether to add the value of the specified register to the model ID. When this check box is checked, the value of the specified register is added to the model ID.

7.11.2 Setting a Window

Create a new window, and delete or change a window.

Creating a new window

Tap  button. A new window is created.

Deleting a window

Tap  button. The window is deleted.

Moving up

Tap  button. You can change the window.

Moving down

Tap  button. You can change the window.

Search Window

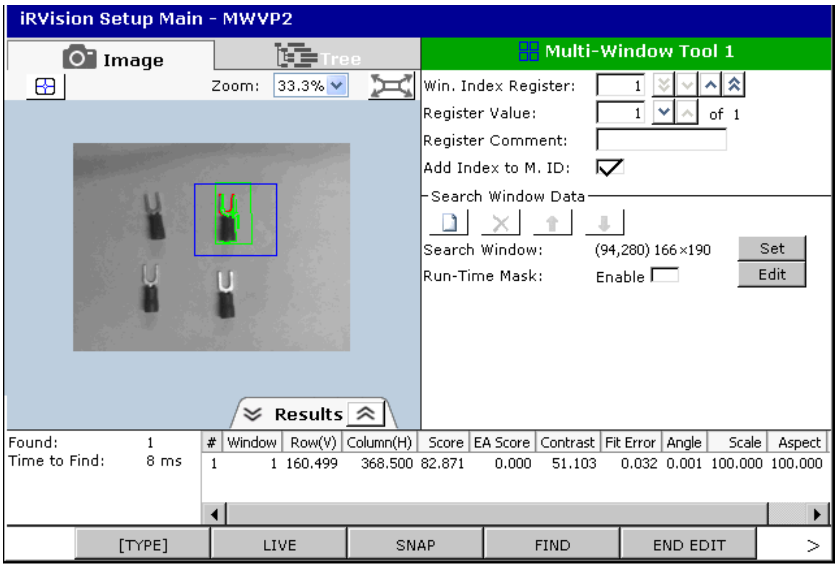
Specify the range of the area of the image to be searched. The default value is the entire image. To change the search window, tap the [Set] button. When a rectangle appears on the image, change the search window. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.

Run-Time Mask

Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.

7.11.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Found

The number of found workpieces is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Results table

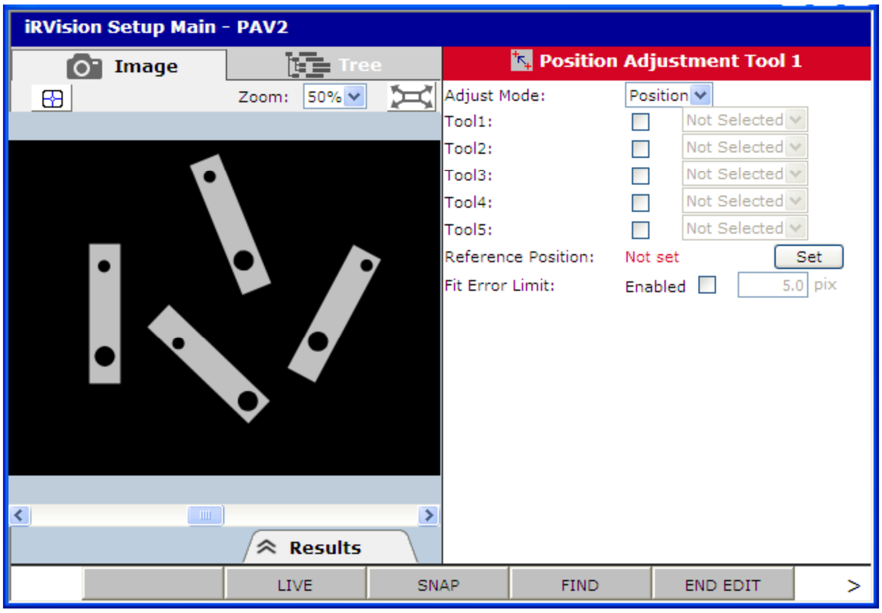
The items displayed differ depending on the tools set as child tools of the multi-window tool. For the explanation of each measured value, see the pages describing the set child tools.

7.11.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.12 POSITION ADJUSTMENT TOOL

The position adjustment tool fine-adjusts the position found by the parent locator tool using the found result of its child locator tools. If it is difficult to find the position or angle accurately for the entire workpiece, find the entire workpiece using the parent locator tool, then find some parts with which positioning can be made easy, such as holes, using its child locator tools, and modify the entire found position for more accurate offset data. If you select the position adjustment tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.12.1 Setting Parameters

Set the parameters.

Adjust Mode

Specify the value(s) to be adjusted.

Position

The coordinates (Row and Column) of the position found by the parent locator tool are adjusted.

Angle

The angle found by the parent locator tool is adjusted.

Position and Angle

The coordinates (Row and Column) of the position and angle found by the parent locator tool is adjusted.

> ⚠ **CAUTION**
> To adjust both the position and orientation, at least two child locator tools must be specified. If only one child locator tool is set, either the position or orientation can be adjusted only.

Selecting tools

Up to five tools can be specified. Select a tool you want to use the position adjustment of the parent locator tool from the drop-down list.

Setting the Reference Position

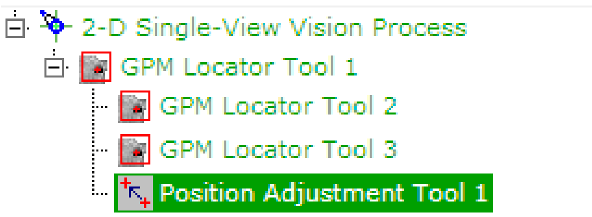
1. Press F2 LIVE to change to the live image display.
2. Place the workpiece at a position where the parent and child locator tools can find it.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4. Tap the [Set] button.
5. The parent and child locator tools find the workpiece and the position found by each tool is set as the reference position.

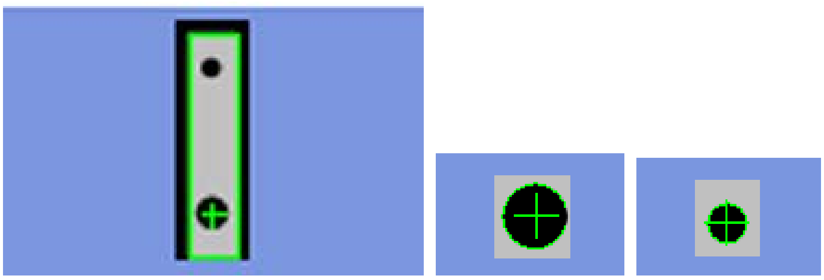
Fit Error Limit

This is the threshold for the combine error (units: pixels) between the point found when the reference position is set and the point found when the detection process is executed actually. If the combine error exceeds this threshold, the workpiece is not found. When this check box is unchecked, the combine error is not checked.

7.12.2 Running a Test

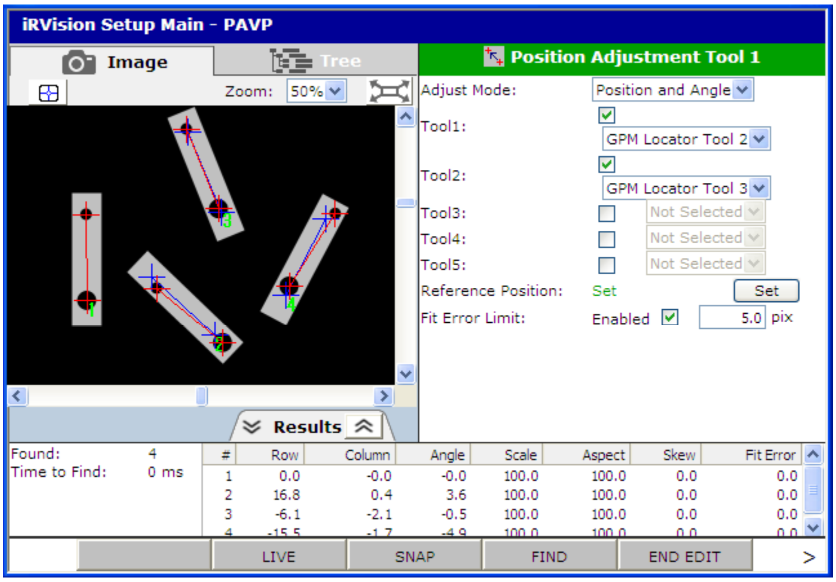
The Vision process has the following structure





Tool1, Tool2, and Tool3 Training Models

Press F4 SNAP to run a test and see if the tool can adjust the position properly.



Found

The number of found workpieces is displayed.

Time to Find

The time the location and position adjustment amount calculation processes took is displayed in milliseconds.

Found result table

The following values are displayed.

Row

Adjustment amount in the virtual direction in the window (units: pixels).

Column

Adjustment amount in the horizontal direction in the window (units: pixels).

Angle

Adjustment amount in the rotation direction (units: degrees).

Scale

Adjustment amount for the scale (units: %).

Aspect

Adjustment amount for the aspect ratio (units: %).

Skew

Adjustment amount for the direction for the aspect ratio (units: degrees).

Fit Error

The combine error between the point found when the reference position (units: pixels).

7.12.3 Overridable Parameters

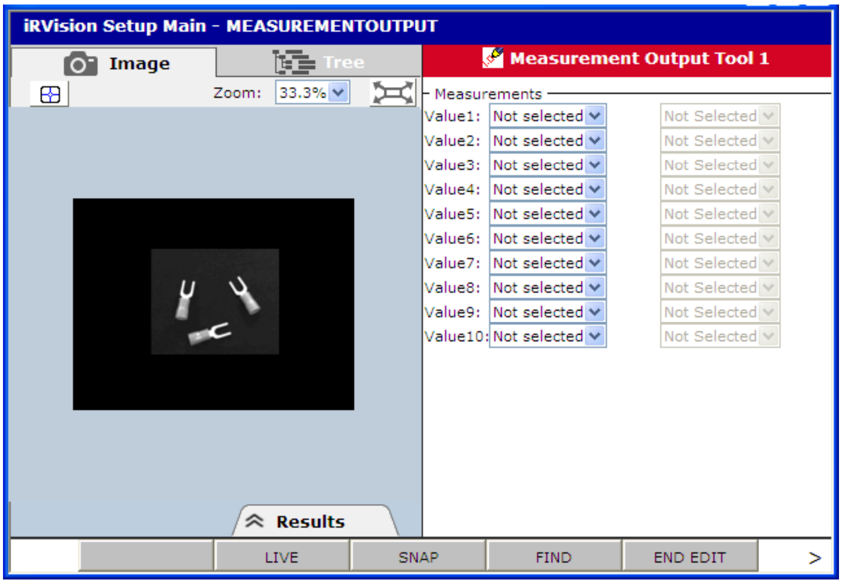
This command tool has no overridable parameters that can be overridden with Vision Override.

7.13 MEASUREMENT OUTPUT TOOL

The measurement output tool outputs the measurement values of histogram tools and other tools together with offset data to a vision register.

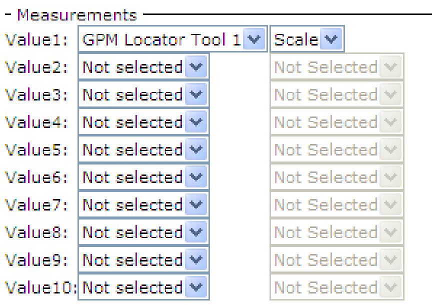
When offset data measured by a vision process is obtained using the GET_OFFSET command described in Section 9.2, “PROGRAM COMMANDS”, the measurement values specified here are stored in a vision register together with offset data. You can copy the obtained measurement values into a robot register to be used in a robot program.

If you select the measurement output tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.13.1 Setting the Measurement Values

Select values you want to set in a vision register in [Measurements].
Up to 10 values can be specified.



1. From the drop-down box on the left, select a tool.
2. From the drop-down box on the right, select a measurement value.

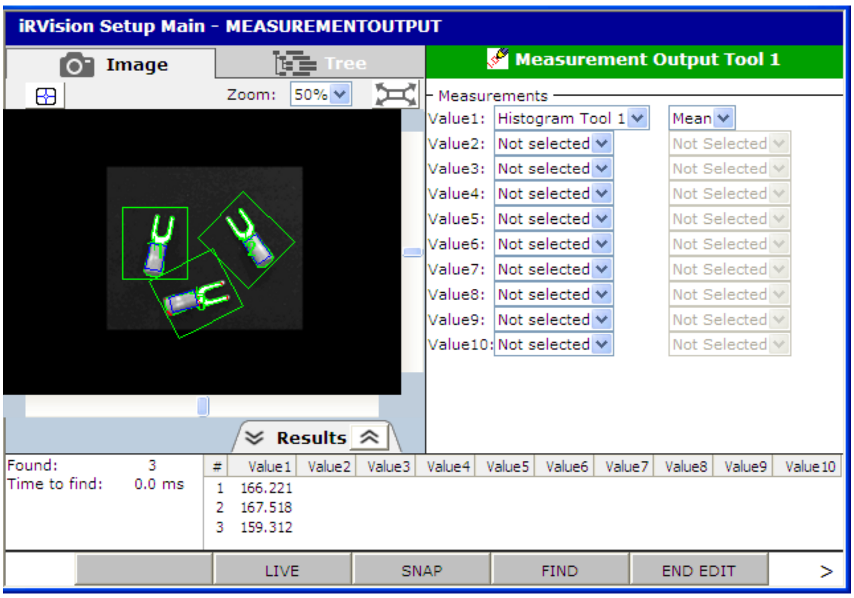
For a vision process such as “2D multi-view vision process” or “3D multi-view vision process” that has two or more camera views, you can set a measurement output tool for each camera view as shown in the figure below.

In this case, the values from Measurement Output Tool 1 and Measurement Output Tool 2 are output to the vision register. For example, when [Value 1] to [Value 5] are specified in the Measurement Output Tool 1 and [Value 6] to [Value 10] are specified in the Measurement Output Tool 2, the measurement values specified in the Measurement Output Tool 1 are written to measurement values 1 to 5 in the vision register and measurement values specified in the Measurement Output Tool 2 are written to measurement values 6 to 10 in the vision register.

> ⚠ **CAUTION**
> If the same measurement values are specified the Measurement Output Tool 1 and the Measurement Output Tool 2, the values from camera view 1 are written to the vision register.

7.13.2 Running a Test

Press F4 to run a test and see if the tool can output measurement values properly.



Found

The number of found workpieces is displayed.

Time to Find

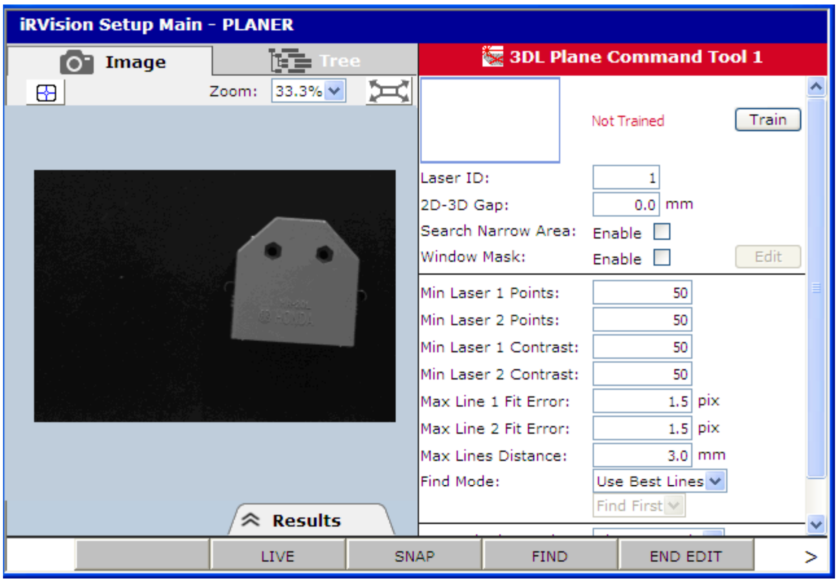
The time the location process took is displayed in milliseconds.

7.13.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.14 3DL PLANE COMMAND TOOL

The 3DL plane command tool measures the position and posture of the workpiece by illuminating the planar section of the workpiece with a laser with a 3D laser sensor. If you select [3DL Plane Command Tool] in the tree view, a screen like the one shown below appears.



7.14.1 Setting the Measurement Area

Set the area subject to laser measurement, as follows.

> ⚠ **CAUTION**
> If the GPM Locator Tool resides in the same program, teach the GPM Locator Tool before teaching the measurement area. If the model origin of the GPM Locator Tool is changed or the model is re-taught, the measurement area of the plane measurement tool needs to be set again.

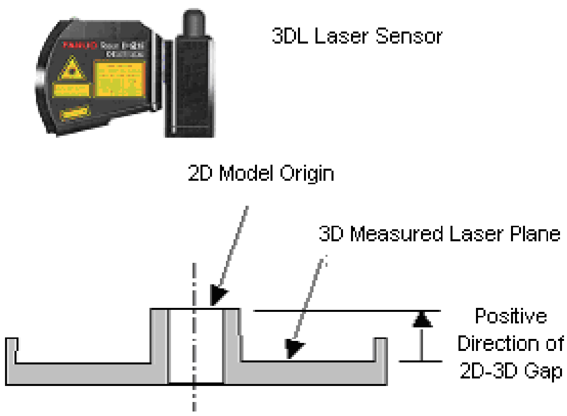
1. Press F6 LASER ON to turn on the laser.
2. Press F2 LIVE to display the live image of the camera.
3. Jog the robot so that the plane of the workpiece to be measured is at the center of the image. You can make positioning easier to do by tapping the button, which displays the center line of the window.
4. Adjust the distance between the 3D laser sensor and workpiece so that the laser intersection point comes around the center of the plane. In this case, the distance between the 3D laser sensor camera and workpiece plane is about 400 mm.
5. Press F2 STOP to stop live. Press F6 LASER OFF to turn off the laser. Press F3 to snap the image.
6. Tap the [Train] button.
7. Enclose the workpiece to be taught within the displayed red rectangle, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.

Laser ID

[Laser ID] can be set to identify which final result corresponds to which 3DL plane command tool when more than one 3DL plane command tool has been added to the vision process. Normally, the initial value is fine when there is only one plane measurement.

2D-3D Gap

In [2D-3D Gap], enter the difference in height relative to the laser plane, if there is a height gap between the plane for which the model of the GPM Locator Tool is taught and the plane to be measured with the laser. This will be a positive value if the model plane is nearer to the camera than the laser plane.



Search Narrow Area

If the plane area to be measured is small and the available points are few, enable [Search Narrow Area], which lets you increase the number of points to be used for the measurement. Note that this increases the processing time as well. Therefore, enable this item only when necessary.

Window Mask

If there is an uneven portion on the plane to be illuminated with the laser in the measurement area, or if there is a region you want to remove from the measurement area, set a mask. To create a mask in the measurement area, tap the [Edit] button. Even when you have edited a mask, the tool will ignore the mask if you uncheck the [Enable] box. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.

7.14.2 Adjusting the Location Parameters

Attempts to adjust the laser point location parameters should be confined to those cases where adjusting the laser measurement settings never yields accurate found results. Forcing the tool to find laser points or changing the values inadvertently might result in inaccurate calculation of the detection position.

> ⚠ **CAUTION**
> Before changing the location parameters, check that the laser measurement exposure time in the vision process has been adjusted so that an image is captured adequately.

Min. Num. Laser Points

If the number of effective points found in the measurement area, excluding the mask area, is below this threshold, the measurement result is invalid. If the laser point found result varies because of a small measurement area or change in image brightness, lowering the minimum number of laser points might make location possible. Note that, because the inclination of the workpiece plane is calculated from the found points, measurement accuracy can degrade as the number of points decreases.

The number of effective laser points to be found is dependent on the [Min. Laser Contrast] and [Max. Laser Fit Error] shown below.

Min. Laser Contrast

This is the threshold for finding points of the laser applied to the measurement area, excluding the mask area.

Max. Line Fit Error

When a straight line is formed by points of the laser applied to the measurement area, excluding the mask area, each point is regarded as an effective point as long as its deviation from the straight line is within this margin of error expressed in pixels. When the plane to be measured is textured, as in a casting surface, increasing this value slightly might allow the tool to find more effective points. Note that setting too large a value might degrade accuracy.

Max. Lines Distance

Theoretically, the straight line formed by laser points calculated from each laser slit intersects at the intersection point of the laser applied to the workpiece plane. In actuality, however, the distance between the two lines rarely becomes 0 because of calibration error or measurement error. The maximum LL distance is the threshold for the shortest distance of the straight line orthogonal to the two straight lines.

The initial value is set to 3.0 mm. If the need arises to set a distance longer than this, the 3D laser sensor might not have been calibrated properly. Although the maximum LL distance can be increased on a temporary basis as long as the position offset of the robot is within the required accuracy range, it is recommended to perform automatic re-calibration as appropriate.

Find Mode

In the case that some laser lines are detected from each laser slit, select the combination of laser lines used for the measurement. The upper drop-down list has two options.

Use Best Lines

The detected laser lines including the most laser points are selected for each laser slit. The measurement uses the combination of the selected laser lines.

Use All Lines

All the detected laser lines are selected in order for each laser slit. The measurement uses all the combinations of the different laser slits' laser lines.

When "Use All Lines" is selected, the lower drop-down list is enabled. It has two options.

Find First

The measurement uses the combinations of the laser lines selected in descending order of the number of laser points. When the distance between the combined laser lines becomes less than the maximum lines distance at first, the plane measured by the combined laser lines is output and the measurement is terminated.

Find Best

The plane measured by the combined laser lines whose distance is the smallest is output.

Laser Plotting Mode

Select how the laser label is to be displayed on the image when the process is run.

Plot CW Mode

The laser label is displayed clockwise.

Plot CCW Mode

The laser label is displayed counterclockwise.

Plot Nothing

The laser label is not displayed.

Image Display Mode

Select how the found results are to be displayed on the image after the test is run.

2D Image

The camera-captured image is displayed.

Laser Slit Image 1

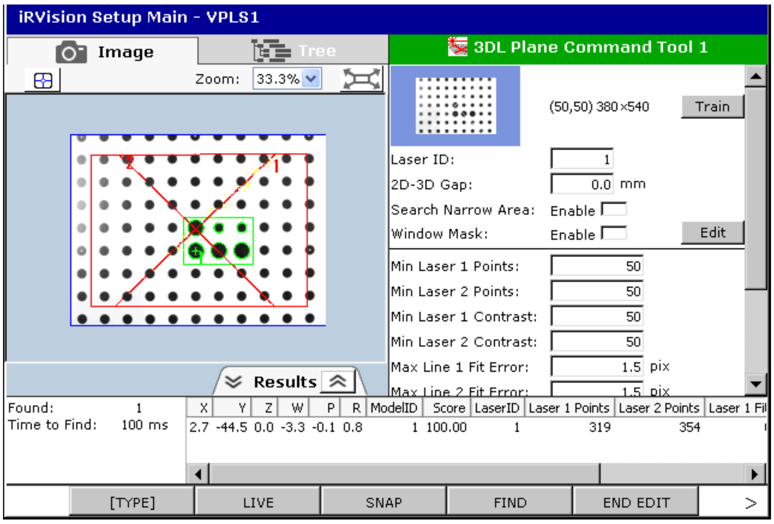
The image of laser slit 1 is displayed.

Laser Slit Image 2

The image of laser slit 2 is displayed.

7.14.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Found

If the result is successfully calculated, 1 is displayed. If the tool fails to find the workpiece, 0 is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y,Z,W,P,R

Coordinate values of the found plane.

Model ID

Model ID of the found GPM Locator Tool.

Score

Score of the found GPM Locator Tool.

Laser ID

Measurement number of the found plane.

Laser 1 Points

Number of found laser 1 points.

Laser 2 Points

Number of found laser 2 points.

Laser 1 Fit Err

Straight-line approximation error of laser 1 (units: pixels).

Laser 2 Fit Err

Straight-line approximation error of laser 2 (units: pixels).

Laser Distance

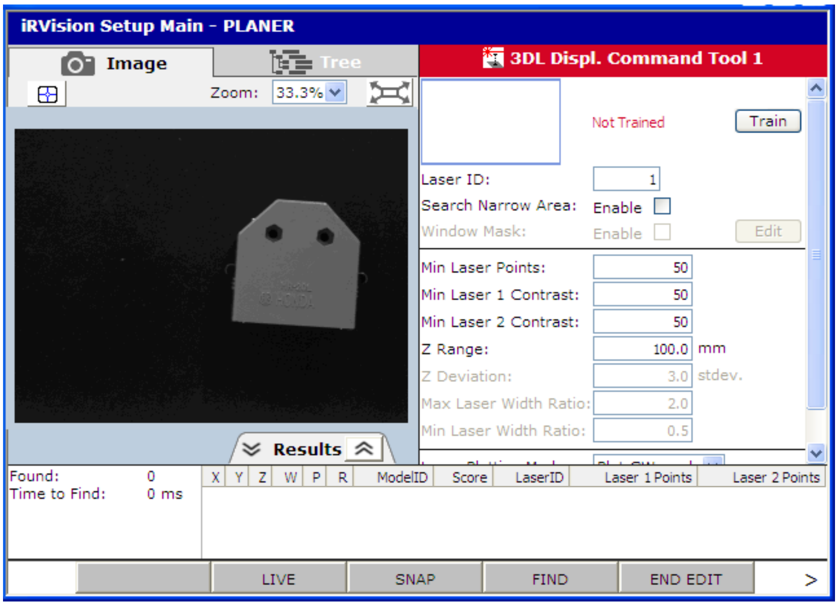
Straight-line distance between found laser 1 and laser 2 (units: mm).

7.14.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.15 3DL DISPL COMMAND TOOL

The 3DL displ. command tool measures the distance to the workpiece by illuminating the workpiece with a laser with a 3D laser sensor. If you select [3DL Displ. Command Tool] in the tree view, a screen like the one shown below appears.



7.15.1 Setting the Measurement Area

Set the area subject to laser measurement, as follows.

> ⚠ **CAUTION**
> If the GPM Locator Tool resides in the same program, teach the GPM Locator Tool before teaching the measurement area. If the model origin of the GPM Locator Tool is changed or the model is re-taught, the measurement area of the plane measurement tool needs to be set again.

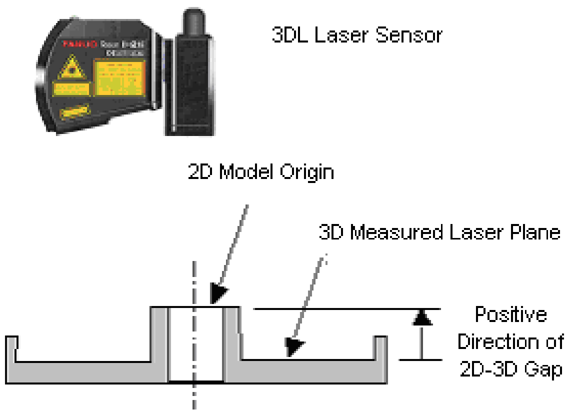
1. Press F6 LASER ON to turn on the laser.
2. Press F2 LIVE to display the live image of the camera.
3. Jog the robot so that the plane of the workpiece to be measured comes at the center of the image. You can make positioning easier to do by tapping the  button, which displays the center line of the window.
4. Adjust the distance between the 3D laser sensor and workpiece so that the laser intersection point comes at the center of the plane. In this case, the distance between the 3D laser sensor camera and workpiece plane is about 400 mm.
5. Press F2 STOP to stop live. Press F6 LASER OFF to turn off the laser. Press F3 SNAP to snap the image of the workpiece.
6. Tap the [Train] button.
7. Enclose the workpiece to be taught within the displayed red rectangle, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, "Window Setup".

Laser ID

[Laser ID] can be set to identify which final result corresponds to which 3DL laser displacement tool when more than one 3DL displ. command tool has been added to the vision process. Normally, the initial value is fine when there is only one plane measurement.

2D-3D Gap

In [2D-3D Gap], enter the difference in height relative to the laser plane, if there is a height gap between the plane for which the model of the GPM Locator Tool is taught and the plane to be measured with the laser. This will be a positive value if the model plane is nearer to the camera than the laser plane.



Search Narrow Area

If the plane area to be measured is small and the available points are few, enable [Search Narrow Area], which lets you increase the number of points to be used for the measurement. Note that this increases the processing time as well. Therefore, enable this item only when necessary.

Window Mask

If there is an uneven portion on the plane to be illuminated with the laser in the measurement area, or if there is a region you want to remove from the measurement area, set a mask. To create a mask in the measurement area, tap the [Edit] button. Even when you have edited a mask, the tool will ignore the mask if you uncheck the [Enable] box. For detailed information about the operation method, see Subsection 3.7.9, “Edit Masks”.

7.15.2 Adjusting the Location Parameters

Attempts to adjust the laser point location parameters should be confined to those cases where adjusting the laser measurement settings never yields accurate found results. Forcing the tool to find laser points or changing the values inadvertently might result in inaccurate calculation of the detection position.

> ⚠ **CAUTION**
> Before changing the location parameters, check that the laser measurement exposure time in the vision process has been adjusted so that an image is captured adequately.

Min. Num. Laser Points

If the number of effective points found in the measurement area, excluding the mask area, is below this threshold, the measurement result is invalid. If the laser point found result varies because of a small measurement area or change in image brightness, lowering the minimum number of laser points might make location possible. Note that, because the inclination of the workpiece plane is calculated from the found points, measurement accuracy can degrade as the number of points decreases.
The number of effective laser points to be found is dependent on the [Min. Laser Contrast] described below.

Min. Laser Contrast
This is the threshold for finding points of the laser applied to the measurement area, excluding the mask area.

Z Range
This is the range of Z-direction points to be used for calculation from the average value of laser points. Set this to a value between 0 and 200.

Z Deviation
This is the deviation range of Z-direction points with respect to the average. Set this a value between 0 and 5.

Laser Plotting Mode
Select how the laser label is to be displayed on the image when the process is run.

Plot CW Mode
The laser label is displayed clockwise.

Plot CCW Mode
The laser label is displayed counterclockwise.

Plot Nothing
The laser label is not displayed.

Image Display Mode
Select how the found results are to be displayed on the image after the test is run.

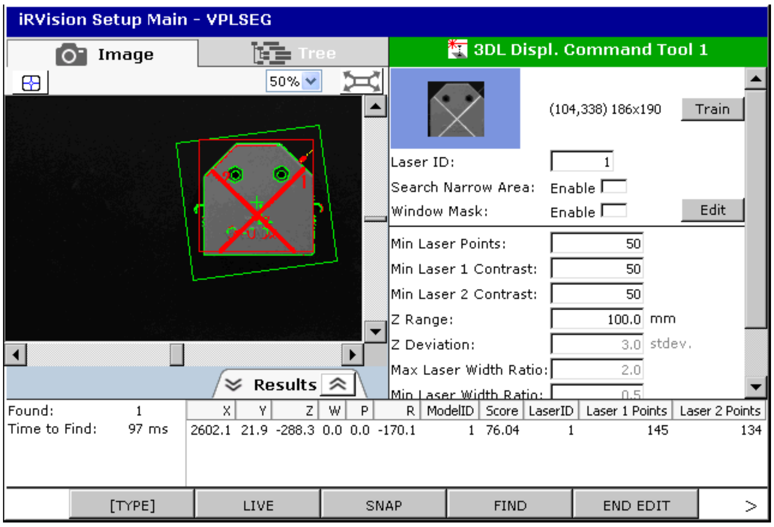
2D Image
The camera-captured image is displayed.

Laser Slit Image 1
The image of laser slit 1 is displayed.

Laser Slit Image 2
The image of laser slit 2 is displayed.

7.15.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find workpieces properly.



Found

If the result is successfully calculated, 1 is displayed. If the tool fails to find the workpiece, 0 is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X,Y,Z,W,P,R

Coordinate values of the found plane. (W and P are always zero.)

Model ID

Model ID of the found GPM Locator Tool.

Score

Score of the found GPM Locator Tool.

Laser ID

Measurement number of the found plane.

Laser 1 Points

Number of found laser 1 points.

Laser 2 Points

Number of found laser 2 points.

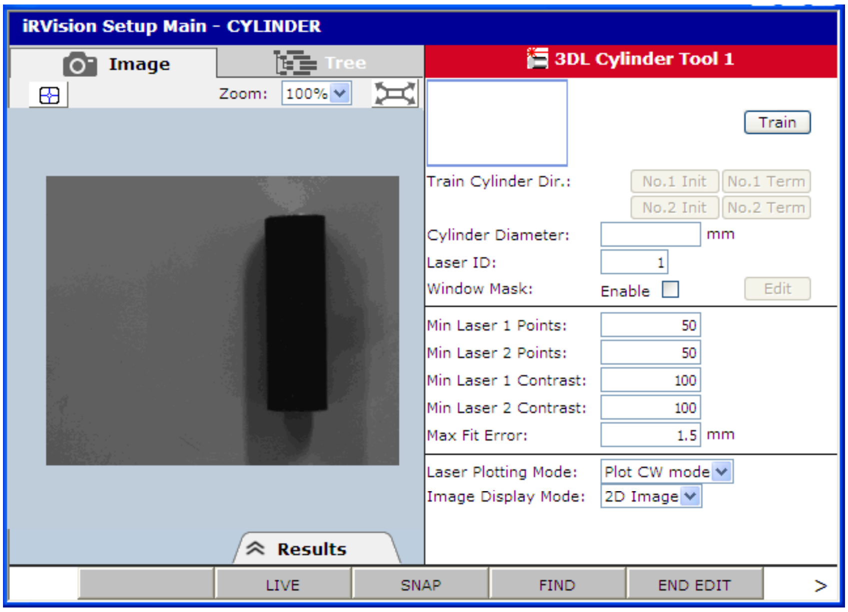
7.15.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.16 3DL CYLINDER TOOL

The 3DL cylinder tool measures the surface of a cylinder workpiece, like the one shown below, using a 3D laser sensor, in order to estimate the central axis of the workpiece.

If you select [3DL Cylinder Command Tool] in the tree view, a screen like the one shown below appears.



7.16.1 Setting the Measurement Area

Set the area subject to laser measurement, as follows.

> ⚠ **CAUTION**
> If the GPM locator tool or curved surface locator tool resides in the same program, teach the GPM locator tool or curved surface locator tool before setting this measurement area. If the model origin of the GPM locator tool or curved surface locator tool is changed or the model is re-taught, the measurement area of the cylinder measurement tool needs to be set again.

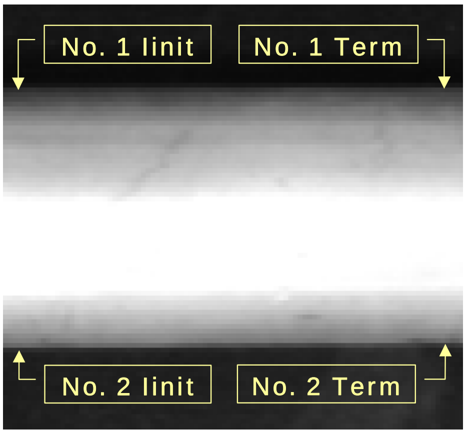
1. Press F6 LASER ON to turn on the laser.
2. Press F2 LIVE to display the live image of the camera.
3. Jog the robot so that the cylinder to be measured is at the center of the image.
   You can make positioning easier to do by tapping the button, which displays the center line of the window.
4. Adjust the distance between the 3D laser sensor and cylinder so that the laser intersection point comes around the center of the plane. In this case, the distance between the 3D laser sensor camera

and workpiece plane is about 400 mm or 600 mm, depending on how laser and camera portion of the 3DL sensor are connected.

5. Press F2 STOP to stop live. Press F6 LASER OFF to turn off the laser. Press F3 SNAP to snap the image of the workpiece.
6. Tap the [Train] button.
7. Enclose the workpiece to be taught within the displayed red rectangle, and press F4 OK. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.
   If there is a laser image, the laser is displayed on the workpiece surface. Set the window to enclose the laser.

Train Cylinder Dir.

After training the window, teach a total of four points to indicate the cylinder direction - two initial points and two terminal points along the two lines at the curved surface ends of the cylinder. Tap the [No.1 Init] button, and move the + mark to a desired position with the standard cursor. Pressing F4 OK registers the initial point of the first line. For [No.1 Term], [No.2 Init], and [No.2 Term], teach points in the same way. The orientations of the two lines from the initial point to the terminal point must be roughly the same (within an angle of 30 degrees).



Cylinder Diameter

Set the diameter of the part where the cylinder direction has been taught. This value must be between 10 mm and 200 mm.

Laser ID

When more than one cylinder tool is added to the process, [Laser ID] can be set to identify which cylinder tool corresponds to the final result. Normally, when the process uses one cylinder tool, the default value may be used as is.

Window Mask

If the model data has any unnecessary region (e.g., a region that does not belong to the cylinder or a region with irregularities), masking that region enables stable measurement. To create a mask in the measurement area, tap the [Edit] button. Even when you have edited a mask, the tool will ignore the mask if you uncheck the [Enable] check box. For detailed information about the operation method, see Subsection 3.7.10, "Editing Masks".

7.16.2 Adjusting the Location Parameters

Attempts to adjust the laser point location parameters should be confined to those cases where adjusting the laser measurement settings never yields accurate found results. Forcing the tool to find laser points or changing the values inadvertently might result in inaccurate calculation of the detection position.

> ⚠ **CAUTION**
> Before changing the location parameters, check that the laser measurement exposure time in the vision process has been adjusted so that an image is captured adequately.

Min. Num Laser Points 1

If the min. number laser points 1 found in the measurement area, excluding the mask area, is below this threshold, the measurement result is invalid. Set this to a value between 2 and 480.

Min. Num Laser Points 2

If the min. number laser points 2 found in the measurement area, excluding the mask area, is below this threshold, the measurement result is invalid. Set this to a value between 2 and 480.

Laser 1 Contrast

This is the threshold for finding points of the laser 1 applied to the measurement area, excluding the mask area. Set this to a value between 0 and 255.

Laser 2 Contrast

This is the threshold for finding points of the laser 1 applied to the measurement area, excluding the mask area. Set this to a value between 0 and 255.

Max Fit Error

When a cylinder surface is formed by laser points applied to the measurement area, excluding the mask area, each of these points is regarded as valid if the point's error from the cylinder surface is below this threshold. Set this to a value between 0 and 10 mm. The maximum value may change depending on the cylinder diameter.

Laser Plotting Mode

Select how the laser label is to be displayed on the image when the process is run.

Plot CW mode

The laser label is displayed clockwise.

Plot CCW mode

The laser label is displayed counterclockwise.

Plot nothing

The laser label is not displayed.

Image Display Mode

Select the mode for displaying the found results on the window when running a test.

2D Image

The camera-captured 2D image and the found results will be displayed.

Laser Slit Image 1

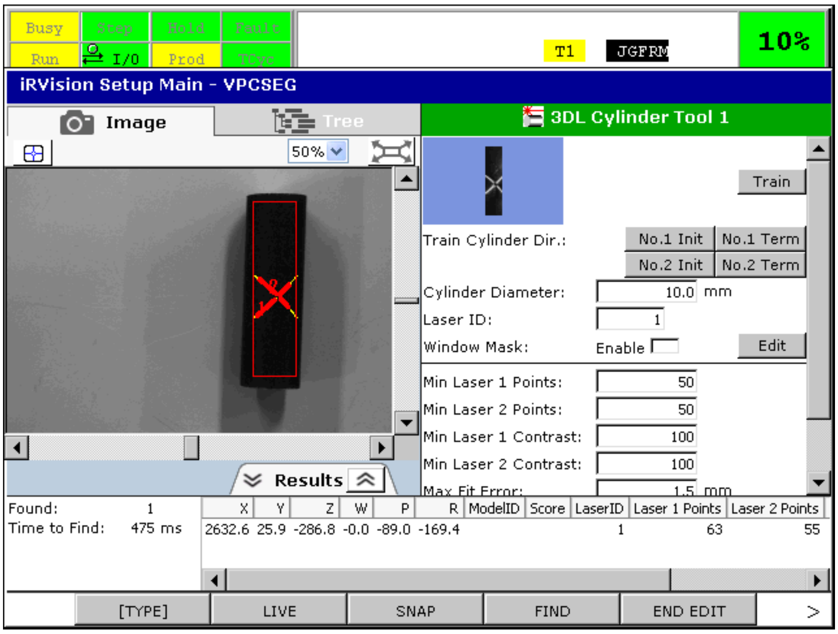
Laser slit image 1 will be displayed.

Laser Slit Image 2

Laser slit image 2 will be displayed.

7.16.3 Running a Test

Press F4 SNAP to run a test and see if the tool can find the workpiece properly.



Found

If the result is successfully calculated, 1 is displayed. If the tool fails to find the workpiece, 0 is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Result Table

The following values are displayed.

X, Y, Z

X, Y, and Z direction positions of the model origin of the found target in the user frame specified for output during the camera calibration (unit: mm).

W, P, R

W, P, and R direction postures of the found cylinder in the user frame specified for output (unit: degree).

Model ID

Model ID of the found curved surface locator tool or GPM locator tool model.

Score

This indicates how well the features of the found target match those of the taught curved surface locator tool or GPM locator tool model. If they completely match, 100 is displayed.

Laser ID

Laser ID of the cylinder tool used for the measurement.

Laser1 Points

Number of valid laser 1 points found in the measurement area.

Laser2 Points

Number of valid laser 2 points found in the measurement area.

Laser1 Fit Err

Average error between valid laser 1 points and the generated cylinder surface (unit: pixel).

Laser2 Fit Err

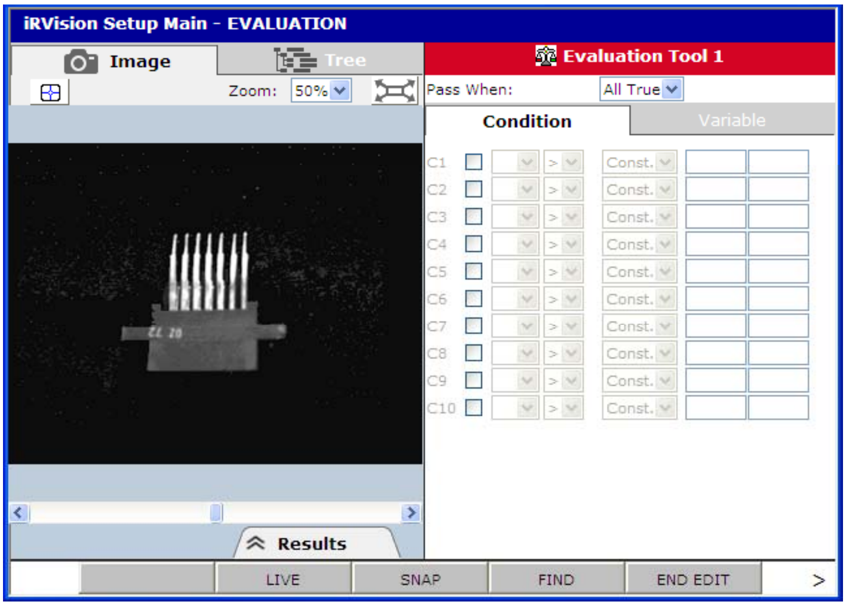
Average error between valid laser 2 points and the generated cylinder surface (unit: pixel).

7.16.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.17 EVALUATION TOOL

The evaluation tool determines whether a workpiece has passed or failed the inspection, by evaluating one or more conditional expressions. You can write more than one conditional expression and have the tool evaluate those multiple conditional expressions in a comprehensive fashion. The tool is available only with the single-view inspection vision process. If you select the evaluation tool in the tree view of the setup page of the single view inspection vision process, a screen like the one shown below appears.

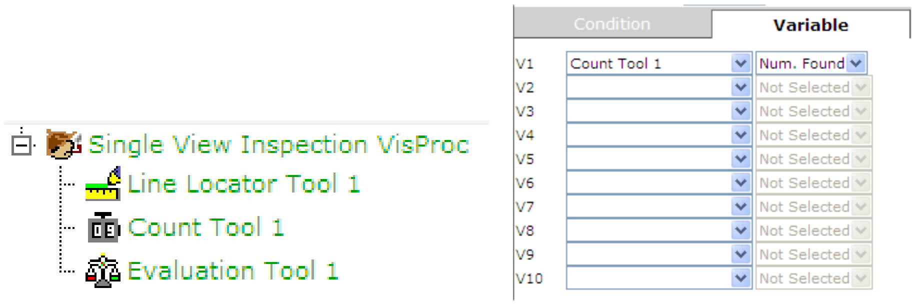


7.17.1 Setting the Parameters

Set the measured values and conditional expressions to be evaluated, as well as the [Pass When] condition for making overall judgment based on the results of the individual conditional expressions.

Value 1 to 10

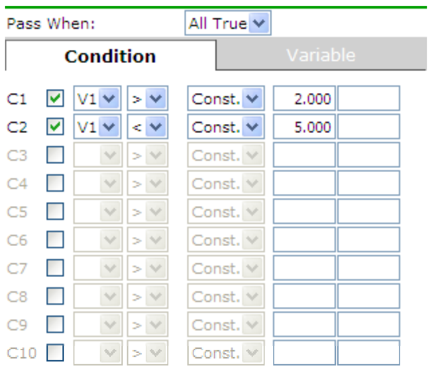
Tapping the [Variable] tab displays a screen like the one shown below.
Select a value to be evaluated with a conditional expression. Up to 10 values can be specified.



1. From the drop-down box on the left, select a command tool.
2. From the drop-down box on the right, select a measurement value to be evaluated.

Condition 1 to 10

Tapping the [Condition] tab displays a screen like the one shown below.
Set a conditional expression. Up to 10 conditional expressions can be specified.



1. Enable the condition by tapping the check box.
2. From the leftmost drop-down list, select the value to be evaluated, from the following:
   - Variable 1 to Variable 10
   - Result of a conditional expression preceding this conditional expression
3. From the second drop-down list, select the logical expression to be used for evaluation. The available items are described later.
4. From the third drop-down list, select the value to be compared for evaluation, from the following:
   - Const
   - Variable 1 to Variable 10
   - Result of a conditional expression preceding this conditional expression
5. If you select [Const] in step 4, enter a constant value in the text box on the right side.

Logical expression for evaluation

As a logical expression to be specified in a conditional expression, one of the following can be selected. The available options differ depending on the type of evaluation.

=

The expression is "true" if the evaluation target value is equal to the comparison value; otherwise, it is "false".

>

The expression is "true" if the evaluation target value is larger than the comparison value; otherwise, it is "false".

>=

The expression is "true" if the evaluation target value is larger than or equal to the comparison value; otherwise, it is "false".

<

The expression is "true" if the evaluation target value is smaller than the comparison value; otherwise, it is "false".

<=

The expression is "true" if the evaluation target value is smaller than or equal to the comparison value; otherwise, it is "false".

<>

The expression is "true" if the evaluation target value is not equal to the comparison value; otherwise, it is "false".

IN

The expression is "true" if the evaluation target value is within the range defined by two comparison values; otherwise, it is "false".

OUT

The expression is "true" if the evaluation target value is outside the range defined by two comparison values; otherwise, it is "false".

AND

The expression is "true" if both the evaluation target value and the comparison value are "true"; otherwise, it is "false".

OR

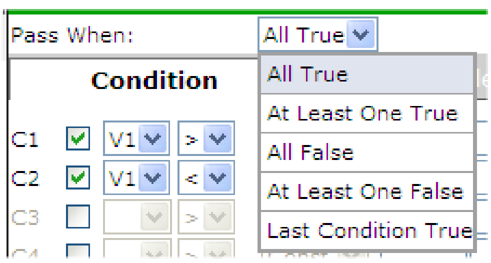
The expression is "true" if either the evaluation target value or the comparison value is "true"; otherwise, it is "false".

XOR

The expression is "true" if both the evaluation target value and the comparison value are "true" or "false"; otherwise, it is "false".

Pass When

Set a condition for making overall judgment as to whether the workpiece has passed or failed the inspection, based on the evaluation results of the individual conditional expressions.



Select one of the following:

All True

The workpiece is judged to have "passed" if all the specified conditional expressions are "true" or to have "failed" if any of the specified conditional expressions are "false". [Undetermined] is displayed if there are no “false” conditions and there is at least one condition that cannot be evaluated. Typically a condition cannot be evaluated if the locator tool does not find a workpiece.

At Least One True

The workpiece is judged to have "passed" if any of the specified conditional expressions is "true" or to have "failed" if all the specified conditional expressions are "false". [Undetermined] is displayed if there are no “true” conditions and there is at least one condition that cannot be evaluated. Typically a condition cannot be evaluated if the locator tool does not find a workpiece.

All False

The workpiece is judged to have "passed" if all the specified conditional expressions are "false" or to have "failed" if any of the specified conditional expressions is "true". [Undetermined] is displayed if there are no “true” conditions and there is at least one condition that cannot be evaluated. Typically a condition cannot be evaluated if the locator tool does not find a workpiece.

At Least One False

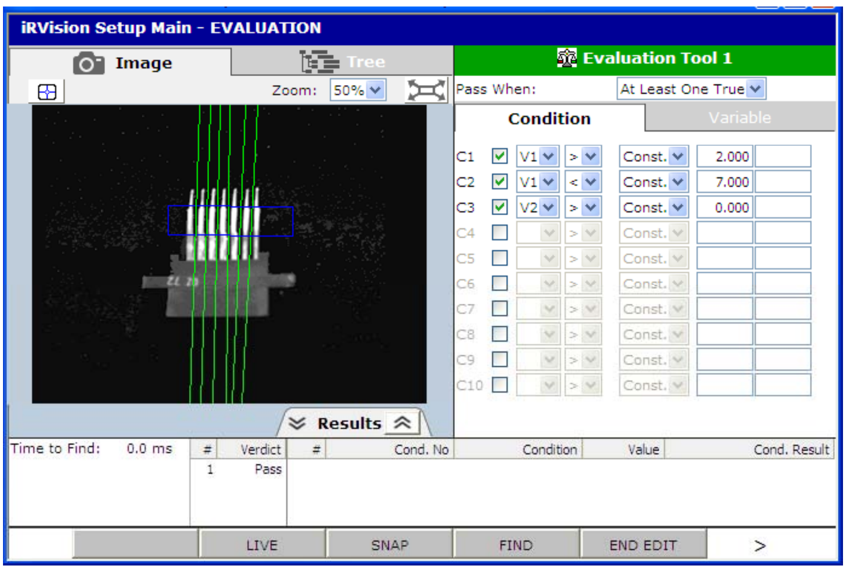
The workpiece is judged to have "passed" if any of the specified conditional expressions is "false" or to have "failed" if all the specified conditional expressions are "true". [Undetermined] is displayed if there are no “false” conditions and there is at least one condition that cannot be evaluated. Typically a condition cannot be evaluated if the locator tool does not find a workpiece.

Last Condition True

The workpiece is judged to have "passed" if the last expression of the specified conditional expressions is "true" or to have "failed" if that expression is "false". [Undetermined] is displayed if the conditional expression cannot be evaluated.

7.17.2 Running a Test

Press F4 SNAP to run a test and see if the tool can perform evaluation properly.



Time to Find

The time the evaluation took is displayed in milliseconds.

Verdict
The overall evaluation result of the evaluation tool is displayed.

Found Result Table
The number of each conditional expression evaluated and the associated evaluation logical expression, evaluation target value, comparison value, and evaluation result are displayed.

Cond. No
Number of the conditional expression.

Condition
Conditional expression that is set.

Value
Evaluation target value evaluated with the conditional expression.

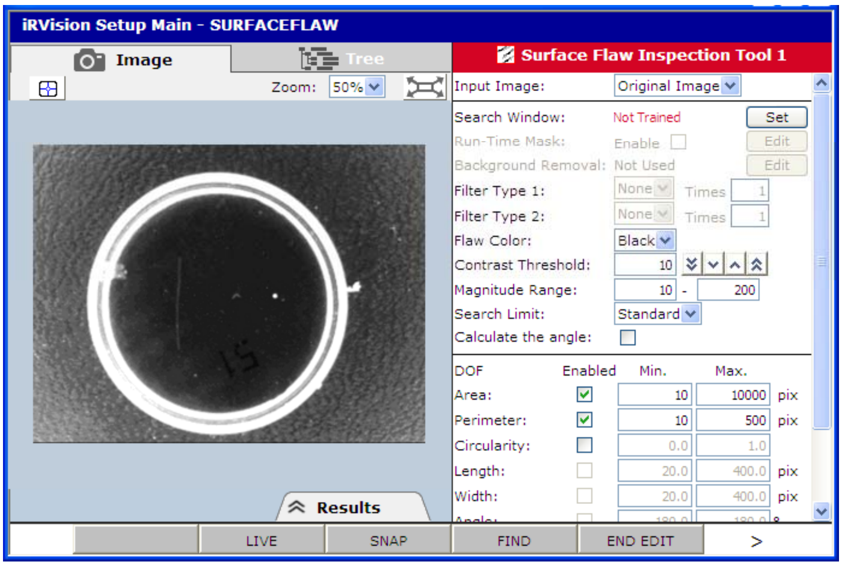
Cond. Result
Evaluation result of the conditional expression.

7.17.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.18 SURFACE FLAW INSPECTION TOOL

Surface Flaw Inspection tool finds defects on the planer surface of a target object. First, regions that seem suspicious are extracted by searching within the specified search window. Then, the measurements of potential flaws such as individual flaw area and length, as well as the number of found flaws and the ratio of total flaw area to the search window area, are evaluated. This tool is only available with Single-view Inspection vision process. If you select a surface flaw inspection tool in the tree view of the setup page for a vision process, a setup page like the one shown below appears.



Input Image

Select the image which is used for training area to inspection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Surface Flaw Inspection Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

7.18.1 Adjusting the Search Parameters

Adjust the parameters for finding flaws from the image.

Search Window

Specify the region of the image to be inspected. The narrower the region is, the faster the inspection process ends. Set the search window as follows.

1. Press F2 LIVE to change to the live image display.
2. Place a workpiece near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the workpiece.
4. Tap the [Set] button.
5. Enclose the inspection region within the red rectangle that appears, and press F4 OK.

For detailed information about the operation method, see Subsection 3.7.9, “Setting Window”.

Run-Time Mask

Specify an area of the search window that you do not want to inspect, with an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle- or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to inspection. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, “Editing a Mask.”

Flaw Color

Select the color of the flaw to be found from the following options:

White

Finds white flaws.

Black

Finds black flaws.

Contrast Threshold

Specify how clearly the contour is perceivable in order to be considered as a flaw. If the average contrast of the contour of the found region is below this threshold, then the region will not be considered as a flaw. Faint flaws can be detected when a lower threshold value is specified, but some flaws may be recognized larger and the contour fuzzier. On the other hand, faint flaw are not found when a higher threshold value is specified, and only apparent flaws are found. The default value is 10, and the specifiable range is from 1 to 200.

Magnitude Range

Specify the range of pseudo-depth of individual flaw to be found. The magnitude is determined as the difference between the darkest gray within the found flaw region and the gray of the contour. The default values are 10 for minimum and 200 for maximum, and the specifiable value range is from 1 to 255.

Search Limit

The search limit is used to adjust the extent of the individual flaw contour. This parameter is normally left at [Standard].

Min

The flaws tend to be recognized in smaller segments.

Low

The flaws tend to be recognized in segments.

Standard

Standard setting is used to find flaws.

High

The flaws tend to be recognized in masses.

Max

The flaws tend to be recognized in larger masses.

7.18.2 Image Preprocessing

Surface Flaw Inspection command tool has its own image preprocessing in order to generate an image suitable for inspection. There are two types of preprocessing available, and both are applied to the pixels within the search window. Multiple preprocessing can be specified, and they are applied in a pre-determined order.

7.18.2.1 Background removal

Background Removal is a function that removes features that seems to be a part of the background. This preprocessing is applied before other preprocessing.

Method

Select the method of background removal from the following options:

Not Used

Background removal is not applied.

Static

By registering a flawless image as the master image, features identical to the master image are removed as the background from the image to be inspected. This method has the effect of removing features that appear the same in all images such as, the shape of the inspected object. The processed image will be the difference of the registered master image and the captured image. Be advised that not all background features are removed, due to individual variability of objects, lens disparity, or lighting conditions.

Dynamic

An image representing the background features (a pseudo-master image) is dynamically generated from the captured image, and is used as the master image for background removal. This method has the effect of removing minor undulation of the image when there are no abrupt changes in the grayscale level of the pixels. The processed image will be the difference of the pseudo-master image and the captured image.

Shading

The gradual grayscale changes in the image due to uneven lighting is removed. It is essential for inspection to have the image area evenly lit, and this method has the effect of generating an image as if the lighting is constant across the entire pixels. A master image, captured by showing a flat surface such as a sheet of paper, needs to be registered to calculate the coefficients for adjustment. If there are grayscale changes not associated with the lighting non-uniformity, this method may not work properly.

Train Master

Registers an image as a master image. A master image needs to be registered when the background removal method is either "Static" or "Shading."

When a master image is already registered, the text on the button becomes [Append Master]. When the [Append Master] button is tapped, the captured image and the registered master image are integrated to generate a new master image. By appending multiple images and registering the integrated image as the master image, the S/N ratio of the master image can be improved.

Clear Master

Clears the registered master image. The button is disabled when a master image is not registered.

Dynamic Size

Specify the unit size for processing the image. Dynamic size is a parameter used to generate a pseudo-master image in the dynamic background removal method. This parameter is only enabled when the method is "Dynamic." The default value is 7, and the specifiable value range is from 1 to 10.

Num Images

The number of images used to generate the master image is displayed.

Runtime Mask

Specify an area of the shading background removal master image with an arbitrary geometry. The masked pixels will not be included in calculating the coefficients for adjusting the lighting non-uniformity. Use this function when there are grayscale changes not associated with the lighting non-uniformity in the master image. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, "Editing a Mask."

Image Display Mode

Select the mode to display an image in the background removal setup from the following options:

Original

Displays the image as it is captured by the camera.

Master

Displays the registered master image. A pseudo-master image is displayed when the background removal method is "Dynamic."

Background Removed

Displays the background removed image.

F4 OK

Returns to the Surface Flaw Inspection setup after saving the changes.

F5 Cancel

Returns to the Surface Flaw Inspection setup discarding all changes.

7.18.2.2 Filters

Multiple filters can be applied to the image prior to the inspection. Filters are applied in the order of [Filter Type 1] and [Filter Type 2], after applying the background removal.

Filter Types

None

Does not use a filter.

Blur

Applies a filter to blur the image. Blurring an image obscures brightness differences in the image, thus helping alleviate the effect of noise.

Sharpen

Applies a filter to sharpen the image.

Blur & Sharpen

Applies a blur filter followed by a sharpen filter.

Sharpen & Blur

Applies a sharpen filter followed by a blur filter.

Erode

Erodes the black area. Helps reduce the black pixel noise.

Dilate

Dilates the black area. Helps reduce the white pixel noise.

Open

Erodes the black area and then dilates it. This will connect white regions that are close to touching or disconnect black regions that are slightly touching.

Close

Dilates the white area then erodes it. This will connect black regions that are close to touching or disconnect white regions that are slightly touching.

Times

Specify the number of times the selected filter is to be applied. The larger the number is, the stronger the filter effect becomes. The default value is 1, and the specifiable value range is from 1 to 20.

7.18.3 Adjusting the Range Parameters

The found regions based on the specified flaw color are examined using the following measurements, to determine whether each region should be considered as a flaw. Each measurement has “Enabled”, “Min”, and “Max” to change the acceptable range. Measurements without a check in the “Enabled” checkbox will not be used to evaluate whether the found regions are flaw or not.

Calculate the Angle

When this checkbox is checked, a rectangle circumscribing the flaw is calculated, and its length, width, angle, and elongation are calculated as measurements. The rectangle is formed such that the longer sides are parallel to the major axis of the flaw. The inspection process will take longer when this feature is enabled. Use this feature only when you want to judge the flaws based on length, width, angle, and/or elongation.

Area

Specify the range of area values (in pixels) for judging the found region as a flaw. The default values are 10 for minimum and 10000 for maximum, and the specifiable value range is from 1 to 1000000.

Perimeter

Specify the range of perimeter values (in pixels) for judging the found region as a flaw. The default values are 10 for minimum and 500 for maximum, and the specifiable value range is from 1 to 8200.

Circularity

Specify the range of circularity values for judging the found region as a flaw. Circularity represents how closely the found flaw resembles a circle. If the flaw is a perfect circle, this value is 1.0. The more complex the flaw contour becomes in geometry, the smaller the value becomes. The default values are 0.0 for minimum and 1.0 for maximum, and the specifiable value range is from 0.0 to 1.0.

Length

Specify the range of length values (in pixels) for judging the found region as a flaw. The length is calculated as the length of a rectangle circumscribing the flaw, with its sides parallel to the major axis of the flaw. The default values are 20.0 for minimum and 400.0 for maximum, and the specifiable value range is from 1.0 to 50000.0.

Width

Specify the range of width values (in pixels) for judging the found region as a flaw. The width is calculated as the width of a rectangle circumscribing the flaw, with its sides parallel to the major axis of the flaw. The default values are 20.0 for minimum and 400.0 for maximum, and the specifiable value range is from 1.0 to 50000.0.

Angle

Specify the range of angle values (in degrees) for judging the found region as a flaw. The angle is calculated as the angle of the major axis of the rectangle circumscribing the flaw. A flaw with an angle of 0 degrees has its major axis vertical with respect to the image. The default values are -180.0 for minimum and 180.0 for maximum, and the specifiable value range is from -180.0 to 180.0.

Elongation

Specify the range of elongation values for judging the found region as a flaw. Elongation is calculated by dividing the length by the width, and represents how slender the found flaw is. The longer the flaw is, the larger the value becomes. The default values are 1.0 for minimum and 800.0 for maximum, and the specifiable value range is from 1.0 to 50000.0.

7.18.4 Display Modes

Plot Mode

Select the mode to plot results from the following options:

Position

Only the center of mass of each flaw will be plotted.

Contour

Only the contour of each flaw will be plotted.

Position & Contour

The center of mass and the contour of each flaw will be plotted.

Position & Bound Box

The center of mass and the box circumscribing each flaw will be plotted.

All

The center of mass, the contour, and the box circumscribing each flaw will be plotted.

Image Display Mode

Select the image to display from the following options:

Original

Displays the image as it is captured by the camera.

Original + Results

Displays the image as it is captured by the camera, and the results if any.

Master

Displays the registered master image. A pseudo-master image is displayed when the background removal method is “Dynamic.”

Background Removed

Displays the background removed image.

Filtered

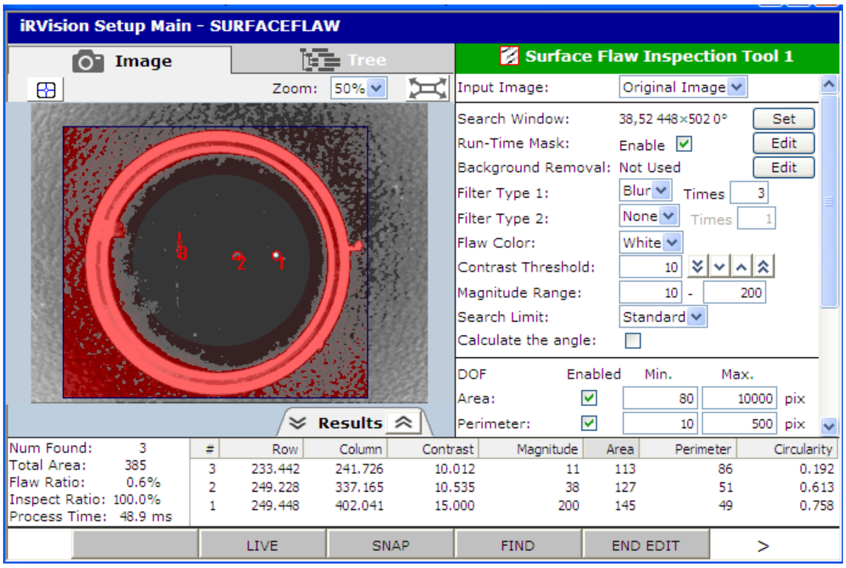
Displays an image with both background removal and filters applied, if any.

Filtered + Results

Displays an image with both background removal and filters applied, and the results if any.

7.18.5 Running a Test

Press F4 SNAP to run a test and see if the tool can find flaws properly.



Num Found
The number of found flaws is displayed.

Total Area
The total area of found flaws is displayed.

Flaw Ratio
The ratio of Total Area and the search window area is displayed.

Inspect Ratio
The ratio of the area inspected and the area supposed to be inspected is displayed.

Process Time
The time the inspection took is displayed in milliseconds.

Found Result Table

Row, Column
Coordinate values of the center of mass of the found flaw (units: pixels).

Contrast
Average contrast value of the flaw contour pixels.

Magnitude
Magnitude (pseudo-depth) of the found flaw.

Area
Area of the found flaw (units: pixels).

Perimeter

Perimeter of the found flaw (units: pixels).

Circularity

Degree of circularity of the found flaw.

Length

Length of the found flaw (units: pixels). This is displayed only when the checkbox for “Calculate the Angle” is checked.

Width

Width of the found flaw (units: pixels). This is displayed only when the checkbox for “Calculate the Angle” is checked.

Angle

Orientation of the found flaw (units: degrees). This is displayed only when the checkbox for “Calculate the Angle” is checked.

Elongation

Elongation of the found flaw. This is displayed only when the checkbox for “Calculate the Angle” is checked.

7.18.6 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. See 8.1 "VISION OVERRIDE" and 9.2.2.13 "OVERRIDE" for details.

Flaw Color

Specify 1 for black flaw or 0 for white flaw.

Contrast Threshold

Specify a number between 1 and 250.

Magnitude Range

Minimum magnitude and maximum magnitude can be specified. Specify a number between 1 and 250.

Search Limit

Specify 1 for “Min”, 2 for “Low”, 4 for “Standard”, 8 for “High”, or 16 for “Max”.

Area

Enable/disable selection for area checking, minimum area and maximum area can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum area.

Perimeter

Enable/disable selection for perimeter checking, minimum perimeter and maximum perimeter can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum perimeter.

Circularity

Enable/disable selection for circularity checking, minimum circularity and maximum circularity can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number between 0 and 1 for minimum and maximum circularity.

Semi Major

Enable/disable selection for semi-major axis length checking, minimum semi-major axis length and maximum semi-major axis length can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum semi-major axis length.

Semi Minor

Enable/disable selection for semi-minor axis length checking, minimum semi-minor axis length and maximum semi-minor axis length can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum semi-minor axis length.

Angle

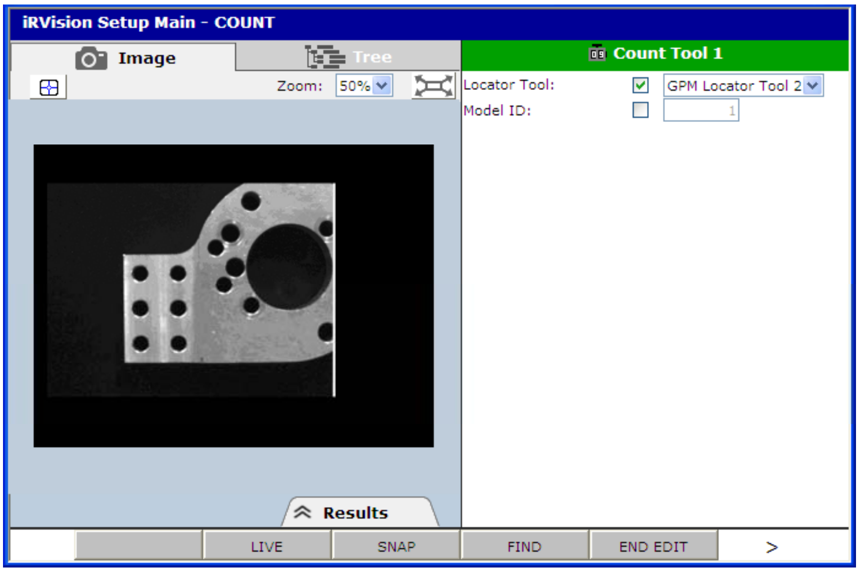
Enable/disable selection for angle checking, minimum angle and maximum angle can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number between –180 and 180 for minimum and maximum angle.

Elongation

Enable/disable selection for elongation checking, minimum elongation and maximum elongation can be specified. Specify 0 for disabling checking or 1 for enabling. Specify a number equal to or larger than 0 for minimum and maximum elongation.

7.19 COUNT TOOL

The count tool counts the number of targets found by locator tools. In addition, it can also count the number of found targets having a specific model ID. The conditional execution tool can use the count result for evaluation, and the measurement output tool can write the count result to a vision register. If you select the count tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.19.1 Setting the Parameters

Specify the target to count.

Locator Tool

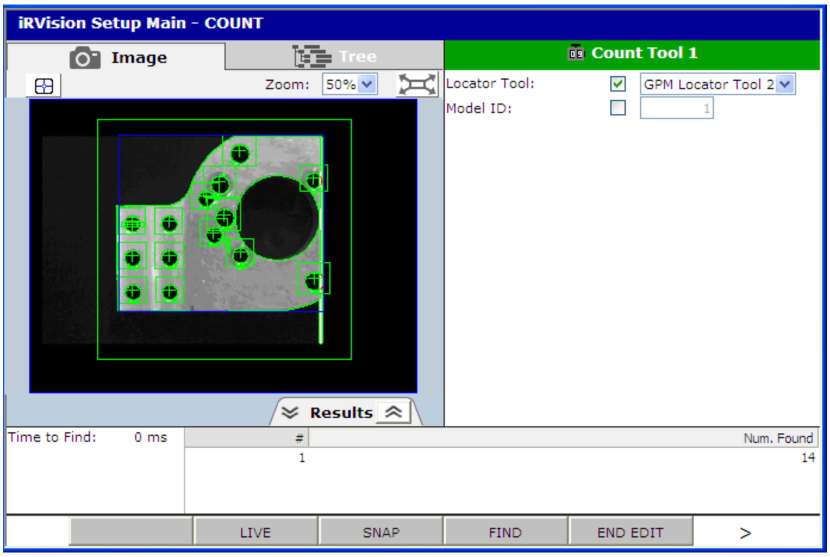
Specify this item when you want to count the number of targets found by a specific locator tool. If you check the box and select a locator tool name, the count tool counts the number of targets found by that specified locator tool. If you leave the box unchecked, the count tool counts the total number of targets found by all the locator tools preceding the count tool that are at the same level as the count tool.

Model ID

Specify this item when you want to count the number of found results having a specific model ID. If you check the box and specify a model ID, the count tool counts the number of found results having that specified model ID. If you leave the box unchecked, the count tool counts the total number of found results, irrespective of the model ID. If you check both the [Locator Tool] and [Model ID] boxes, the count tool counts the number of targets found by the specified locator tool that have the specified model ID.

7.19.2 Running a Test

Press F4 SNAP to run a test and see if the count tool operates properly.



Time to Find

The time the count tool process took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Num. Found

Number of targets found.

Num. Passed

Number of targets that the evaluation tool judged to have passed. This is shown only for a single-view inspection vision process.

Num. Failed

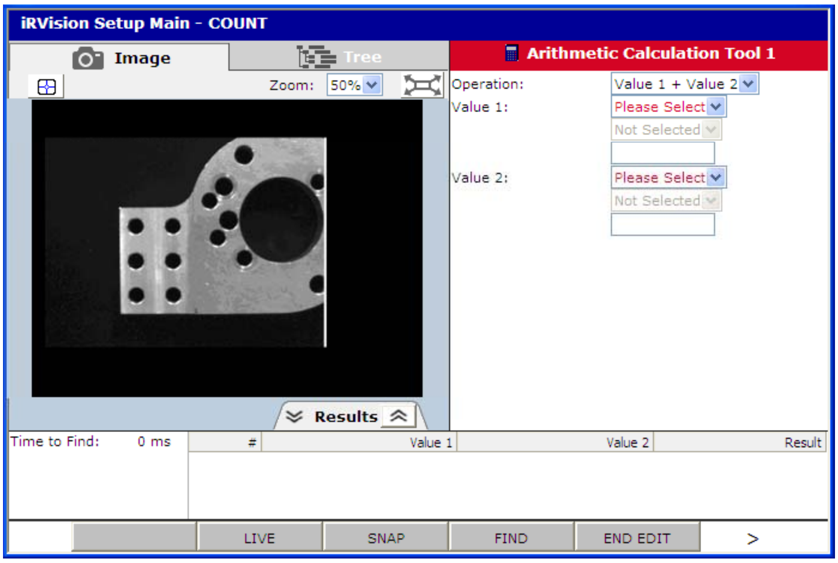
Number of targets that the evaluation tool judged to have failed. This is shown only for a single-view inspection vision process.

7.19.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.20 ARITHMETIC CALCULATION TOOL

The arithmetic calculation tool performs four arithmetic operations for specified measured values. For example, it can calculate the difference between the mean brightness values measured by two histogram tools. The conditional execution tool can use the calculation result for evaluation, and the measurement output tool can write the calculation result to a vision register. If you select the arithmetic calculation tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.20.1 Setting the Parameters

Set what the tool is to calculate.

Operation

Set what kind of calculation is to be performed, by using [Value 1] and [Value 2].
One of the following can be selected:

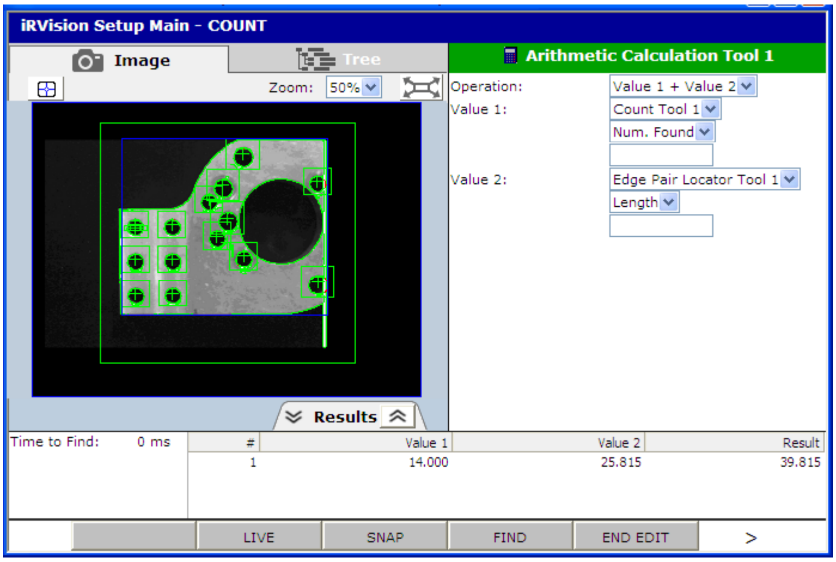
- Value 1 + Value 2
- Value 1 – Value 2
- Value 1 × Value 2
- Value 1 ÷ Value 2
- Value 1 Mod Value 2

Value 1, Value 2

Set the values to be used for the calculation. The measured values of the parent tool, the measured values of preceding command tools that are at the same level as this tool or constants can be selected. In the first drop-down box, select a command tool name or [Constant]. If you select a command tool name, then go to the next drop-down box and select the measured value to be used for the calculation. If you select [Constant], enter a constant value in the text box.

7.20.2 Running a Test

Press F4 SNAP to run a test and see if the arithmetic calculation tool operates properly.



Time to Find

The time the arithmetic calculation tool process took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Value 1, Value 2

The values used for the calculation are displayed.

Result

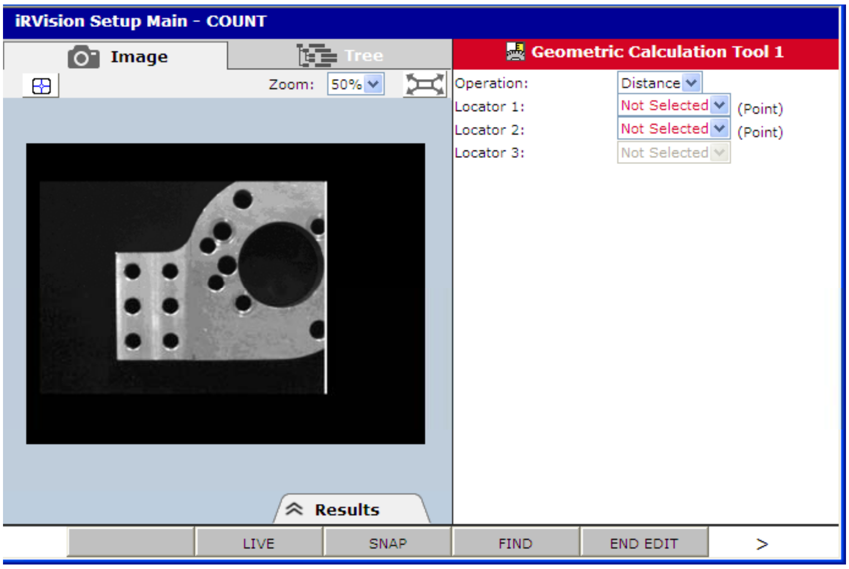
The result of the calculation is displayed.

7.20.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.21 GEOMETRIC CALCULATION TOOL

The geometric calculation tool performs a geometric calculation using the positions found by specified locator tools. For example, it can calculate the distance between the holes found by two locator tools. The conditional execution tool can use the calculation result for evaluation, and the measurement output tool can write the calculation result to a vision register. If you select the geometric calculation tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.21.1 Setting the Parameters

Set what the tool is to calculate.

Operation

Select the geometric calculation to be performed. One of the following can be selected:

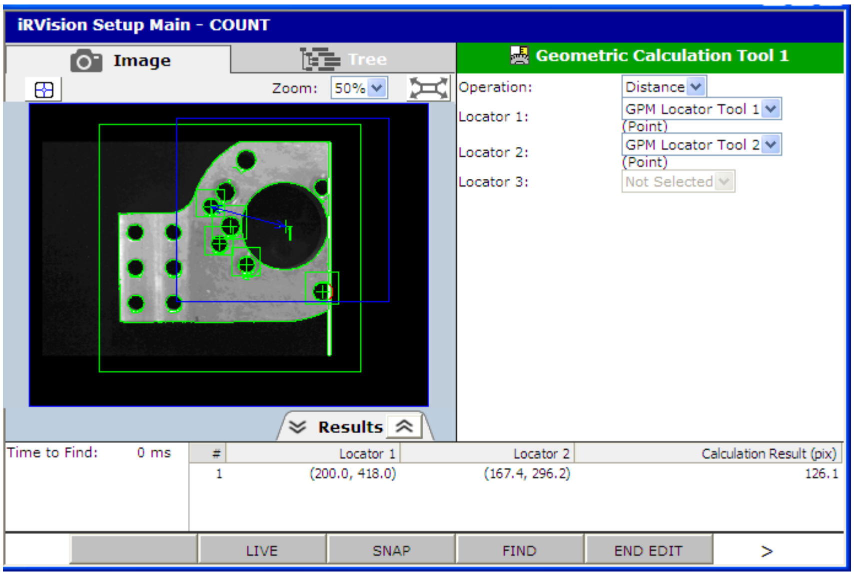
- Distance
- 3-Point Angle

Locator 1...3

Select the locator tools that will detect the positions to be used for the calculation. The parent tool or preceding locator tools that are at the same level as this tool can be selected. If you select [Distance] for [Operation], select [Locator 1] and [Locator 2]. If you select [3-Point Angle], select [Locator 1] to [Locator 3].

7.21.2 Running a Test

Press F4 SNAP to run a test and see if the geometric calculation tool operates properly.



Time to Find

The time the geometric calculation tool process took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Locator 1~3

The positions used for the calculation are displayed. The unit is the pixel.

Calculation Result

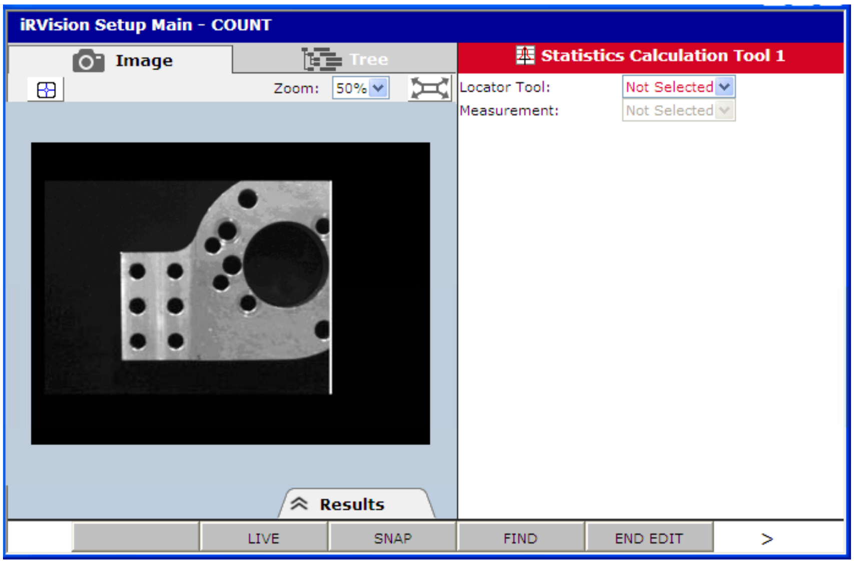
The values used for the calculation are displayed.

7.21.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.22 STATISTIC CALCULATION TOOL

The statistic calculation tool performs a statistic calculation for the measured values of targets found by a specified locator tool. For example, when the blob locator tool has found five blobs, it can calculate the average area or standard deviation of the five blobs. The conditional execution tool can use the calculation result for evaluation, and the measurement output tool can write the calculation result to a vision register. If you select the statistic calculation tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.22.1 Setting the Parameters

Set what the tool is to calculate.

Locator

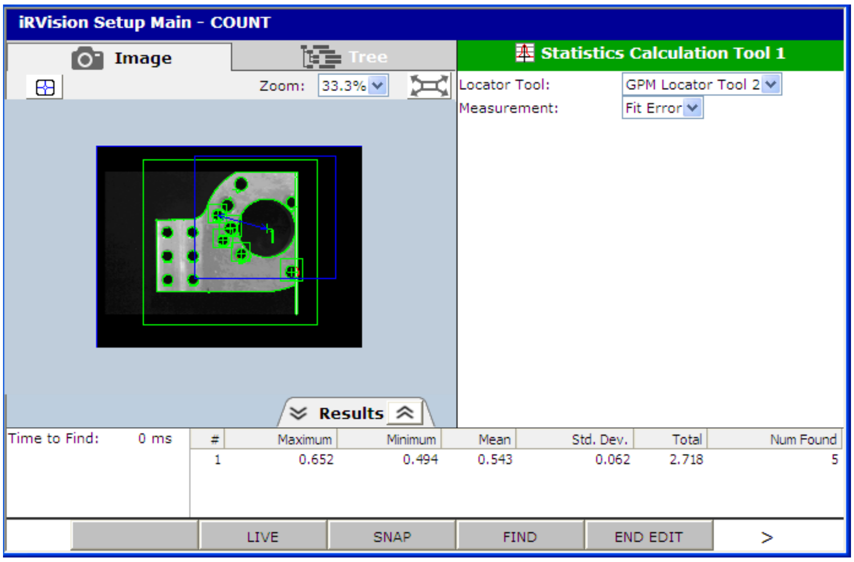
Select the name of the locator tool from which to obtain measured values. Only a locator at the same level and above the statistical calculation tool can be selected.

Measurement

Select the measured value for which the statistic calculation is to be performed.

7.22.2 Running a Test

Press F4 SNAP to run a test and see if the statistic calculation tool operates properly.



Time to Find

The time the statistic calculation tool process took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Maximum

Maximum value of the selected measured values.

Minimum

Minimum value of the selected measured values.

Mean

Mean value of the selected measured values.

Std. Dev.

Standard deviation of the selected measured values.

Total

Total of the selected measured values.

Num. Found

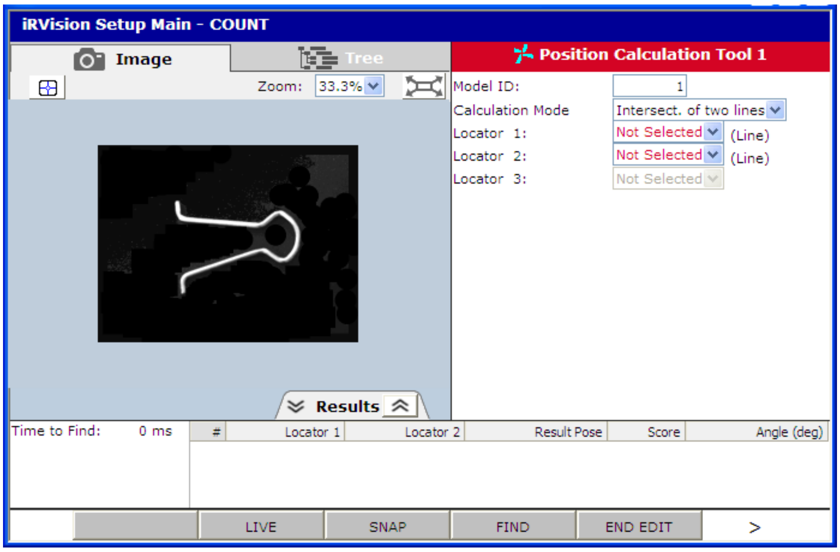
Number of targets found.

7.22.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.23 POSITION CALCULATION TOOL

The position calculation tool calculates a new position from other found positions. For example, it can calculate the intersection of two lines found by two line locator tools, the foot of perpendicular from a hole found by a GPM locator tool to a line found by a line locator tool, and so on. If you select the position calculation tool in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



7.23.1 Setting the Parameters

Set the parameters.

Model ID

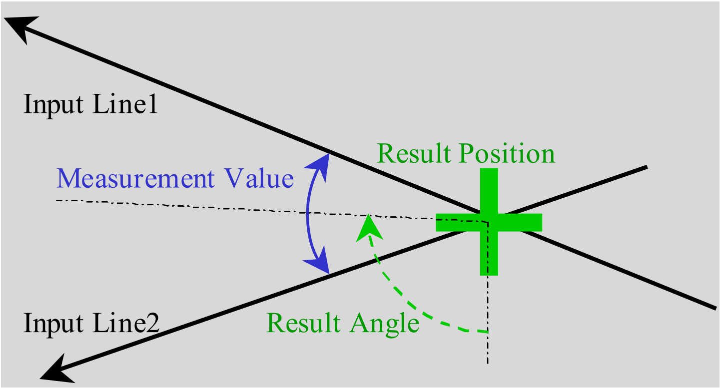
When you have taught two or more position calculation tools and want to identify which tool was used to calculate the position, assign a distinct model ID to each tool. The model ID of the tool, which calculated the positions, is reported to the robot controller along with offset data. This enables a robot program to identify the type of the calculated position.

Calculation Mode

Select a position calculation to be performed. According to the calculation mode that you select, locator tools that you can select at drop-down boxes of [Locator 1~3] is determined. Results of some locator tools are treated as a "point", and some are as a "line".

Intersect. of two lines

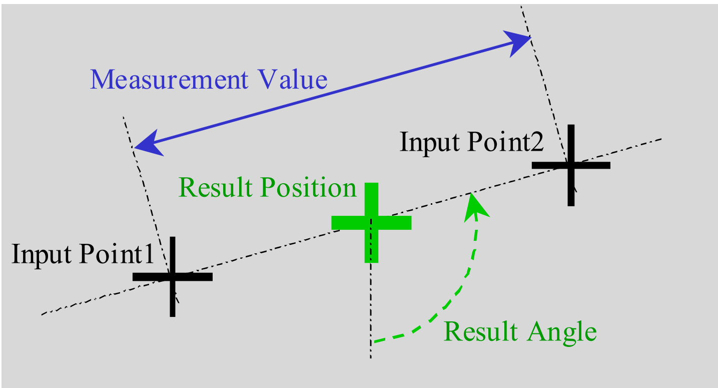
An intersection of two lines is calculated from two input lines.



The result position is the intersection of two input lines, and the result angle is the bisector direction of the angle between two input lines. In addition, the angle between two lines is calculated as its measurement value. The unit of the measurement value is degree. If [Intersect. of two lines] is selected for [Calculation Mode], "(Line)" is displayed at the right of drop-down boxes of [Locator 1~2]. You can select locator tools that output "Line" at the drop-down boxes of [Locator 1~2]. The result of a position calculation tool that is configured to calculate [Intersect. of two lines] is treated as a "Point", and you can use it as an input to another position calculation tool.

Midpoint of two points

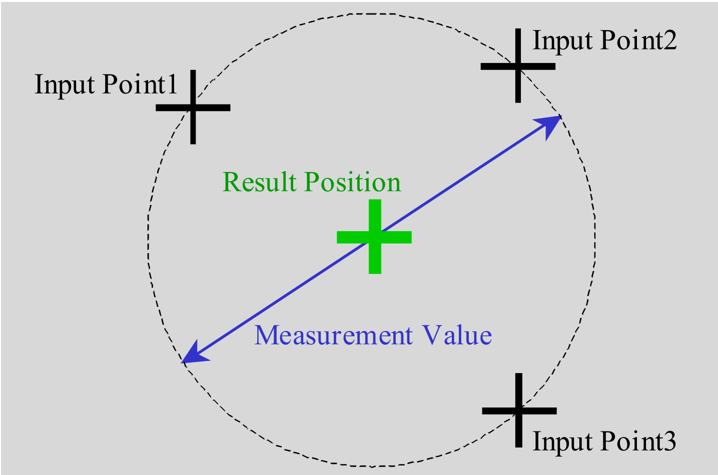
A middle point of two points is calculated from two input points.



The result position is the middle point of two points, and the result angle is the direction from the input point 1 to the input point 2. In addition, the distance between two input points is calculated as its measurement value. The measurement value is in pixels by default, but in millimeters if its parent vision process is configured to make millimeter conversion. If [Midpoint of two points] is selected for [Calculation Mode], "(Point)" is displayed at the right of drop-down boxes of [Locator 1~2]. You can select locator tools that output "Point" at the drop-down boxes of [Locator 1~2]. The result of a position calculation tool that is configured to calculate [Midpoint of two points] is treated as a "Point", and you can use it as an input to another position calculation tool.

Center of circle

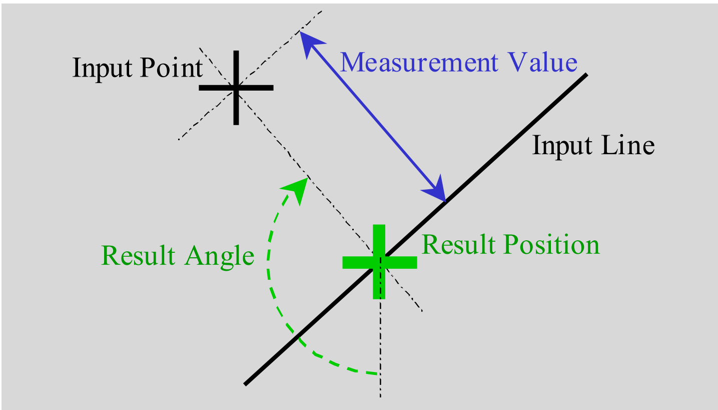
A center of a circle that passes through three input points is calculated from three input points.



The result position is the center of the circle, and the result angle is always zero. In addition, the diameter of the circle that passes through three input points is calculated as its measurement value. The measurement value is in pixels by default, but in millimeters if its parent vision process is configured to make millimeter conversion. If [Center of circle] is selected for [Calculation Mode], "(Point)" is displayed at the right of drop-down boxes of [Locator 1~3]. You can select locator tools that output "Point" at the drop-down boxes of [Locator 1~3]. The result of a position calculation tool that is configured to calculate [Center of circle] is treated as a "Point", and you can use it as an input to another position calculation tool.

Foot of perpendicular

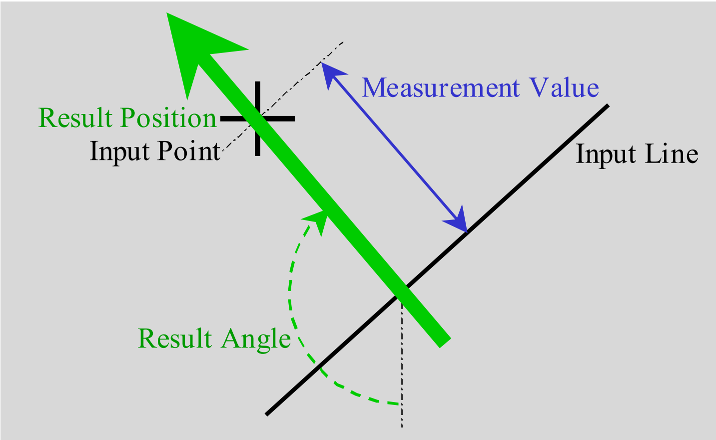
A foot of perpendicular which drops down from a point to a line is calculated from an input point and an input line.



The result position is the foot of perpendicular which drops down from the input point to the input line, and the result angle is the direction from the foot to the input point. In addition, the perpendicular distance from the input point to the input line is calculated as its measurement value. The measurement value is in pixels by default, but in millimeters if its parent vision process is configured to make millimeter conversion. If [Foot of perpendicular] is selected for [Calculation Mode], "(Point)" is displayed at the right of the drop-down list of [Locator 1], and "(Line)" is displayed at the right of the drop-down list of [Locator 2]. You can select a locator tool that outputs a "Point" at the drop-down list of [Locator 1], and a locator tool that outputs a "Line" at the drop-down list of [Locator 2]. The result of a position calculation tool that is configured to calculate [Foot of perpendicular] is treated as a "Point", and you can use it as an input to another position calculation tool.

Perpendicular line

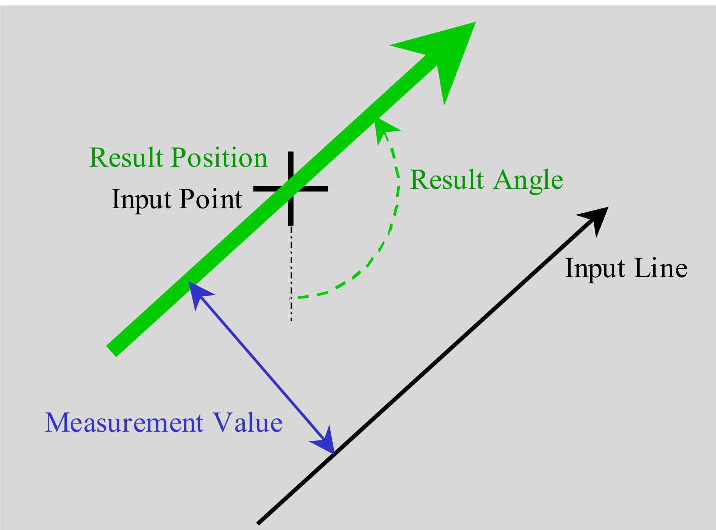
A line which passes through a point and is perpendicular to a line is calculated from an input point and an input line.



The input point is used as a point on the line. The result angle is the direction from the foot to the input point. In addition, the perpendicular distance from the input point to the input line is calculated as its measurement value. The measurement value is in pixels by default, but in millimeters if its parent vision process is configured to make millimeter conversion. If [Perpendicular line] is selected for [Calculation Mode], "(Point)" is displayed at the right of the drop-down list of [Locator 1], and "(Line)" is displayed at the right of the drop-down list of [Locator 2]. You can select a locator tool that output a "Point" at the drop-down list of [Locator 1], and a locator tool that outputs a "Line" at the drop-down list of [Locator 2]. The result of a position calculation tool that is configured to calculate [Perpendicular line] is treated as a "Line", and you can use it as an input to another position calculation tool.

Parallel line

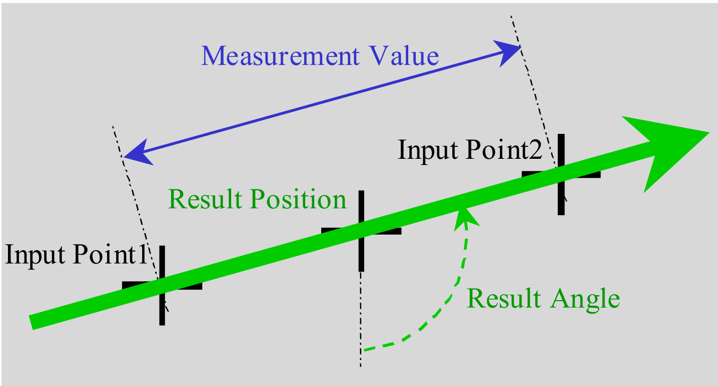
A line that passes through a point and is parallel to a line is calculated from an input point and an input line.



The input point is used as a point on the line. The result angle is the same direction as the direction of the input line. In addition, perpendicular distance from the input point to the input line is calculated as its measurement value. The measurement value is in pixels by default, but in millimeters if its parent vision process is configured to make millimeter conversion. If [Parallel line] is selected for [Calculation Mode], "(Point)" is displayed at the right of the drop-down list of [Locator 1], and "(Line)" is displayed at the right of the drop-down list of [Locator 2]. You can select a locator tool that outputs a "Point" at the drop-down list of [Locator 1], and a locator tool that outputs a "Line" at the drop-down list of [Locator 2]. The result of a position calculation tool that is configured to calculate [Parallel line] is treated as a "Line", and you can use it as an input to another position calculation tool.

Line through two points

A line that passes through two points is calculated from two input points.



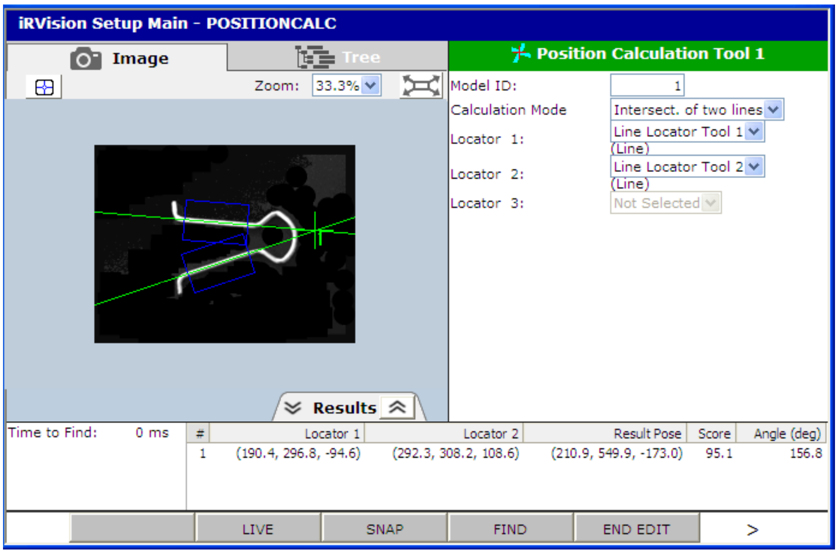
The middle point of two input points is used as a point on the line. The result angle is the direction from the input point 1 to the input point 2. In addition, the distance between two points is calculated as its measurement value. The measurement value is in pixels by default, but in millimeters if its parent vision process is configured to make millimeter conversion. If [Line through two points] is selected for [Calculation Mode], "(Point)" is displayed at the right of the drop-down boxes of [Locator 1~2]. You can select locator tools which output "Point" at the drop-down boxes of [Locator 1~2]. The result of a position calculation tool that is configured to calculate [Line through two points] is treated as a "Line", and you can use it as an input to another position calculation tool.

Locator 1~3

Select locator tools that output positions to be used as inputs to position calculation tool. Its parent locator tool or preceding sibling locator tools can be selected. If [center of circle] is selected for [Calculation Mode], select [Locator 1~3]. If you select the other options for [Calculation Mode], select [Locator 1~2].

7.23.2 Running a Test

Press F4 SNAP to run a test and see if the position calculation tool operates properly.



Time to Find

The time the position calculation tool process took is displayed in milliseconds.

Measurement Result Table

The following values are displayed.

Locator 1~3

The input positions and angles to the position calculation tool are displayed. Only when [center of circle] is selected for [Calculation mode], the column of [Locator 3] is displayed. The positions are in pixels, and the angle is in degrees.

Result Pose

The calculated position and angle are displayed. The position is in pixels, and the angle is in degrees.

Score

The average score of command tools which was used by position calculation are displayed.

Measurement Value

The resulting measurement value is displayed. The column header depends on the calculation mode.

- Intersect. of two lines : Angle
- Midpoint of two points : Distance
- Center of circle : Diameter
- Foot of a perpendicular : Perpendicular Distance
- Perpendicular line : Perpendicular Distance
- Parallel line : Perpendicular Distance
- Line through two points : Distance

Popup alarm at running a test

Depending on the input positions, calculation may fail. If failed at production runtime the position calculation just does not output results. On the other hand, the reason why the position calculation failed is displayed when running a test.

Input poses are too near

It is displayed when the distance between two input points or the distance between an input point and an input line is less than 1 pixel.

Input lines are parallel

It is displayed when [Intersect. of two lines] is selected for [Calculation Mode] and the angle between two input lines is less than 1 degree.

Relation of input points is inappropriate

It is displayed when [Center of circle] is selected for [Calculation Mode] and one of the interior angles of three input points is less than 1 degree.

Result pose is out of image

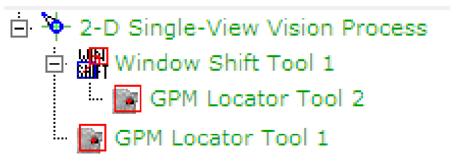
It is displayed when the result position is out of image.

7.23.3 Overridable Parameters

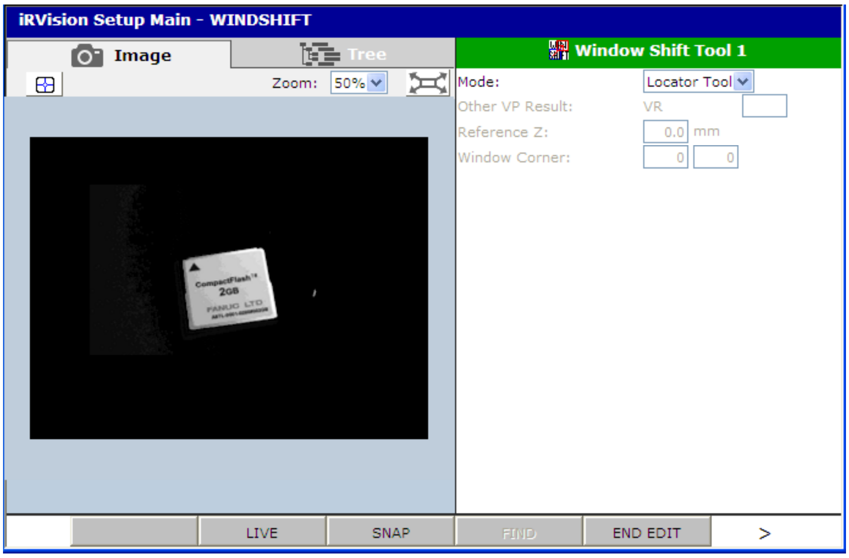
This command tool has no overridable parameters that can be overridden with Vision Override.

7.24 WINDOW SHIFT TOOL

The window shift tool dynamically shifts a locator tool window or measurement tool window based on the result of a locator tool or another vision process. For example, when you use an application that retrieves workpieces from a basket or rack, you may set the tool to shift the search window of the locator tool based on the position of the basket or rack, thereby preventing objects outside the basket or rack from being found inadvertently. Place the window shift tool directly below the vision process. The windows of the locator tools and measurement tools that are at the same level as the window shift tool and that are inserted below the window shift tool are shifted according to the window shift tool settings.



If you select the window shift tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.24.1 Setting the Parameters

Set the parameters.

Mode

Select the window shift mode from the following:

Locator Tool

A locator tool is placed as a child tool of the window shift tool, which in turn shifts windows based on the found results of that locator tool. Use this mode when the locator tool can find the basket and the workpieces in the same field of view.

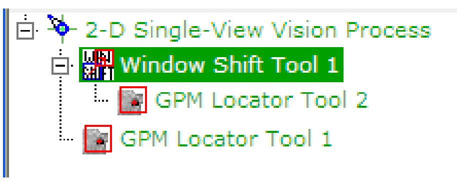
Other VP Result

The tool shifts windows based on the found results of another vision process that are stored in a vision register. Use this mode when you want to use different exposure times when finding the basket then when finding the workpieces in it. A vision process for finding the workpieces and for the basket needs to be prepared separately. In cases where the position of the basket changes only when it is replaced, rather than every time a workpiece is found, you can reduce the cycle time by having the system run the vision process for finding the basket only when the basket is replaced.

The parameters other than [Mode] depend on the mode you select.

7.24.1.1 Shifting windows based on a locator tool's results

When windows are shifted based on the found results of a locator tool, the only parameter to set is the [Mode], which is set to “locator tool”. Insert a locator tool as a child tool of the window shift tool, and teach a model pattern of the child locator tool.



Setting the Reference Position

Once you teach a command tool that is at the same level and below the window shift tool, the child locator tool of the window shift tool automatically runs. The position found by the child locator tool of the window shift tool is automatically saved as the reference position for shifting the window of the taught command tool. The saved window shift reference position is displayed as follows (shown below is an example of the GPM locator tool).

7.24.1.2 Shifting windows based on another vision process' results

When shifting windows based on another vision process' results, make the settings as follows.

Vision Register Number

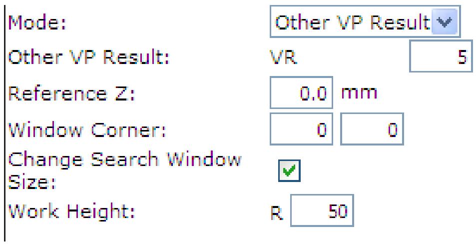
Specify the number of the vision register that stores the vision process results to be used for shifting windows. Make sure that the vision processes for finding the basket and the workpieces are calibrated to the same [Application User Frame]. Please set the reference position when the offset value in the vision register specified here is zero.

Reference Z

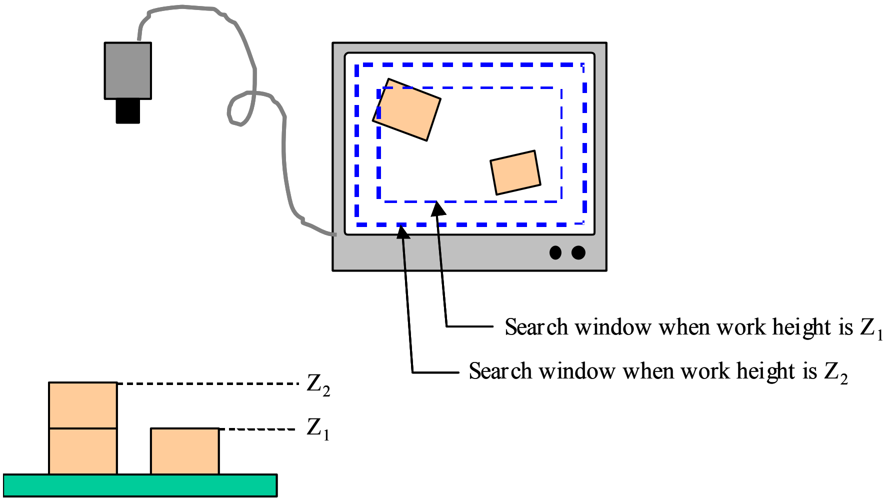
Set the Z value of found position set in the vision register specified at [Vision Register Number].

Change Search Window Size

If [Depalletizing Vision Process] or [Bin-Pick Search Vis. Process] are selected as the vision process that uses the window shift tool, the size of the search window can be expanded or reduced according to the height of the workpiece to be found. If one of these vision processes is used, the setting window of the window shift tool has the following two additional parameters:

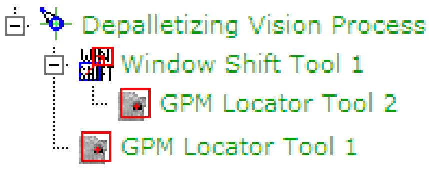


To expand or reduce the size of the search window, check the [Change Search Window Size] box and specify the number of the register storing the workpiece height information in [Work Height]. The window shift tool fetches the value in the register during execution, and changes the size of the search window according to the value.



Setting the Reference Position

Once you teach a command tool that is at the same level and below , the window shift tool automatically runs. The window shift tool obtains information from the specified vision register and relevant register and generates position data for window shifting. The position data generated by the window shift tool is saved as the window shift reference position for the locator tool detecting the model.



The saved window shift reference position is displayed as follows (shown below is an example of the GPM locator tool).

Parent Tool Ref. Pos.: (0.0, -0.0) 0.0° 100.0%

> ⚠ **CAUTION**
>
> 1 The window shift tool reads the values that are set in the vision register at the time of access. If the values stored in the vision register do not match the actual position of the basket, the tool cannot shift the window properly. Run the vision process for finding the basket to make sure that the latest information about the basket position is saved in the vision register.
>
> 2 With vision processes that do not use Application User Frame, the “Other VP Result” mode cannot be used. For example, Single View Inspection Vision Process cannot use a Window Shift Tool when its **Mode** is *Other VR Result* since it does not use an application frame

Window Corner

Set the upper left corner of the search window of the command tool that at the same level and below.

7.24.2 Running a Test

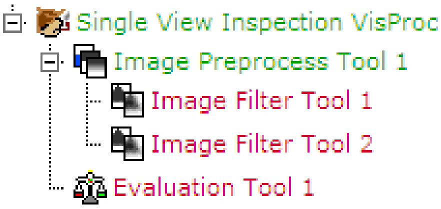
The window shift tool setup page does not offer the capability to run a test. To check whether the search window is shifted properly, run a test using the setup page of a locator tool that is inserted below the window shift tool.

7.24.3 Overridable Parameters

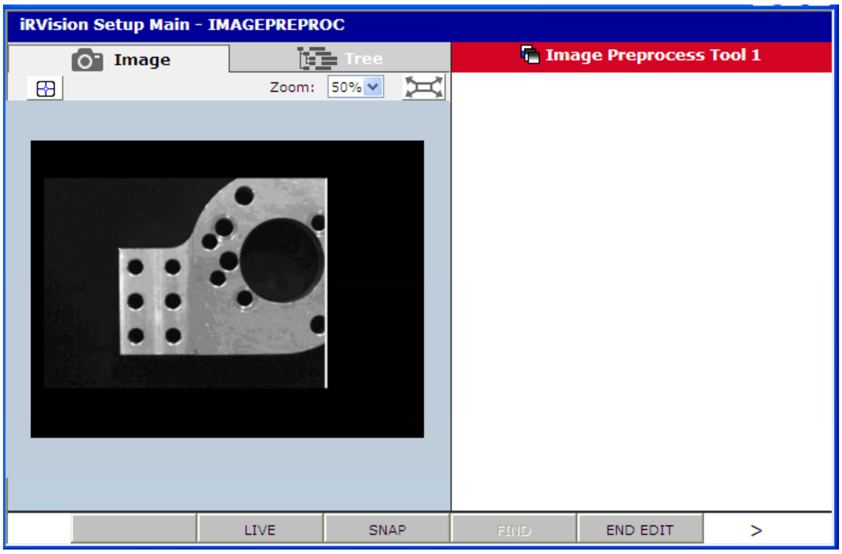
This command tool has no overridable parameters that can be overridden with Vision Override.

7.25 IMAGE PREPROCESS TOOL

The image preprocess tool has the color extraction tool and the image filter tool which are described below as a child tool and has its place as the container of the command tool of the image processing. You can treat the image which is processed by the color extraction tool and the image filter tool which are the child tool of the image preprocess tool as the input image of the command tool which is used for a detection and an inspection. Only one image preprocess tool can be inserted just below the vision process, as follows.



If you select the image preprocess tool in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



7.25.1 Running a Test

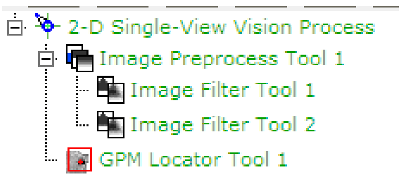
The image preprocess tool setup page does not offer the capability to run a test.

7.25.2 Overridable Parameters

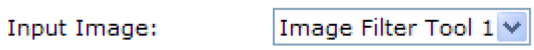
This command tool has no overridable parameters that can be overridden with Vision Override.

7.26 IMAGE FILTER TOOL

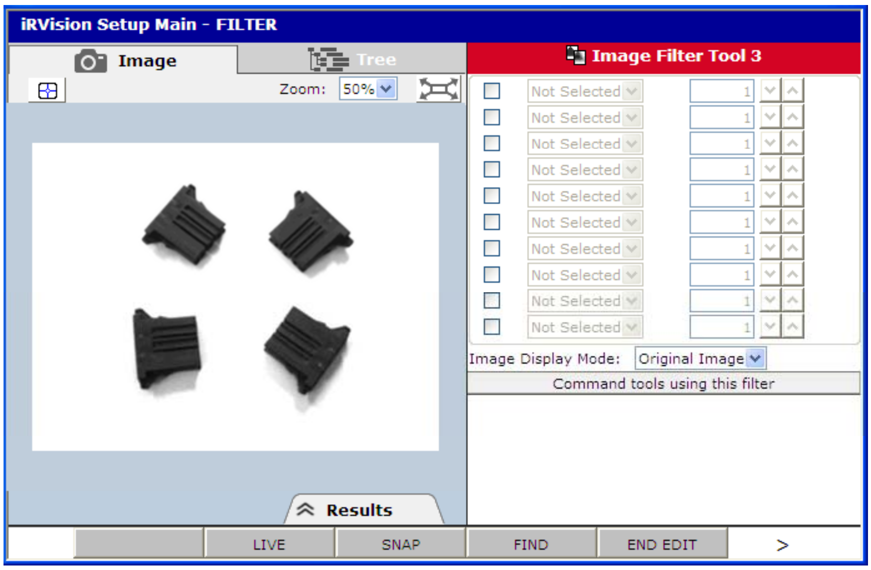
The image filter tool execute image preprocessing(e.g, Blur, Sharpen and so on) with respect to the image which is acquired by the camera. This tool can be inserted only under the image preprocess tool. By adding several types of the image filter tool, as follows, the image filter tool create the image which is preprocessed by several different filters and each command tools which is the child tool of the vision process can use images which is preprocessed by several different filters.



To use the image which is created by the image filter tool in the other command tool, open the setup page of the command tool, and then select the name of the image filter tool in the drop down box of the [Input Image].



If you select the image filter tool in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



Tip

As in the case of the Histogram Tool and the Surface Flaw Inspection Tool, some command tools have their own local filter functions. The difference between the local filter functions and the Image Filter Tools (global) is the size of the image area that is filtered. The filter command tools filter the whole image. The filter functions local to a command tool filter only the search area of the commend tool. Since the local filter functions have a smaller image area, they execute faster. In the case where more than one tool shares the same filtered image it may be faster to use the global image filter tool.

7.26.1 Setting the Parameters

Filters

Set up the filters. You can set up filters up to 10. After enabling the checkbox, select the filter from options listed below in the drop-down box. The number of filter iterations is specified by the textbox.

Blur

Enable this filter to eliminate fine surface texture or image noise.

Sharpen

Enable this filter to enhance the contrast of the edges.

Erode

Erode the black area.

Dilate

Dilate the black area.

Image Display mode

Select the image display mode for the Setup Page.

Original Image

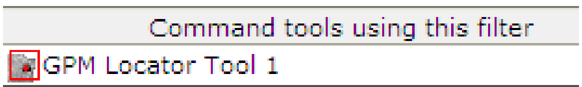
Display the camera image as it is.

Filtered Image

Display the image resulting from the filtering.

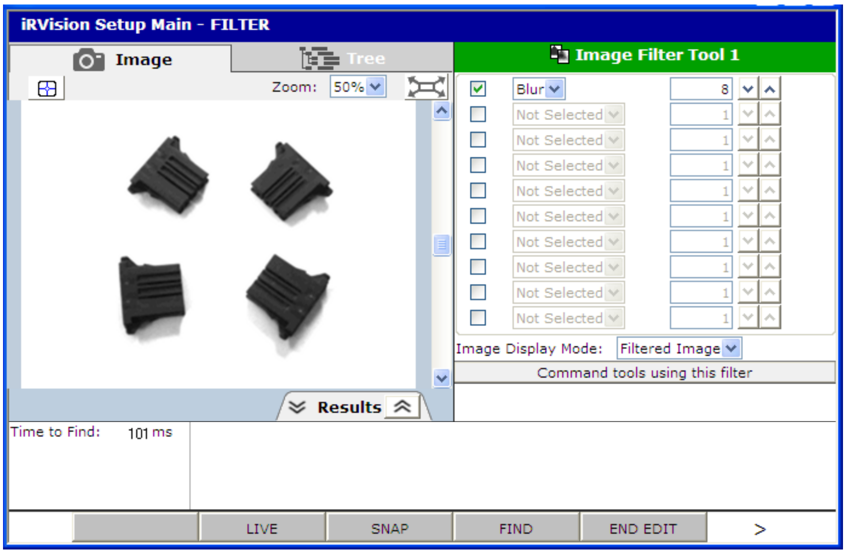
Command tools using this filter

The name list of command tools are displayed , which command tools use the image which is created by this image filter tool.



7.26.2 Running a Test

Press F4 SNAP to run a test and see if the image filter tool operates properly.



Time to Find

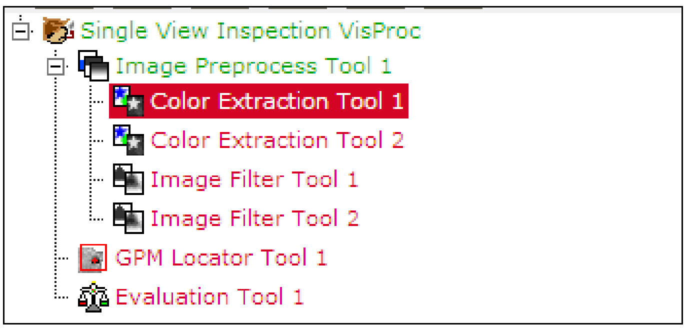
The time the image filter tool process took is displayed in milliseconds.

7.26.3 Overridable Parameters

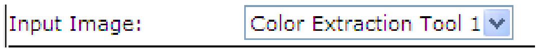
This command tool has no overridable parameters that can be overridden with Vision Override.

7.27 COLOR EXTRACTION TOOL

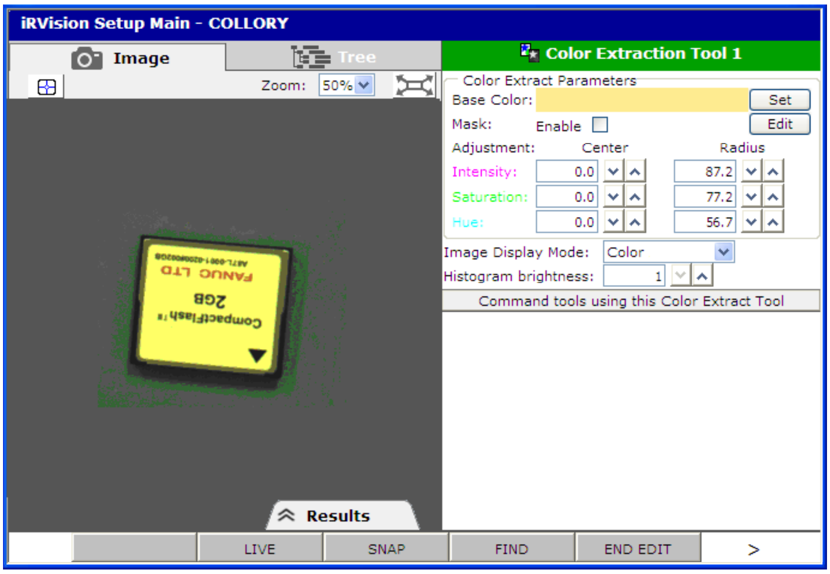
The color extraction tool creates the color extracted image from the image of the color camera on the basis of the color extraction parameters. This tool can be inserted only under the image preprocess tool. And, in the case of the camera which is set up in the vision process or camera view is the color camera, this tool can be used. By adding several types of the color extraction tool, as follows, the color extraction tool create the color extracted image which is based on several different color extraction parameters and each command tools which is the child tool of the vision process can use color extracted images which is based on several different color extraction parameters.



When the command tool use the image which is created by the color extraction tool, open the setup page of the command tool, and then select the name of the color extraction tool in the drop down box of the [Input Image].



If you select the color extraction tool in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



7.27.1 Setting the Parameters

Color Extraction Parameters

Base Color

Tap the [Set] button to set the rectangle on an area of the color to be extracted. When the base color is trained, it is displayed on the left side of the [Set] button.

Mask

Tap the [Edit] button to mask colors other than the color to be extracted. When the [Enable] check box is unchecked, the mask is ignored.

Adjustment

Adjust the color extraction ranges (the position and size of white ellipses which are displayed on the histogram images).

Intensity

Adjust the intensity range of the color extraction. The center position and radius of the ellipse can be adjusted along the intensity axis (the magenta axis on the histogram image).

Saturation

Adjust the saturation range of the color extraction. The center position and radius of the ellipse can be adjusted along the saturation axis (the green axis on the histogram image).

Hue

Adjust the hue range of the color extraction. The center position and radius of the ellipse can be adjusted along the hue axis (the cyan axis on the histogram image).

Image Display Mode

Select the image display mode from the following items.

Color

Display a color image.

Gray

Display a gray-scale image.

Color Extracted

Display a color extract image (image in which the specified color is displayed brightly).

Histogram

Display how the specified color is distributed in the intensity/saturation/hue space (the color space).

Histogram (All)

Display how all colors of the image are distributed in the color space.

Histogram (Trained)

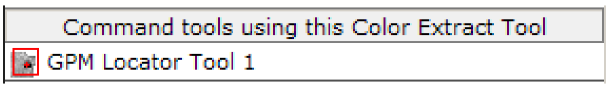
Display how all colors in the trained area are distributed in the color space.
This mode is enabled only after training the base color.

Histogram brightness

Adjust the brightness (intensity) of a histogram only when one of three histogram modes is selected.

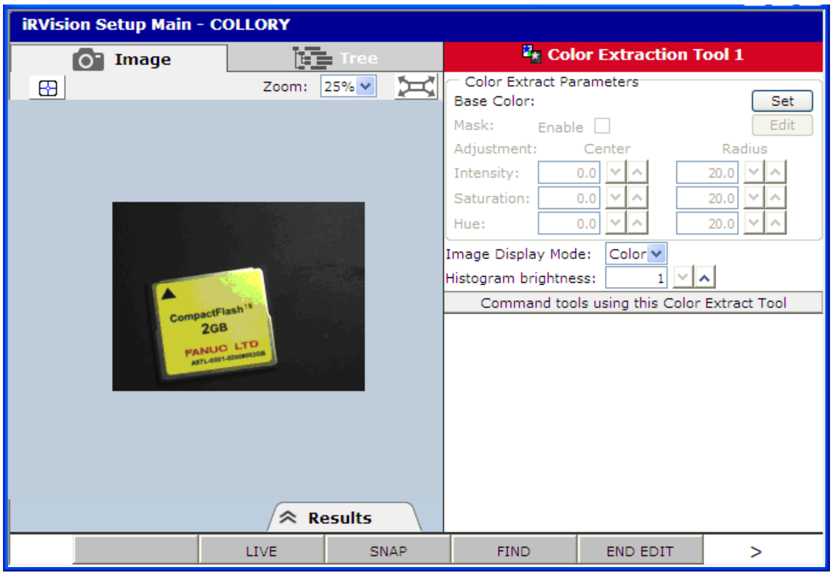
Command tools using this Color Extract Tool

The name list of command tools are displayed, which command tools use the color extracted image which is created by this color extraction tool.



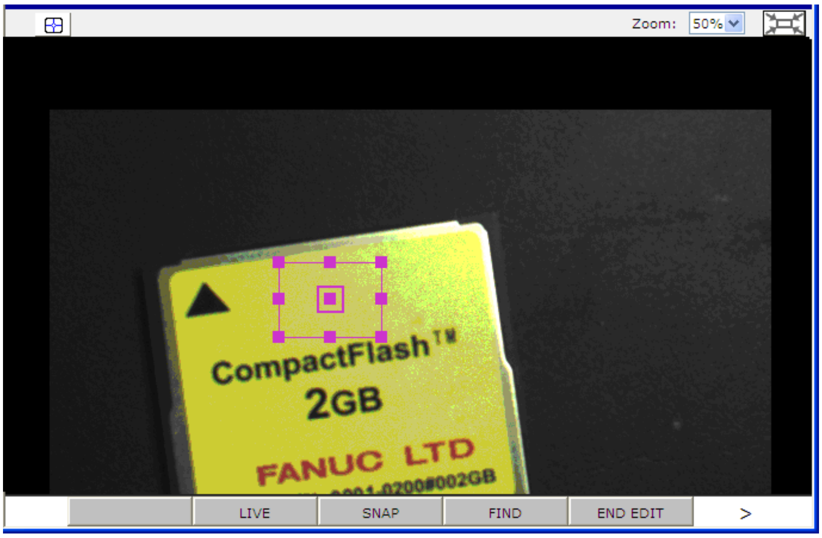
7.27.2 Training the Parameter of the Color Extraction

Here is an example of the training procedure



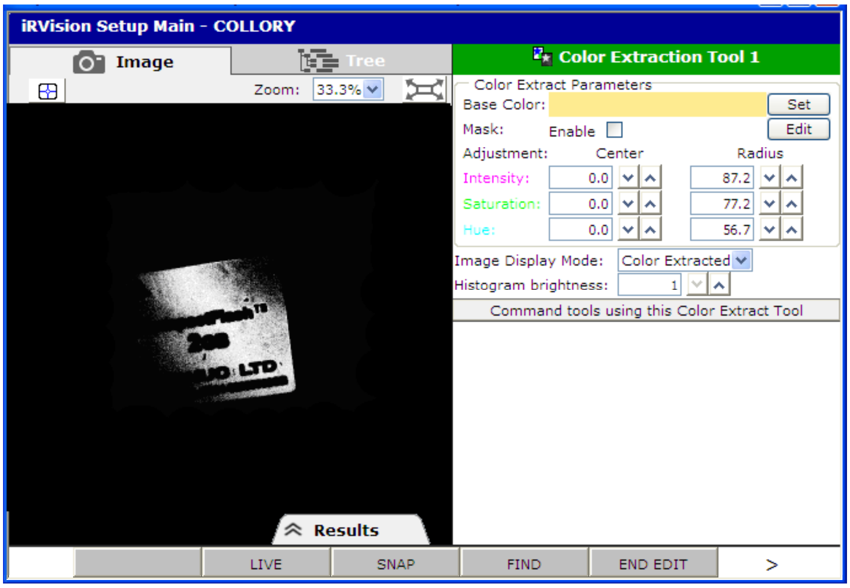
When you want to extract the yellow area (the label), train color extraction parameters with the following steps.

1 Tap the [Set] button of [Base Color] and enclose the target color to be extracted within the purple rectangle that appears.

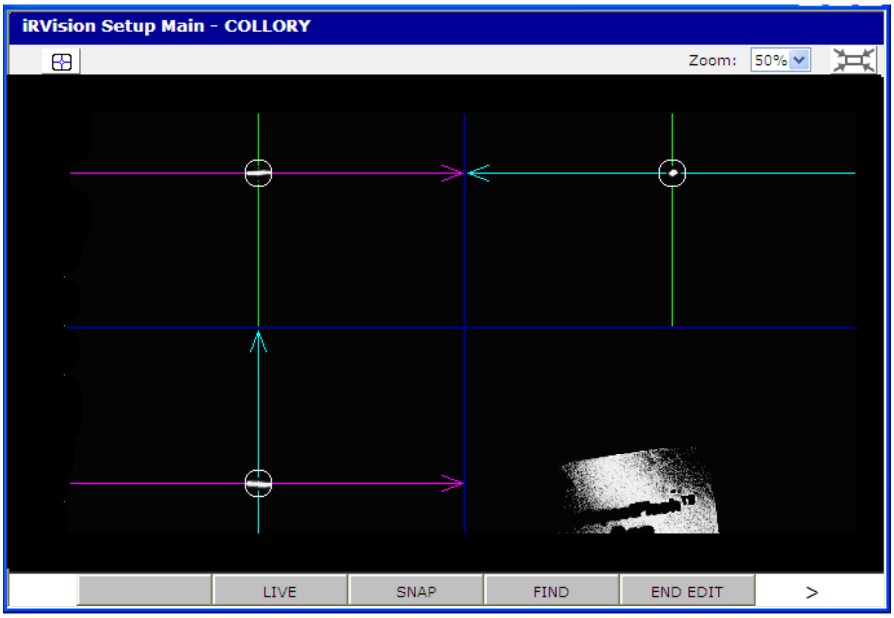


2 Press F4 OK, then the average color in the specified rectangle is set to [Base Color].

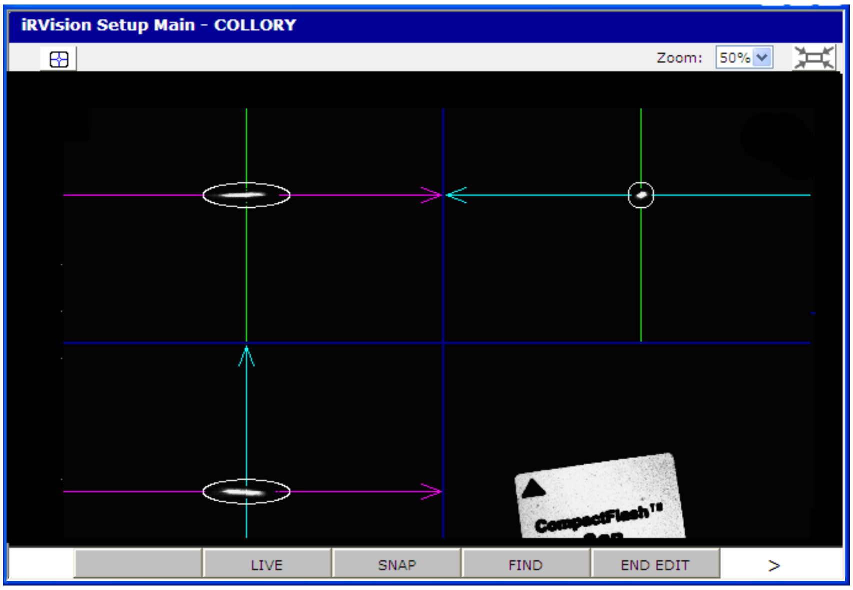
3 Change [Image Display Mode] to [Color Extracted]. You can see that the area trained as [Base Color] and their neighborhoods are extracted clearly but the left side of the label is not extracted clearly.



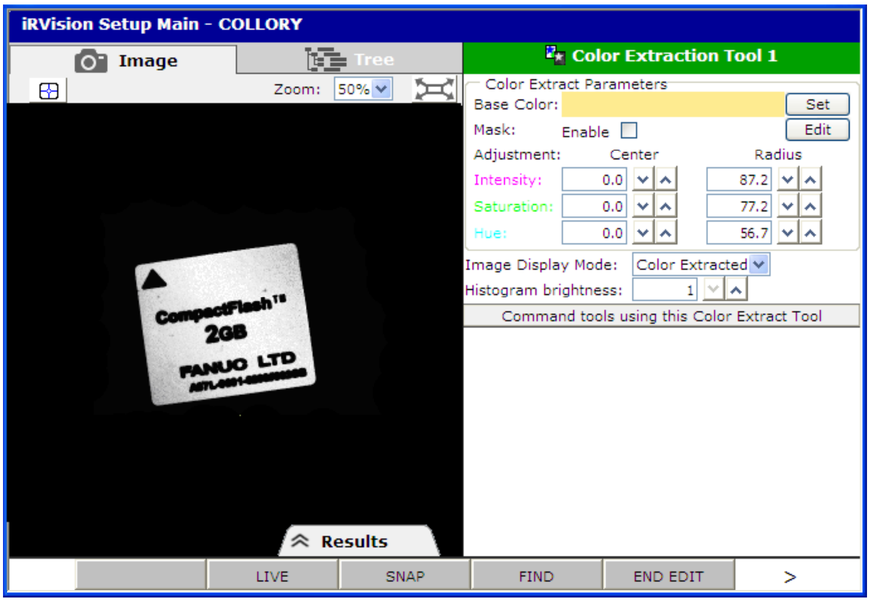
4 Change [Image Display Mode] to [Histogram]. You can see that the label color, indicated by a white blob in the center of each coordinate, is distributed widely along the intensity axis (the magenta axis).



5 Increase [Radius] of [Intensity] to enclose the distribution of the label color.



6 Change [Image Display Mode] to [Color Extracted]. You can see that the whole label area is extracted clearly.

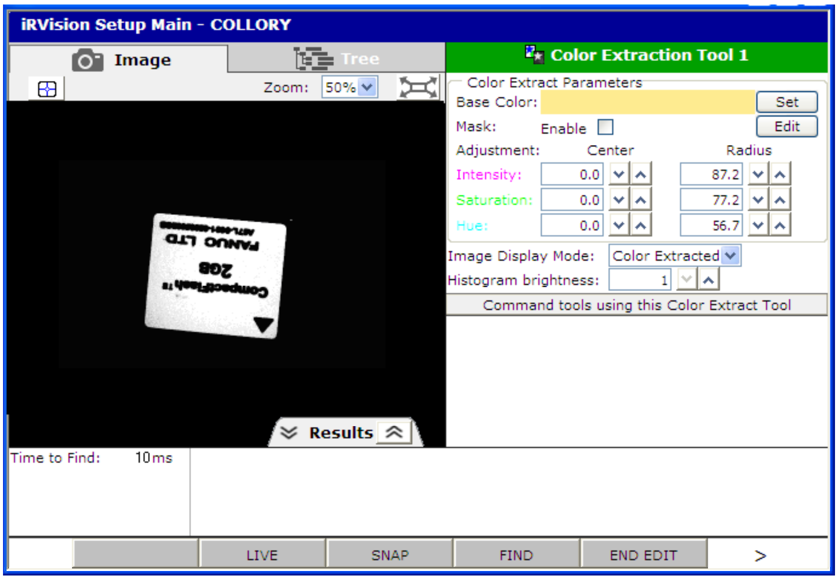


Tip

When there is only one Color Extraction Tool in the vision process, the color extraction can be executed on the camera. When the color extraction is executed on the camera, the execution time will be short. For details, please refer to the Subsection 4.1.2 "Color Camera".

7.27.3 Running a Test

Press F4 SNAP to run a test and see if the color extraction tool operates properly.



Time to Find

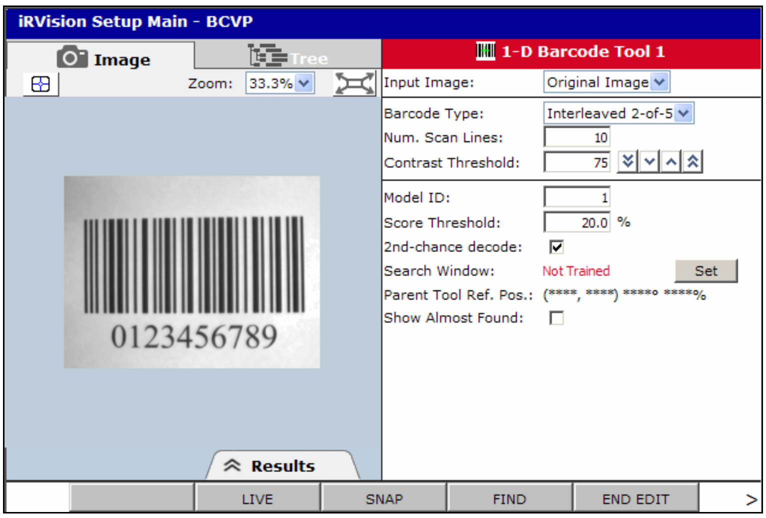
The time the color extraction tool process took is displayed in milliseconds.

7.27.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.28 1-D BARCODE TOOL

The 1-D barcode tool finds 1-D barcode in an image and reads the string contained in the 1-D barcode. The tool is available only with the reader vision process. If you select the 1-D barcode tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



The following 1-D barcode are supported.

- Interleaved 2-of-5

- Code 39
- NW7 (Codabar)
- EAN (JAN)
- UPC

7.28.1 Teaching the Search Window

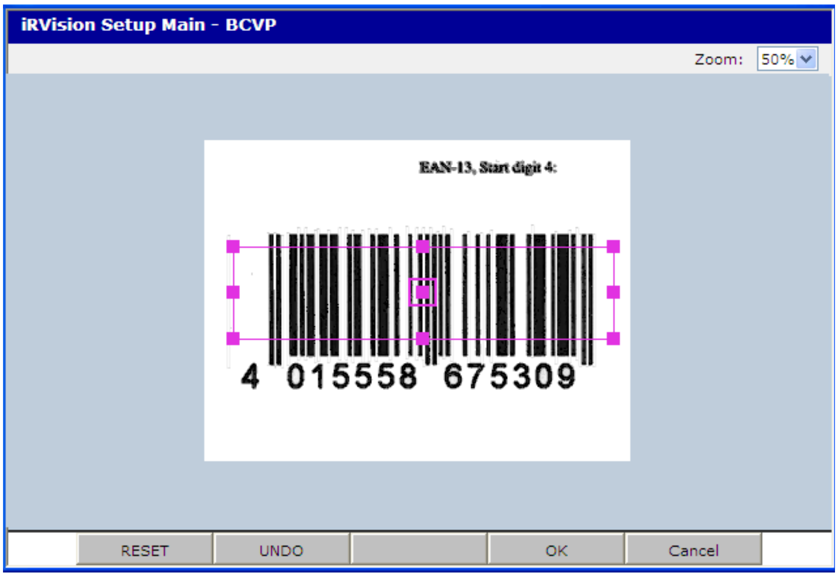
Teach the region for searching 1-D barcode.

Teaching the search window

Teach the search window as follows.

1. Press F2 SNAP to change to the live image display.
2. Place the 1-D barcode near the center of the camera view.
3. Press F2 STOP and then press F3 SNAP to snap the image of the 1-D barcode.
4. Tap the [Set] button.
5. Enclose the 1-D barcode within the purple rectangle that appears, and press F4 OK. The search window should have blanks on both sides of the barcode with tenfold width of Narrow Bar.

For detailed information about the operation method, see Subsection 3.7.9, "Setting Window"



7.28.2 Setting the Parameters

Set the barcode parameters.

Input Image

Select the image which is used for training search area and detection 1-D Barcode. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this 1-D Barcode Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool"

Barcode Type

The types of barcodes supported by the 1-D barcode tool. Select one of the followings:

- Interleaved 2-of-5
- Code 39

- NW7 / Codabar
- EAN / UPC

Refer to “7.28.5 Terminologies” for more information.

Num. Scan Lines
The number of scan lines used to read the 1-D barcode. Each scan line goes across the 1-D barcode and reads the edge transitions and uses the data to decode the 1-D barcode.

Contrast Threshold
The minimum acceptable contrast of boundaries between bars and spaces. The default value is 76.5, and the minimum threshold to be input is 1. The smaller the value is and the more an obscure barcode is detected, but it could take more time for the image processing.

Code Subtype
The subtype of EAN barcodes. This can be selected when "Barcode Type" is "EAN/UPC". Select one of the followings:

- EAN-13
- UPC

Start Digit
The start digit for EAN barcodes. This can be selected when "Barcode Type" is "EAN / UPC" and "Code Subtype" is "EAN-13".

Model ID
When you have two or more 1-D barcode tools, you can assign each a unique model ID so that your TP program can distinguish with which 1-D barcode tool the barcode is decoded.

Score Threshold
The score is the percentage of scan lines that successfully decoded the 1-D barcode. The whole find is regarded as success when the score exceeds the threshold. The value from 10 to 100 can be set, and the default is 20. The smaller value could lead to a wrong detection.

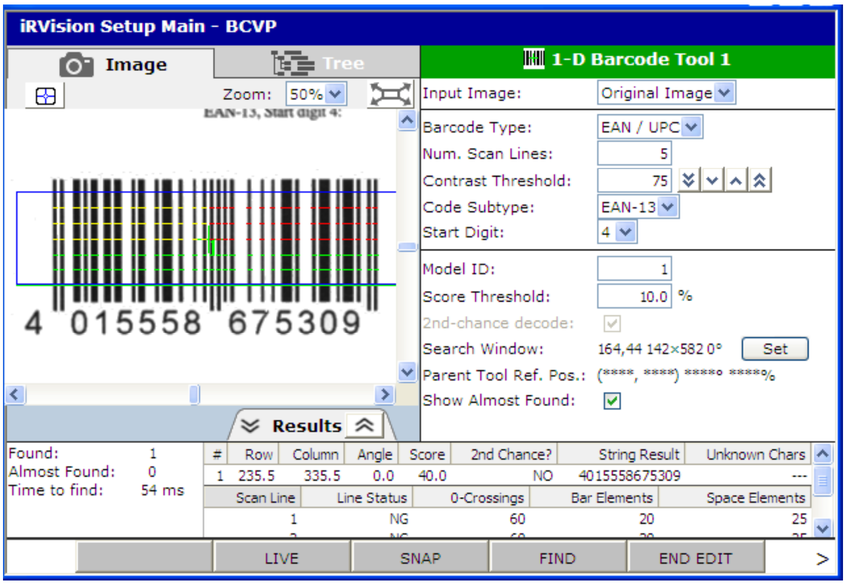
Use second chance decode
When a usual 1-D barcode decoding fails, a 1-D barcode decoding using the second chance decode algorithm is executed if this checkbox is checked. The second chance decode algorithm is effective when the barcode that appears in the image is small or the 1-D barcode is not perpendicular to the camera optical axis. The chance of decoding a barcode improves if the "Use second chance decode" checkbox is checked, but the accuracy of decoding may deteriorate, sometimes resulting in a wrong string output. Therefore, you have to be careful when enabling the "Use second chance decode" checkbox. "Use second chance decode" is available when "Barcode Type" is " Interleaved 2-of-5" or "Code 39" or "NW7 / Codabar".

Search Window
The window that the 1-D barcode tool searches for the specified barcode.
If you want to change the search window, tap the [Set] button. Set the search window a few pixels larger than the 1-D barcode for best results.

Show Almost Found
If the 1-D barcode failed to be found because it fell just short of meeting the score, its test result is displayed. The result appears in a red rectangle on the image.

7.28.3 Running a Test

Press F4 SNAP to run a test and see if the 1-D barcode was properly found.



Found

If the result is successfully obtained, 1 is displayed. If the tool fails to find the 1-D barcode, 0 is displayed.

Almost Found

If the "Show Almost Found" checkbox is checked and the 1-D barcode failed to be found because it was slightly outside the specified range, 1 is displayed. Otherwise 0 is displayed.

Time to Find

The time the decoding process took is displayed in milliseconds.

Found Result Table 1

The following values are displayed.

Row, Column

The found position of the 1-D barcode (unit: pixel).

Angle

The found angle of the 1-D barcode (unit: degrees).

Score

The percentage of scan lines that successfully decoded the barcode. If the barcode is decoded by using the second chance decode algorithm, the score is always 100.

Second Chance?

If the barcode decoded by using the second chance decode algorithm, "YES" is displayed. "NO" is displayed in the following cases.

- "Use second chance decode" checkbox is not checked.
- "Barcode Type" is "EAN / UPC".

- The second chance decode algorithm was not used when decoding the barcode.
- The decoding failed.

String Result

The decoded string.

Unknown Chars

The number of unknown characters in the decoded string.

Found Result Table 2

The following values are displayed.

Scan Line

The index of the scan line.

Line Status

Scan status of the scan line. "OK" is displayed when the scan line successfully decoded the barcode. "NG" is displayed when the scan line failed decoding.

0-Crossings

The number of the boundaries between bars and spaces.

Narrow bars

The number of found Narrow Bars on the scan line. This column is displayed only when "Barcode Type" is " Interleaved 2-of-5" or "Code 39" or "NW7 / Codabar".

Narrow Spaces

The number of found Narrow Spaces on the scan line. This column is displayed only when "Barcode Type" is " Interleaved 2-of-5" or "Code 39" or "NW7 / Codabar".

Wide bars

The number of found Wide Bars on the scan line. This column is displayed only when "Barcode Type" is " Interleaved 2-of-5" or "Code 39" or "NW7 / Codabar".

Wide Spaces

The number of found Wide Spaces on the scan line. This column is displayed only when "Barcode Type" is "Interleaved 2-of-5" or "Code 39" or "NW7 / Codabar".

Bar Elements

The number of found bars on the scan line. This column is displayed only when "Barcode Type" is "EAN / UPC".

Space Elements

The number of found spaces on the scan line. This column is displayed only when "Barcode Type" is "EAN / UPC".

7.28.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.28.5 Terminologies

This section explains some terminologies for 1-D barcode tool.

Interleaved 2-of-5

Interleaved 2-of-5 is mainly used on the distribution industry. The following figure shows an example of Interleaved 2-of-5.

0123456789

Interleaved 2-of-5 is made up of black lines that have two kinds of width and blanks that have two kinds of width. A heavier black line is referred to as Wide Bar, a finer black line is referred to as Narrow Bar, a heavier blank will be referred to as Wide Space, and a finer blank is referred to as Narrow Space in this manual. Interleaved 2-of-5 can encode an even-figure number.

Code 39

Code 39 is mainly used on the automobile and electronics industry. The following figure shows an example of Code 39.

CODE39

Code 39 is made up of Wide Bar, Narrow Bar, Wide Space, and Narrow Space the same as Interleaved 2-of-5. Code 39 can encode a string that consists of single byte characters such as alphabets, numerals, and some symbols.

NW7 (Codabar)

NW7, which is also known as Codabar in the North American market, is mainly used tags for delivery service. The following figure shows an example of NW7.

012345

NW7 is made up of Wide Bar, Narrow Bar, Wide Space, and Narrow Space the same as Interleaved 2-of-5. NW7 can encode a string that consists of single byte characters such as alphabets, numerals, and some symbols.

EAN

EAN is used world wide for various consumer products. The following figure shows an example of EAN.

0 123456 789012

EAN is made up of black lines that have four kinds of width and blanks that have four kinds of width. A black line is referred to as Bar, a blank is referred to as Space in this manual. There are several variations of EAN, but *i*RVision supports only EAN-13. EAN-8 is not supported. EAN can encode a 13-digit number. JAN is compatible to EAN, and *i*RVision can decode JAN too. If you want to decode JAN, select "EAN / UPC" for "Barcode Type".

UPC

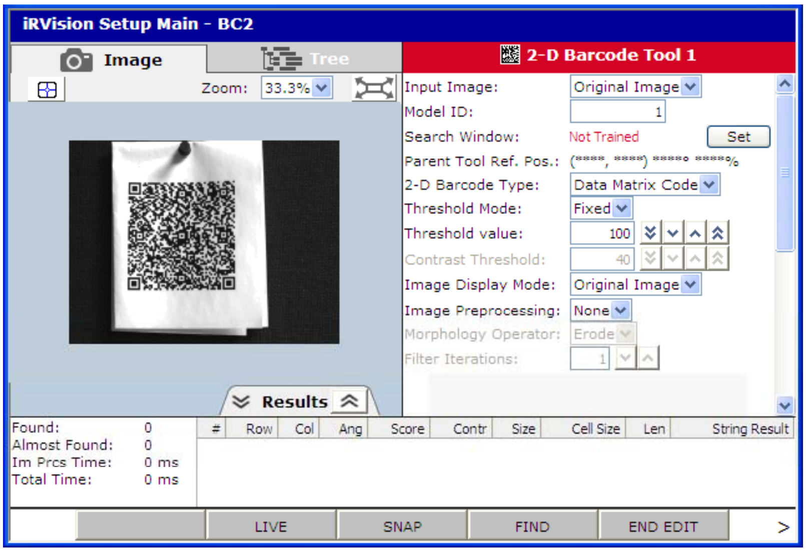
UPC is used for marking products in the North American markets. The following figure shows an example of UPC.

0 12345 67890 5

UPC is made up of bars and spaces the same as EAN. There are several variations of UPC, but *i*RVision supports only UPC-A. UPC-E is not supported. UPC can encode a 12-digit number.

7.29 2-D BARCODE TOOL

The 2-D barcode tool finds 2-D barcode in an image and reads the string contained in the 2-D barcode. The tool is available only with the reader vision process. If you select the 2-D barcode tool in the tree view of the setup page for the vision process, a screen like the one shown below appears.



The following 2-D barcode are supported.

- Data Matrix Code
- QR Code

7.29.1 Teaching the Search Window

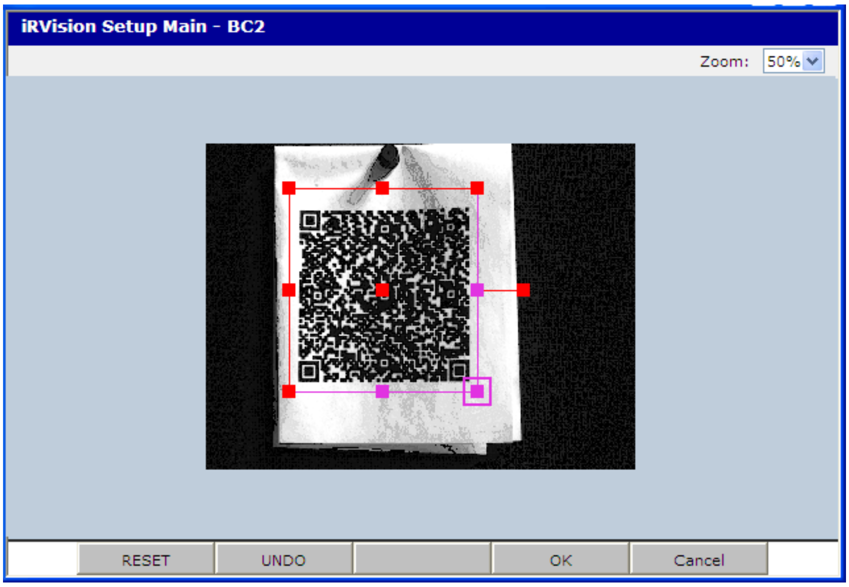
Teach the region for searching 2-D barcode.

Teaching the search window

Teach the search window as follows.

1 Press F2 LIVE to change to the live image display.
2 Place a 2-D barcode near the center of the camera view.
3 Press F2 STOP and the press F3 SNAP to snap the image of the 2-D barcode.
4 Tap the [Set] button.
5 Enclose the 2-D barcode within the purple rectangle that appears, and press F4 OK. Data Matrix Code requires at least a 1 cell wide white blank around the entire barcode, and QR Code requires a 2 cell wide white blank around the entire barcode.

For detailed information about the operation method, see Subsection 3.7.9, “Setting Window”



7.29.2 Setting the Parameters

Set the barcode parameters.

Input Image

Select the image which is used for training search area and detection 2-D Barcode. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this 2-D Barcode Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

Model ID

Specify the model ID of the found 2-D barcode.

Search Window

Specify the area of the image to be searched.
If you want to change the search window, tap the [Set] button.

Barcode Type

The types of 2-D barcodes supported by the 2-D barcode tool. Select one of the following:

- Data Matrix Code
- QR Code

Refer to “7.29.5 Terminologies” for more information.

Threshold Mode

The threshold value to binarize the image. This can be selected when "Barcode Type" is “Data Matrix Code”. Select one of the followings:

Fixed

The binary threshold is set to the specified threshold set in “Threshold Value”.

Auto

The binary threshold is automatically adjusted according to the brightness of the image.

Threshold Value

Set the threshold by entering a value or by tapping , , , and buttons.
This can be selected when "Barcode Type" is “Data Matrix Code”.

Contrast Threshold

Set the contrast threshold by entering the value or by tapping , , , and buttons. This can be selected when "Barcode Type" is “QR Code”.

Image Display mode

Select the image display mode for the Setup Page.

Original Image

Display the camera image as it is.

Processed Image

Display the image resulting from the image processing.

Binary Image

Display the processed image in binary using the current threshold. This can select when “Barcode Type” is “Data Matrix Code”.

Image + Edge

Display the processed image with the edges found above the current contrast threshold plotted in green. This can be selected when "Barcode Type" is “QR Code”.

Image Preprocessing Filter

Select the filter to be applied to the image from the options listed below.

None

Do not perform Image processing filter.

Blur
Enable this filter to eliminate fine surface texture or image noise that may make it difficult to read the 2-D barcode.

Median
Enable this filter to eliminate fine surface texture or image noise that may make it difficult to read the 2-D barcode, but without blurring the edges.

Sharpening
Enable this filter to enhance the contrast of the edges to make it easier to read the 2-D barcode.,

Morphology
Enable this filter to perform morphology operations on the image to enable it to read the 2-D barcode. The operation is selected on the drop down list of "Morphology Operator".

Morphology Operator
Select the filter to be applied to the binarized image from the options listed below.

Erode
Erodes the black area. Helps reduce the black pixel noise.

Dilate
Dilates the black area. Helps reduce the white pixel noise.

Open
Erodes the black area and then dilates it. This will connect white blobs that are close to touching or disconnect black blobs that are slightly touching,

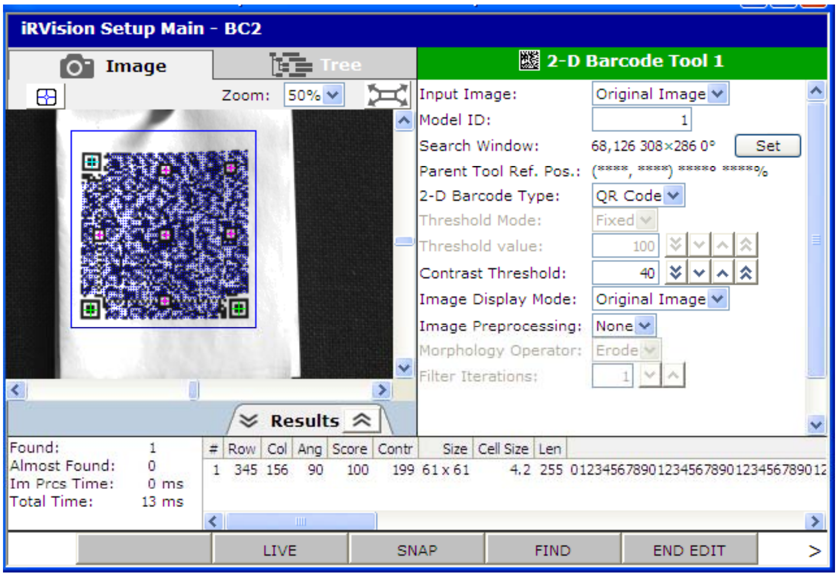
Close
Dilates the white area then erodes it. This will connect black blobs that are close to touching or disconnect white blobs that are slightly touching.

Filter Iteration
The number of iterations to perform on the selected filter.

Grayscale Histogram
It displays the grayscale histogram when "Barcode Type" is “Data Matrix Code”. It also displays a vertical green line to indicate the binary threshold.

7.29.3 Running a Test

Press F4 SNAP to run a test and see if the barcode was properly found.



Found

If the result is successfully obtained, 1 is displayed. If the tool fails to find the 2-D barcode, 0 is displayed.

Almost Found

If the 2-D barcode is located but not decoded correctly, 1 is displayed. Otherwise 0 is displayed.

Im Prcs Time

The time it took to perform the image processing.

Total Time

The total time it took to read the 2-D barcode, not including the time it took to snap the image.

Found Result Table

The following values are displayed in black if the number found is 1 and in red if the number almost found is 1. The following values are displayed.

Row, Column

The found position of the found code in the image in pixels. It is the coordinates of the pixel at the "L" corner of the Data Matrix code when "Barcode Type" is Data Matrix Code. It is the coordinates of the pixel at the center of top-left Position Detection Pattern when "Barcode Type" is "QR Code".

Ang

The found angle of the barcode in degrees.

Score

The relative number of bit errors that were corrected when reading the code. 100% indicates that there were no bit errors. A value of 80% indicates that some number of bit values were corrected equal to about 20% of the error-correcting capacity of this particular 2-D barcode. The error-correcting capacity varies from 14% to 28% for Data Matrix Code and from 7% to 30% for QR Code. If the score reaches 0%, the code cannot be read.

Contr

The average contrast between dark cells and light cells.

Size

The size of the found 2-D barcode in terms of the number of cells of width and height.

Cell Size

The average width and height of the individual cells in pixels. If this value is below about 2.5, the code may be found less reliably.

Len

The length of the decoded string.

String Result

The first 254 characters of the decoded string.

7.29.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

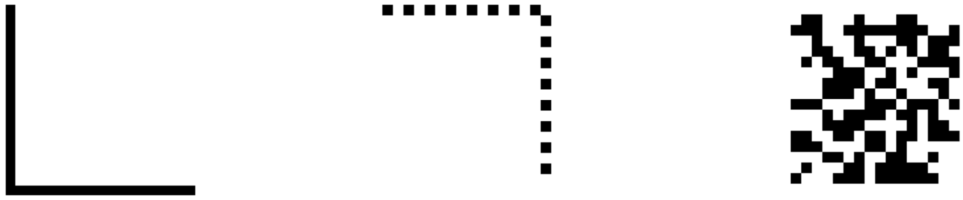
7.29.5 Terminologies

This section explains terminologies of 2-D barcode tool.

Data Matrix Code

Data Matrix Code is the 2-D barcode which is also called Data Code or Data Matrix. Data Matrix Code is used in the production of LCD, semiconductor wafer and so on. Data Matrix Code is capable of encoding up to 3116 digits, 2335 alphanumeric characters, or 1555 bytes. The 2-D barcode tool only sends the first 254 characters of the string to a string register. The following figure shows an example of Data Matrix Code.

Data Matrix Code is made up of Alignment Pattern, Timing Cell and Data Region. Each square that makes up Data Region is referred to as Cell.



Alignment Pattern Timing Cell Data Region

There are two types of Data Matrix Code: ECC 200 and the older ECC 000-140. The 2-D barcode tool only decodes ECC 200.

The 2-D barcode tool does not support the following encoding methods:

- EDIFACT
- ANSI X12

The 2-D barcode tool requires that the cell width and height be at least 2.5 pixels in order to decode reliably. The specification of Data Matrix Code requires a 1 cell wide white border around the entire code. The following table shows how big various sizes of Data Matrix Code have to be relative to the 640x480 *i*RVision image to be found reliably.

For example, the 36x16 Data Matrix Code shown in the example image would require minimum pixel dimensions of 95x45 to be found reliably.

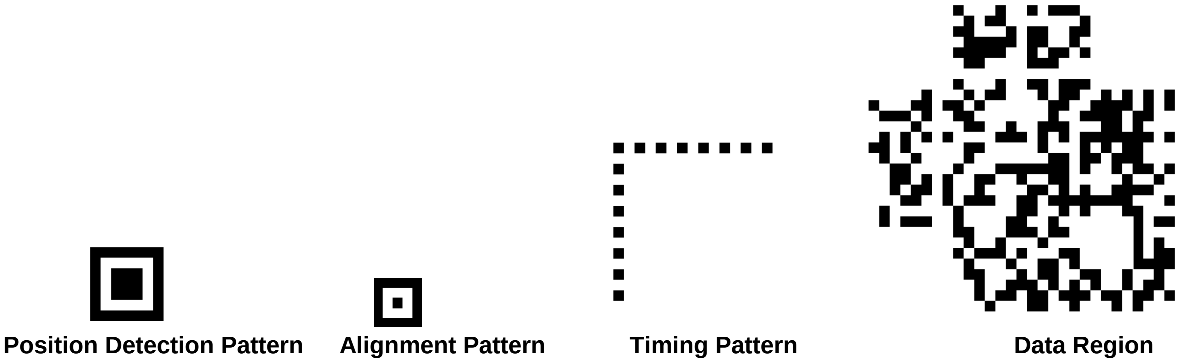
Data Matrix Code size (unit: the number of cell)		The Maximum number of characters	The minimum size of Data Matrix Code (unit: pixel)	
Row	Col		Width	Height
10	10	6	30	30
12	12	10	35	35
14	14	16	40	40
16	16	24	45	45
18	18	36	50	50
20	20	44	55	55
22	22	60	60	60
24	24	72	65	65
26	26	88	70	70
32	32	124	85	85
36	36	172	95	95
40	40	228	105	105
44	44	288	115	115
48	48	348	125	125
52	52	408	135	135
64	64	560	165	165
72	72	736	185	185
80	80	912	205	205
88	88	1152	225	225
96	96	1392	245	245
104	104	1632	265	265
120	120	2100	305	305
132	132	2608	335	335
144	144	3116	365	365

Data Matrix Code size (unit: the number of cell)		The Maximum number of characters	The minimum size of Data Matrix Code (unit: pixel)	
Row	Col		Width	Height
18	8	10	50	25
32	8	20	85	25
26	12	32	70	35
36	12	44	95	35
36	16	64	95	45
48	16	98	125	45

QR Code

QR Code is used on automobile parts, stationary and so on. QR Code is capable of encoding up to 7089 digits, 4296 alphanumeric characters, 2953 bytes of characters, or 1817 Kanji characters. The 2-D barcode tool only sends the first 254 characters of the string to a string register. The following figure shows an example of QR Code.

QR Code is made up of Position Detection Pattern, Alignment Pattern, Timing Pattern and Data Region. Each square that makes up Data Region is referred to as Cell.



There are several types of QR Code: QR Code Model 1, QR Code Model 2, Micro QR Code, and so on. The 2-D barcode tool supports QR Code Model 2 and Micro QR Code.

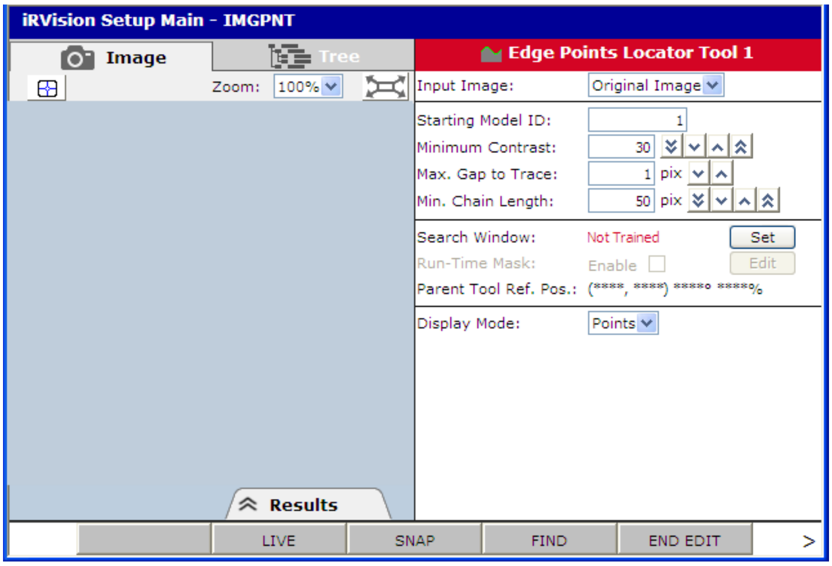
The 2-D barcode tool requires that the cell width and height be at least 2.5 pixels in order to decode reliably. The specification of QR Code requires a 2 cell wide white border around the entire code. The following table shows how big various sizes of QR Code have to be relative to the 640x480 *i*RVision image to be found reliably.

For example, the 29x29 QR Code shown in the example image would require minimum pixel dimensions of 83x83 to be found reliably.

Data Matrix Code size (unit: the number of cell)		The version of QR code (M* is micro QR code)	The minimum size of Data Matrix Code (unit: pixel)	
Row	Col		Row	Col
11	11	M1	38	38
13	13	M2	43	43
15	15	M3	48	48
17	17	M4	53	53
21	21	1	63	63
25	25	2	73	73
29	29	3	83	83
33	33	4	93	93
37	37	5	103	103
41	41	6	113	113
45	45	7	123	123
49	49	8	133	133
53	53	9	143	143
57	57	10	153	153
61	61	11	163	163
65	65	12	173	173
69	69	13	183	183
73	73	14	193	193
77	77	15	203	203
81	81	16	213	213
85	85	17	223	223
89	89	18	233	233
93	93	19	243	243
97	97	20	253	253
101	101	21	263	263
105	105	22	273	273
109	109	23	283	283
113	113	24	293	293
117	117	25	303	303
121	121	26	313	313
125	125	27	323	323
129	129	28	333	333
133	133	29	343	343
137	137	30	353	353
141	141	31	363	363
145	145	32	373	373
149	149	33	383	383
153	153	34	393	393
157	157	35	403	403
161	161	36	413	413
165	165	37	423	423
169	169	38	433	433
173	173	39	443	443
177	177	40	453	453

7.30 EDGE POINTS LOCATOR TOOL

This locator tool extracts all the points on the outline of a workpiece.



7.30.1 Adjusting the Parameters

Adjust the parameters.

Input Image

Select the image which is used for training area and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Edge Point Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

Starting Model ID

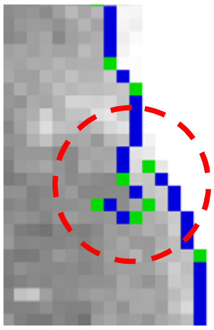
Specify the head of the model IDs that are assigned to found chains in order.

Minimum Contrast

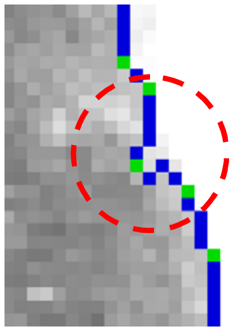
Specify the minimum permissible grayscale contrast for the search. If you set a small value, this locator tool will be able to find the chains in obscure images as well but take longer to complete the location process. If this locator tool tends to inadequately find blemishes and other unwanted edges with low contrast, try setting a larger value. Those image features whose contrast is lower than the specified value are ignored.

Max. Gap to Trace

Specify the maximum permissible size of gaps to fill when tracing a chain, in pixels. If the size of the gap between two chains is smaller than the specified value before filtering, this locator tool connects the chains by filtering. When chains get disconnected because of blemishes, this locator tool can connect the chains smoothly by making the specified value larger.



Maximum Gap to Trace: 1



Maximum Gap to Trace:2

Min. Edge Chain Length

Specify the minimum permissible length required for chains to be found, in pixels. If the length of a chain is shorter than the specified value, the chain is ignored.

Search Window

Specify the area of the image to be searched. The smaller the area is, the faster the location process will be. To change the search window, tap the [Set] button. When a rectangle appears on the image, adjust its size and location.
If this locator tool is a child tool of another location tool, the search window will automatically move and rotate in accordance with the found result from the parent tool.

Run-Time Mask

Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle- or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button.

Display Mode

Choose whether to display points or chains.

Points

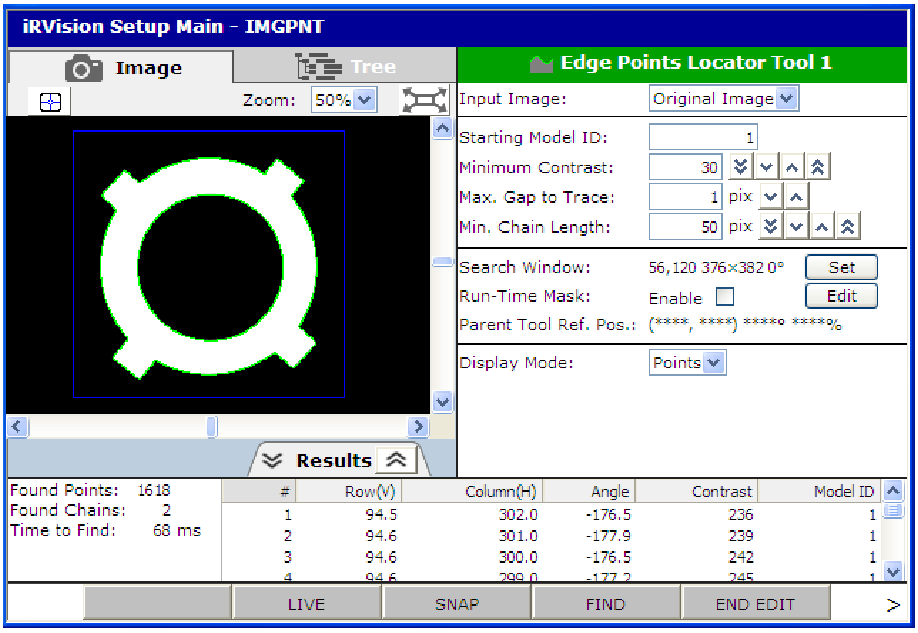
Extracted points are displayed.

Chains

Found chains are displayed.

7.30.2 Running a Test

Press F4 to run a test and see how properly the tool can find chains and extract points.



Found Points
The total number of points extracted from found chains is displayed. These points are returned to the vision process.

Found Chains
The number of found chains is displayed.

Time to Find
The time the location process took is displayed in milliseconds.

Found Result Table (When Display Mode is Points)
The following values are displayed.

Row(V), Column(H)
The coordinate values of the extracted point (unit: pixels).

Angle
The orientation of the edge gradient vector at the extracted point (unit: degrees). The vector points from the bright side to the dark side.

Contrast
The grayscale magnitude of the edge contrast at the extracted point.

Model ID
The Model ID assigned to the found chain that contains the extracted point.

Found Result Table (When Display Mode is Chains)
The following values are displayed.

Length

The number of points extracted from the found chain (unit: pixel).

Avg. Contrast.

The average grayscale contrast of the points extracted from the found chain.

Model ID

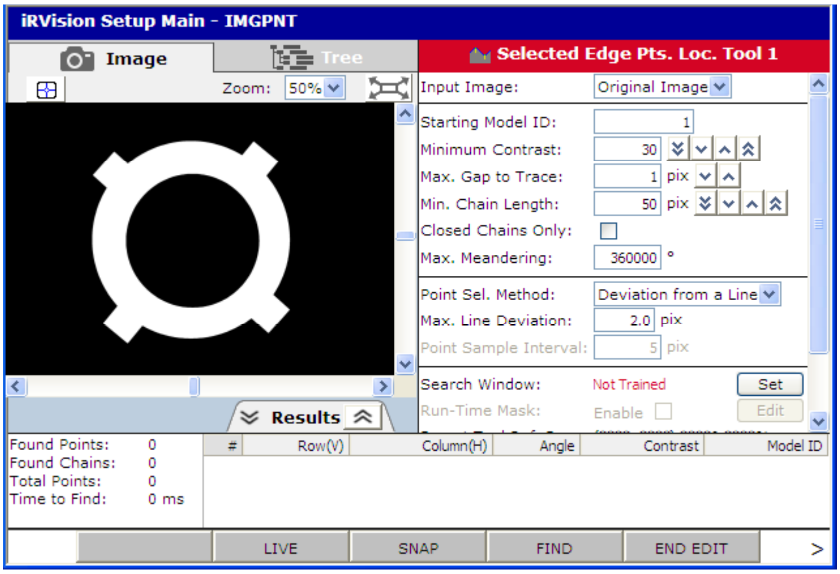
The Model ID assigned to the found chain.

7.30.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

7.31 SELECTED EDGE POINTS LOCATOR TOOL

This locator tool extracts the selected points on the outline of a workpiece by filtering.



7.31.1 Adjusting the Parameters

Adjust the parameters.

Input Image

Select the image which is used for training area and detection. When the vision process has a Image Filter Tool or a Color Extraction Tool, you can select a filtered image as the input image to this Selected Edge Point Locator Tool, instead of the camera snapped original image. For details, please refer to Subsection 7.25 "Image Preprocess Tool", 7.26 "Image Filter Tool", and 7.27 "Color Extraction Tool".

Starting Model ID

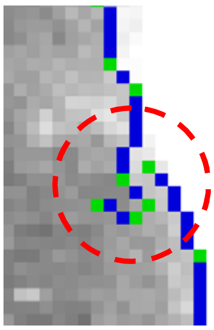
Specify the head of the model IDs that are assigned to found chains in order.

Minimum Contrast

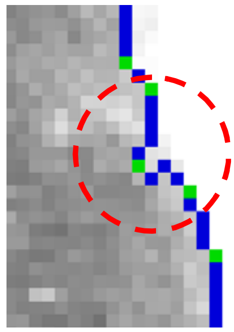
Specify the minimum permissible grayscale contrast for the search. If you set a small value, this locator tool will be able to find the chains in obscure images as well but take longer to complete the location process. If this locator tool tends to inadequately find blemishes and other unwanted edges with low contrast, try setting a larger value. Those image features whose contrast is lower than the specified value are ignored.

Max. Gap to Trace

Specify the maximum permissible size of gaps to fill when tracing a chain, in pixels. If the size of the gap between two chains is smaller than the specified value before filtering, this locator tool connects the chains by filtering. When chains get disconnected because of blemishes, this locator tool can connect the chains smoothly by making the specified value larger.



Maximum Gap to Trace: 1



Maximum Gap to Trace:2

Min. Edge Chain Length

Specify the minimum permissible length required for chains to be found, in pixels. If the length of a chain is shorter than the specified value, the chain is ignored.

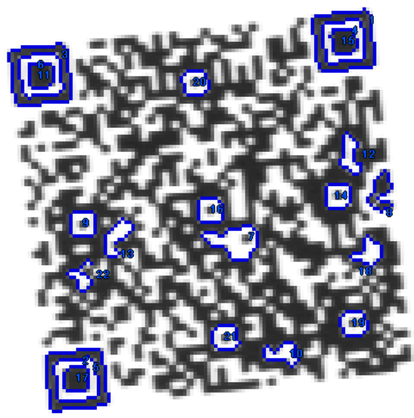
Closed Loops Only

If checked, only find chains that form closed loops.

Maximum Meandering

Specify the maximum allowed meandering in degrees. A meandering is the amount that a chain changes direction. If the meandering of a chain is larger than the specified value, the chain is ignored. For example, an "S" shape will have a meandering value of about 360 degrees, since it turns 180 degrees to the left and then 180 degrees to the right. The more meandering and longer a chain is, the larger this value is. On the other hand, a perfect straight line will have a meandering value of 0 since it does not change direction.

Maximum Meandering: 9000
Found Chains: 42



Maximum Meandering: 90
Found Chains: 22

Point Sel. Method

Choose the method used to select points from found chains.

Deviation from a Line

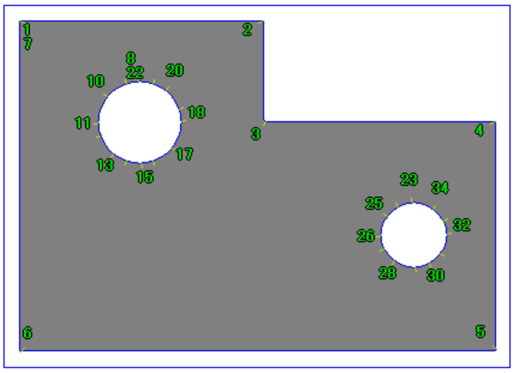
Each chain is approximated by a polygonal line whose vertices are on the chain. And the vertices are selected points. The polygonal line is chosen so that the maximum of distances from each straight segment of the polygonal line to the farthest point on the chain's curved segment corresponding to the straight segment is less than the value specified for "Max. Deviation From a Line". This results in fewer points along straighter sections of the chain and more points along sharply curved sections.

Equal Length Segments

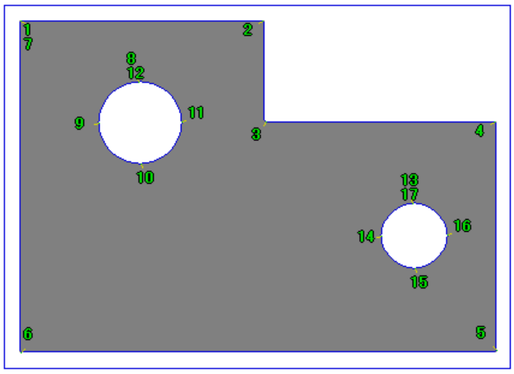
The points in each chain are sampled at an interval specified as the value of "Point Sample Interval".

Max. Line Deviation

Specify the permissible maximum of distances from each straight segment of polygonal lines to the farthest point on chains' curved segment corresponding to the straight segment when "Deviation from a Straight Line" is selected as "Point Selection Method". It is specified in pixels. Specify 0.0 to select every point on the chains.



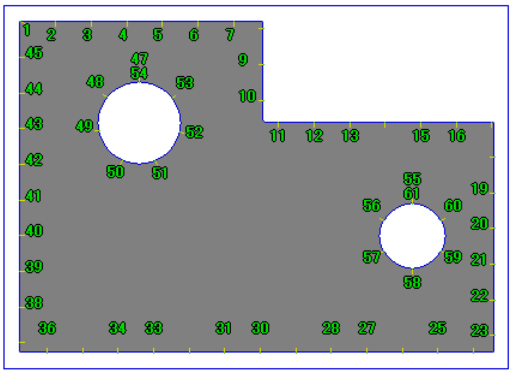
Max. Deviation From a Line: 2.0
Found Points: 35/1682



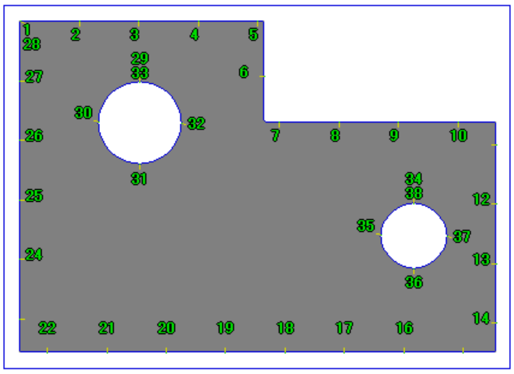
Max. Deviation From a Line: 10.0
Found Points: 17/1682

Point Sample Interval

Specify the interval for selecting points from chains when "Equal Length Segments" is selected "Point Selection Method". It is specified in pixels. Specify 1 to select every point on the chains.



Point Sample Interval: 30
Found Points: 61/1682



Point Sample Interval: 50
Found Points: 38/1682

Search Window

Specify the area of the image to be searched. The smaller the area is, the faster the location process will be. To change the search window, tap the [Set] button. When a rectangle appears on the image, adjust its size and location. If this locator tool is a child tool of another location tool, the search window will automatically move and rotate in accordance with the found result from the parent tool.

Run-Time Mask

Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle- or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button.

Display Mode

Choose whether to display points or chains.

Points

Selected points are displayed.

Chains

Found chains are displayed.

Result Plotting Mode

This setting controls how found chains and selected edge points are plotted when the found results pane is in points display mode. Select one of the following plotting modes.

Plot Edge Points Only

The found chains are plotted in blue and the selected points are plotted in green.

Plot Direction Vectors

The found chains are plotted in blue. The selected points are plotted in green. The direction vectors s are plotted in yellow. Each direction vector corresponds to a selected point and points from the selected point towards the dark side of the edge at that point.

Plot Labels

The found chains are plotted in blue. The selected points and their index numbers are plotted in green. The index numbers are also displayed in the Found Result Table. Some of the index numbers are not plotted if the selected points are too close together.

Index number

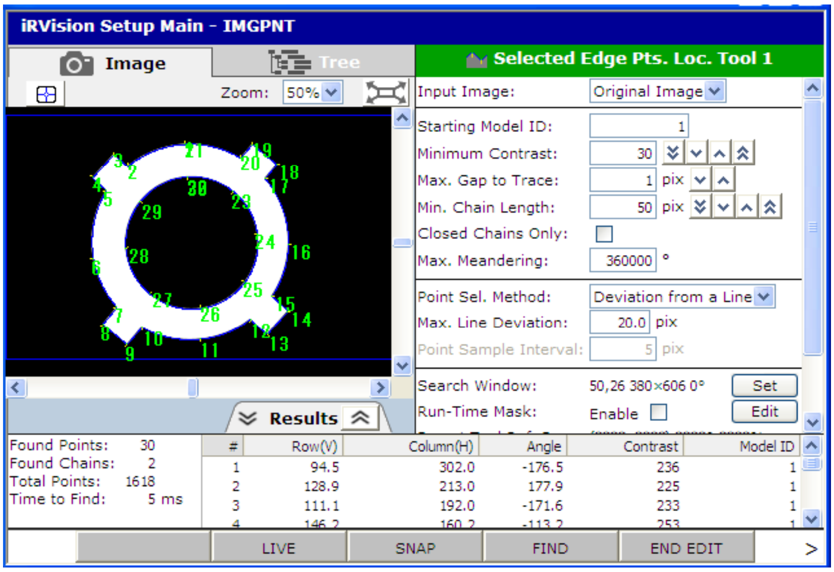
	Row	Column	Angle	Contrast	Model ID
1	370.8	198.0	-2.1	89	1
2	375.6	323.0	-1.4	171	1
3	374.6	351.0	13.4	133	1
4	367.7	375.7	22.5	108	1
5	360.7	389.7	30.2	91	1
6	353.7	399.7	29.5	74	1
7	338.8	414.8	53.4	89	1
8	318.7	426.7	70.3	94	1
9	291.0	434.8	78.0	120	1

Plot Vectors and Labels

The found chains are plotted in blue. The selected points and their index numbers are plotted in green. The direction vectors corresponding to the selected points are plotted in yellow, in green.

7.31.2 Running a Test

Press F4 SNAP to run a test and see how properly the tool can find chains and select points.



Found Points

The total number of the points selected from found chains is displayed. These points are returned to the vision process.

Found Chains

The number of found chains is displayed.

Total Points

The total number of all the points extracted (but not selected) from found chains.

Time to Find

The time the location process took is displayed in milliseconds.

Found Result Table (When Display Mode is Points)

The following values are displayed.

Row(V), Column(H)

The coordinate values of the selected point (unit: pixels).

Angle

The orientation of the edge gradient vector at the selected point (unit: degrees). The vector points from the bright side to the dark side.

Contrast

The grayscale magnitude of the edge contrast at the selected point.

Model ID

The Model ID assigned to the found chain that contains the selected point.

Found Result Table (When Display Mode is Chains)

The following values are displayed.

Length

The number of points extracted from the found chain (unit: pixel).

Avg. Contrast.

The average grayscale contrast of the points extracted from the found chain.

Closed.

Whether the chain is a closed loop or not. If the chain is a closed loop, [Yes] is displayed. If the chain is not a closed loop, [No] is displayed.

Meandering

The meandering value of the edge chain.

Model ID

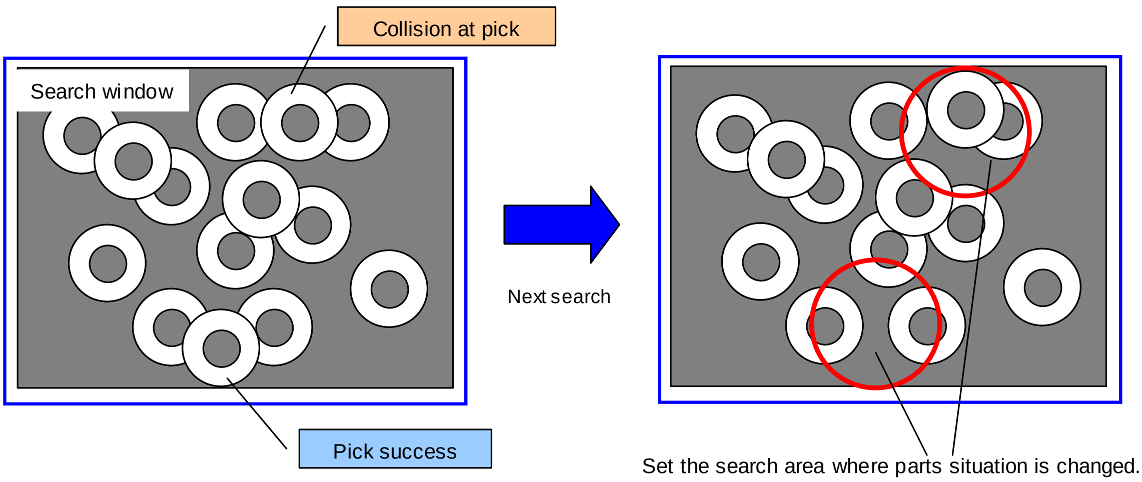
The Model ID assigned to the found chain.

7.31.3 Overridable Parameters

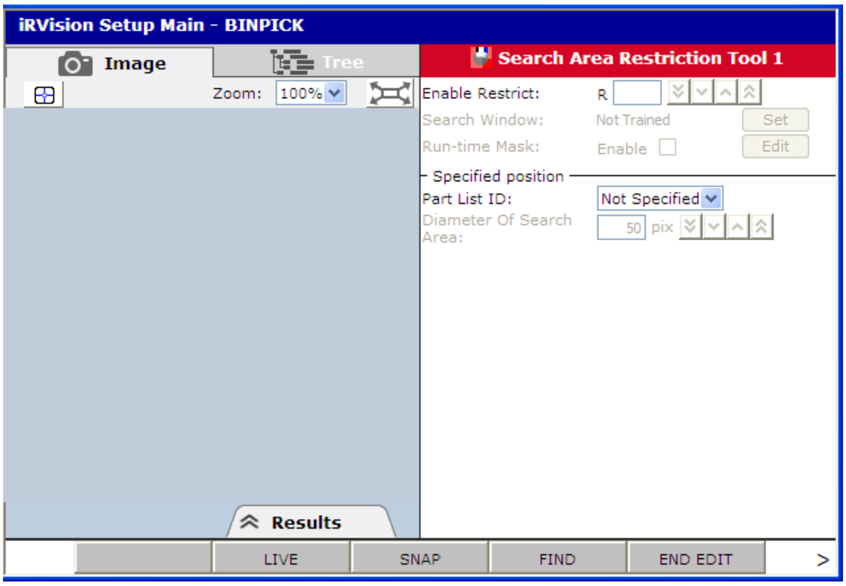
This command tool has no overridable parameters that can be overridden with Vision Override.

7.32 SEARCH AREA RESTRICTION TOOL

The search area restriction tool enables a search vision process for bin picking to process only small limited areas of the input image where states of plies of workpieces have just been changed. By processing only the small areas, the processing time can be reduced. The search area restriction tool is used with the workpiece management function that is included in the *i*RVision Bin Picking option.



If you select the search area restriction tool in the tree view of the setup page of the vision process, a screen like the one shown below appears.



7.32.1 Setting the Parameters

Set the parameters.

Enable Restrict

Specify the index number of the register you want to use to change the following two modes.

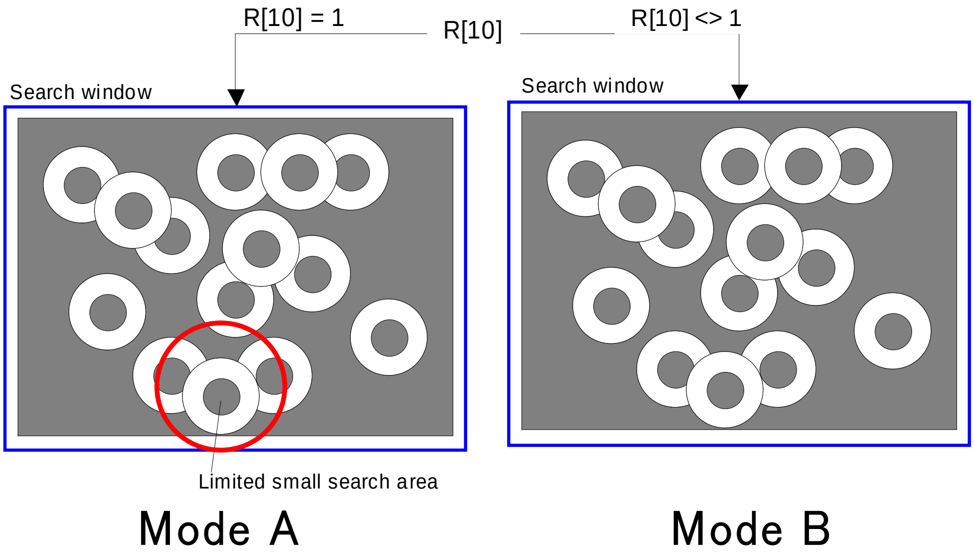
Mode A

The vision process finds workpieces in the small search areas where the situations of piles of workpieces have just been changed in the last cycle.

Mode B

The vision process finds workpieces in a fixed wide search window on the image that corresponds to the bin area.

To change the above two modes, the value of the register specified in [Enable Restrict] must be changed. If the specified register is set to 1, Mode A is selected. If the specified register is set to a value other than 1, Mode B is selected.



Search Window
Specify the range of the area of the image to be searched. The default value is the entire image. To change the search window, tap the [Set] button. When a rectangle appears on the image, change the search window. For detailed information about the operation method, see Subsection 3.7.9, “Window Setup”.

Run-Time Mask
Specify an area of the search window that you do not want processed, as an arbitrary geometry. Use this function when you want to specify a search window of an arbitrary geometry, such as a circle or donut-shaped window. The filled area will be masked in the rectangle specified as the search window and will not be subject to the image processing. To change the run-time mask, tap the [Edit] button. For detailed information about the operation method, see Subsection 3.7.10, “Editing Masks”.

Parts List ID
Specify a parts list ID to use.

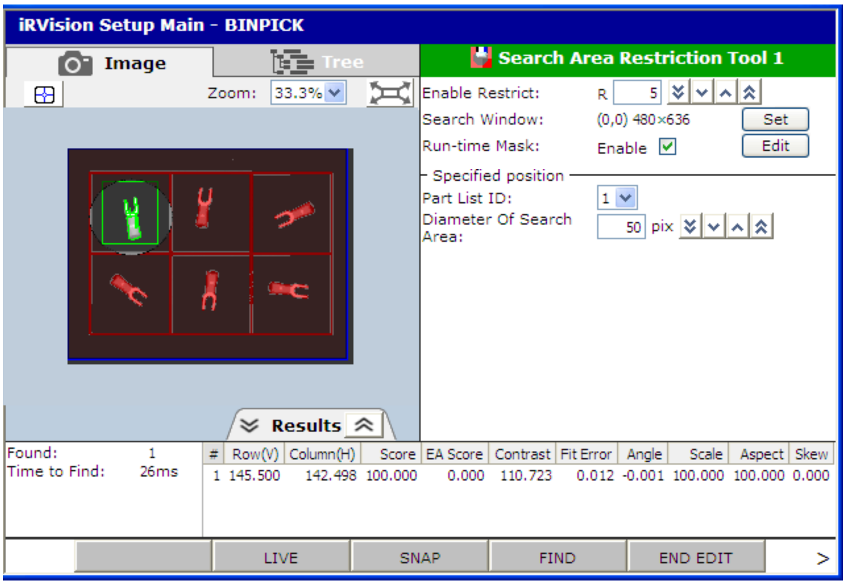
Diameter Of Search Area
Specify the size of limited search area set at a poison where states of piles of workpieces have been changed.

7.32.2 Setting a Position where State of Plies of Workpieces has been Changed

When to set a position where the states of piles of workpieces is the time of executing IVSETTARPOS.PC. For this KAREL programs, please refer to “R-30*i*B CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL”.

7.32.3 Running a Test

Press F4 to run a test and see if the tool can find workpieces properly.



Found

The number of found workpieces is displayed.

Time to Find

The time the location process took is displayed in milliseconds.

Found Results table

The items displayed differ depending on the tools set as child tools of the search area restriction tool. For the explanation of each measured value, see the pages describing the set child tools.

7.32.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

8 APPLICATION DATA

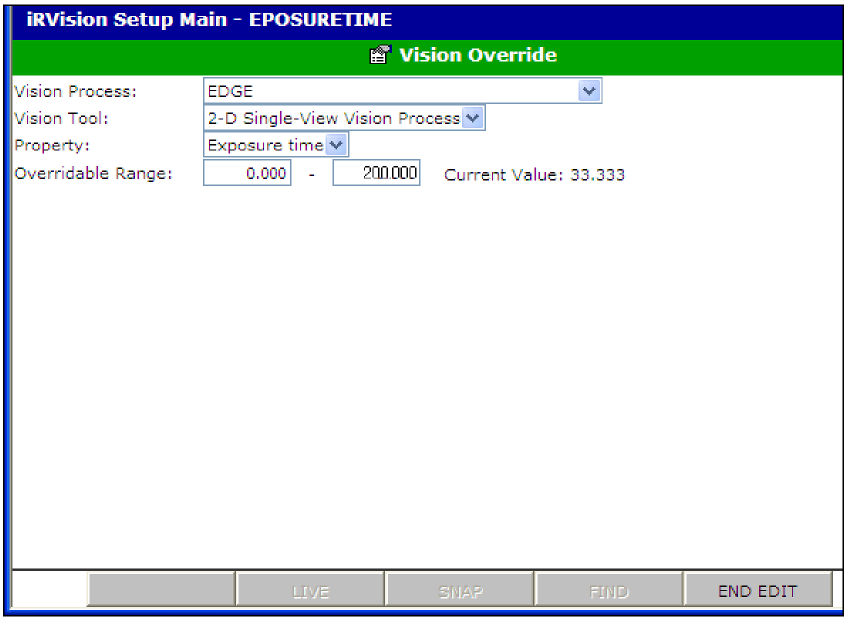
This chapter describes how to set application data.

8.1 VISION OVERRIDE

Vision override is a function that allows you to change a vision process property from a robot program on a temporary basis. By using the vision override function, for example, you can retry a vision process with an exposure time that is different from that originally taught in that vision process.

Each vision override needs to be associated in advance with a specific property of a vision process. For example, when you create a vision override called "EXPO1", you may associate "EXPO1" with the property "Exposure Time" for the vision tool "Camera View 1" of the vision process "FIND1". This is tantamount to assigning a short alias "EXPO1" to the "Exposure Time of Camera View 1 of FIND1". Defining a vision override enables you to temporarily change the associated property from a robot program by using the VISION OVERRIDE instruction. For information about the VISION OVERRIDE instruction, see Subsection 9.2.2, "Vision Execution Commands".

When the window for vision override is opened, the following screen is displayed.



Associate the vision override with a specific vision process property.

Vision Process

Select a vision process to be associated.

Vision Tool

Select the name of the vision tool to be associated (a name displayed in the tree view of the vision process setup page).

Property

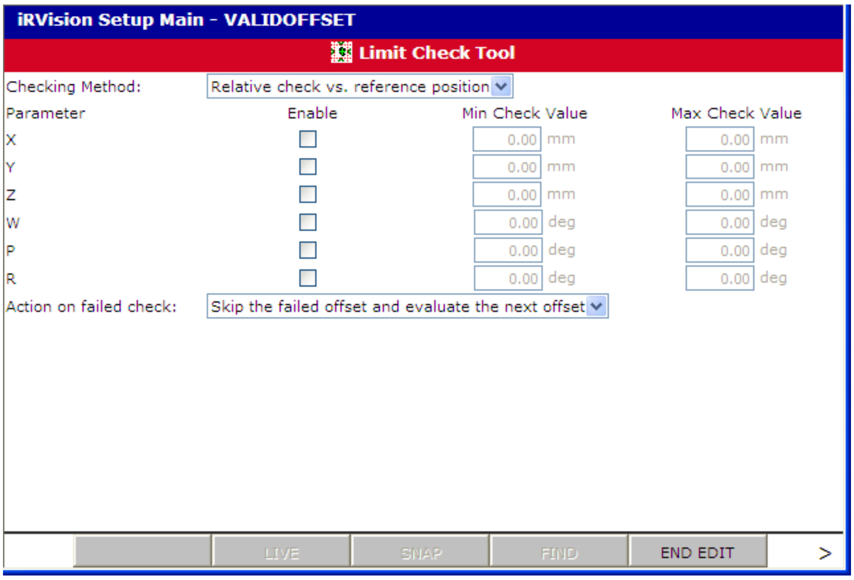
Select a property to be associated.

Overridable Range

Display maximum value, minimum value, and current value.

8.2 OFFSET LIMIT

Offset limit is a function that checks whether the offset found by a vision process is within a specified range. If the check finds the offset is within the range, the tool does nothing. If the offset is found to be outside the range, the tool takes a specified action. The offset limit setup screen lets you define the conditions to be checked and the action to be taken if the offset is found to be outside the range. To actually perform the offset limit check, select which offset limit tool to use in the vision process setup page. The offset limit check is performed when the robot program executes the GET_OFFSET instruction. When the window for offset limit is opened, the following screen is displayed.



Checking Method

Select the offset limit checking method from the following:

Relative check vs. reference position

A check is made to see whether the found position is within a range specified by relative positions from the reference position.

Absolute check in the application user frame

A check is made to see whether the found position is within a range specified by coordinates of the application user frame.

Parameter

Specify which element (X, Y, Z, W, P, or R) of the found position is to be checked, as well as the allowable range. Check the check box of the element to be checked, and enter the allowable minimum and maximum values. If [Relative check vs. reference position] is selected for [Checking Method], enter the difference from the reference position. If [Absolute check in the application user frame] is selected for [Checking Method], enter the coordinates of the application user frame.

Action on failed check

The offset limit check is performed when the GET_OFFSET instruction is executed. Here, select the action to be taken if the offset limit check fails, from the following:

Cause the GET_OFFSET instruction to fail

If the offset limit check fails, the robot program jumps to the label specified by the GET_OFFSET instruction; that is, the robot program behaves in the same way as when the offset fails to be found.

Skip the failed offset and evaluate the next offset

If the offset limit check fails, the GET_OFFSET instruction skips this found result and attempts to obtain the next one. In this case, the number of found results that the robot program can obtain decreases by one.

Raise robot alarm and pause program execution

If the offset limit check fails, the robot program pauses on the line of the GET_OFFSET instruction. This stops the production operation and should not be specified under normal circumstances.

9 STARTING FROM A ROBOT PROGRAM

This chapter describes how to start *i*RVision from a robot program.

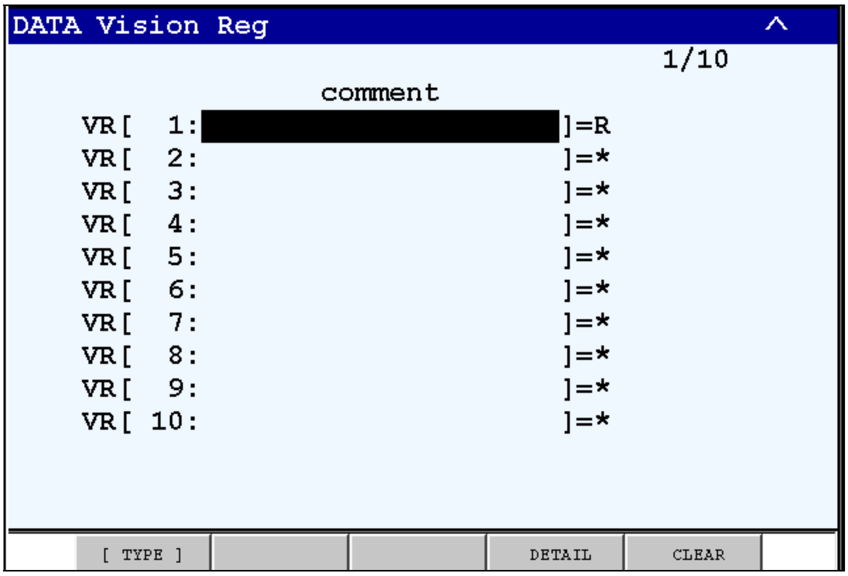
9.1 VISION REGISTERS

The robot controller has special registers for storing *i*RVision found results. These registers are called *vision registers*. Each vision register contains data for one found workpiece. The vision register contents can be checked on the teach pendant of the robot.

9.1.1 Vision Register List Screen

Perform the following steps to display the vision register list screen.

1. Press DATA on the teach pendant.
2. Press F1 [TYPE].
3. Select [Vision Reg]. The following screen is then displayed:



The rightmost character "R" indicates that a value is set.

Entering a comment

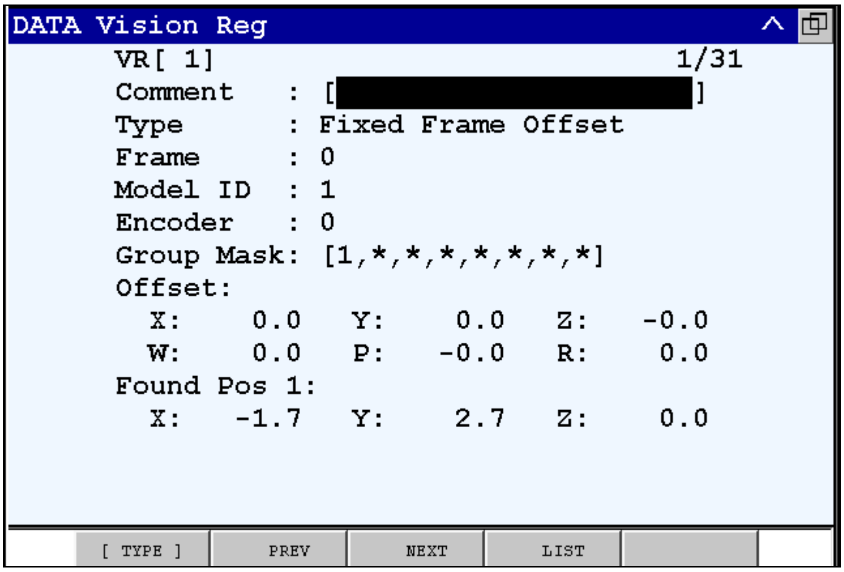
1. Move the cursor to the line of a vision register for which a comment is to be entered.
2. Press the Enter key.
3. Press an appropriate function key to enter the comment.
4. After completing the entry of the comment, press ENTER.

Erasing a value

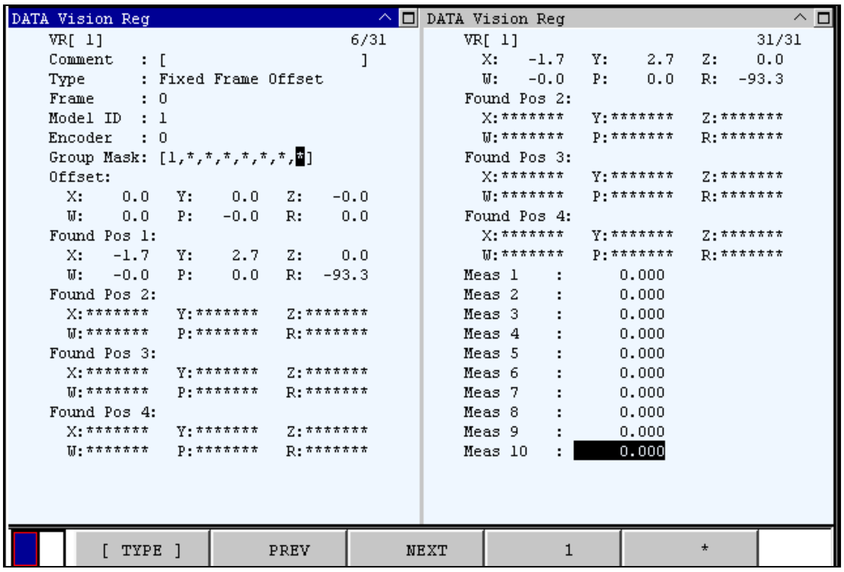
1. Move the cursor to the line of a vision register of which contents are to be erased.
2. While holding down the SHIFT key, press F5 CLEAR.

9.1.2 Detail Screen of a Vision Register

On the list screen of vision registers, move the cursor to the line of the vision register of which contents are to be checked, then press F4 DETAIL.



To show the whole detail screen of vision register, select "Double" display.



> ⚠ **CAUTION**
> Basically, this screen is designed for reference although values can be entered on this screen. Entering an inappropriate value can cause an unpredictable robot motion.

Type
Type of offset data stored in the vision register.

Fixed Frame Offset
Fixed frame offset data

Tool Offset
Tool offset data

Found Position
Actual found position, which is not offset data. This item remains to provide compatibility with the old software edition.

Found Position (TOOL)
Actual found position, which is not offset data. This item remains to provide compatibility with the old software edition.

Frame
Frame number for offset data. If [Type] is [Fixed Frame Offset] or [Found Position], it is the user frame number. If [Type] is [Tool Offset] or [Found Position (TOOL)], it is the user tool number.

Model ID
Model ID of the found workpiece.

Encoder
Count of the encoder that triggers visual tracking for a found workpiece. This item is not used for purposes other than visual tracking.

Group Mask
Group mask of offset data.

Offset
Offset data represented in the XYZWPR format.

Found Pos
Actual position of each camera view.

Meas
Measurement value of a tool such as a histogram.

F2 PREV
Displays the detail screen of the previous vision register.

F3 NEXT
Displays the detail screen of the next vision register.

F4 LIST
Brings you back to the vision register list screen.

9.2 PROGRAM COMMANDS

Program commands for *i*RVision are provided.

9.2.1 Vision Offset

This command offsets the robot position by using offset data stored in a vision register.

9.2.1.1 VOFFSET

VOFFSET is an optional operation command that is added to a robot motion statement. This command moves the robot to a position compensated with a vision offset data in a specified vision register.

If the type of offset data stored in the specified vision register is [Fixed Frame Offset], a fixed frame offset is applied. If the type is [Tool Offset], a tool offset is applied. Position offset is performed properly based on the coordinate system in which *i*RVision calculated the offset data, regardless of the currently selected user frame/user tool and the user frame/user tool of the position data of the motion statement.

> ⚠ **CAUTION**
> VOFFSET command does not support Dynamic UFrame. When you want to use the vision offset with Dynamic UFrame, copy the vision offset data to a position register by "9.2.3.5 Offset data command" and use OFFSET command. For details of Dynamic UFrame, please refer to the "Coordinated Motion Function OPERATOR'S MANUAL".

There are two types of syntax:

VOFFSET,VR

This command directly specifies a vision register in-line.

```
L P[1] 500mm/sec FINE VOFFSET,VR[a]
```

VOFFSET

This command uses a vision register specified with VOFFSET CONDITION command. See also 9.2.1.2 "VOFFSET CONDITION".

```
L P[1] 500mm/sec FINE VOFFSET
```

9.2.1.2 VOFFSET CONDITION

This command selects a vision register that is used with VOFFSET command. The vision offset condition must be specified before VOFFSET command is used. The specified vision offset condition is effective until the program is aborted or another vision offset condition is specified.

```
VOFFSET CONDITION VR[a]
```

9.2.1.3 LOCK VREG

This command locks vision registers.

```
LOCK VREG
```

While the robot is executing a program, it reads the lines ahead of the line currently being executed. It is called "look-ahead execution". Look-ahead execution is performed for motion statements, but it cannot be performed for motion statements that use vision registers or any other variable (position registers for example). Motion statements using vision registers cannot have the motion planned in advance because the values in the vision registers could change before the cursor reaches the statement.

This command enables look-ahead execution for motion statements that use vision registers to proceed. By means of these instructions, the user can explicitly specify a program portion that use vision registers to perform look ahead. Basically the instruction is making the vision register data a constant value. This is analogous to how the LOCK PREG instruction works.

When the vision registers are locked they can not be updated by vision. (The VISION GET_OFFSET instruction will fail).

9.2.1.4 UNLOCK VREG

This command unlocks vision registers.

```
UNLOCK VREG
```

9.2.2 Vision Execution

These commands instruct *i*RVision to perform processing.

9.2.2.1 RUN_FIND

This command starts a vision process.
When a specified vision process has more than one camera view, location is performed for all camera views.

```
VISION RUN_FIND (vision-process-name)
```

When a vision process has multiple camera views, and location is to be performed for one of these views, add CAMERA_VIEW[] command.

```
VISION RUN_FIND (vision-process-name) CAMERA_VIEW[a]
```

In the execution of a vision location command, when the vision process has snapped an image, the next line of the program is executed, and image processing is performed in the background. This allows vision image processing and another operation such as a robot motion to be performed in parallel.

9.2.2.2 RUN_FIND SR[ ]

This command works like RUN_FIND except the vision process name is stored in a String Register

9.2.2.3 GET_OFFSET

This command gets a vision offset from a vision process and stores it in a specified vision register. This command is used after RUN_FIND. If image processing is not yet completed when GET_OFFSET is executed, it waits for the completion of the image processing.

```
VISION GET_OFFSET (vision-process-name) VR[a] JMP,LBL[b]
```

GET_OFFSET stores the vision offset for a workpiece in a vision register. When the vision process finds more than one workpiece, GET_OFFSET should be called repeatedly.

If no workpiece is detected or no more offset data is available because of repeated execution of GET_OFFSET, it jumps to the specified label.

> **TIP**
> Measurement values specified with the measurement value output tool are written to the vision register together with vision offset data when the GET_OFFSET command is executed.

It is possible for the controller without *i*RVision to get offset data from other controllers. This is generally used when the robots work big workpieces together. You should add the name of the robot before the name of vision process to gain offset data from other controllers.

```
VISION GET_OFFSET CONTROLLER1.VISPRO1 VR[1]
```

In order to get a vision offset from a remote controller, ROS Internet Packet over Ethernet function (RIPE) need to be set up. As for the RIPE function, refer to Section 3.6 “INTER-CONTROLLER COMMUNICATION” and "R-30*i*B Controller Ethernet Function Operator's Manual".

> ⚠ **CAUTION**
> With a vision process that detects multiple small workpieces in one measurement such as the 2-D single view vision process, the offset data obtained by a robot cannot be obtained by another robot. On the other hand, with a vision process that has multiple views (such as the 2-D multi-view vision process) will return the same offset data to multiple robots until another snap updates one of the views.

9.2.2.4 GET_OFFSET SR[ ]

This command works like GET_OFFSET except the vision process name is stored in a String Register

9.2.2.5 GET_PASSFAIL

This command gets the PASS/FAIL result of an inspection or error proofing vision process, then the command stores the result in a specified numeric register.

```
VISION GET_PASSFAIL (vision-process-name) R[a]
```

The following value is set in the numeric register:

Value	Description
0	FAIL
1	PASS
2	Could not be determined

9.2.2.6 GET_PASSFAIL SR[ ]

This command works like GET_PASSFAIL except the vision process name is stored in a String Register.

9.2.2.7 GET_NFOUND

This command gets the number of found results from a vision process and stores it in a specified register. The command is used after the VISION RUN_FIND command. If image processing is not yet completed when GET_NFOUND is executed, the command waits for the completion of the image processing.

VISION GET_NFOUND *(vision-process-name)* R[*a*]

If the vision process has more than one camera view, add the CAMERA_VIEW[] command.

VISION GET_NFOUND *(vision-process-name)* R[*a*] CAMERA_VIEW[*b*]

9.2.2.8 GET_READING

This command gets a result string of a reader vision process, then the command stores the string in a specified string register and also stores the length of the string in a specified numeric register. This command is used after RUN_FIND.

VISION GET_READING *(vision-process-name)* SR[*a*] R[*b*] JMP,LBL[*c*]

If no barcode is found, it jumps to the specified label. If the string that the barcode contains is longer than 254 bytes, the first 254 characters are stored in the specified string register.

9.2.2.9 SET_REFERENCE

This command sets the reference position in a vision process. The command is used after RUN_FIND. The command has the same effect as the [Set Ref. Pos.] button in the setup window for a vision process.

VISION SET_REFERENCE *(vision-process-name)*

If a setup window of a vision process remains open when SET_REFERENCE is executed for the vision process, the reference position cannot be written to the vision process, which results in CVIS-103 “The vision data file is already open for writing” alarm. Close the setup window, then re-execute the command.

When the vision process finds more than one workpiece, the position of the workpiece having the highest score is set as the reference position. It is recommended that only one workpiece be placed within the camera view so that an incorrect position is not set as the reference position.

9.2.2.10 SET_REFERENCE SR[ ]

This command works like SET_REFERENCE except the vision process name is stored in a String Register.

9.2.2.11 CAMERA_CALIB

This command performs camera calibration.

```
VISION CAMERA_CALIB (camera-calibration-name) (request-code)
```

The value specified as the request code varies depending on the type of camera calibration. Refer to the following table:

Calibration Type	Request Code
Grid Pattern Calibration	Specify the index of the calibration plane, 1 or 2.
Robot-Generated Grid Calibration	Specify a different number for each calibration point. In the case of robot-generated grid calibration, a robot program using this command is automatically generated. For details, see Section 10.1, “ROBOT-GENERATED GRID CALIBRATION”.
3D Laser Calibration	Specify the index of the calibration plane, 1 or 2.
Visual Tracking Calibration	Not supported

9.2.2.12 CAMERA_CALIB SR[ ]

This command works like CAMERA_CALIB except the camera calibration name is stored in a String Register

9.2.2.13 OVERRIDE

This command sets a value for a vision override. The command is used immediately before the VISION RUN_FIND command.

```
VISION OVERRIDE (vision-override-name) a
```

The OVERRIDE command enables a vision process to run with part of its taught properties changed. For vision override, see Section 8.1, "VISION OVERRIDE"

The value you set with the OVERRIDE command is temporary and is not meant to rewrite the content of a vision process. The value set by this command takes effect only for the RUN_FIND command that is executed immediately after the OVERRIDE command. Once the RUN_FIND command is executed, all the values set by the OVERRIDE command (including those vision overrides associated with vision processes other than the vision process that executes location) are cleared.

9.2.3 Vision Registers

These commands assign the value of a vision register to a register or a position register.

9.2.3.1 Model ID

This command copies the model ID of the found workpiece from a vision register to a register.

```
R[a]=VR[b].MODELID
```

9.2.3.2 Measurement value

This command copies the measurement value of the found workpiece from a vision register to a register.

```
R[a]=VR[b].MEAS[c]
```

9.2.3.3 Encoder count

This command is used for visual tracking. It copies the encoder count of the found workpiece from a vision register to a register.

```
R[a]=VR[b].ENC
```

9.2.3.4 Found position

This command copies the actual position data of the found workpiece from a vision register to a position register.

```
PR[a]=VR[b].FOUND_POS[c]
```

In c, specify a camera view number.

> ⚠ **CAUTION**
> The configuration of the position register at the assignment destination is replaced with a predetermined value. The robot may not be able to move to this position with this configuration.

> **NOTE**
> The position register format after assignment is XYZWPR.

9.2.3.5 Offset data

This command copies the offset data of the found workpiece from a vision register to a position register.

```
PR[a]=VR[b].OFFSET
```

> **NOTE**
> The position register format after assignment differs depending on the value of the system variable $OFFSET_CART. If $OFFSET_CART is FALSE, the matrix format is used. If the value is TRUE, the XYZWPR format is used. $OFFSET_CART allows you to select behavior of the OFFSET command. The command described in this section selects an appropriate position register format depending to the value of $OFFSET_CART so that the OFFSET command can work expectedly with the offset data.

9.3 ASYNCHRONOUS EXECUTION

*i*RVision stores the execution results of the five vision processes most recently executed. Thus, the VISION RUN_FIND command and the VISION GET_OFFSET command can be executed asynchronously with each other.

In the sample program below, measurements are made successively at two locations by using a robot mounted camera then the results of the two measurements are obtained and a compensation operation is performed on the measurement results.

```
   UFRAME_NUM=1
   UTOOL_NUM=1

L P[1] 500mm/sec FINE
   VISION RUN_FIND VISION1

L P[2] 500mm/sec FINE
   VISION RUN_FIND VISION2

   VISION GET_OFFSET VISION1 VR[1] JMP,LBL[99]
   CALL HANDOPEN
L P[3:Approach1] 500mm/sec FINE VOFFSET,VR[1]
L P[4:Pick_pos1] 100mm/sec FINE VOFFSET,VR[1]
   CALL HANDCLOS
L P[3:Approach1] 100mm/sec FINE VOFFSET,VR[1]

   VISION GET_OFFSET VISION2 VR[1] JMP,LBL[99]
   CALL HANDOPEN
L P[5:Approach2] 500mm/sec FINE VOFFSET,VR[1]
L P[6:Pick_pos2] 100mm/sec FINE VOFFSET,VR[1]
   CALL HANDCLOS
L P[5:Appraoch2] 100mm/sec FINE VOFFSET,VR[1]

   END

   LBL[99]
   UALARM[1]
```

If six or more vision processes are executed asynchronously, the oldest stored detection result is discarded.

9.4 KAREL TOOLS

The KAREL programs below can be used.

9.4.1 IRVSNAP, IRVNFIND

IRVSNAP and IRVFIND are the functions to store a snapped image in an image register on a temporary basis and restore the image from the image register later to find a vision process.

Image Register

An image register is an area to store captured images on a temporary basis. By storing captured images in an image register, as well as the data necessary for finding a vision process such as the robot position at the time of snapping, the image capturing and location operations can be performed separately. This allows you to reduce the cycle time because, in such cases as when you process the same image multiple times for different purposes, you can omit the capturing of the image for the second and subsequent image processing steps.

> ⚠ **CAUTION**
> Since securing an image register requires a large amount of memory space, a CPU card with more than 64 MB of DRAM.

The number of image registers is determined by the system variable $VISION_CFG.$NUM_IMREGS. The default value is 0. Enter the necessary number of image registers.

The size of each individual image register is determined by the system variable $VISION_CFG.$IMREG_SIZE. The default value is 300. Where appropriate, set the register size as follows:

- Gray Digital Camera

320 x 240	75
640 x 480	300
1024 x 768	768
1280 x 1024	1280
1280 x 480	600
640 x 960	600

- Color Digital Camera

640 x 480	1200
1024 x 768	2304

- Analog Camera 300
- 3D Laser Sensor 1500

> ⚠ **CAUTION**
> After changing the value of the system register $VISION_CFG.$NUM_IMREGS or $VISION_CFG.$IMREG_SIZE, turn off the power of the controller and then back on in order to re-create the image register.

IRVSNAP

This KAREL program captures an image according to the shooting condition of a specified vision process and stores the captured image in an image register. It also stores the data necessary to find the specified vision process (e.g., the robot position in the case of a robot-mounted camera) in the image register. To find a vision process using images stored in the image register, you use IRVFIND, which is described later. Using IRVSNAP and IRVFIND in combination lets you perform the same operation that the VISION RUN_FIND command does.

The following three arguments need to be passed.

Argument 1: Vision Process Name

Specify a vision process name as a character string.

Argument 2: Camera View Number

Specify a camera view number in case of a multi-view vision process. Specify 1 in case of a single-view vision process.

Argument 3: Image Register Number

Specify the number of the image register that stores the image.

IRVFIND

This KAREL program runs a specified vision process using images stored in an image register. To store images in an image register, you use IRVSNAP, which is described above. Using IRVSNAP and IRVFIND in combination lets you perform the same operation that the VISION RUN_FIND command does.

The following three arguments need to be passed:

Argument 1: Vision process name

Specify a vision process name as a character string.

Argument 2: Camera View Number

Specify a camera view number in case of a multi-view vision process. Specify 1 in case of a single-view vision process.

Argument 3: Image Register Number

Specify the number of the image register to be used for finding the vision process.

Program Example

Shown below is an example in which a multi-view vision process with three camera views is found by using the same image for all the camera views. In this case, the same camera calibration needs to be specified for all the camera views.

```
1:    CALL IRVSNAP(VISION1, 1, 1)
2:    CALL IRVFIND(VISION1, 1, 1)
3:    CALL IRVFIND(VISION1, 2, 1)
4:    CALL IRVFIND(VISION1, 3, 1)
5:    VISION GET_OFFSET VISION1 VR[1] JUMP,LBL[99]
```

9.4.2 IRVLEDON、IRVLEDOFF

The multiplexer for analog camera of R-30*i*B Controller has electrical power supply function of LED. IRVLEDON and IRVLEDOFF are the functions to put a LED which is connected to LED electrical power supply of multiplexer for analog camera on / off.

IRVLEDON

Turn on the specified channel of LED light connected to the multiplexer for analog camera.

The following arguments can be passed:

Argument 1: LED Channel Number

Specify a channel number of a LED. Specify the one of the number from 1 to 4.

Argument 2: Intensity

Specify the intensity of LED. Intensity can be specified scale of 1 to 16. Specify the one of the number from 1 to 16.

⚠ **CAUTION**

Only one LED light can be turned on at the same time even when multiple LED lights are connected to the multiplexer for analog camera. While a channel is turned on, turning another channel on will turn on the new channel after turning on the former channel.

IRVLEDOFF

Turn off LED lights connected to the multiplexer for analog camera..

This program has no arguments.

Program Example

Shown below is an example that turns on an LED light, execute a vision detection, and finally turns the LED light off. The intensity of the LED light is about 50% of maximum value.

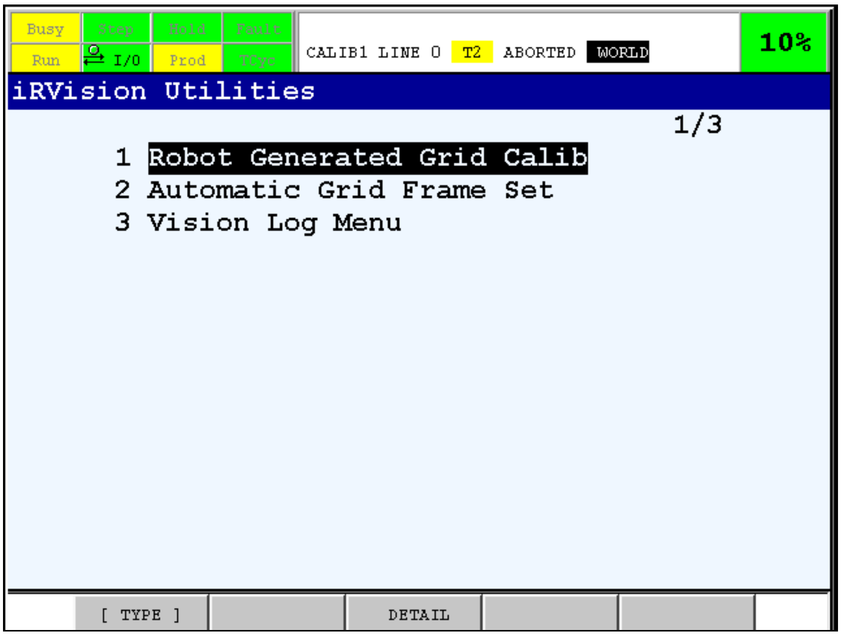
```
1:  CALL IRVLEDON(1, 8)
2:  VISION RUN_FIND 'VISION1'
3:  CALL IRVLEDOFF
```

10 UTILITY MENU

The *i*RVision utilities are a set of functions that help you operate *i*RVision.

To display the *i*RVision utility menu, perform the following steps:

1. Press MENUS on the teach pendant, and select [8 iRVision].
2. Press F1 [TYPE], and choose [5 Utility]. A screen like the one shown below appears.



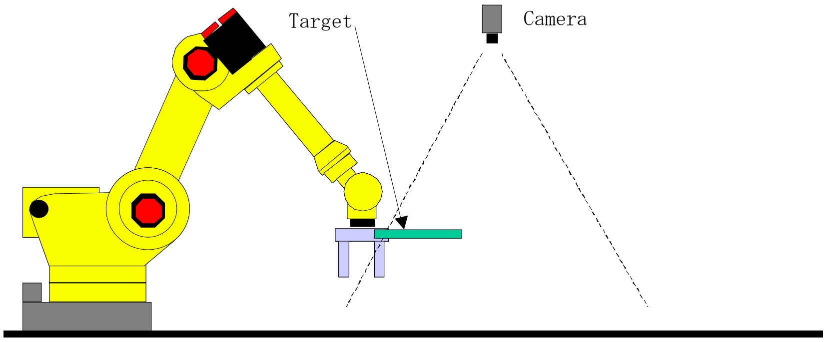
10.1 ROBOT-GENERATED GRID CALIBRATION

Robot-Generated Grid Calibration is a type of general-purpose camera calibration function similar to Grid Pattern Calibration. Compared to grid pattern calibration, this calibration function is suitable for calibrating a camera with a wide field of view.

10.1.1 Overview

The function moves the target, mounted on the robot end of arm tooling, in the camera's field of view to generate a virtual grid pattern for camera calibration. Unlike Grid Pattern Calibration, this calibration method does not require a calibration grid as large as the camera’s field of view and is therefore suitable for calibrating a wide-view-angle camera. Also, since it performs 2-plane calibration, the calibration method enables you to accurately calculate the position of the camera and the focal distance of the lens in use. The robot automatically moves and measures the position of the target and the size of the camera's field of view.

Robot-Generated Grid Calibration calibrates a fixed mounted camera. The target should be mounted on the robot end of arm tooling so that the arm does not get in the camera's field of view.



The procedure for robot-generated grid calibration is outlined below.

1. Create Robot-Generated Grid Calibration data on the camera calibration tools page. Setup the robot generated grid calibration data by selecting the camera to be calibrated, teaching the measurement start position, and training the locator tool to find the target mark.
2. Measure the position of the target mounted on the robot end of arm tooling.
3. Measure the size of the camera's field of view, and generate a calibration program.
4. Execute the generated calibration program to calibrate the camera.

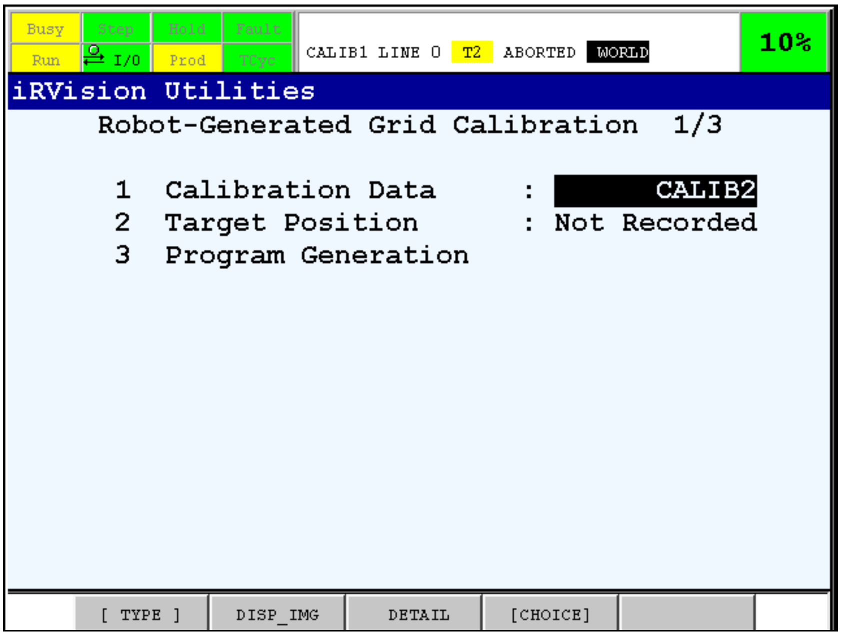
As long as the position of the target mounted on the robot end of arm tooling is not changed, you can re-calibrate the camera only by taking the step 4.

10.1.2 Structure of the Menus

Here, the menu structure of Robot-Generated Grid Calibration Utility is first described.

10.1.2.1 Main menu

If you select [Robot-Generated Grid Calibration] in the *i*RVision Utility menu, a menu like the one shown below appears. This is the main menu for Robot-Generated Grid Calibration.



> ⚠ **CAUTION**
> Robot-Generated Grid Calibration menu cannot be opened in more than one window at a time.

Calibration Data

Select a camera calibration. Place the cursor on this line and press F4 [CHOICE]. A camera calibration list is displayed. From this list, select the camera calibration you want to train. Pressing F3 DETAIL with the cursor placed on this line lets you view the details of the currently selected camera calibration.

Target Position

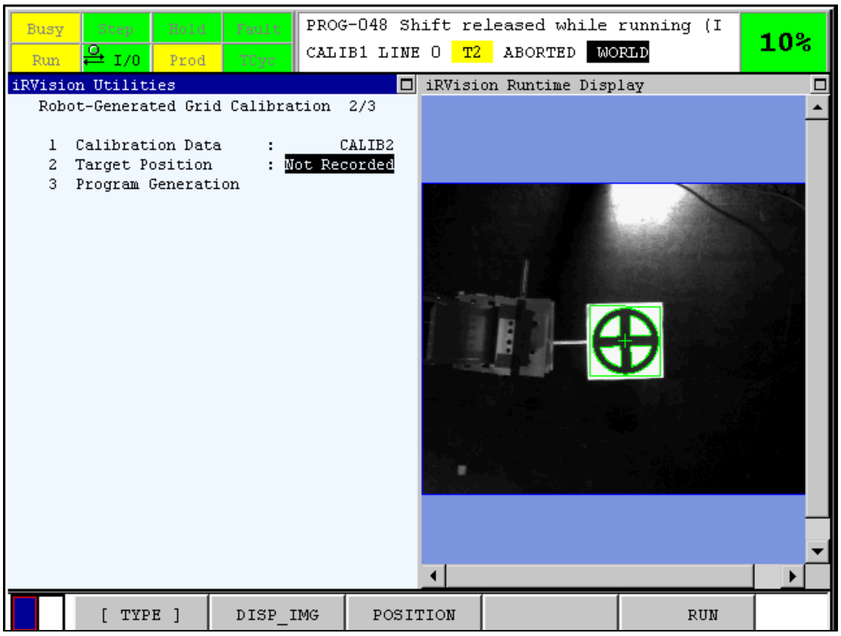
This item indicates whether the position of the target mounted on the robot end of arm tooling has been recorded. If the position of the target has been recorded, [Recorded] is displayed. Otherwise, [Not Recorded] is displayed. Pressing F3 DETAIL with the cursor placed on this line lets you view the position information of the recorded target. If you place the cursor on this line and press SHIFT and F5 RUN at the same time, the robot moves and measures the position of the target.

Program Generation

Generate a TP program for camera calibration. If you place the cursor on this line and press SHIFT and F5 RUN at the same time, the robot moves and measures the size of the camera's field of view to generate a calibration program automatically.

F2 DISP_IMG

Pressing F2 DISP_IMG shows the menu for Robot-Generated Grid Calibration and the vision runtime display in a double-window display, as shown below.



10.1.2.2 Calibration data menu

If you press F3 DETAIL with the cursor placed on [Calibration Data] in the main menu for Robot-Generated Grid Calibration, a menu like the one shown below appears. This menu displays what has been set in the Robot-Generated Grid Calibration setup page. Normally, there is no item you need to set on this menu.

Calibration Data

The name of the selected camera calibration is displayed. Pressing F4 [CHOICE] with the cursor placed on this line shows a list of camera calibration that you can select. From this list, you can select a camera calibration you want to teach.

Camera Setup

The name of the camera specified in the selected camera calibration is displayed.

Robot-mounted

[NO] is displayed if the camera is secured to a fixed surface, or [YES] is displayed if it is mounted on the robot end of arm tooling.

> ⚠ **CAUTION**
> For V8.10P/02, Robot-Generated Grid Calibration does not support a robot-mounted camera.

Application UFrame

The number of the application user frame specified in the selected camera calibration is displayed. In the case of 2D application, the XY plane of the application user frame needs to be parallel to the plane where the workpiece is to be offset.

Plane Spacing [mm]

Display the spacing between calibration planes 1 and 2.

Start Position

This item indicates whether the measurement start position is recorded in the selected camera calibration. If the start position is recorded, [Recorded] is displayed. Otherwise, [Not Recorded] is displayed. Pressing F3 POSITION with the cursor placed on this line displays the start position menu.

UTool for work space

Robot-Generated Grid Calibration uses a user tool for the work space when measuring the position of the target or generating a calibration program. Here, specify the number of the user tool for the work space. Since the function conducts the measurement as it rewrites the values of the specified user tool, specify the number of a user tool whose values can be changed without causing any problem.

Num. of Grid (Col.)

Specify the number of grid points of the grid pattern that the robot draws by moving the target. Here, set the number of grid points to be created in the horizontal direction of the image.

Num. of Grid (Row)

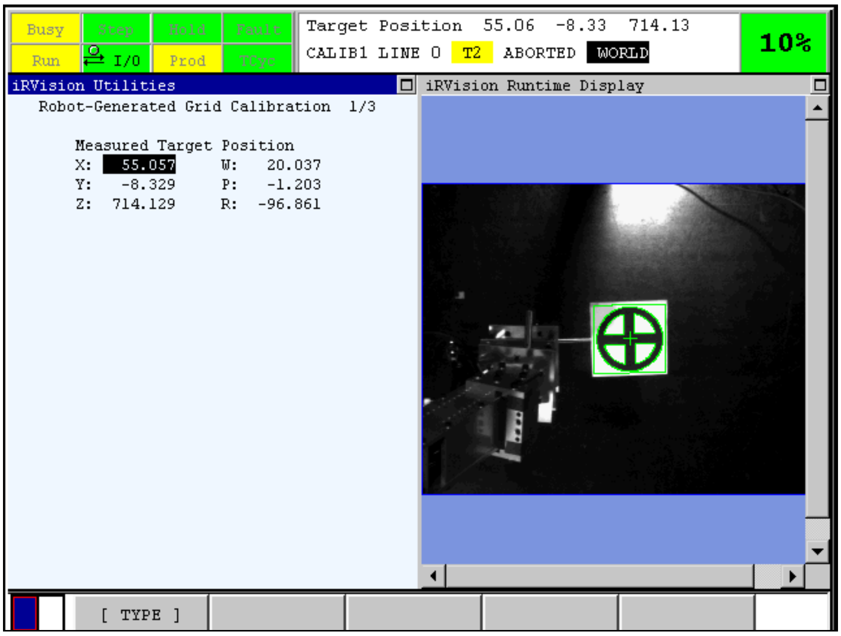
Specify the number of grid points of the grid pattern that the robot draws by moving the target. Here, set the number of grid points to be created in the vertical direction of the image.

Program Name

Specify the name of the calibration program to be generated. By default, this program name is the same as the name of the selected camera calibration. Normally, you do not need to change the default name.

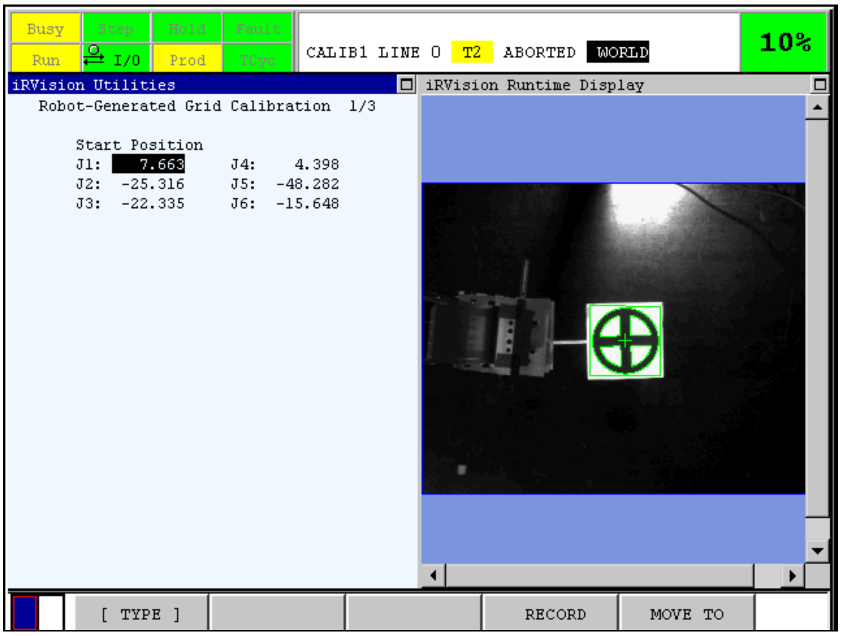
10.1.2.3 Target position menu

If you press F3 POSITION with the cursor placed on [Target Position] in the main menu for Robot-Generated Grid Calibration, a menu like the one shown below appears.



10.1.2.4 Start position menu

If you press F3 POSITION with the cursor placed on [Start Position] in the calibration data menu, a menu like the one shown below appears.



F4 RECORD

If you press SHIFT and F4 RECORD at the same time causes the current robot position to be recorded as the measurement start position. The position is recorded in the joint format.

F5 MOVE_TO

If you press SHIFT and F5 MOVE_TO at the same time moves the robot to the currently recorded measurement start position.

10.1.3 Performing Calibration

Perform Robot-Generated Grid Calibration.

10.1.3.1 Selecting and mounting the target

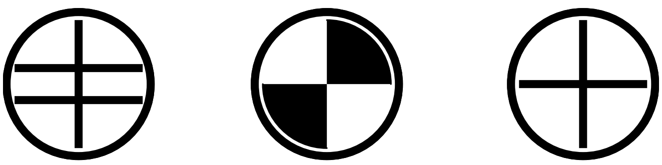
Select the target mark to be used for calibration.

Geometry of the target

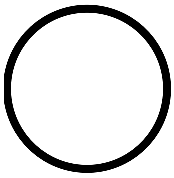
The target must meet the following conditions:

- The features to be taught are on the same one plane.
- The target has a geometry for which any rotation of ±45° or so can be identified.
- The target has a geometry whose size can be identified.

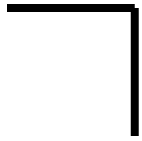
Examples of appropriate target geometries:



Examples of inappropriate target geometries:



The rotation angle cannot be identified.



The size cannot be identified.

Size of the target

Make sure that the size of the target, when captured as an image, is 80 to 100 pixels in both vertical and horizontal directions. For example, when the camera's field of view is about 900 mm (8-mm lens; distance between camera and target is 2000 mm or so), prepare a target that is 120 to 160 mm in diameter.

Mounting the target

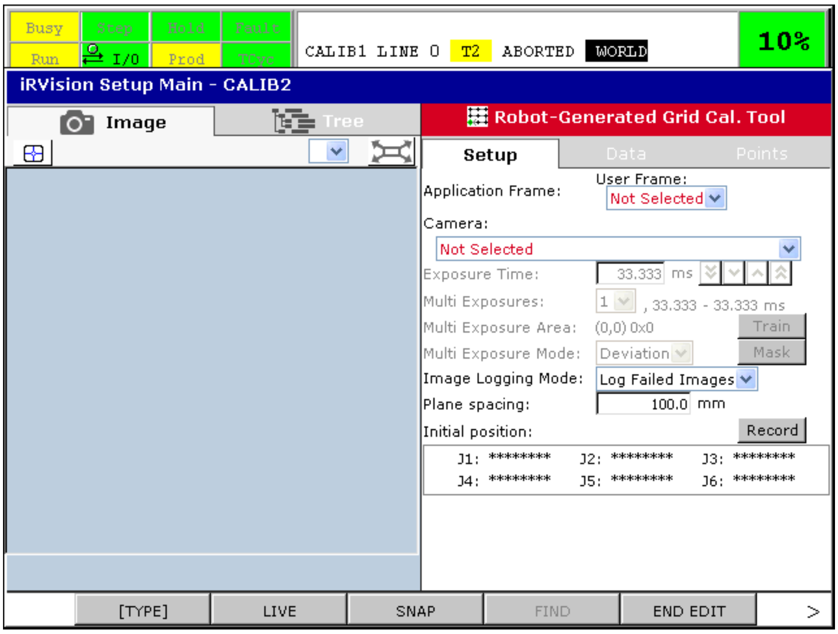
Mount the target at the robot end of arm tooling. Make sure that the target does not get behind the robot arm or the tooling even when the robot moves in the camera's field of view.

> ⚠ **CAUTION**
> Make sure that the target is fixed securely to the robot end of arm tooling so that it remains in place while the robot moves.

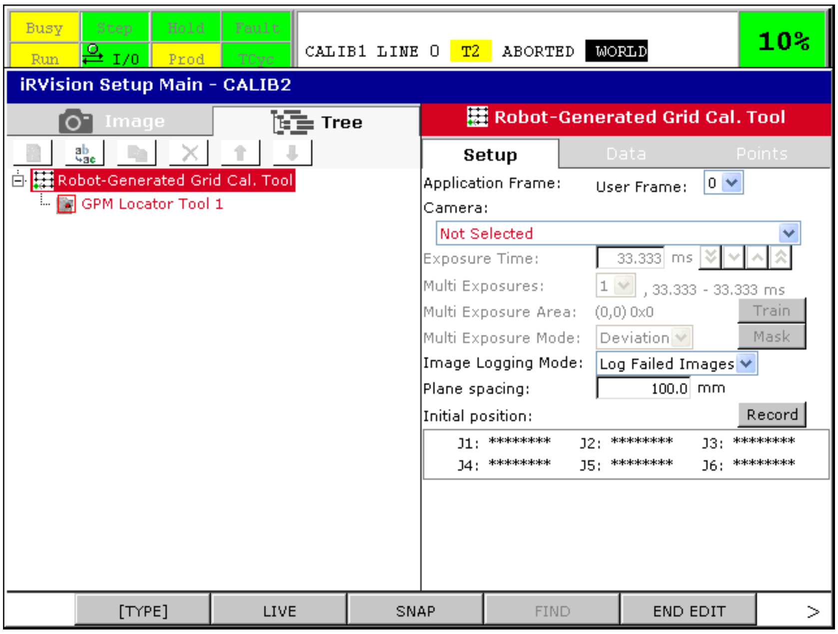
> **TIP**
> 1 Normally, the robot position and posture are set so that the range of robot motion becomes maximal when the robot actually operates. Therefore, mounting the target so that it can be captured by the camera when the robot is in a posture that it takes during operation makes it easier to secure the range of robot motion.
> 2 Positioning pins or other appropriate means may be used so that the target can be mounted at the same position for each measurement. This way, a robot program generated for a previous calibration operation can be used for re-calibration.

10.1.3.2 Preparing camera calibration tool

Visit the Vision Setup screen, and create a Robot-Generated Grid Calibration Tool and teach some parameters necessary prior to the execution. If you open the Robot-Generated Grid Calibration setup page, a page like the one shown below appears.



If you tap [Tree] tab, a screen like the one shown below appears.



Robot-Generated Grid Calibration Setup Page

Select the “Robot-Generated Grid Calibration” on the tree view. According to Subsection 5.2.1 "Camera Calibration Tools", select a Camera Setup, teach Start Position, and make other necessary setups.

GPM Locator Tool Setup Page

Select the “GPM Locator Tool” on the tree view, and teach the model pattern.

After moving the robot to the recorded start position, teach the model pattern by reference to Section 7.1 "GPM LOCATOR TOOL". And then, verify the [Training Stability] of the model pattern to see if [Good] is shown for [Location], [Orientation], and [Scale], respectively. If [None] is shown for any of these items, calibration cannot be performed properly. In that case, use a different shape of target mark.

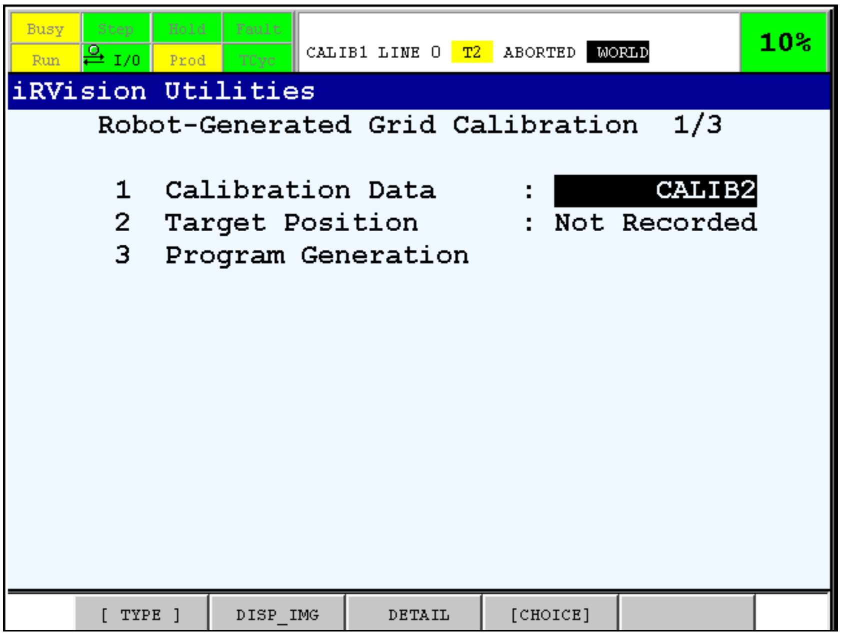
By default, the range of [Angle] is set to be searched to ±30° and the range of [Scale] is set to be searched to 95% to 120% and the range of [Aspect Ratio] is set to be searched to 90% to 100%. Usually, you don't have to change these parameters. Please adjust these parameters if necessary.

TIP

When training the model pattern, the rectangle should not be unnecessarily larger than the area of the target mark. The robot moves the target mark keeping the trained rectangle within the search area. So the larger the trained rectangle is, the smaller the target mark displacement range is, therefore more likely to decrease the accuracy of the camera calibration.

10.1.3.3 Selecting calibration data

Visit the [Robot-Generated Grid Calibration] in the Vision Utility screen, and select the camera calibration data that you just created in [1 Calibration Data].

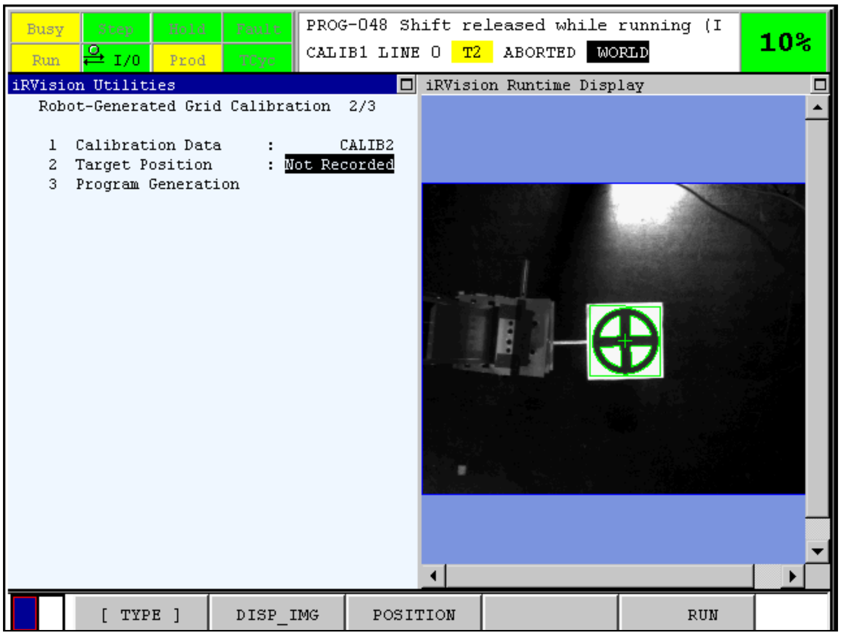


10.1.3.4 Measuring target position

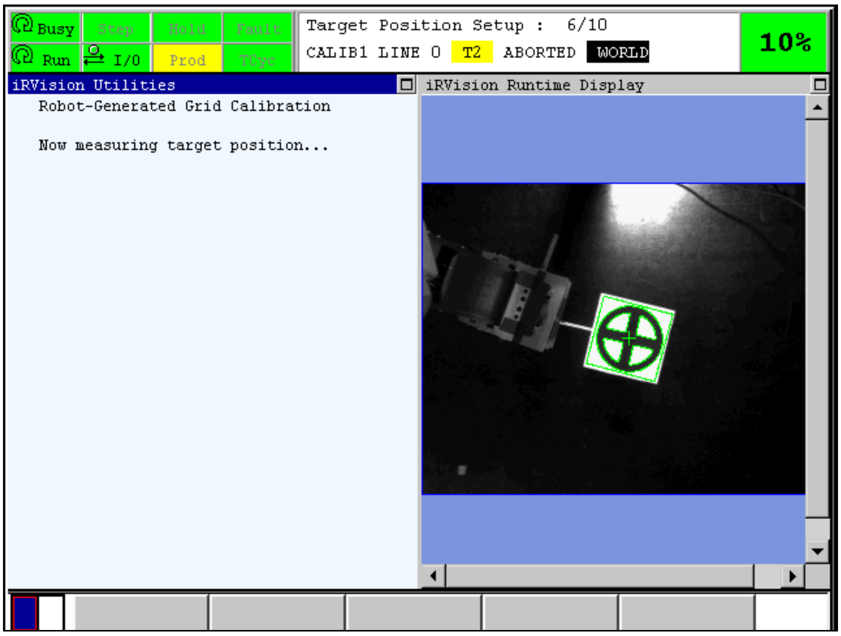
Measures the position of the target mounted on the robot end of arm tooling.

6-axis robot

A 6-axis robot can measure the position of robot-mounted target mark by vision.



1. Veriry whether the calibration data which is selected [1 Calibration Data] is proper.
2. Place the cursor on [2 Target Position].
3. Enable the teach pendant, and reset the alarm.
4. Press SHIFT + F5 RUN to start the measurement. Keep holding down SHIFT while the measurement is in progress.



5. When the measurement is complete, the robot stops and the message [Measurement is successfully finished.] appears on the screen.
6. Press F4 OK to return to the main menu.

If the last target position measurement was aborted before completion, the message [Are you sure to resume?] appears when you attempt to perform the target position measurement again. To resume the measurement, press SHIFT + F4 RESUME. To restart the measurement from the beginning, press SHIFT + F5 RESTART.

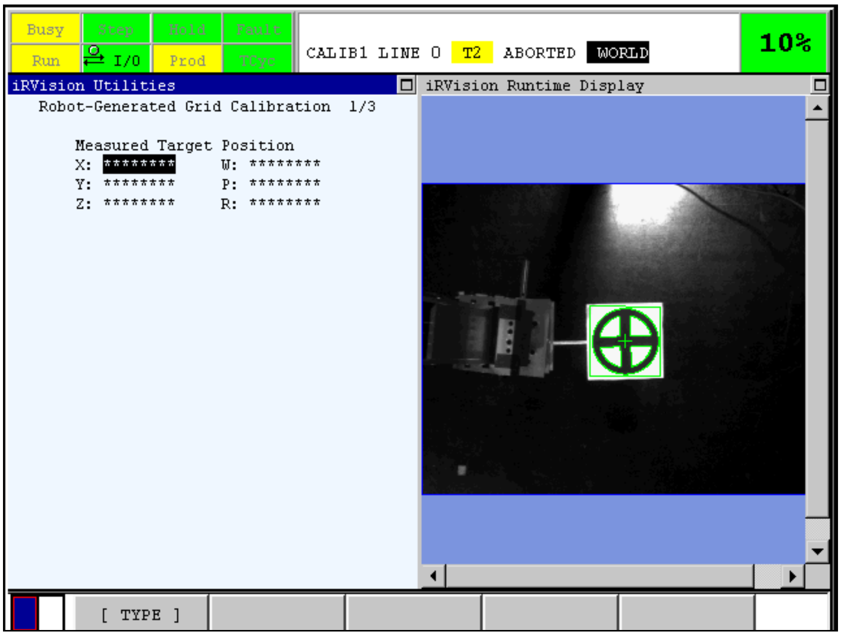
> ⚠ **CAUTION**
> If the camera calibration setup page is opened in the Vision Setup screen, Robot-Generated Grid Calibration cannot perform the measurement. Make sure that the setup page is closed. You can see the status of the measurement on the Vision Runtime screen.

> **TIP**
> When the field of view contains some area that the robot cannot reach, the robot sometimes cannot measure the target mark position by vision. In this case, you can set the target position by the same steps as a 4- or 5-axis robot.

4- or 5-axis robot

A 4- or 5-axis robot cannot use vision-based measuring. Train the position of the target mark manually.

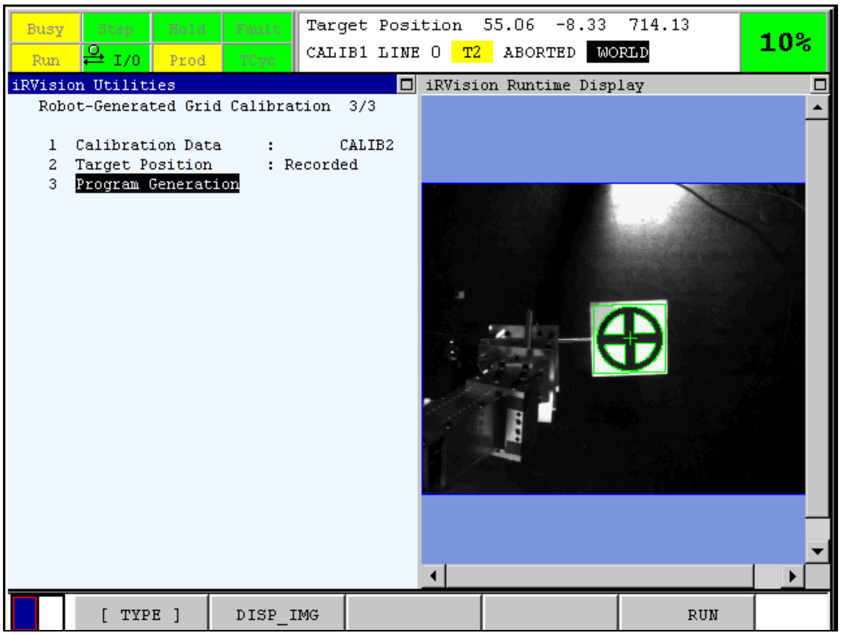
1. Place the cursor on [2 Target Position], and press F3 POSITION to visit the target position menu.
2. Input X, Y and Z to the position of the target mark.
3. Input W, P and R to zero.



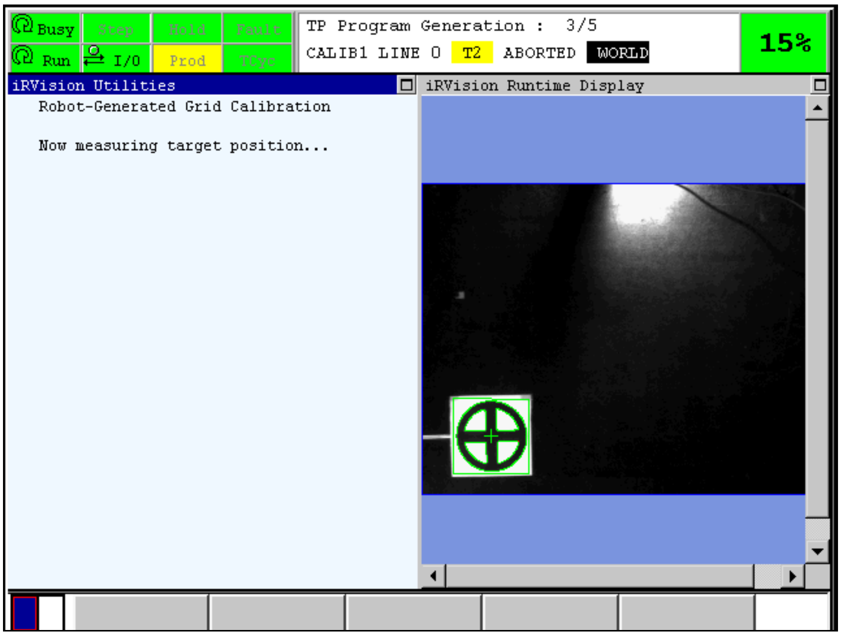
> **TIP**
> The target position should correspond to the model origin trained in section 10.1.3.2, “Preparing Camera Calibration Tool”. If the positions are different, the camera cannot be calibrated properly.

10.1.3.5 Generating calibration program

Measures the size of the camera's field of view, and generates a robot program for camera calibration.



1. Verify whether the calibration data which is selected [1 Calibration Data] is proper.
2. Verify whether [2 Target Position] is RECORDED.
3. Place the cursor on [3 Program Generation].
4. Enable the teach pendant, and reset the alarm.
5. Press SHIFT + F5 RUN to start the program generation. Keep holding down SHIFT while the measurement is in progress.



6. When the measurement is complete, the robot stops and the message [Measurement is successfully finished.] appears on the screen.
7. Press F4 OK to return to the main menu.

If the last program generation process was aborted before completion, the message [Are you sure to resume?] appears when you attempt to generate a program again. To resume the process, press SHIFT + F4 RESUME. To restart the process from the beginning, press SHIFT + F5 RESTART.

> ⚠ **CAUTION**
> If the camera calibration setup page is opened in the Vision Setup screen, Robot-Generated Grid Calibration cannot perform the measurement. Make sure that the setup page is closed. You can see the status of the measurement on the Vision Runtime screen.

The way to limit the target displacement range

In order to avoid the interference with peripheral equipment, you can limit the target displacement range.

1. Open the camera calibration setup page and choose GPM Locator Tool in the tree view.
2. Shrink the search window and omit the area that the interference occurred.
3. Press F10 SAVE to save the camera calibration.
4. Press F5 END EDIT to close the setup page.
5. Visit the Robot-Generated Grid Calibration in Vision Utility, and generate a calibration program again.

Calibration Program

The generated calibration program is like the one shown below. All the robot positions in the calibration program are taught in the joint format.

```
  1:   UFRAME_NUM=2
  2:   UTOOL_NUM=2
  3:L P[1] 1000mm/sec FINE
  4:   VISION CAMREA_CALIB 'CALIB1' REQUEST=1
  5:L P[1001] 1000mm/sec FINE
  6:   CALL IRVBKLSH(1)
  7:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1001
  8:L P[1002] 1000mm/sec FINE
  9:   CALL IRVBKLSH(1)
 10:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1002

          (Repeat as many times as the number of points)

293:L P[2048] 1000mm/sec FINE
294:   CALL IRVBKLSH(1)
295:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2048
296:L P[2049] 1000mm/sec FINE
297:   CALL IRVBKLSH(1)
298:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2049
299:L P[2] 1000mm/sec FINE
300:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
```

The section of the program that finds an individual calibration program consists of the three lines shown below. This set of three lines is repeated in the middle of the calibration program above.

```
  5:L P[1001] 1000mm/sec FINE
  6:   CALL IRVBKLSH(1)
  7:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1001
```

Each command in the program is briefly explained below.

```
4:   VISION CAMREA_CALIB 'CALIB1' REQUEST=1
```

If you specify 1 in the request code of the CAMERA_CALIB command, all the calibration points in the specified camera calibration are deleted. This is the first command to be executed in the calibration program.

```
300:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
```

If you specify 2 in the request code of the CAMERA_CALIB command, camera calibration data is calculated using the found calibration points. This is the last command to be executed in the calibration program.

```
7:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1001
```

If you specify 1000 or a larger value in the request code of the CAMERA_CALIB command, the program attempts to find a calibration point. The value specified in the request code is recorded as the index of the calibration point, along with the found position.

In an automatically generated calibration program, 1000 to 1999 represent the calibration points on calibration plane 1, and 2000 to 2999 the calibration points on calibration plane 2. Note also that the index of the position data of the preceding motion statement is the same as the request code that is passed to the CAMERA_CALIB command.

Calibration points do not necessarily need to be found in the order of request codes. If a calibration point is found twice with the same request code, the data of the calibration point that is found first is overwritten by the data of the calibration point found later.

```
6:   CALL IRVBKLSH(1)
```

If the KAREL program IRVBKLSH.PC is called, the robot performs an operation intended to remove the backlash effect at its current position. As the argument, specify the motion group number of the robot that performs the backlash removal operation.

10.1.3.6 Executing calibration program

Select the generated calibration program in the SELECT menu, and play it back from the first line to calibrate the camera.

> ⚠ **CAUTION**
> If running the program as is can cause interference, use lower override values. In this case, execute the program while making sure that no interference occurs during operation.

Each calibration point in the generated calibration program can be re-taught or deleted as necessary.

If there is any calibration point that causes the robot to interfere with peripheral equipment, re-teach that point to move it to a position where it does not cause interference, or delete the calibration point. When deleting a calibration point, delete not only the motion statement but also the lines of IRVBKLSH and the CAMERA_CALIB command that are executed after the motion statement.

If there is any calibration point that hinders the robot operation because it is near singularity, re-teach that point to move it to a position where it can avoid singularity, or delete the calibration point. When deleting a calibration point, delete not only the motion statement but also the lines of IRVBKLSH and the CAMERA_CALIB command that are executed after the motion statement.

When re-teaching a calibration point, you may place the target closer to or further away from the camera within a range in which the camera lens remains in focus.

> ⚠ **CAUTION**
> The calibration program does not stop even if the target fails to be found or it is found incorrectly during the program execution. After the program ends, open the robot-generated grid calibration setup page in the Vision Setup screen and check to see if there is any point incorrectly found.

> **TIP**
> As long as the position where the target is mounted remains unchanged, you can re-calibrate the camera simply by executing the generated calibration program.

After executing the calibration program to the last, camera calibration is complete. Please verify the calibration points and the calibration results by reference to Subsection 5.2.2 "Checking Calibration Points" and Subsection 5.2.3 "Checking Calibration Data".

10.2 GRID FRAME SETTING

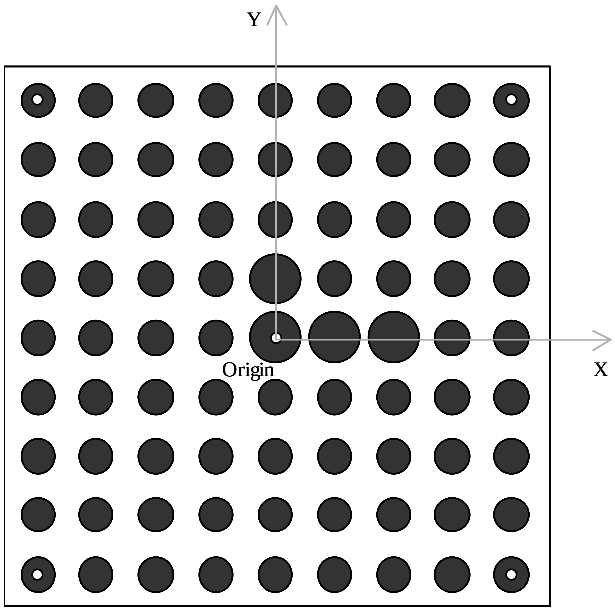
The grid frame setting function sets the calibration grid frame using a camera. Compared with the manual touch-up setting method, the function offers a number of merits, including accurate setting of the frame without requiring user skills, no need for touch-up pointers or to set the TCP for touch-up setting, and semi-automatic easy-to-do operation.

In grid frame setting, the calibration grid is measured from multiple directions by using a camera and the measured calibration grid frame is set in the user frame area or tool frame area of the robot controller.

> ⚠ **CAUTION**
> The grid frame setting function is usable with 6-axis robots only. The function cannot be used with 4-axis robots and 5-axis robots.

10.2.1 Overview

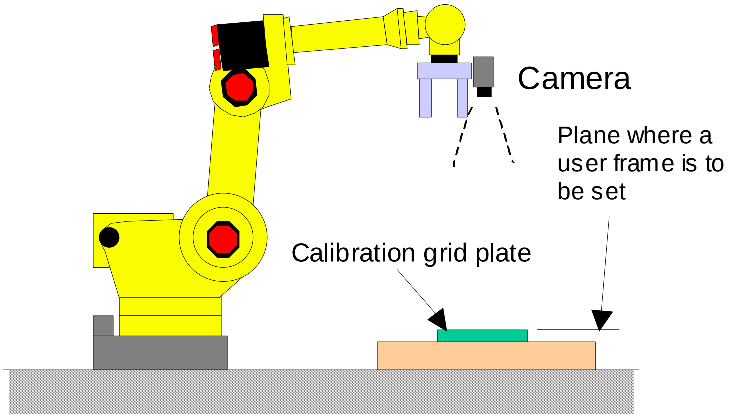
In the grid frame setting function, the robot holding the camera or the robot holding calibration grid automatically moves to change relative position and orientation between the camera and the calibration grid, and find the grid pattern repeatedly. Finally, the position of the calibration grid frame relative to the robot base frame or the robot mechanical interface frame (the robot face place) is identified. When the grid frame setting function is executed, a frame is set on the calibration grid, as shown in the following figure.



During the measurement, detection results and measurement execution steps are displayed on the vision runtime display. When the measurement is successfully finished, the robot moves to such a position that the camera and calibration grid directly face each other and the origin of the calibration grid frame is seen at the center of the image.

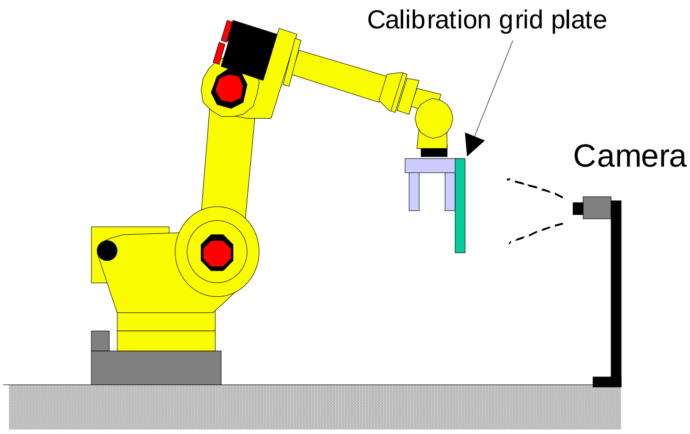
When the calibration grid is secured to a fixed surface

When the calibration grid is secured to fixed surface, a camera mounted on the robot end of arm tooling is used to measure the position of the calibration grid frame. The grid frame setting function identifies the position of the calibration grid frame relative to the robot base frame (world), and sets the results in a user specified user frame.



When the calibration grid is mounted on the robot

When the calibration grid is mounted on the robot, a fixed camera is used to measure the position of the calibration grid frame. The robot moves the calibration grid within the field of view of the fixed camera. The grid frame setting function identifies the position of the calibration grid frame relative to the robot mechanical interface frame (the robot face plate), and the results is written in a user defined user tool.



Mounting of the calibration grid

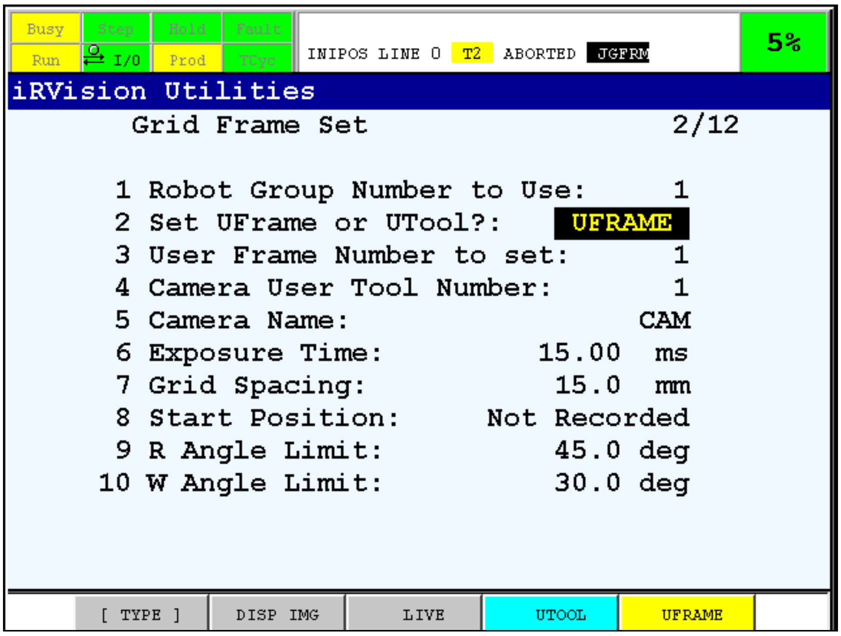
When securing the calibration grid to a fixed surface, place the calibration grid at the position where the camera will be calibrated. When mounting the calibration grid on the robot, attach the calibration grid to the robot end of arm tooling. In either case, make sure that the calibration grid is fixed securely so that it does not move during measurement.

TIP

To prevent unnecessary circles from being found, check that the calibration grid is free of dirt and flaws. Spreading a plain sheet in the background is effective. Also, make sure to cover the printed text on the calibration grid.

10.2.2 Setting the Parameters

If you select [Grid Frame Set] on the *i*RVision utility menu, a menu like the one shown below appears.



> ⚠ **CAUTION**
> The Grid Frame Set menu cannot be opened in more than one window at a time.

Robot Group Number to Use

Specify the group number of the robot to be used for measurement.

Set UFrame or UTool?

Select the frame to be set with the grid frame setting function - user frame or user tool. To set the user tool with the calibration grid mounted on the robot, select F4 UTOOL. To set the user frame with the calibration grid secured to a table or other fixed surface, select F5 UFRAME.

User Frame Number to set

Specify the number of the user frame to be set. This parameter is used only when [UFRAME] is selected for [Set UFrame or UTool?]. The range of specifiable user frame numbers is 1 to 9.

Tool Frame Number to set

Specify the number of the user tool to be set. This parameter is used only when [UTOOL] is selected for [Set UFrame or UTool?]. The range of specifiable user tool numbers is 1 to 10.

Camera User Tool Number

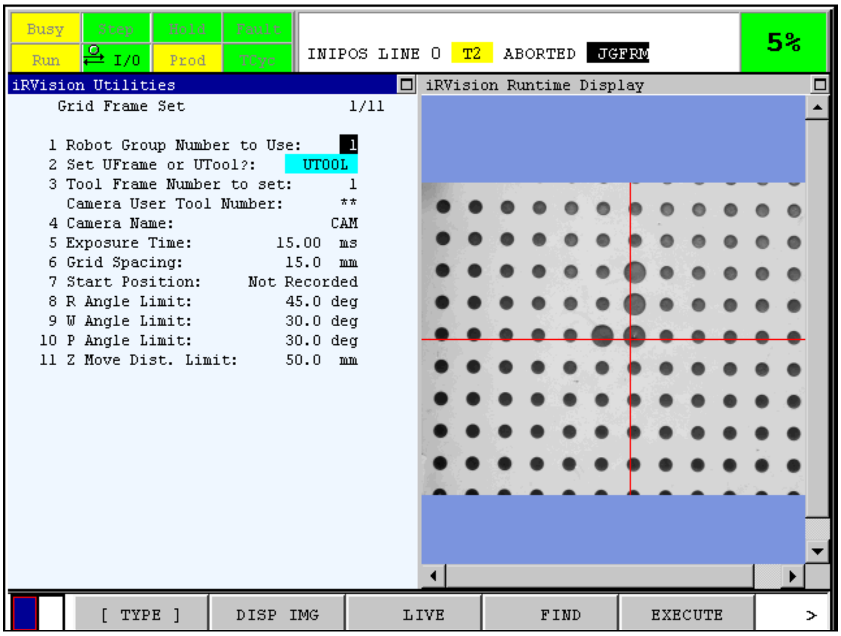
Specify the number of the user tool for the work space to be used during calculation. This parameter is used only when [UFRAME] is selected for [Set UFrame or UTool?]. The user tool you specify here will be rewritten during the measurement for grid frame setting. The range of specifiable user tool numbers is 1 to 10.

Camera Name

Specify the name of the camera to be used for measurement. Place the cursor on the line of [Camera Name], press F4 CHOICE, and select a camera from the pull down menu. If camera setups have yet to be created, create a camera setup, as instructed in Chapter 4, "CAMERA SETUP", and select the name of the created camera setup.

F2 DISP_IMG

Pressing F2 DISP IMG provides a double-window display, with the vision runtime display (camera image) shown on the right side.



F3 LIVE

Pressing F3 LIVE displays the live image of the selected camera on the vision runtime display, as the F3 label changes to [STOPLIVE]. If you press F3 STOPLIVE, the display of the live image is stopped and the F3 label returns to [LIVE].

F4 FIND

Pressing F4 FIND detect the calibration grid for a trial. The found result is displayed on the vision runtime display.

Exposure Time

Specify the exposure time for the camera to capture an image. Adjust the exposure time so that the black circles of the calibration grid are clearly visible.

Grid Spacing

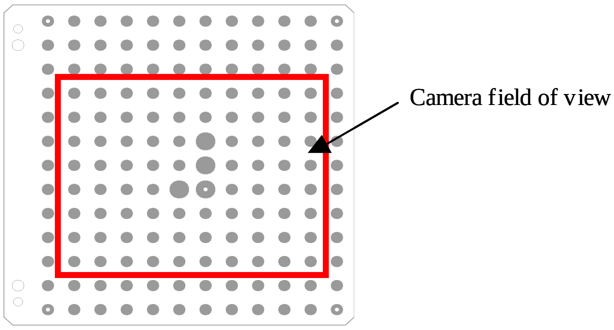
Set the grid spacing of the calibration grid in use.

Start Position

Teach the position where measurement is to be started. To teach the start position, take the following steps:

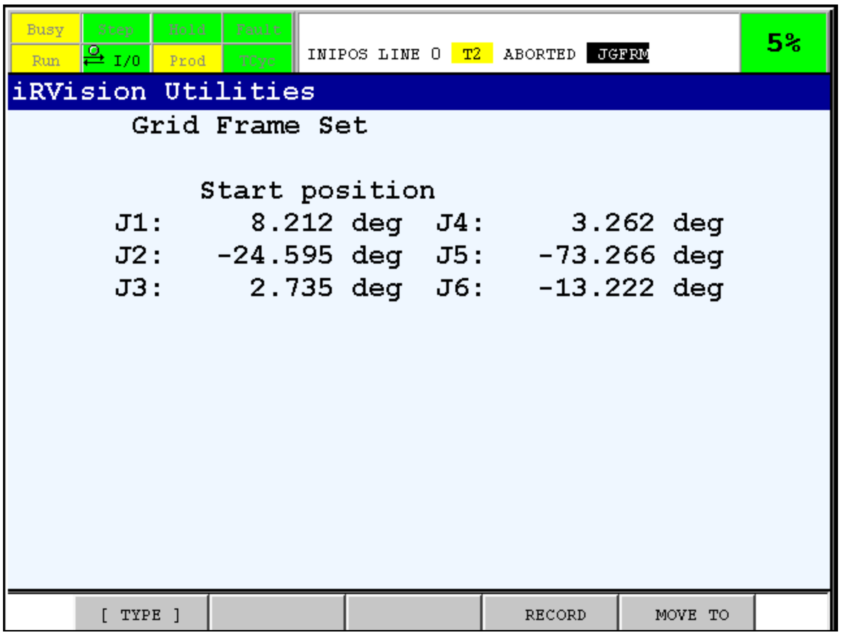
1. Move the cursor to [7 Start Position].

2. Jog the robot so that the camera's optical axis is approximately perpendicular to the plate surface of the calibration grid and that all of the four large black circles of the calibration grid are inside the camera's field of view. The distance between the calibration grid and the camera should be appropriate for the grid to come into focus, which is, under normal circumstances, roughly the same as the distance at which camera calibration is performed.



3. Press SHIFT and F4 RECORD at the same time to record the start position. When the start position is recorded, the label changes to [Recorded].

To check the trained start position, press F3 POSITION. The value of each axis of the start position is displayed, as shown below. To return to the previous menu, press PREV.



To move the robot to the start position, press SHIFT and F5 MOVE TO at the same time.

Operation range

During measurement, the robot automatically moves within the range specified by parameters. To prevent the robot from interfering with peripheral equipment, make sure that there is a sufficient operation space around the measurement area. When the default settings are used, the robot makes the following motions:

- Move ±100 mm horizontally in the X, Y, and Z directions
- Rotate by ±45 degrees around the camera's optical axis
- Rotate at ±30-degree inclination (WP) relative to the camera's optical axis at the robot start position

- Rotate at ±30-degree inclination (WP) relative to the camera's optical axis at the position where the camera directly faces the calibration grid

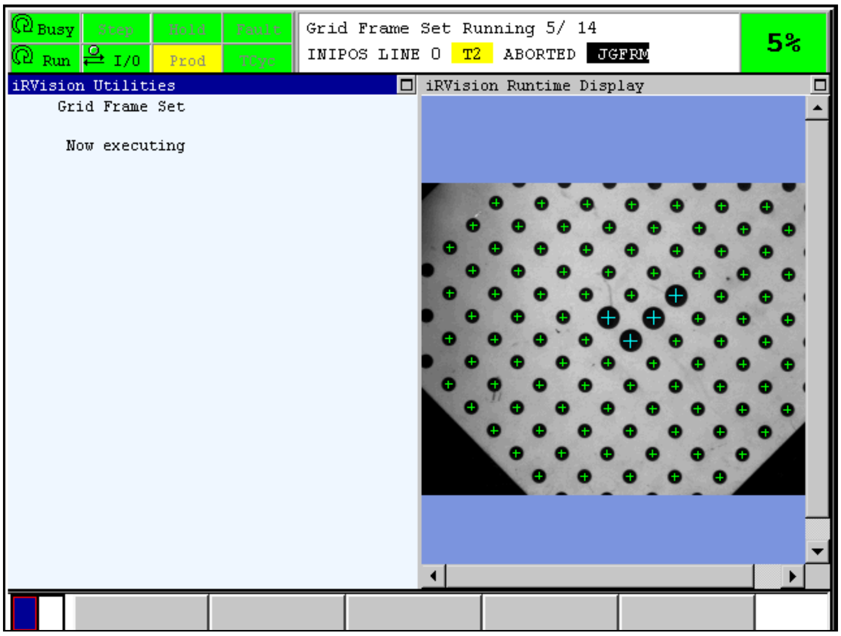
If the operation range defined by the default settings cannot be secured, you can make the operation range smaller by changing the parameters such as [R Angle Limit], [W Angle Limit], and [P Angle Limit]. Note, however, that the precision of grid frame setting depends on the amount of motion at the time of measurement. A smaller operation range can lead to lower measurement precision. It is therefore recommended that measurements be made using a range as close to the default operation range as possible.

Value initialization

If you press [NEXT→] and then F2 DEFAULT, the set values are initialized. Note that [Camera Name] and [Start Position] are not initialized; set these parameters again individually.

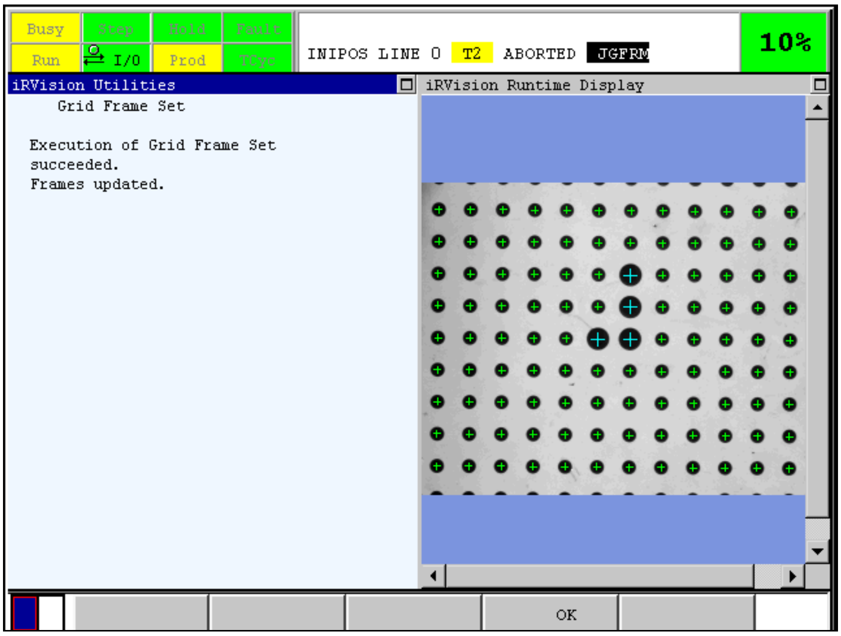
10.2.3 Run Measurement

Pressing SHIFT and F5 EXECUTE at the same time starts measurement, causing the robot to start moving. During execution watch image displayed and verify that there are no improperly found calibration grid circles.



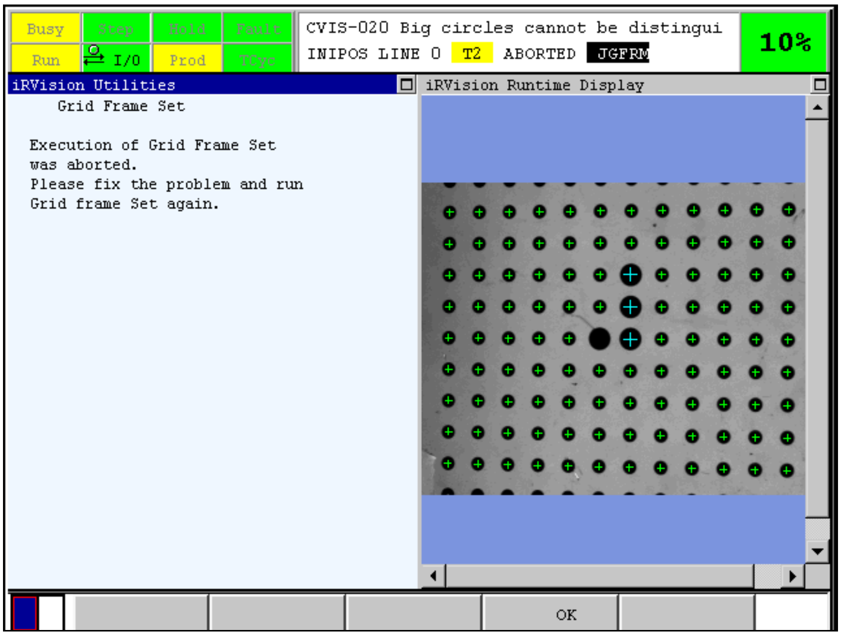
> ⚠ **CAUTION**
>
> 1 Releasing SHIFT while measurement is in progress stops the measurement. In that case, perform the measurement again.
>
> 2 During measurement, if you perform any operation intended to move to another menu, such as pressing SELECT, the measurement is stopped. In that case, visit the Grid Frame Set menu again and perform the measurement again.
>
> 3 The robot usually performs operations within an expected range according to the parameter setting. However, the robot can make a motion beyond an expected range, depending on the parameter setting. When running the Grid Frame Set, check that the related parameters are set correctly and decrease the override to 30% or less to ensure that the robot does not interfere with peripheral equipments.
>
> 4 If another program is paused, the Grid Frame Set may not be able to move the robot. In that case, abort all the programs using the FUNC menu.

When the measurement is successfully completed, a menu like the one shown below appears. The robot stops after moving to a position where the camera directly faces the calibration grid and the origin of the calibration grid comes to the center of the image.



> **TIP**
>
> You can confirm that the frame is set accurately with the following procedures. First, change the manual-feed coordinate system to the measured frame. When you set a user tool with Grid Frame Setting, change the manual-feed coordinate system to the user tool. When you set a user frame, change the manual-feed coordinate system to the user frame, and then select the user tool selected as “Camera User Tool Number” in the Section 10.2.2.
> Next, start the live image display and jog the robot around the X-, Y- and Z-axes. If the frame is set accurately, the center grid of the gird pattern will keep appearing at the center of the image.

If the measurement is fails, a menu like the one shown below appears. In that case, press F4 OK to return to the previous menu. Then, change the parameters as appropriate and perform the measurement again. After changing the parameters, pressing SHIFT and F5 RUN at the same time starts the measurement again from the beginning.



10.2.4 Troubleshooting

If the Grid Frame Set does not operate as expected, first check the information provided here.

[CVIS-020 Big circles cannot be distinguished] is issued.

This alarm is posted when the four large black circles of the calibration grid could not be detected. Detection of large black circles failed because of an improper exposure time, or an object other than a grid point was detected. The Vision Runtime screen shows the image when a measurement failed. Check the image and adjust the snapping condition. When some of the large circles are not seen in the camera field of view, try the followings:

- Use a smaller grid pattern
- Use a lens with smaller focal length
- Lengthen the distance between the camera and the grid pattern so that the grid pattern is seen smaller in the image
- Rotate the camera or the grid pattern so that the X axis of the grid pattern does not point below in the image

[CVIS-015 Too few calibration points] is issued.

This alarm is posted when the number of grid points of the calibration grid detected during measurement is less than 4. Check whether the grid points are contained in the camera's visual field when the robot is placed at the measurement start position, whether the exposure time is proper, and whether the camera port number is correct. This alarm is posted also if a measurement is made when the camera is disabled for hardware trouble.

The program was terminated abnormally with an error.

If an error occurs, the program is terminated forcibly. Modify the setting to enable correct measurement then execute the program from the beginning.

10.3 VISION LOG MENU

The vision log menu allows you to perform the following operations for the *i*RVision log data:

Export

Convert the vision log data stored in the robot controller to a text format and output the converted data to a specified external device.

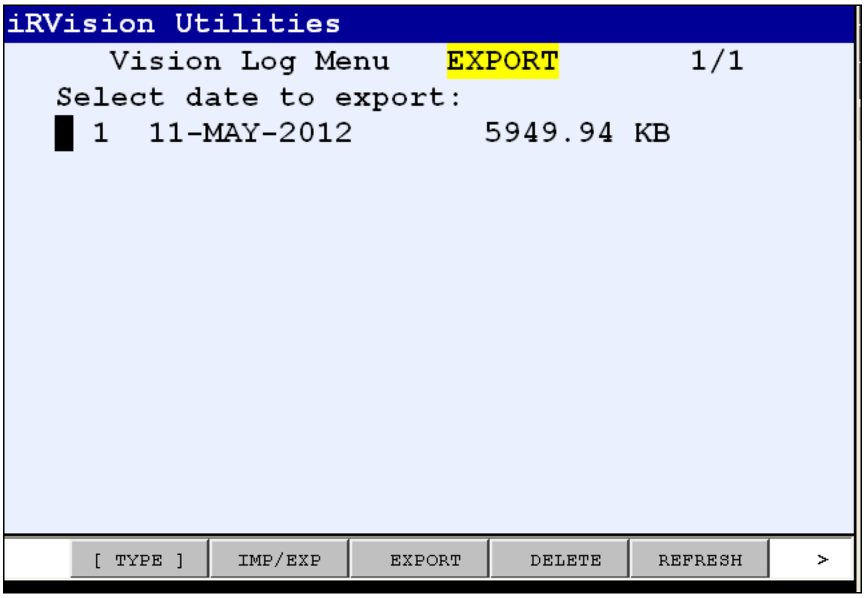
Import

Convert the exported vision log data to the binary format and read the converted data into the robot controller.

Delete

Delete the vision log data stored in the robot controller.

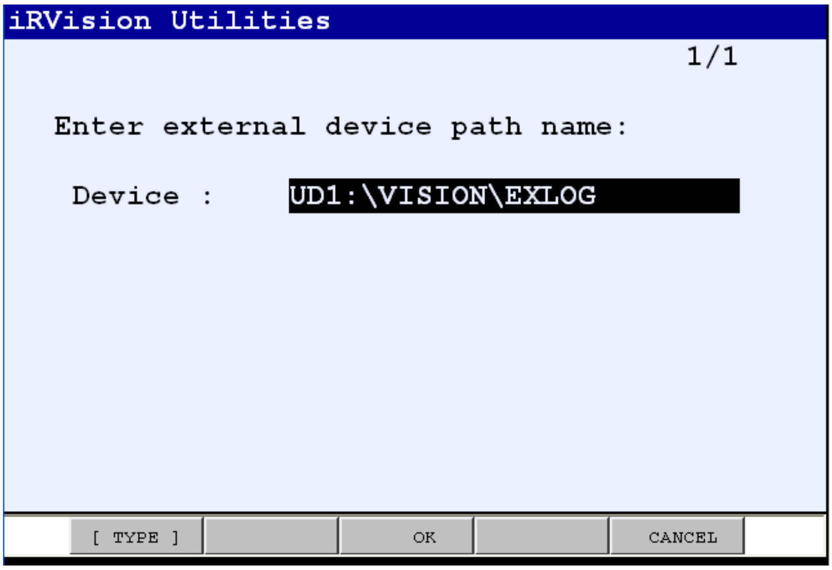
If you select [Vision Log Menu] on the *i*RVision Utility menu, a menu like the one shown below appears.



10.3.1 Setting the Device

By default, UD1:\VISION\EXLOG\ is set as the external device. You can change the external device path name by taking the following steps:

1. On the vision log menu, press [NEXT→] and then F4 DEVICE. A menu like the one shown below appears.



2. In [Device], enter a text string that represents the path name of the external device.
3. To save the path name of the external device, press F3 OK.
   To quit changing the external device path name, press F5 CANCEL.

If the specified path does not exist on the external device, the message [xxx will be made, OK?] appears. Pressing F4 YES creates a directory with the specified path name on the external device.

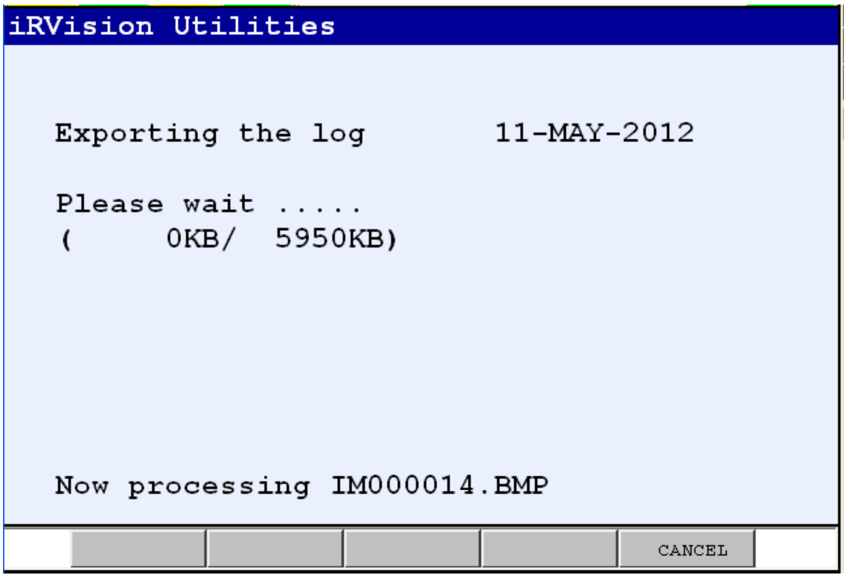
> ⚠ **CAUTION**
> 1 An external device that you can specify is a memory card, USB memory device of the controller, or PC share client.
> 2 Set up a necessary device as appropriate for the export device setting. Under the default setting, for example, you need to insert a USB memory device into the robot controller.

10.3.2 Exporting Vision Log of a Specified Date

To export one day worth of vision log stored in the robot controller to the external device, take the following steps:

1. Place the cursor on the date of the vision log you want to export.

2. Press F3 EXPORT to start the export of the vision log. During the export, a menu like the one shown below stays displayed.



3. When the export is complete, the message [Log export succeeded.] appears.

If the external device contains any vision log of the same date, the message [xxx will be overwritten, OK?] appears. If you press F4 YES, the vision log of that date is deleted from the external device before the export begins. If you press F5 NO, the export is canceled.

To cancel the export, press F5 CANCEL. Pressing F5 CANCEL displays the prompt [Operation will be cancelled, OK?]. If you press F4 YES, the export is canceled. If you press F5 NO, the export is continued.

10.3.3 Exporting Vision Logs of All Dates

To export all vision log data stored in the robot controller, take the following steps:

1. Press [F→] and then F2 ALL EXP. The export begins.
2. When the export completes, the message [All log export succeeded.] appears.

If the external device contains any vision log of the same date, the message [xxx will be overwritten, OK?] appears for each date in question. If you press F4 YES, the vision log of that date is deleted from the external device before the export begins. If you press F5 NO, the export is canceled.

To cancel the export, press F5 CANCEL. Pressing F5 CANCEL displays the prompt [Operation will be cancelled, OK?]. If you press F4 YES, the export is canceled. If you press F5 NO, the export is continued.

10.3.4 Deleting a Vision Log of a Specified Date

To delete one day worth of vision log on the robot controller, take the following steps:

1. Place the cursor on the date of the vision log you want to delete.
2. Press F4 DELETE.

3. The prompt [Log xxxx will be deleted, OK ?] appears. If you press F4 YES, the vision log of the selected date is deleted. If you press F5 NO, the deletion operation is canceled.
4. When the deletion operation is complete, the message [Log deletion succeeded.] appears.

To cancel the ongoing deletion operation, press F5 CANCEL. The prompt [Operation will be cancelled, OK?] appears. If you press F4 YES, the deletion operation is canceled. If you press F5 NO, the deletion operation is resumed.

10.3.5 Deleting Vision Logs of All Dates

To delete all vision logs stored in the robot controller, take the following steps:

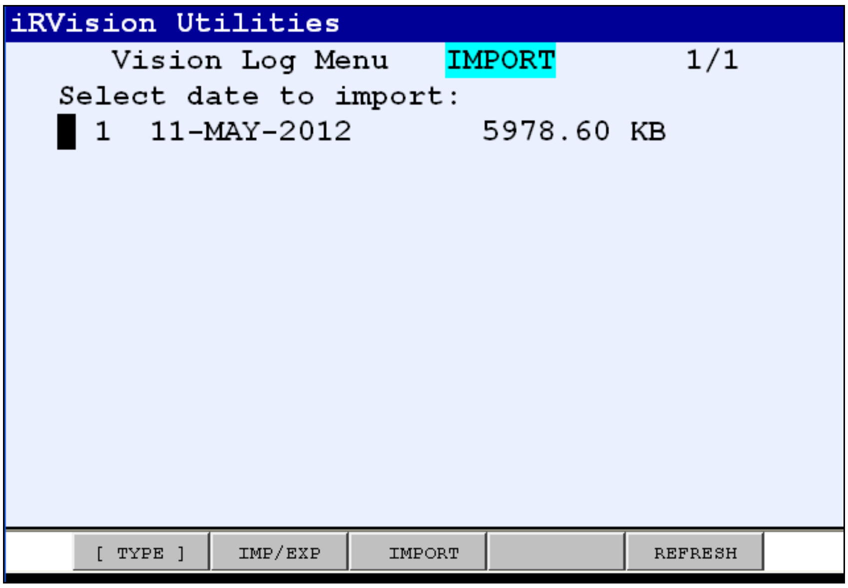
1. Press [F→] and then F2 ALL DEL.
2. The message [All logs will be deleted, OK?] appears. If you press F4 YES, the deleting all vision logs is stared. If you press F5 NO, the deletion operation is canceled.
3. When all vision logs have been deleted successfully, the message [All log deletion succeeded.] appears.

To cancel the ongoing deletion operation, press F5 CANCEL. Pressing F5 CANCEL displays the prompt [Operation will be cancelled, OK?]. If you press F4 YES, the deletion operation is canceled. If you press F5 NO, the deletion operation is resumed.

10.3.6 Importing a Vision Log of a Specified Date

To import one day worth of vision log exported to the external device, take the following steps:

1. Press F2 IMP/EXP. A vision log import menu like the one shown below appears.



> ⚠ **CAUTION**
> This menu does not appear if the specified external device does not contain any vision log.

2. Place the cursor on the date of the vision log you want to import.
3. Press F3 IMPORT. The import begins.
4. When the import is complete, the message [Log import succeeded.] appears.

If the controller contains any vision log of the same date, the message [xxx will be overwritten, OK?] appears. If you press F4 YES, the vision log of that date stored in the controller is deleted before the import begins. If you press F5 NO, the import is canceled.

To cancel the import, press F5 CANCEL. The prompt [Operation will be cancelled, OK?] appears. If you press F4 YES, the import is canceled. If you press F5 NO, the import is continued.

10.3.7 Refreshing the Display

Pressing F5 REFRESH refreshes the list of vision logs so as to show the latest information.

10.3.8 File Configuration of the Exported Vision Log

By default, when a vision log is exported, a sub-folder named the export date is created under the specified external device path, for instance:

UD1:\VISION\EXLOG\Y12APR10\ …Vision log for April 10, 2012

Under the sub-folder for the sub-folder of each day, three types of files are saved.

.VL Logged data file
.BMP Logged image file(Original Image)
.PNG Logged image file(Graphics)

⚠ **CAUTION**

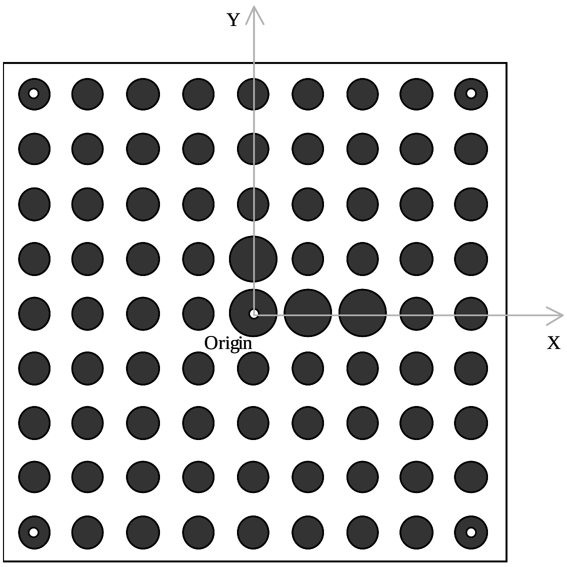
If the directory structure of exported vision log files and logged image files is changed, or if any of these exported files is renamed, the correspondence between vision logs and logged images is lost, making it impossible to identify logged images with dates. When you copy or move an exported vision log or logged image, do not change the directory structure or file name.

11 CALIBRATION GRID

This chapter provides information about a calibration grid used for *i*RVision camera calibration.

11.1 CALIBRATION GRID

*i*RVision performs camera calibration by using a calibration grid on which a predetermined pattern is drawn. When a grid as shown below is viewed through the camera, *i*RVision will automatically recognize the positional relationship between the calibration grid and the camera, lens distortion, focal distance, etc.



All of the black circles are arranged so that they are uniformly spaced horizontally and perpendicularly. Four larger black circles placed in the vicinity of the center indicate the origin and directions of a coordinate system as shown. The ratio of the diameter of a large circle to that of a small circle is about 10:6.

The grid points at the center and the four corners contain a white circle with a diameter of 1 mm. These white circles are used when a coordinate system is set up by touching up them with the TCP of the robot.

11.2 CALIBRATION GRID FRAME

The calibration grid might be secured to a table or another place or mounted on the robot end of arm tooling according to the applications. In either case, when camera calibration is performed, it is necessary to set information about the installation position of the calibration grid as viewed from the robot. That information is called the *calibration grid frame*. This section describes how to teach the calibration grid frame.

When the calibration grid is mounted to a fixed surface, the position of the calibration grid frame relative to the robot base frame should be set in the user frame area. On the other hand, when the calibration grid is mounted on a robot, the position of the calibration grid frame relative to the robot mechanical interface frame (robot face plate) should be set in the user tool area.

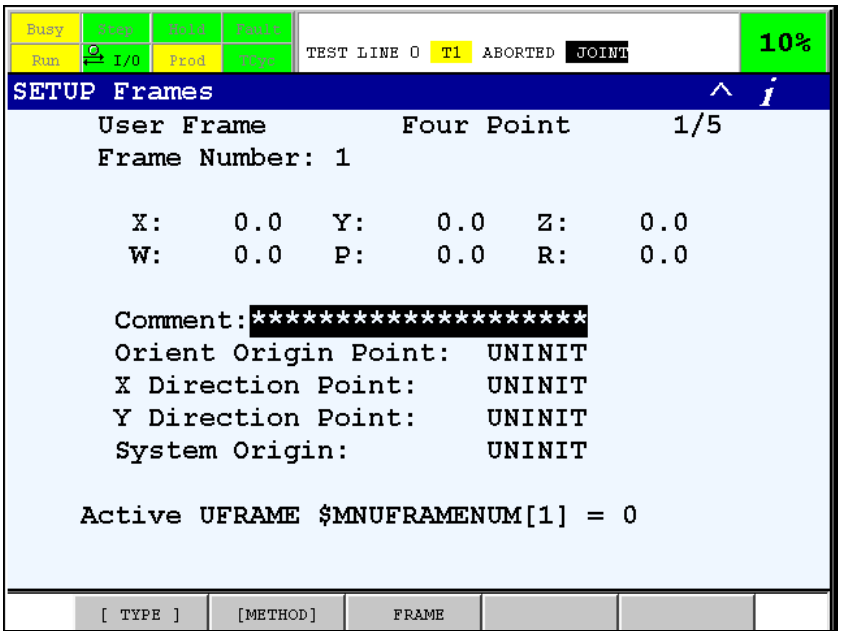
Two methods of setting the calibration grid frame are available: With one method, the calibration grid frame is set by physically teaching the calibration grid with a pointer attached on the robot end of the arm tooling. With the other method, the calibration grid frame is set by measuring the grid pattern with a camera without contact. In the following subsections, these two methods are explained.

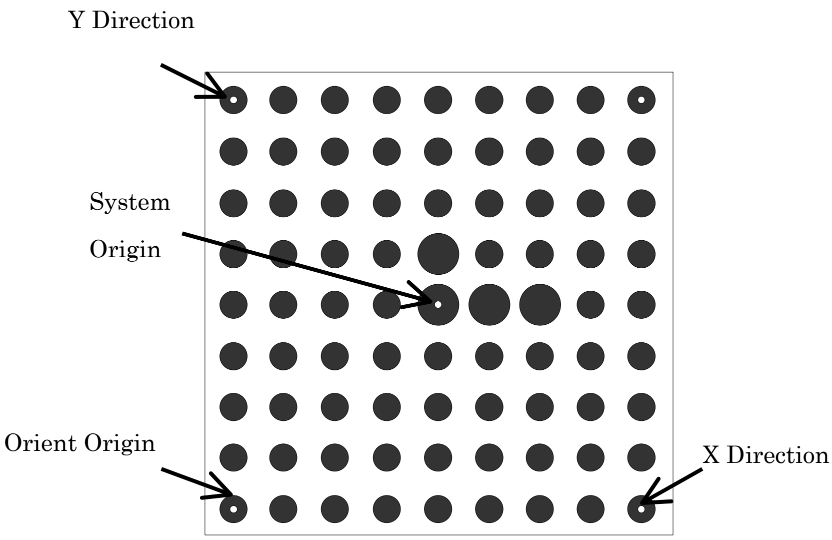
11.2.1 Setting Based on Touch-up

This section explains how to set the calibration grid frame with the legacy method, namely physically touching-up the calibration grid with a pointer mounted on a robot end of the arm tooling.

When the calibration grid is secured to a fixed surface

When the calibration grid is installed in a fixed place, the position of the calibration grid frame relative to the robot base frame should be set in the user frame area. After a pointer for touch-up is mounted on the robot end of the arm tooling and TCP is set to the tip of the pointer, select [User Frame Setup / Four Points], and teach the four points shown in the figure below by touch-up operation with the TCP of the robot.

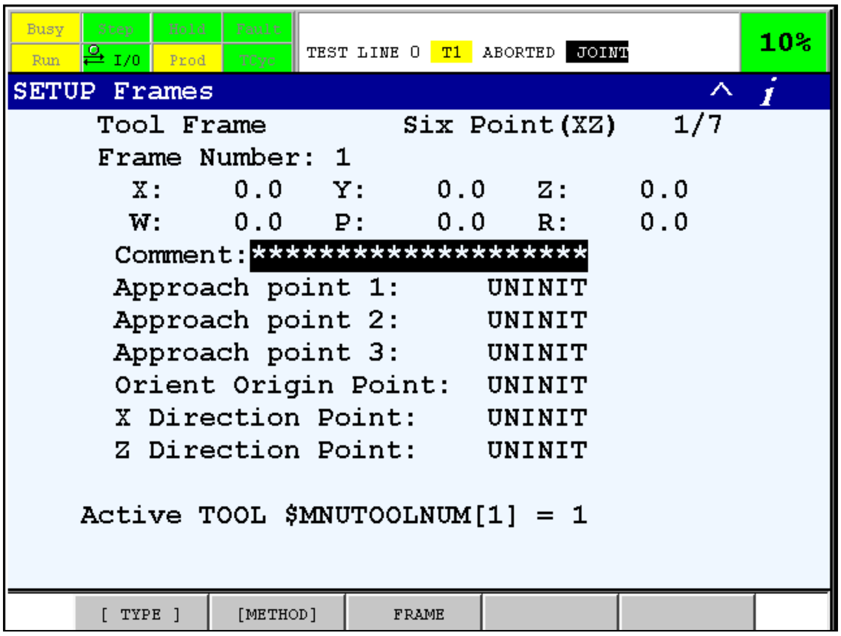


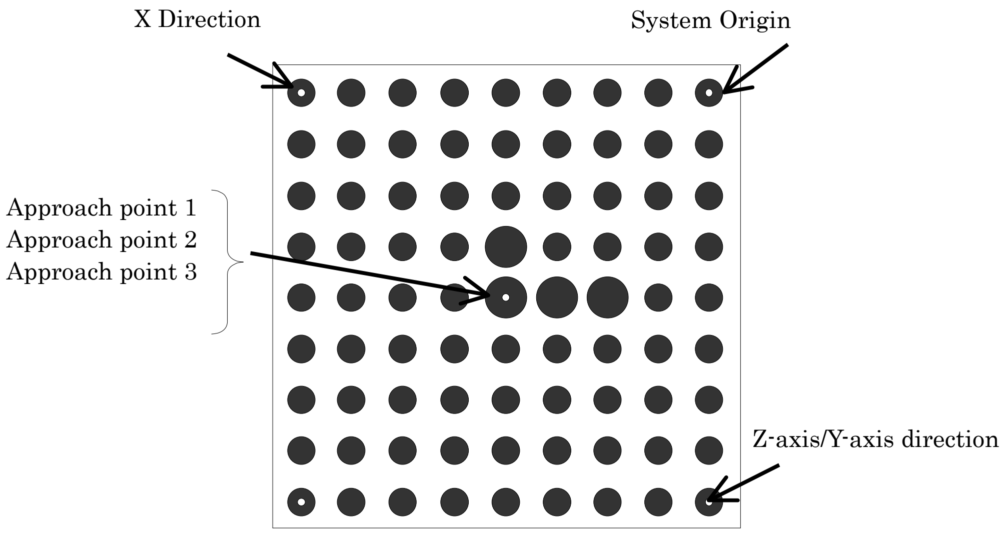


When the calibration grid is mounted on the robot end of arm tooling

When the calibration grid is mounted on the robot end of arm tooling, the position of the calibration grid frame relative to the robot mechanical interface frame (robot face plate) should be set in the user tool area. After the pointer for touch-up is secured to a secured table, select [Tool Frame Setup / Six Point(XY)] or [Tool Frame Setup / Six Point(XZ)], and teach the six points shown in the figure below by touch-up operation.

The user tool set using the [Tool Frame Setup / Six Point(XZ)] method is rotated by 90 degrees about the X-axis with respect to a desired coordinate system. Upon completion of setting the user tool frame by touch-up operation, **manually enter the value of W plus 90**. The three approach points must have different robot posses. Ideally two of the approach points are close to 180 degrees from each other rotated about tool Z.





11.2.2 Setting Based on Measurement with a Camera

Please refer the Grid Frame Setting function described in Section 10.2, "Grid Frame Setting".

12 OTHER OPTIONS

This chapter describes other software options, which occasionally used with *i*RVision.

12.1 VISION SUPPORT TOOLS

Vision Support Tools are software option consisting of a set of tools intended to support a vision-based robot system. Using these tools, you can have the KAREL programs installed to the controller and run those programs by means of the relevant call commands.

Offset calculation

Special offset calculation mechanisms are provided that cannot be supported by the standard functions.
OFS_RJ3, MATRIX, INVERSE, MERGE3D2, and STVS1

Saving and restoration of position register data

Functions to store and restore 1000 position registers' worth of data are provided.
SAVENOM and LOADNOM

Offset adjustment

A function is provided that allows the offset error to be adjusted with ease.
ADJ_OFS

Sorting of found results

A function is provided that sorts found results.
SORT_RJ3

Offset position checking

A function is provided that checks whether the offset position is within the valid range of robot motion.
CHK_POS

Vision Log

Functions are provided that change the vision log folder and delete old vision logs.
VL_EXPORT

Restrictions

- These functions are included in the vision support tool option.
- To use these functions, be sure to set the system variable $KAREL_ENB to 1.
- The position register formats that you can specify for these tools are the XYZWPR format, matrix format, XYZWPR format with an additional axis, and matrix format with an additional axis. Position registers of the joint format are not supported. If the specified position register is of the joint format, an error occurs.
- If the position register specified by any of these tools has not been initialized (the value in the position register is ******), an error occurs.

Behavior at the time of an error

All the KAREL programs have an argument that specifies "the register number to store the error number". This argument can be omitted in most of the KAREL programs. How a KAREL program behaves if an error occurs during the execution of the program differs depending on whether "the register number to store the error number" is specified or not.

When "the register number to store the error number" is specified, 0 is stored in the specified register if the program ends normally. If an error occurs, the corresponding error code is stored in the specified register and an error message appears in the upper part of the teach pendant screen.

If an error occurs when "the register number to store the error number" is omitted, the program is forced to end and the user screen displays a message describing the error. Note that this argument cannot be omitted in CHK_POS and STVS1.

12.1.1 OFS_RJ3

This program calculates offset data based on the found position and reference position stored in position registers. The robot can perform offset operations using the offset data calculated by OFS_RJ3. Since *i*RVision normally calculates offset data within the vision process, it is not necessary to use OFS_RJ3. Use this program when you need any offset mode that is not supported by vision processes.

Argument 1:Register number

Specify the number of the register storing a flag that indicates whether to set the reference position. When 1 is set in the specified register, the found position will be set as the reference position in the position register specified by argument 4. When 0 is set, the reference position will not be set.

Argument 2:Position register number

Specify the number of the position register storing the found position of the first camera.

Argument 3:Position register number

Specify the number of the position register storing the found position of the second camera.

Argument 4:Position register number

Specify the number of the position register that currently stores the reference position or that will store the reference position.

Argument 5:Position register number

Specify the number of the position register to store the calculated fixed frame offset data of the sensor A format.

Argument 6:Position register number

Specify the number of the position register to store the calculated fixed frame offset data of the sensor B format.

Argument 7:Position register number

Specify the number of the position register to store the calculated tool offset data.

Argument 8:Register number

Specify the number of the position register to store the error number. This argument can be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: The program ended normally.
501: A required argument is not specified.

502: An invalid argument is specified.
503: The nominal flag is invalid.
504: Data cannot be written to the specified register.
505: The format of the specified position register failed to be acquired.
506: The format of the specified position register is invalid.
507: The specified position register cannot be read.
508: The specified position register has not been initialized.
509: Offset data failed to be calculated (the two points are too close to each other).
510: Data cannot be written to the specified position register.

Usage example 1

This is an example where one camera is used to find a workpiece and fixed frame offsetting is performed for the robot according to the calculated offset data of the sensor A type.

```
11:     CALL OFS_RJ3(P1,P2,0,P4,P5,0,0)
12: L P[1] 1000mm/sec FINE OFFSET,PR[P5]
```

Usage example 2

This is an example where one camera is used to find a workpiece and fixed frame offsetting is performed for the robot according to the calculated offset data of the sensor B type (the offset data of the sensor A type is referenced). Since fixed frame offsetting is performed using the sensor B format, the format of the position register used for the fixed frame offset command is converted to the matrix format, by copying the offset data to the user frame and then copying it back to the position register.

```
11:     CALL OFS_RJ3(P1,P2,0,P4,P5,P6,0)
12:     UFRAME[9]=PR[P6]
13:     PR[n]=UFRAME[9]
14: L P[1] 1000mm/sec FINE OFFSET,PR [n]
```

Usage example 3

This is an example where one camera is used to find a workpiece and fixed frame offsetting is performed for the robot according to the offset data of the sensor B type (the offset data of the sensor A type is not referenced). Since fixed frame offsetting is performed using the sensor B format, the format of the position register used for the fixed frame offset command is converted to the matrix format, by copying the offset data to the user frame and then copying it back to the position register.

```
11:     CALL OFS_RJ3(P1,P2,0,P4,0,P6,0)
12:     UFRAME [9]=PR[P6]
13:     PR[n]= UFRAME [9]
14: L P[1] 1000mm/sec FINE OFFSET,PR[n]
```

Usage example 4

This is an example where one camera is used to find a workpiece and tool offsetting is performed for the robot.

```
11:     CALL OFS_RJ3(P1,P2,0,P4,0,0,P7)
12:     UFRAME[9]=PR[P7]
13:     PR[n]=UFRAME[9]
14: L P[1] 1000mm/sec FINE TOOL_OFFSET,PR[n]
```

Usage example 5

This is an example where two cameras are used to find one workpiece, or one hand camera is used to find two positions on one workpiece, to perform fixed frame offsetting for the robot (offset data of the sensor A type). The two found positions are merged to generate one set of position data. Found positions that can be input are the 2D data of X, Y, and R. The merged position data are also the 2D data of X, Y, and R. X, Y, and R in the merged position data represent an intermediate point between the two positions. To generate 3D data, use MERGE3D2.

```
11:   CALL OFS_RJ3(P1,P2,P3,P4,P5,0,0)
12: L PR[1] 1000mm/sec FINE OFFSET,PR[P5]
```

Usage example 6

This is an example where two cameras are used to find one workpiece, or one hand camera is used to find two positions on one workpiece, to perform fixed frame offsetting for the robot (offset data of the sensor B type). The two found positions are merged to generate one set of position data. Found positions that can be input are the 2D data of X, Y, and R. The merged position data are also the 2D data of X, Y, and R. X, Y, and R in the merged position data represent an intermediate point between the two positions. To generate 3D data, use MERGE3D2.

```
11:   CALL OFS_RJ3(P1,P2,P3,P4,0,P6,0)
12:   UFRAME[9]=PR[P6]
13:   PR[n]=UFRAME[9]
14:   L P[1] 1000mm/sec FINE OFFSET,PR[n]
```

Usage example 7

This is an example where two cameras are used to find one workpiece, or one hand camera is used to find two positions on one workpiece, to perform tool offsetting for the robot. The two found positions are merged to generate one set of position data. Found positions that can be input are the 2D data of X, Y, and R. The merged position data are also the 2D data of X, Y, and R. X, Y, and R in the merged position data represent an intermediate point between the two positions. To generate 3D data, use MERGE3D2.

```
11:   CALL OFS_RJ3(P1,P2,P3,P4,0,0,P7)
12:   UFRAME[9]=PR[P7]
13:   PR[n]=UFRAME[9]
14:   L P[1] 1000mm/sec FINE TOOL_OFFSET,PR[n]
```

12.1.2 MATRIX

This program regards the position register values given in the XYZWPR or matrix format as a homogeneous transform matrix and calculates the product of that matrix. When the input matrixes are A and B and the output matrix is C, the program calculates the equation C = AB.

Argument 1:Position register number

Specify the number of the position register storing input matrix A.

Argument 2:Position register number

Specify the number of the position register storing input matrix B.

Argument 3:Position register number

Specify the number of the position register storing input matrix C.

Argument 4:Register number

Specify the number of the position register to store the error number. This argument can be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.
301: A required argument is not specified.
302: An invalid argument is specified.
303: An invalid argument is specified.
304: Data cannot be written to the specified register.
305: The format of the specified position register failed to be acquired.
306: The format of the specified position register is invalid.
307: The specified position register cannot be read.
308: The specified position register has not been initialized.
309: Data cannot be written to the specified position register.

Usage example 1

This is an example where the user frame is shifted using 2D offset data. The robot motion can be offset without adding the fixed frame offset command to the motion command.

```
 1:  VISION RUN_FIND VISION1
 2:  VISION GET_OFFSET VISION1 VR[1] JUMP,LBL[99]
 3:  PR[20]=VR[1].OFFSET
 4:  PR[30]=UFRAME[2]
 5:  CALL MATRIX(20,30,40)
 6:  UFRAME[3]=PR[40]
 7:
 8:  UFRAME_NUM=3
 9:  UTOOL_NUM=1
10: L P[1] 100mm/sec FINE
11: L P[2] 100mm/sec FINE
12: L P[3] 100mm/sec FINE
```

Line 3 The offset data of the sensor B type is calculated in position register [20].
Line 5 The shifted user frame is calculated in position register [40].
Line 10 Since user frame No. 3 itself is shifted, the vision offset is applied to the operation.

Usage example 2

This is an example where the reference position is calculated back from the offset data and found position stored in the vision register. In this example, the reference position is stored in position register [1].

```
VISION RUN_FIND VISION1
VISION GET_OFFSET VISION1 VR[1] JUMP,LBL[99]
PR[1]=VR[1].FOUND_POS[1]
PR [2]=VR[1].OFFSET
CALL INVERSE(2,2)
CALL MATRIX(2,1,1)
```

Usage example 3

This is an example where the offset robot position is calculated.
It is assumed that the robot moves to the position that is offset by the following motion command:

```
L P[10] 500mm/sec FINE VOFFSET,VR[1];
```

```
1:  VISION RUN_FIND VISION1
2:  VISION GET_OFFSET VISION1 VR[1] JUMP,LBL[99]
3:  PR[21]=VR[1].OFFSET
4:  PR[20]=P[10]
5:  CALL MATRIX(21,20,22)
```

Line 4: The position of P[10] and the offset data of the vision register are copied to the position register.

Line 5: Multiply the position with the offset data. The offset position is stored in position register [22].

12.1.3 INVERSE

This program regards the position register values given in the XYZWPR or matrix format as a homogeneous transform matrix and calculates the inverse matrix of the input matrix. When the input matrix is A and the output matrix is B, the program calculates the equation $B=A^{-1}$.

Argument 1:Position register number

Specify the number of the position register storing input matrix A.

Argument 2:Position register number

Specify the number of the position register storing input matrix B.

Argument 3:Register number

Specify the number of the position register to store the error number. This argument can be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: The program ended normally.
201: A required argument is not specified.
202: An invalid argument is specified.
203: An invalid argument is specified.
204: The format of the specified position register failed to be acquired.
205: The format of the specified position register is invalid.
206: The specified position register cannot be read.
207: The specified position register has not been initialized.
208: Data cannot be written to the specified position register.
209: Data cannot be written to the specified register.

Usage example 1

This is an example where the matrix format of a position register is converted to the XYZWPR format. Executing INVERSE twice, as shown below, converts the matrix format of position register No. 1 to the XYZWPR format.

```
11:  CALL INVERSE(1, 2)
12:  CALL INVERSE(2, 1)
```

12.1.4 MERGE3D2

This program conducts 3D measurements at two or three positions on one workpiece and merges the results of those measurements to calculate the position and orientation of the entire workpiece. OFS_RJ3 generates 2D data, while MERGE3D2 generates 3D data.

Argument 1:Position register number

Specify the number of the position register storing 3D measurement results.

Argument 2:Position register number

Specify the number of the position register storing 3D measurement results.

Argument 3:Position register number

Specify the number of the position register storing 3D measurement results.

Argument 4:Position register number

Specify the number of the position register storing 3D measurement results.

Argument 5:Position register number

Specify the number of the position register to store generated 3D position data.

Argument 6:Register number

Specify the number of the position register storing the heights of the first and second points. This argument can be omitted. Note that argument 6 is required when argument 7 is specified.

Argument 7:Register number

Specify the number of the position register to store the error number. This argument can be omitted.

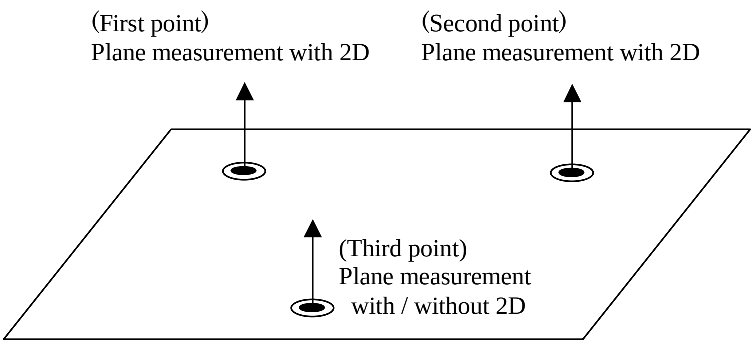
For information about how to specify arguments 1 to 4, see usage examples 1 to 3.

When the first point is measured as a 3D position and the second point is measured as a 3D gaze line (see usage example 3 below), the second point must normally be on the same plane (same height) as point 1. Otherwise, specify a register number in argument 6 and set the height difference between points 1 and 2 in that register.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: The program ended normally.
401: A required argument is not specified.
402: An invalid argument is specified.
403: The plane is parallel to the line.
404: The two points are too close to each other.
405: The two points are too far away from the plane.
406: The combination of arguments is invalid.
407: Data cannot be written to the specified register.
408: The format of the specified position register failed to be acquired.
409: The format of the specified position register is invalid.
410: The specified position register cannot be read.
411: The specified position register has not been initialized.
412: Data cannot be written to the specified position register.
413: The specified register cannot be read.

Usage example 1

This is an example where the 3D position of the entire work is calculated from three 3D positions.

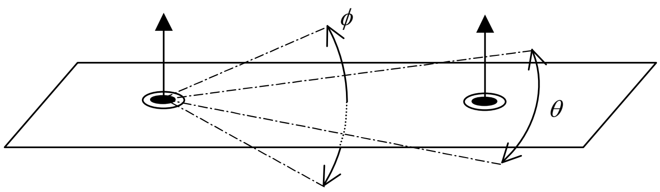


The example calculates a coordinate system in which the first, second, and third points are determined as the origin, an X direction point, and an XY plane point, respectively.

```
11:    CALL MERGE3D2(P1, P2, P3, 0, P5)
```

Usage example 2

This is an example where a coordinate system is calculated from two 3D position/posture values.

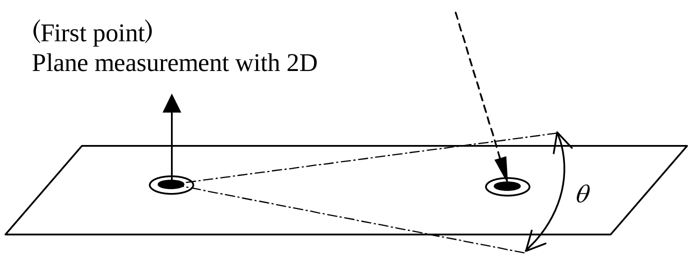


The example calculates a coordinate system in which the first point is determined as the origin, the direction connecting the first and second points is determined as the X axis, and the plane including the normal line of the first point and the just mentioned X axis is determined as the XY plane point. The second point determines the phase along the Z axis. This is effective for a large panel or other type of workpiece that has a severe phase requirement for the Z axis.

```
11:    CALL MERGE3D2(P1, P2, 0, 0, P5)
```

Usage example 3

This is an example where a coordinate system is calculated from one 3D position/posture value and one 3D gaze line.



Of the two points, the one that gives the 3D position/posture value is the first point, and the point where the XY plane of the first point intersects the 3D gaze line is internally regarded as the second point. The example calculates a coordinate system in which the first point is determined as the origin, the normal line of the first point is determined as the Z axis, and the second point is determined as the XY plane point. The second point determines the phase along the Z axis. This is effective for a large panel or other type of workpiece that has a severe phase requirement for the Z axis. Although it is similar to usage example 2, the method shown in usage example 3 is used in cases where 3D position/posture measurement cannot be done for the second point.

```
11:    CALL MERGE3D2(P1, 0, 0, P4, P5)
```

> ⚠ **CAUTION**
> In case of calculating a coordinate system from two position data, if one point is on the normal line of another point, calculation cannot be done, and an error occurs.

12.1.5 LOADNOM and SAVENOM

If the free space of a position register is insufficient, the data in that position register can be saved.
The total number of position registers that can be saved is 1470 - 30 position registers multiplied by 49 tables. Register data is saved and restored on a table-by-table basis.

SAVENOM

This program saves position register data.

Argument 1: Table number

Specify the number of the table to which to save data. The specifiable value range is 1 to 49.

Argument 2: Number of position registers

Specify the number of position registers to save. The specifiable value range is 1 to 30.

Argument 3:Position register number

Specify the number of the first position register to save.

Argument 4:Register number

Specify the number of the position register to store the error number. This argument can be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: The program ended normally.
701: A required argument is not specified.
702: An invalid argument is specified.
703: An invalid argument is specified.
704: The format of the specified position register failed to be acquired.
705: The format of the specified position register is invalid.
706: The specified position register cannot be read.
707: The specified position register has not been initialized.
708: Data cannot be written to the specified register.

LOADNOM

This program restores saved data to one or more position registers.

Argument 1: Table number

Specify the number of the table whose data is to be restored. The specifiable value range is 1 to 49.

Argument 2: Number of position registers

Specify the number of position registers to which to restore saved data. The specifiable value range is 1 to 30.

Argument 3:Position register number

Specify the number of the first position register to which to restore saved data.

Argument 4:Register number

Specify the number of the position register to store the error number. This argument can be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.
601: A required argument is not specified.
602: An invalid argument is specified.
603: An invalid argument is specified.
604: Data cannot be written to the specified position register.
605: Data cannot be written to the specified register.
606: The format of the specified position register failed to be acquired.
607: The format of the specified position register is invalid.
608: The specified table does not have any saved data.

Usage example 1

This is an example where the data of 10 position registers, [31] to [40], is saved to table 1 and then restored.

```
  3:    CALL SAVENOM(1,10,31)
         :
 27:    CALL LOADNOM(1,10,31)
```

Backup of the variable

The saved data is stored in the KAREL variable defined in the KAREL program SAVENOM. If you choose to save all files on the file screen, the saved data is saved in a file named SAVENOM.VR.

12.1.6 ADJ_OFS

When a system performs 2D compensation, there may be cases where the system accomplishes fixed frame offsetting properly if the workpiece only moves horizontally without rotating, whereas an invalid fixed frame offset result is obtained if the workpiece rotates. The reason for this is that the coordinate system that the vision process recognizes through camera calibration does not match the user frame of the robot. To solve this problem:

1 After resetting the touch-up pin TCP for setting the coordinate system, reset the user frame, camera calibration, and reference position, and re-teach the robot position.
2 If the fixed frame offset result is still invalid, perform vision mastering for the robot and then take step 1.

This procedure may not be viable.
In that case, using ADJ_OFS can improve the situation.

Argument 1: Type of the register storing offset data

Specify the type of register. Set 1 for a vision register and 2 for a position register.

Argument 2: Vision register or position register number

Specify the number of the vision register or position register storing offset data.

Argument 3: Position register number

Specify the number of the position register storing the amount of adjustment.

Argument 4: Vision register or position register number

Specify the number of the vision register or position register to store adjusted offset data.

Argument 5: Register number

Specify the number of the position register to store the error number. This argument can be omitted.

You can specify the same number in arguments 2 and 4.

If the register storing offset data is a position register, namely if 2 is set in argument 1, the format of the position register specified in argument 4 is automatically converted to the XYZWPR format.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.
101: A required argument is not specified.
102: An invalid argument is specified.
103: The specified register type is invalid.
104: Data cannot be written to the specified register.
105: The specified vision register cannot be read.
106: Data cannot be written to the specified vision register.
107: The format of the specified position register failed to be acquired.
108: The format of the specified position register is invalid.
109: The specified position register cannot be read.
110: The specified position register has not been initialized.
111: Data cannot be written to the specified position register.

Usage example 1

This is an example where the offset data stored in vision register [1] is adjusted using the amount of adjustment stored in position register [11] and the adjusted offset data is output to vision register [2]. The adjusted offset data stored in vision register [2] is used to offset the robot position. If an error occurs, the program jumps to label [99].

```
11:    CALL ADJ_OFS(1, 1, 11, 2, 3)
12:    IF R[3]<>0, JUMP,LBL[99]
13: L P[1] 100mm/sec FINE VOFFSET,VR[2]
```

Setting of the amount of adjustment

Set the amount of adjustment as follows:

1. Set XYZWPR=(0, 0, 0, 0, 0, 0) in the position register that stores the amount of adjustment.
2. Place the workpiece in the camera's field of view at the same angle as when the reference position was set, and then run the program.
3. Touch up the workpiece using the robot.
4. If the position is invalid, subtract the offset value and re-teach the position.
5. Replace the workpiece by rotating it by 180 degrees, and then run the program.
6. Touch up the workpiece again using the robot.
7. If the touched up position is 10 mm off the expected position in the X direction, set half of 10 mm - 5 mm - in X of the position register that stores the amount of adjustment.
8. Set Y in the same way.

Repeating steps 5 to 8 determines the amount of adjustment.

⚠**CAUTION**
When ADJ_OFS handles a vision register, ADJ_OFS modifies only the offset data (XYZWPR) in the vision register specified by the argument 4. ADJ_OFS does not modify the other data in the vision register.
So, when different vision register numbers are specified for the argument 2 and 4, if the user frame number specified in those vision registers are different, the robot cannot be offset properly. Correct the user frame number of the output vision register to be the same as the one of the input vision register in advance.

12.1.7 SORT_RJ3

This program sorts a position register storing found results of a vision process according to a specified sorting method. There are 13 specifiable sorting methods, as described later.

Argument 1: Sorting method

Specify the sorting method. The specifiable value range is 1 to 4, 11 to 18, and 21.

Argument 2: Register number

Specify the number of the register storing the number of found results to be sorted.

Argument 3: Start number of the position register to sort

Specify the start number of the position register storing the found results to be sorted.

Argument 4: X-direction diameter or width of the workpiece

Specify the X-direction diameter or width of the workpiece in mm. This argument is required when the value set in argument 1 is 11 to 14. Otherwise, specify 0.

Argument 5: Y-direction diameter or width of the workpiece

Specify the Y-direction diameter or width of the workpiece in mm. This argument is required when the value set in argument 1 is 15 to 18. Otherwise, specify 0.

Argument 6: Position register number

Specify the number of the position register storing the specified position when the value set in argument 1 is 21. Sorting begins with the workpiece that is closest to this point. When the value set in argument 1 is not 21, specify 0.

Argument 7: Register number

Specify the number of the register storing the flag that indicates whether to sort a register. If you set 1 in the register specified here, when a position register is sorted, the register having the same number is sorted as well. Use this argument in such cases as when you want to sort the model IDs stored in a register in addition to position data. The argument can be omitted. Note that argument 7 is required when argument 8 is specified.

Argument 8: Register number

Specify the number of the position register to store the error number. This argument can be omitted.

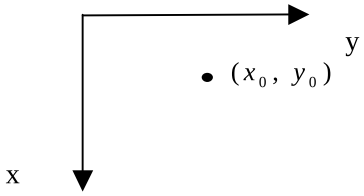
In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.
1201: A required argument is not specified.
1202: An invalid argument is specified.

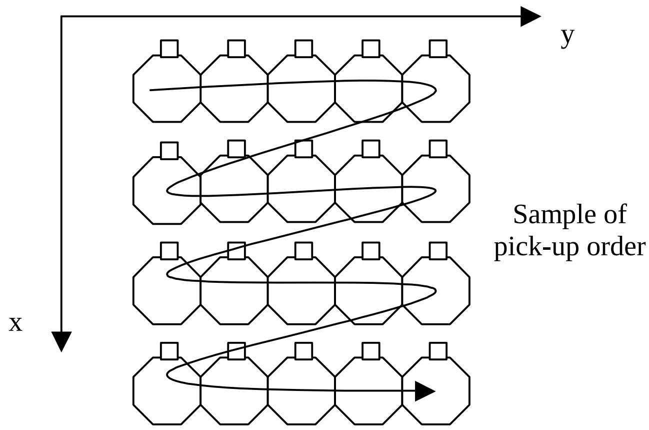
1203: The register storing the number cannot be read.
1204: The format of the register storing the number is invalid.
1205: The number is 0.
1206: The register storing the start number cannot be read.
1207: The format of the specified position register failed to be acquired.
1208: The format of the specified position register is invalid.
1209: The specified position register cannot be read.
1210: Data cannot be written to the specified position register.
1211: The format of an argument is invalid.
1212: The format of an argument is invalid.
1213: The value of the argument must be 0.
1214: The value set in the specified register must be 0.
1215: The value set in the argument must be greater than 0.
1216: The value set in the argument must be greater than 0.
1217: The value set in the argument must be greater than 0.
1218: There is an invalid argument.
1219: The format of the specified position register failed to be acquired.
1220: The format of the specified position register is invalid.
1221: The specified position register cannot be read.
1224: The specified position register has not been initialized.

In argument 1, specify one of the values shown below that corresponds to the desired sorting method.

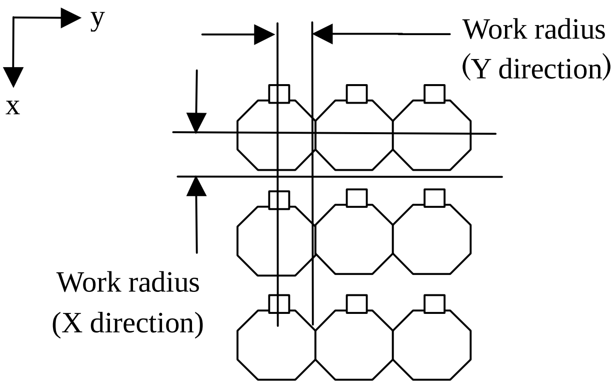
1. The position register is sorted, beginning with the workpiece whose X value is the largest.
2. The position register is sorted, beginning with the workpiece whose X value is the smallest.
3. The position register is sorted, beginning with the workpiece whose Y value is the largest.
4. The position register is sorted, beginning with the workpiece whose Y value is the smallest.



From 11 to 18
Use these values when you want to have orderly aligned workpieces picked up sequentially, as shown below. A total of eight different pick-up methods are defined, each corresponding to a distinct pick-up order.

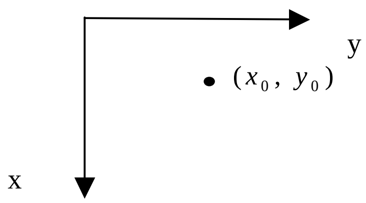


To pick up workpieces on a line-by-line (column-by-column) basis, a workpiece is first selected whose position data X (Y) is the smallest (the largest). Those workpieces that are within the X-direction (Y-direction) radius (half the width) of this workpiece are then selected as a line (row) (see the figure below). This group of workpieces is sorted in the ascending (descending) order of the Y (X) value. By repeating this process for the remaining workpiece groups, you can sort the workpieces on a line-by-line (column-by-column) basis.



11. Workpieces are sorted in the ascending order of the X value on a line-by-line basis. Workpieces on the same line are sorted in the ascending order of the Y value. The value specified in argument 4 is used as the X-direction radius (half the width) of the workpiece.
12. Workpieces are sorted in the ascending order of the X value on a line-by-line basis. Workpieces on the same line are sorted in the descending order of the Y value. The value specified in argument 4 is used as the X-direction radius (half the width) of the workpiece.
13. Workpieces are sorted in the descending order of the X value on a line-by-line basis. Workpieces on the same line are sorted in the ascending order of the Y value. The value specified in argument 4 is used as the X-direction radius (half the width) of the workpiece.
14. Workpieces are sorted in the descending order of the X value on a line-by-line basis. Workpieces on the same line are sorted in the descending order of the Y value. The value specified in argument 4 is used as the X-direction radius (half the width) of the workpiece.
15. Workpieces are sorted in the ascending order of the Y value on a column-by-column basis. Workpieces on the same column are sorted in the ascending order of the X value. The value specified in argument 5 is used as the Y-direction radius (half the width) of the workpiece.
16. Workpieces are sorted in the ascending order of the Y value on a column-by-column basis. Workpieces on the same column are sorted in the descending order of the X value. The value specified in argument 5 is used as the Y-direction radius (half the width) of the workpiece.
17. Workpieces are sorted in the descending order of the Y value on a column-by-column basis. Workpieces on the same column are sorted in the ascending order of the X value. The value specified in argument 5 is used as the Y-direction radius (half the width) of the workpiece.
18. Workpieces are sorted in the descending order of the Y value on a column-by-column basis. Workpieces on the same column are sorted in the descending order of the X value. The value specified in argument 5 is used as the Y-direction radius (half the width) of the workpiece.

19. Workpieces are sorted in the ascending order of the value representing the square $(x_0 - x)^2 + (y_0 - y)^2$ of the distance from the point (x_0, y_0) specified in argument 6.



12.1.8 CHK_POS

Offsetting the robot position with *i*RVision may cause the robot to stop due to an alarm such as one that arises when the workpiece is outside the range of robot motion. This occurs, for example, if the workpiece is within the detection range of *i*RVision but outside the range of robot motion or if the robot cannot take the specified posture to pick up the workpiece. CHK_POS checks whether the robot can move to the offset position before it actually travels there. The use of CHK_POS ensures that *i*RVision proceeds to process the next workpiece smoothly without causing any alarm.

Argument 1: Group number

Specify the motion group number of the robot.

Argument 2: User frame number of the position data

Specify the user frame number of the position data you want to check.

Argument 3: Tool frame number of the position data

Specify the tool frame number of the position data you want to check.

Argument 4: Position register number

Specify the number of the position register storing the position data you want to check.

Argument 5: Position register number

Specify the number of the position register storing the fixed frame offset data.

Argument 6: Position register number

Specify the number of the position register storing the tool offset data.

Argument 7: Register number

Specify the number of the register to store the error number. This argument cannot be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.(The robot can move to the offset position.)
1301: A required argument is not specified.
1302: An invalid argument is specified.
1303: The specified user frame cannot be read.
1304: The specified tool frame cannot be read.
1305: Data cannot be written to the specified register.
1306: The system variable $MOR_GRP[x].$NIL_POS cannot be read.
1307: The format of the specified position register failed to be acquired.
1308: The format of the specified position register is invalid.
1309: The specified position register cannot be read.
1310: The specified position register has not been initialized.
Other: Alarm number indicating the reason why the robot cannot move to the offset position (e.g., 15018 - MOTN-018 Position not reachable).

Error codes from 1300 to 1399 indicate that an error has occurred during the execution of the tool. Other error codes are alarm codes that indicate the reason why the robot cannot move to the offset position.
An alarm code consists of two high-order digits representing an alarm ID and three low-order digits representing an alarm number. In the case of 15018, for example, the alarm ID is 15, which indicates an

operation alarm, and the alarm code is "MOTN-018". For details of the alarm codes, refer to the "R-30*i*B CONTROLLER OPERATOR'S MANUAL (Alarm Code List)".

Usage example 1

```
11: J P[1] 100% FINE
12:     PR[1]=P[2]
13:     CALL CHK_POS(1,0,1,1,2,0,1)
14:     IF R[1]<>0 JUMP,LBL [99]
15: L P[2] 2000mm/sec FINE OFFSET,PR [2]
16:     LBL[99]
```

Line 12 The taught position (pre-offset position) is copied to the position register.
Line 13 The group number is 1, the user frame number is 0, and the tool frame number is 1.
Line 14 If the robot cannot move to the offset position, the program jumps to label [99].
Line 15 If the robot can move to the offset position, the program lets it do so.

12.1.9 STVS1

Based on the result of finding one workpiece with two cameras, this function calculates the 3D position of that workpiece in a stereo fashion. Using the bin-pick search vision process to detect the gaze lines from the camera to the workpiece, STVS1 determines the 3D position (XYZ) of the workpiece through stereo calculation utilizing the two cameras' gaze line data and saves the position in a position register. In the vision processes for both of these cameras, the same user frame needs to be set as [Application UFrame].

Argument 1: Position register number

Specify the number of the position register storing the gaze line data of camera A.

Argument 2: Position register number

Specify the number of the position register storing the gaze line data of camera B.

Argument 3: Register number

Specify the number of the register storing the error limit of the distance between the two gaze lines from the two cameras to the workpiece. The distance between gaze lines is the length of a common line that is perpendicular to the two gaze lines. When the two gaze lines completely cross each other, the distance between them is 0. If they do not cross each other due to error, the distance between them is a positive value. The 3D position is calculated only when the distance between gaze lines is below the error limit specified here.

Argument 4: Position register number

Specify the number of the position register storing the calculated 3D position.

Argument 5: Register number

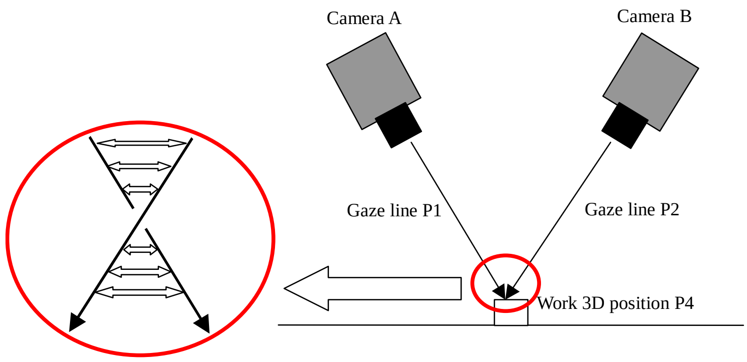
Specify the number of the position register to store the error number. This argument can not be omitted.

In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.
1401: A required argument is not specified.
1402: An invalid argument is specified.
1403: The data of the specified register failed to be obtained.
1404: Data cannot be written to the specified register.

1405: The format of the specified position register failed to be acquired.
1406: The format of the specified position register is invalid.
1407: The specified position register cannot be read.
1408: The specified position register has not been initialized.
1409: Data cannot be written to the specified position register.
1410: The camera inclination is too small.
1411: The gaze lines are too far apart from each other.

Usage example 1




```
11:    CALL STVS1(P1,P2,P3,P4,P5)
12:    IF R[P5]<>0 JUMP,LBL [999]
13:    CALL OFS_RJ3(1,P4,0,1,0,2,0)
14:    UFRAME [n]=PR[2]
15:    PR[2]=UFRAME[n]
16: L P[1] 4000mm/sec FINE OFFSET,PR [2]
```

12.1.10 VL_EXPORT

This KAREL program exports Vision Log and logged images to the specified external device. Export logs and logged images will be removed in the controller. All the logs and logged images will be exported. This KAREL program allows you to perform the same operation as the one described in 10.3 “VISION LOG MENU”. See also 10.3 “VISION LOG MENU” about setting the external device to export to.

The following arguments can be passed:

Argument 1: Register Number

Specify a register number in which the operation status is stored. If the export succeeded, 0 will be stored, otherwise a non-zero value will be stored. This is optional.

Argument 2: Timeout Time

Specify a timeout time in milliseconds. If the export does not complete within the time specified here, the export will be stopped. If all the logs can be exported, 0 will be stored in the register specified with the argument 1. If not all the logs can be exported, 1 will be stored in the register. This is optional.

Program Example 1

The following example exports vision logs just after a vision execution. The robot program execution will proceed after waiting for the completion of the export.

```
1:    VISION RUN_FIND 'VP1'
2:    CALL VL_EXPORT
```

Program Example 2

When processing time for the export takes more than 1000msec, which is specified with the argument 2, the program stops exporting and moves to the next line. And the error status 1 will be stored in R[5], which is specified with the argument 1.

```
1:    CALL VL_EXPORT(5,1000)
```

Program Example 3

The following example exports vision logs in a sub task of multitasking, and the main task continues its process without waiting for the completion of the export.

```
1:    RUN VL_EXPORT
```

12.2 DATA TRANSFER BETWEEN ROBOTS

Data Transfer Between Robots is software option that enables you to transfer data between robots over Ethernet. By calling KAREL program, you can transfer a numeric register or a position register to another robot controllers. This section introduces a part of this software option. For details, please refer to the "R-30*i*B CONTROLLER Software Option OPERATOR'S MANUAL"

> ⚠**CAUTION**
> Data Transfer Between Robots function is different from ROS Interface Packet over Ethernet (RIPE) function, which is introduced in the Section 3.6. Dedicated setting for this function is required separately.

12.2.1 RSETNREG, RSETPREG

These programs send a numeric resister or a position register to another robot controller.

RSETNREG

This program writes the data of a numeric register on this controller in a numeric register on another robot controller.

The following arguments can be passed:

Argument 1：Destination Robot

Specify the name of the destination robot controller.

Argument 2：Destination Register Number

Specify the numeric register number on the destination robot controller.

Argument 3：Source Register Number

Specify the numeric register number on this robot controller.

Argument 4 : Mode

Specify data to write.
0 to write numeric data and comment
1 to write numeric data only
2 to write comment only

RSETPREG

This program writes data of a position register on this controller in a position register on another robot controller.

The following arguments can be passed:

Argument 1 : Destination Robot

Specify the name of the destination robot controller.

Argument 2 : Destination Position Register Number

Specify the position register number on the destination robot controller.

Argument 3 : Destination Group Number

Specify the motion group number on the destination robot controller.

Argument 4 : Source Position Register Number

Specify the position register number on this robot controller.

Argument 5 : Source Group Number

Specify the motion group number on this robot controller.

Argument 6 : Mode

Specify data to write.
0 to write position data and comment
1 to write position data only

Program Example 1

The following example copies the vision offset from a vision register to a position register, and then sends the position register data to another robot controller.

```
1:    VISION RUN_FIND 'FIND1'
2:    VISION GET_OFFSET 'FIND1' VR[1] JUMP,LBL[99]
3:    PR[10]=VR[1].OFFSET
4:    CALL RSETPREG(ROBOT2,20,1,10,1,1)
5:    DO[1]=ON
```

This sample program sets DO[1] to ON in order to let the destination robot controller know. In this case, the destination robot should check that the position register is updated by observing the DI signal.

APPENDIX

A TEACHING FROM PC

You can set up *i*RVision by using a PC. This chapter describes how to setup a PC for *i*RVision and how to open *i*RVision pages on the PC.

A.1 CONNECTING A SETUP PC

Connect a PC to the robot controller and prepare to set up the *i*RVision system. The PC is used only for teaching *i*RVision and can be disconnected during production operation.

A.1.1 Setup PC

A PC can be used to set up *i*RVision. After the setup operation for *i*RVision is completed, the PC can be removed. The tested PC and browser are Windows 7 (32bit) and Internet Explorer 9 (32bit).

> ⚠ **CAUTION**
> 1 *i*RVision supports only Japanese version and US version of Windows.
> 2 All Windows versions assume that the latest Service Pack is installed.
> 3 When you log in to your PC as a user without the Administrator password, the PC might not normally communicate with the robot. Log in to your PC as a user with the Administrator password.

A.1.2 Communication Cable

A cable is used to connect the robot controller and the PC to set up *i*RVision. Choose a 10BASE-T or 100BASE-T cable that meets the specifications shown below.

Cable	Twisted pair
Shield	Shielded
Cable connection	Cross cable (when connecting the PC directly to the robot controller) Straight cable (when connecting the PC to the robot controller via a hub unit)

A.1.3 Connecting a Communication Cable

Connect the robot controller and the PC using an Ethernet cable. On the robot controller side, plug the cable into the Ethernet connector on the front of the MAIN board. On the PC side, plug the cable into the network connector, usually marked 品.

A.1.4 Determining the IP Addresses

Set the IP addresses to be assigned to the robot controller and the setup PC. Typically, these IP addresses are determined by the network administrator. To find out what addresses to assign, contact the network administrator of your organization.

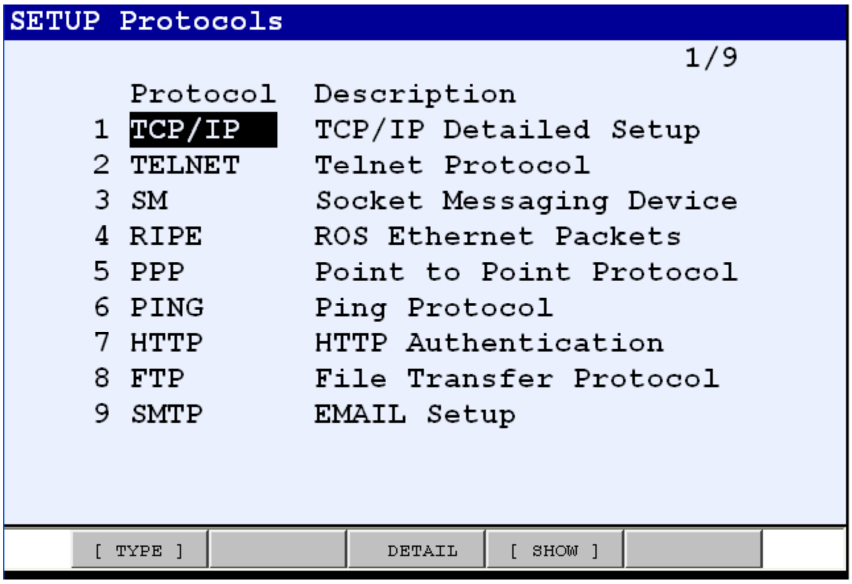
When the robot controller and the PC are connected on a one-on-one basis and not connected to any other network device, the IP addresses can be set as shown below.

Robot controller	192.168.0.1
PC	192.168.0.2
Gateway	192.168.0.3
Subnet mask	255.255.0.0

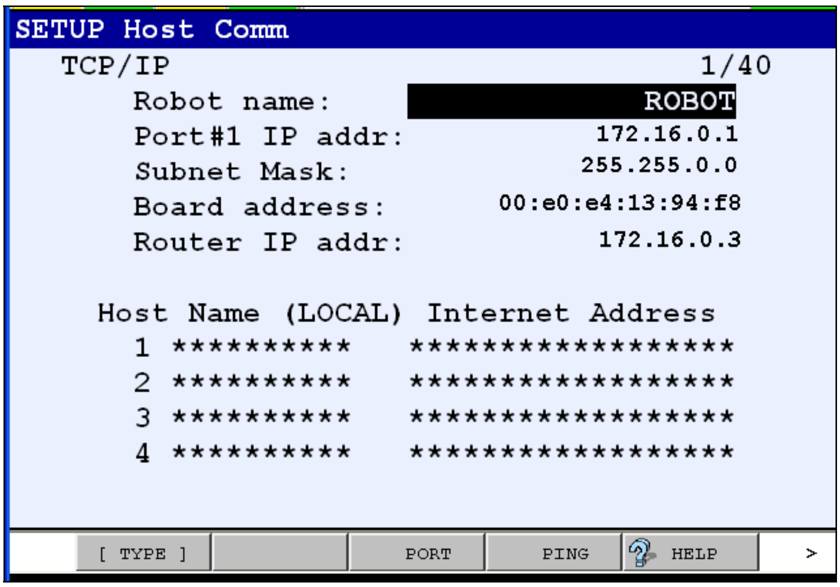
A.1.5 Setting the IP Address of the Robot Controller

Set the IP address of the robot controller.

1 Press MENUS on the teach pendant of the robot controller.
2 From the pull-down menu, select [6 SETUP].
3 Press F1 [TYPE].
4 Select [Host Comm] from the list.



5 Move the cursor to "TCP/IP" and press ENTER.



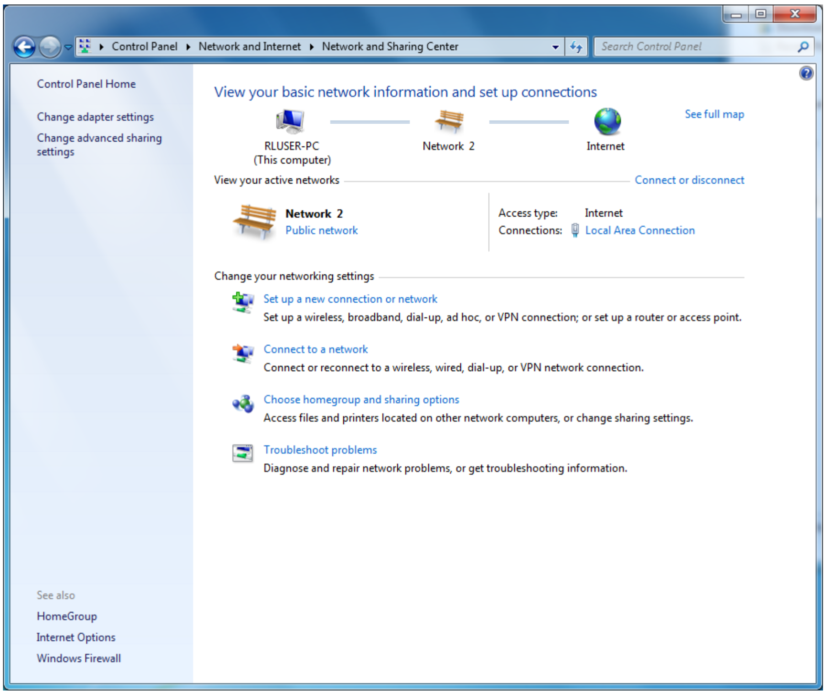
6 Enter the name of the robot controller in [Robot name].
7 Enter the IP address of the robot controller in [Port#1 IP addr].
8 Enter the subnet mask in [Subnet mask].
9 Enter the IP address of the default gateway in [Router IP addr].
10 Turn off the power of the robot controller, and then turn it back on.

> ⚠ **CAUTION**
> 1 When setting the IP address, do not insert any unnecessary spaces or "0". If an unnecessary space or "0" is inserted, communication cannot be performed normally.
> 2 When setting the Robot Name, do not insert any spaces in the name.

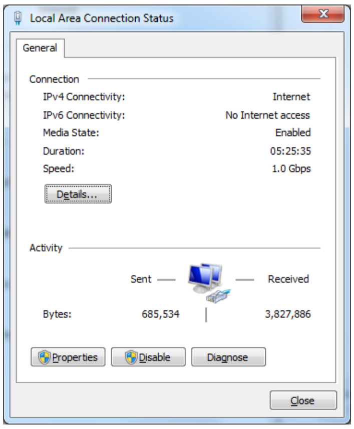
A.1.6 Setting the IP Address of the PC

Set the IP address of the PC.

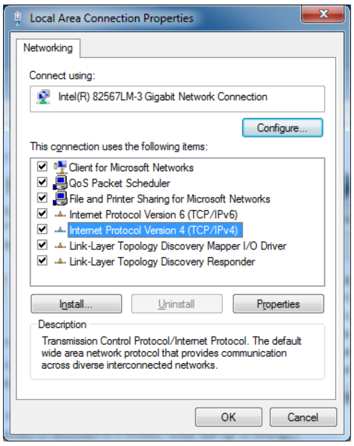
1 In the Control Panel window, open [Network and Sharing Center].



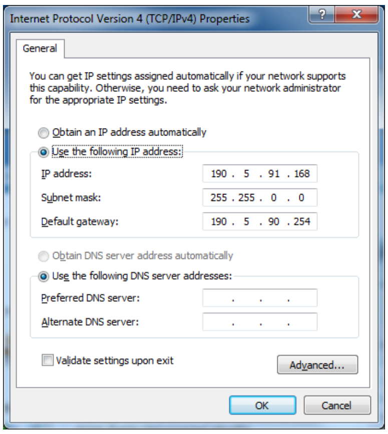
2 Click [Local Area Connections] in [View your active networks].



3 Click the [Properties] button.



4 Select [Internet Protocol Version 4 (TCP/IPv4)], and click the [Properties] button.



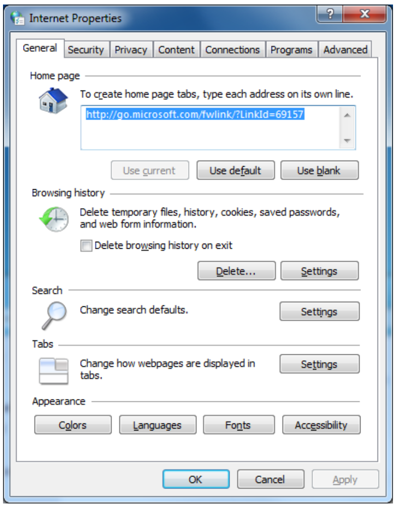
5 Check the [Use the following IP address] box, and enter values in [IP address], [Subnet mask], and [Default gateway].

6 Click the [OK] button to close the window.

A.1.7 Modifying Settings of Internet Explorer

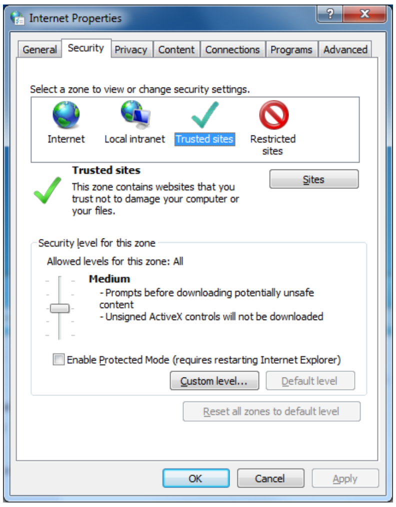
Set Internet Explorer to prevent Windows from blocking communication with the robot controller.

1 In the Control Panel window, open [Internet Options].

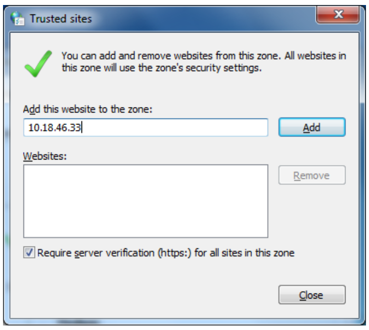


Trusted Sites

1 Select the [Security] tab.



2 Select [Trusted Site], and then click the [Sites] button.



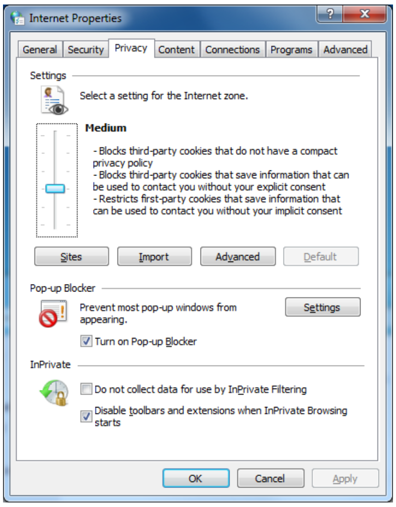
3 Uncheck the [Require server verification (https:) for all the sites in this zone] box.

4 In the [Add this Web site to the zone] textbox, enter the IP address of the robot controller (or the last digit of the IP address can be replaced by *). Then, click the [Add] button.

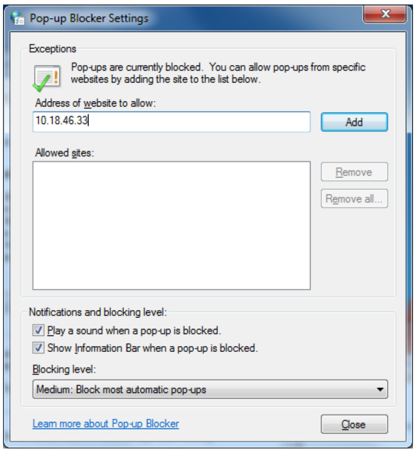
5 Click the [Close] button to close the dialog box.

Popup Blockers

1 Select the [Privacy] tab.



2 Click the [Settings] button of [Pop-up Blocker].

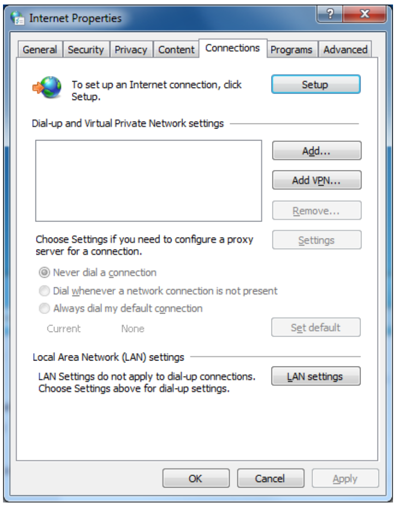


3 Enter the IP address of the robot controller in the [Address of Web site to allow] textbox, and click the [Add] button.

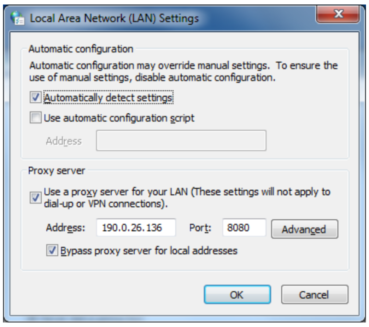
4 Click the [Close] button to close the dialog box.

Proxy Setting

1 Select the [Connections] tab.

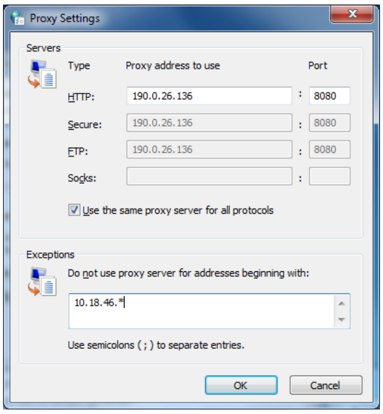


2 Click the [LAN Settings] button.



3 When the [Use a proxy server for your LAN] check box is not checked, proceed to the step 7. When it is checked, perform the steps 4 to 6.

4 Click the [Advanced…] button of [Proxy server].



5 Enter the IP address of the robot controller in the text box under [Exceptions].

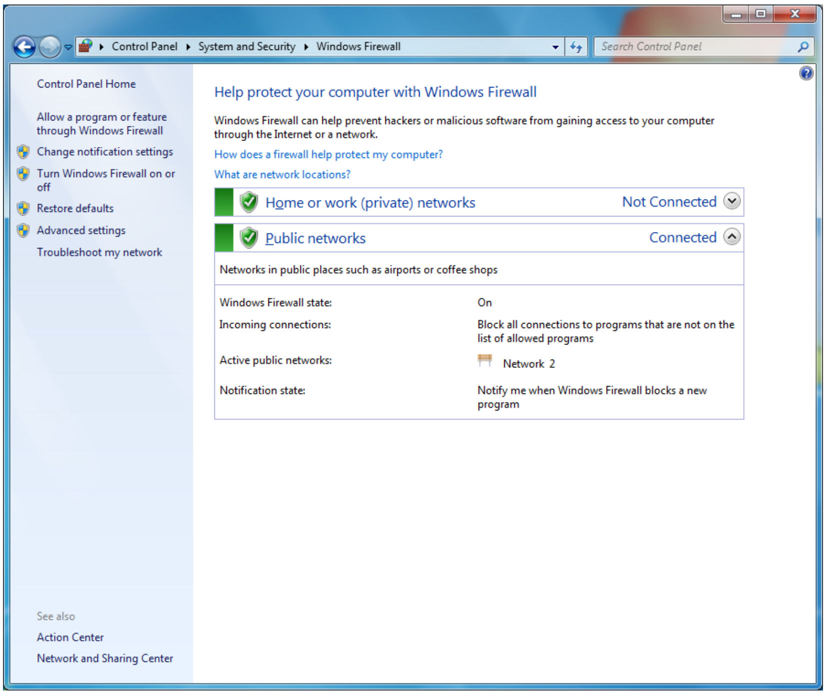
6 Click the [Close] button to close the dialog box.

7 Click the [OK] button to close the Internet property page.

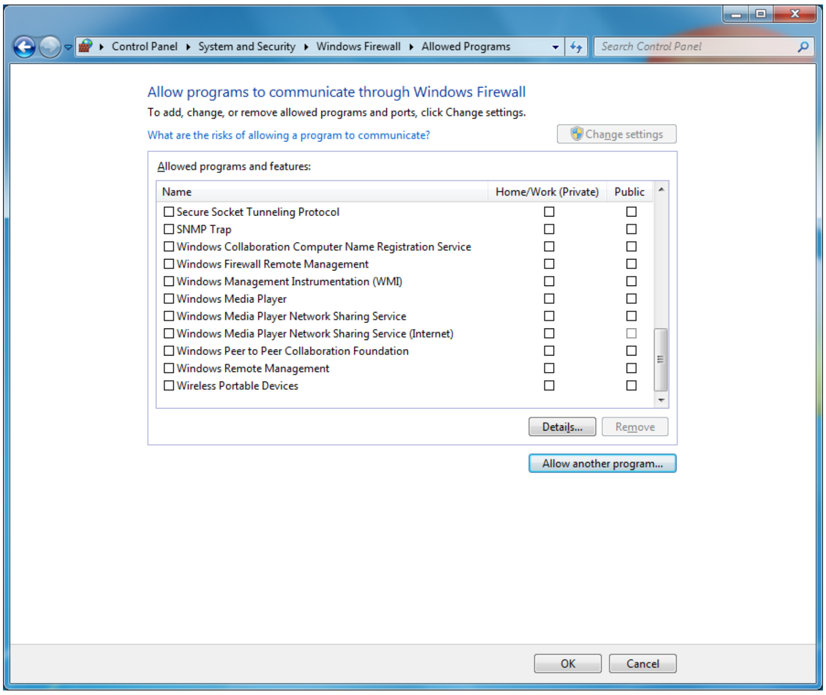
A.1.8 Modifying Setting of Windows Firewall

Modify the settings of Windows Firewall to prevent Windows Firewall from blocking communication with the robot controller.

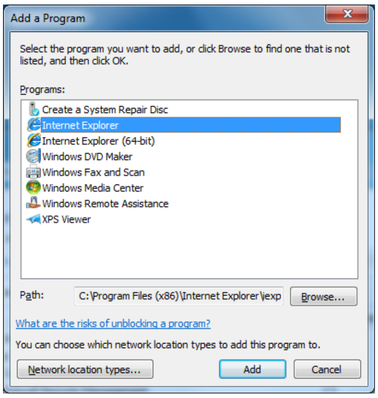
1 In the Control Panel window, open [Windows Firewall].



2 Click [Allow a program or feature through Windows Firewall].



3 Click the [Change settings] button.



4 Select [Internet Explorer] in the list, and click the [Add] button.
5 Click the [OK] button to close the window.

TIP
Communication with the robot controller might be prevented due to a cause other than the above, which is, for example, a Microsoft® Internet Explorer add-on or security software installed in your PC. If an error occurs during teaching of *i*RVision, see Subsection A.4.1, "PC UIF Troubles" first.

A.2 OPENING VISION PAGES

First, display the robot homepage by following the steps below.

1. Click the [Start] button on the PC screen, and start Internet Explorer.

2. Enter the IP address or the host name of the robot controller in [Address].

The robot homepage is not dedicated to *i*RVision but also is provided for every robot controller. When the robot controller has the *i*RVision option, the following three links for *i*RVision appear on the homepage of the robot:

Vision Setup

Displays the Vision Setup page, on which you can setup and test vision data.
For details, see Section 3.1, “VISION SEUTP”.

Vision Runtime

Displays the Vision Runtime page, on which you can monitor *i*RVision execution.
For details, see Section 3.2, “VISION RUN-TIME”.

Vision Log

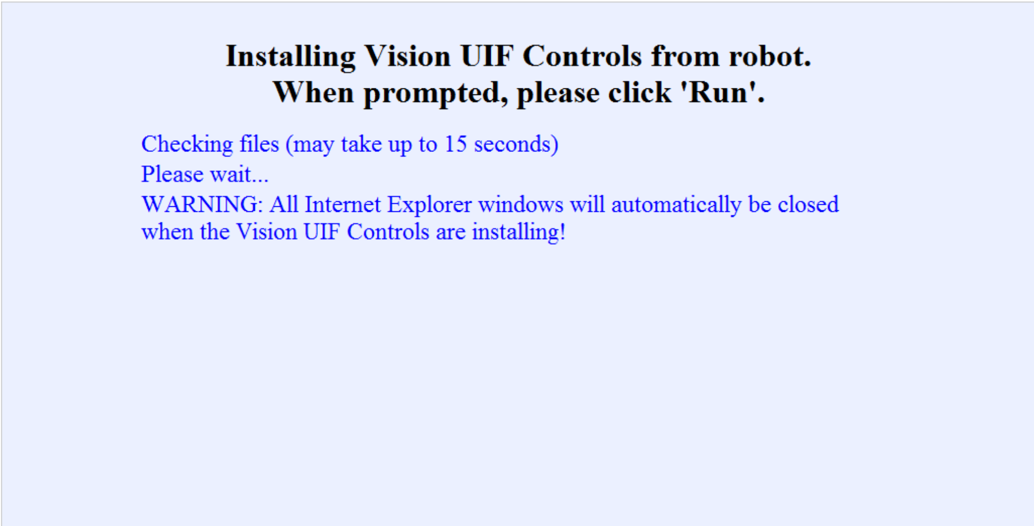
Displays the Vision Log page, on which you can view execution log of *i*RVision.
For details, see Section 3.3, “VISION LOG”.

The system settings of the *i*RVision are not available on PC. It is available only on *i*Pendant. For details, see Section 3.4, “VISION CONFIG”

Installing Vision UIF Controls

You must install Vision UIF Controls on your PC in order to display the *i*RVision user interface. You can install Vision UIF Controls from the robot controller when you click a *i*RVision related link. Follow the steps below:

1 Click [Vision Setup] in the *i*RVision section.
If Vision UIF Controls are already installed in the PC used, the Vision Setup Page opens.
If Vision UIF Controls are not installed in the PC, the following screen appears:

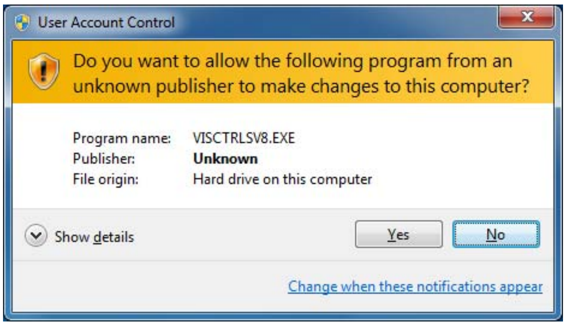


2 After a while, the following dialog appears.

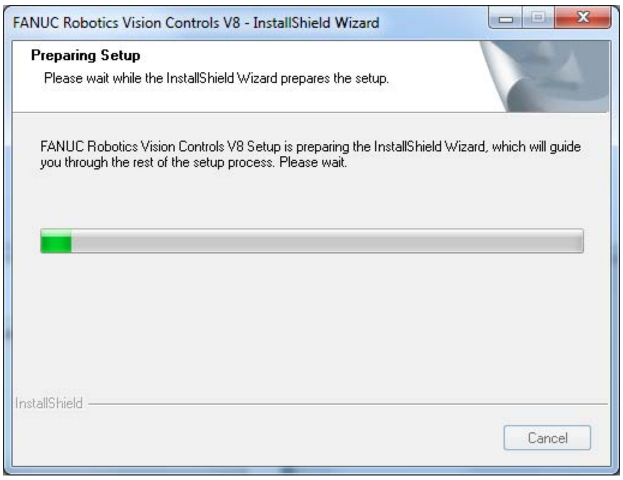
3 Click the [Run] button.

4 After a while, the following dialog appears.

5 Click the [Run] button.
6 The following dialog box appears.

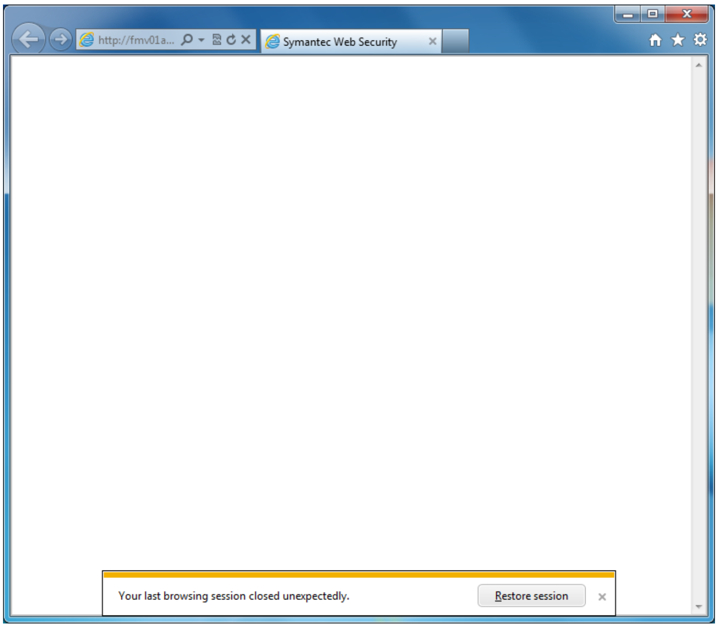


7 Click the [Yes] button.
8 Installation of Vision UIF Controls starts.



9 When the installation is completed, all Internet Explorer windows are closed.
10 Start Internet Explorer again, and open the homepage of the robot.

11 The following message will appear when you start Internet Explorer. Close the message by clicking the [X] button.



A.3 PASSWORD PROTECTION OF VISION DATA

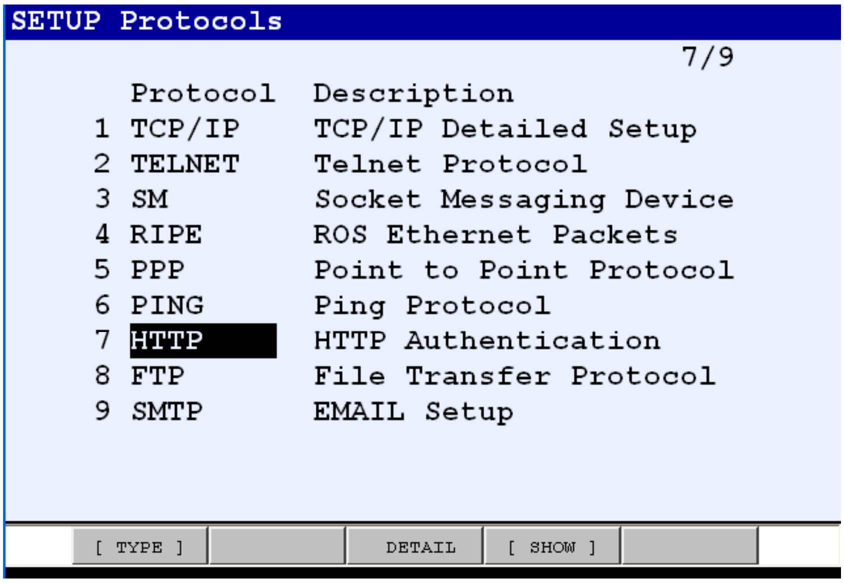
Login to [Vision Setup] of *i*RVision can be protected by password. Password protection prevents setup data for *i*RVision from being modified by unauthorized users.

> **TIP**
> Even when login to [Vision Setup] of *i*RVision is protected by password, the [Vision Log] and [Vision Runtime] pages can be opened without a password.

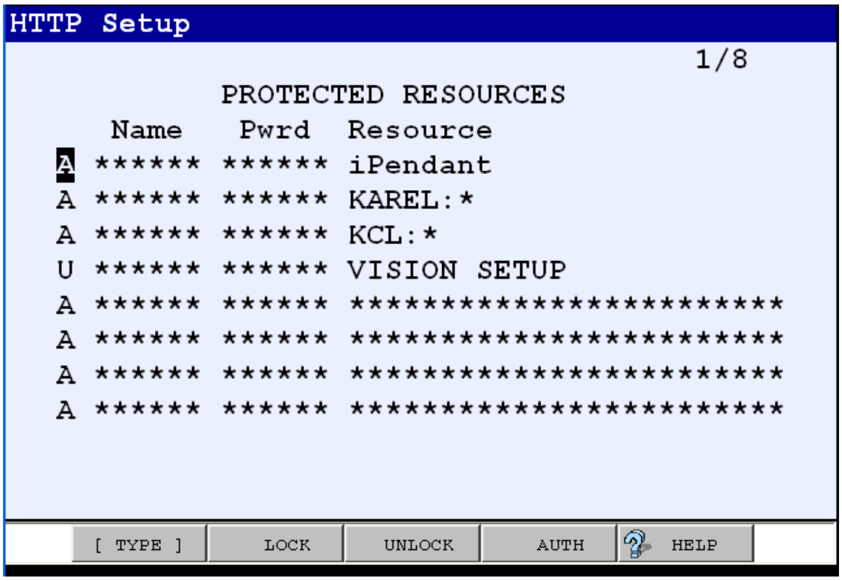
A.3.1 Setting Password Protection

1. Press MENUS on the teach pendant.
2. Select [6 SETUP].
3. Press F1 [TYPE].

4. Select [Host Comm].



5. Move the cursor to [HTTP] and press ENTER.



6. Move the cursor to the [Name] field in the [VISION SETUP] line, press ENTER, and enter a user name that is up to six characters.
7. Move the cursor to the [Pwrd] field in the [VISION SETUP] line, press ENTER, and enter a password that is up to six characters.

> ⚠ **CAUTION**
> The characters entered as a password appear on the teach pendant immediately after the password has been entered, but when the cursor is moved, the displayed password is replaced by "******" and is no longer visible.

8. Move the cursor to [U] in the [VISION SETUP] line, and press F4 [AUTH].

When [Vision Setup] of *i*RVision is clicked on the homepage of the robot when password protection is enabled, a dialog as shown below appears, asking the user to enter a user name and password. If a correct user name and password are entered, the *i*RVision setup page is displayed. If an incorrect user name or password is entered, the login to the setup page is rejected.

Reference: The leftmost character on the HTTP authentication screen indicates the following state:

U:UNLOCK	Enables login without a password.
L:LOCK	Disables login regardless of the password.
A:AUTH	Enables login if a password is entered.

A.3.2 Canceling a Password

1. On the HTTP authentication screen, move the cursor to [A] in the [VISION SETUP] line, and press F3 [UNLOCK].

A.4 FREQUENTLY ASKED QUESTIONS

A.4.1 PC UIF Troubles

If there is a problem with *i*RVision teach operation on a PC, first check this subsection.

The robot home page cannot be opened.

If Internet Explorer of your PC is configured to use the proxy server, the PC and controller may not be able to communicate with each other correctly. Set it as described in Section A.1, "CONNECTING A SETUP PC".

When you click *i*RVision Vision Setup, the message “Failed to login Vision Setup” appears.

The Windows firewall might be set incorrectly. Set it as described in Section A.1, "CONNECTING A SETUP PC".

When you open the *i*RVision Vision Setup, the message “Enables popup on Internet Explorer” appears.

Internet Explorer might be set incorrectly. Set it as described in Section A.1, “CONNECTING A SETUP PC”.

When you create a new vision data file, a runtime error occurs.

Internet Explorer might be set incorrectly. Set it as described in Section A.1 "CONNECTING A SETUP PC".

Clicking *i*RVision Vision Setup displays the alarm [70: Cannot write].

Internet Explorer might be set incorrectly. Set it as described in Section A.1, "CONNECTING A SETUP PC".

No window opens even though *i*RVision Vision Setup is clicked.

The Windows firewall might be set incorrectly. Set it as described in Section A.1, “CONNECTING A SETUP PC”.

If security software is installed in your PC, communication might be blocked by the security software. Disabled the security software.

The alarm [PMON-001 Failed to notify PC Monitor] is displayed on the teach pendant of the robot.

The Windows firewall might be set incorrectly. Set it as described in Section A.1, “CONNECTING A SETUP PC”.

If security software is installed in your PC, communication might be blocked by the security software. Disabled the security software.

Clicking *i*RVision Vision Setup stops processing at icon copy time.

Communication with the robot controller may not be performed normally due to the influence of the add-on software of Internet Explorer. Disable all add-on's issued by other than FANUC Robotics North America or FRNA, by choosing "Manage Add-on's" from the "Tools" menu of Internet Explorer. In this state, check whether *i*RVision teach operation can be performed normally. If no problem arises, enable the disabled add-on's one at a time while checking that *i*RVision teach operation is not affected.

Clicking *i*RVision Vision Setup displays [A problem occurred] and closes Internet Explorer.

Communication with the robot controller may not be performed normally due to the influence of the add-on software of Internet Explorer. Disable all add-on's issued by other than FANUC Robotics North America or FRNA, by choosing "Manage Add-on's" from the "Tools" menu of Internet Explorer. In this state, check whether *i*RVision teach operation can be performed normally. If no problem arises, enable the disabled add-on's one at a time while checking that *i*RVision teach operation is not affected.

The hourglass-shaped mouse cursor remains displayed on the vision data list screen and another operation cannot be performed.

If Internet Explorer in your PC is set to use a proxy server, the PC might not normally communicate with the robot controller. Open the Internet Explorer option setting screen and disable the proxy server setting.

No image is displayed on the *i*RVision teach screen.

When you log in to your PC as a user without the Administrator password, the PC might not normally communicate with the robot. Log in to your PC as a user with the Administrator password.

When Microsoft® Internet Information Server is installed in your PC and Worldwide Web Publishing Service is enabled, the PC might not communicate normally with the robot controller. Disable the Worldwide Web Publishing Service.

When you try to load an image file, [Runtime error '0'] occurs.

When Internet Information Services (IIS) is enabled, communication with the robot controller may not be performed correctly. Choose Control Panel then open "Add or Remove Program". Next, uncheck "Internet Information Services (IIS)" on the list of "Windows Components".

When you try to finish editing masks, the CVIS-005 alarm is issued.

When Internet Information Services (IIS) is enabled, communication with the robot controller may not be performed correctly. Choose Control Panel then open "Add or Remove Program". Next, uncheck "Internet Information Services (IIS)" on the list of "Windows Components".

When you try to finish editing masks, [Runtime error '0'] occurs.

When the password protection function of the robot controller is enabled, communication with the robot controller may not be performed normally. Disable the password protection function of the robot controller.

On ROBOGUIDE, vision data cannot be newly created.

Set ROBOGUIDE so that Internet Explorer is used instead of the browser built into ROBOGUIDE. The installation destination directory of ROBOGUIDE includes the file "OrderInfo.xfr". Open this file with a text editor then modify the line:

<RoboguideFeature Name="UseIE" Support="No"/>

to:

<RoboguideFeature Name="UseIE" Support="Yes"/>

On Roboguide, nothing is displayed on the *i*RVision main setup page

Set ROBOGUIDE so that Internet Explorer is used instead of the browser built into ROBOGUIDE. The installation destination directory of ROBOGUIDE includes the file "OrderInfo.xfr". Open this file with a text editor then modify the line:

<RoboguideFeature Name="UseIE" Support="No"/>

to:

<RoboguideFeature Name="UseIE" Support="Yes"/>

On ROBOGUIDE, when you try to finish editing masks, [Runtime error '0'] occurs.

Set ROBOGUIDE so that Internet Explorer is used instead of the browser built into ROBOGUIDE. The installation destination directory of ROBOGUIDE includes the file "OrderInfo.xfr". Open this file with a text editor then modify the line:

<RoboguideFeature Name="UseIE" Support="No"/>

to:

<RoboguideFeature Name="UseIE" Support="Yes"/>

A.4.2 Vision UIF Control Cannot be Installed

Check that the "*i*RVision UIF Controls" option (A05B-2500-J871) is ordered. If the option is not ordered, contact your FANUC sales representative.

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