FANUC Robot series

R-30*i*B Plus CONTROLLER

*i*RVision

OPERATOR'S MANUAL (Reference)

B-83914EN/01

• Original Instructions

Thank you very much for purchasing FANUC Robot.

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

The products in this manual are controlled based on Japan's “Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan. 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 endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume. It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to ensure the safe use of the robot.
Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.
For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell.
In addition, refer to the “FANUC Robot SAFETY HANDBOOK (**B-80687EN)**”.

1 DEFINITION OF USER

The user can be defined as follows.

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

Programmer:
- Operates the robot
- Teaches the robot inside the safety fence

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

- Operator is not allowed to work in the safety fence.
- Programmers and maintenance engineers are allowed to work in the safety fence. The work inside the safety fence includes lifting, setting, teaching, adjustment, maintenance, etc.
- To work inside the safety fence, the person must receive a professional training for the robot.

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

- Adequate clothes for the operation
- Safety shoes
- A helmet

2 DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users 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 using the robot.

Symbol	Definitions
⚠**WARNING**	Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.
⚠**CAUTION**	Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.
NOTE	Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

- Check this manual thoroughly, and keep it handy for the future reference.

3 SAFETY OF THE USER

User 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 user safety.

(1) Have the robot system users 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 user 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 user 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. 3 (b).

(4) Provide the peripheral equipment with appropriate earth (Class A, Class B, Class C, and Class D).
(5) Try to install the peripheral equipment outside the robot operating space.
(6) Draw an outline on the floor, clearly indicating the range of the robot operating space, 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 user enters the work area.
(8) If necessary, install a safety lock so that no one except the user 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 equipment independently, be sure to turn off the power of the robot.
(10) Operators should be ungloved while manipulating the operator 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. (refer to Controller OPERATOR'S MANUAL.)
(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 inside 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.)
- Outdoor
(16) When connecting the peripheral equipment 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.
(17) When preparing footstep, please consider security for installation and maintenance work in high place according to Fig. 3 (c). Please consider footstep and safety belt mounting position.

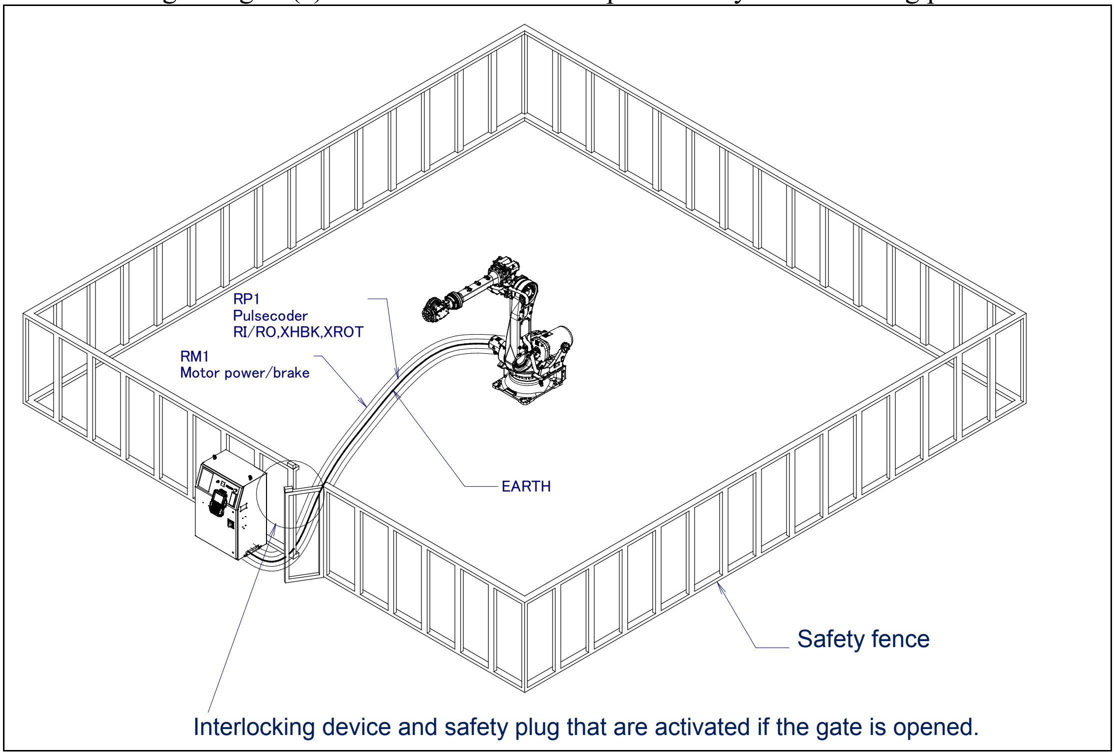

Fig. 3 (a) Safety fence and safety gate

> ⚠**WARNING**
> When you close a fence, please confirm that there is not a person from all directions of the robot.

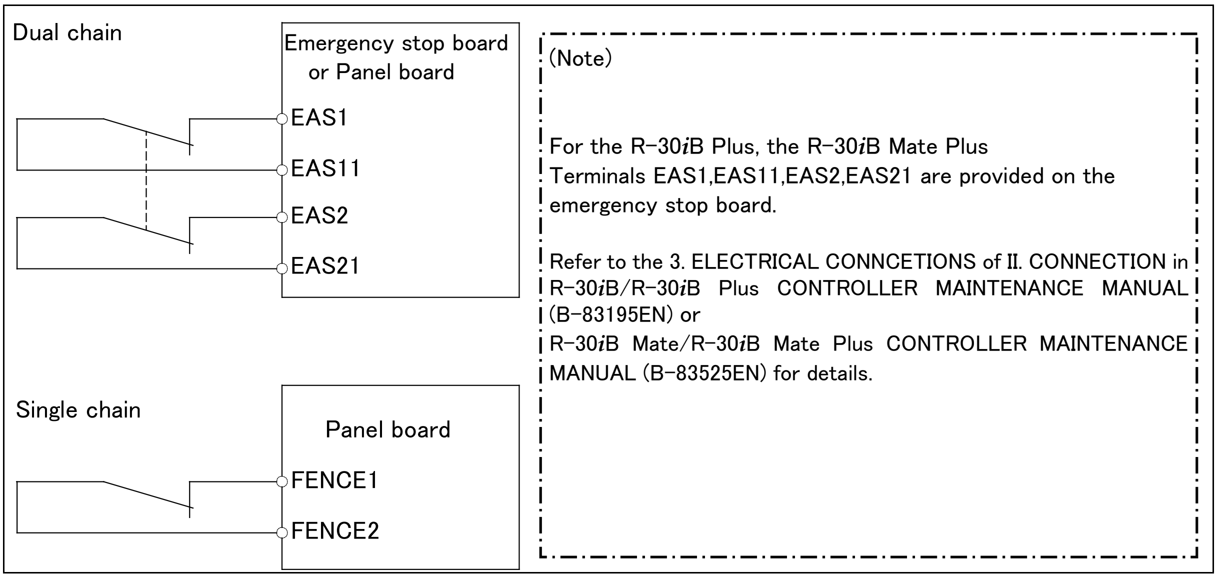

Fig. 3 (b) Connection diagram for the signal of safety fence

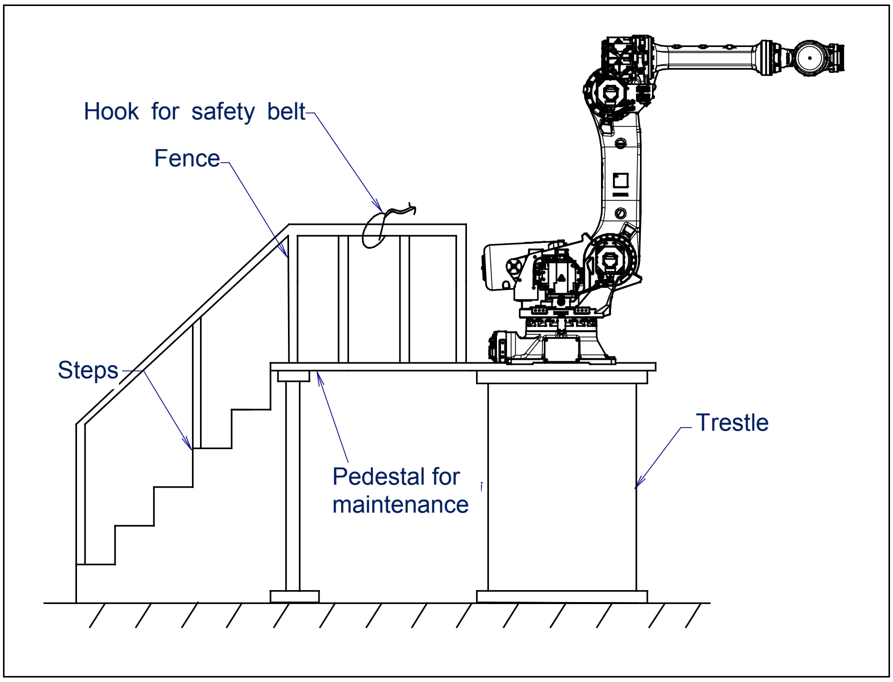

Fig. 3 (c) Pedestal for maintenance

3.1 SAFETY OF THE OPERATOR

An operator refers to a person who turns on and off the robot system and starts a robot program from, for example, the operator panel during daily operation.
Operators cannot work inside of the safety fence.

(1) If the robot does not need to be operated, turn off the robot controller power or press the EMERGENCY STOP button during working.
(2) Operate the robot system outside the operating space of the robot.

(3) Install a safety fence or safety door to avoid the accidental entry of a person other than an operator in charge or keep operator out from the hazardous place.
(4) Install one or more necessary quantity of EMERGENCY STOP button(s) within the operator's reach in appropriate location(s) based on the system layout.

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.

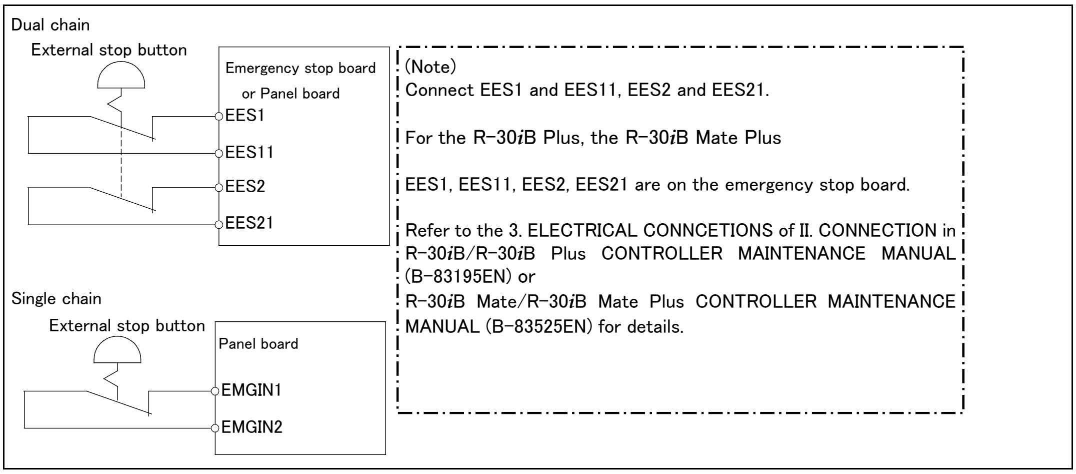

Fig. 3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator may need to enter the robot operation area. The programmer must ensure the safety especially.

(1) Unless it is specifically necessary to enter the robot operating space, carry out all tasks outside the operating space.
(2) Before teaching the robot, check that the robot and its peripheral equipment are all in the normal operating condition.
(3) If it is inevitable to enter the robot operating space 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 operating space.
(5) Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done inside 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 whole robot 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 (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 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 the stop of the robot (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) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
    (b) Disable: The DEADMAN switch is disabled.
    (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 Plus/R-30*i*B Mate Plus 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.

Based on the risk assessment by FANUC, number of operation of DEADMAN SW should not exceed about 10000 times per year.

The teach pendant, operator panel, and peripheral equipment 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.

Mode	Teach pendant enable switch	Software remote condition	Teach pendant	Operator panel	Peripheral equipment
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 box or operator panel, make certain that nobody is the robot operating space area and that there are no abnormalities in the robot operating space.
(7) When a program is completed, be sure to carry out a test operation according to the following procedure.
    (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 continuous operation at low speed.
    (c) Run the program for one operation cycle in continuous operation 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 continuous operation 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 operation above, execute it in the automatic operation.

(8) While operating the system in the automatic operation, the programmer should leave the safety fence.

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 operating space.
(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 as far as possible.
(3) If it becomes necessary to enter the robot operating space while the power is on, press the emergency stop button on the operator box or operator panel, or the teach pendant before entering the range. The maintenance worker 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 worker must check the whole robot 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 whole robot 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 maintenance work, check that the robot and its peripheral equipment are all in the normal operating condition.
(7) Do not operate the robot in the automatic operation while anybody is in the robot operating space.
(8) When you maintain the robot alongside a wall or instrument, or when multiple users are working nearby, make certain that their escape path is not obstructed.
(9) When a tool is mounted on the robot, or when any movable device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.
(10) If necessary, have a user who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the user should be ready to press the EMERGENCY STOP button at any time.
(11) When replacing a part, please contact your local FANUC representative. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the user.
(12) When replacing or reinstalling components, take care to prevent foreign material 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 operating space and that the robot and the peripheral equipment 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 user needs to touch such a part in the heated state, the user should wear heat-resistant gloves or use other protective tools.
- Servo motor
- Inside the controller
- Reducer
- Gearbox
- Wrist unit

(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) When performing maintenance work in high place, secure a footstep and wear safety belt.
(23) 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.
(24) 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.
(25) 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 robot 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.

(26) 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
(27) After a part is replaced, a test execution should be given for the robot according to a predetermined method. (See TESTING section of “Controller operator’s manual”.) During the test execution, the maintenance worker should work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL EQUIPMENT

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 abnormality occurs in any other robots or peripheral equipment, even though the robot itself is normal.
(3) For a system in which the robot and its peripheral equipment 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 equipment 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, operate the robot where insulated from the influence of oil, water, and dust.

(2) Don’t use unconfirmed liquid for cutting fluid and cleaning fluid.
(3) Adopt limit switches or mechanical stoppers to limit the robot motion, and avoid the robot from collisions against peripheral equipment or tools.
(4) Observe the following precautions about the mechanical unit cables. Failure to follow precautions may cause problems.
- Use mechanical unit cable that have required user interface.
- Do not add user cable or hose to inside of the mechanical unit.
- Please do not obstruct the movement of the mechanical unit 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.
- When installing user peripheral equipment on the robot mechanical unit, please pay attention that the device does not interfere with the robot itself.

(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 perform 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 and power-off of the robot is incurred.
- When alteration is necessary, safety switch is operated by opening safety fence and power-off stop is incurred 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 operates routinely and power-off stop is incurred for the robot.
- Power-off stop is regularly incurred due to an inappropriate setting for Dual Check Safety (DCS).

(6) Power-off stop of Robot is executed when collision detection alarm (SRVO-050) etc. occurs. Please try to avoid unnecessary power-off stops. It may cause the trouble of the robot, too. So remove the causes of the alarm.

5 SAFETY OF THE ROBOT MECHANICAL UNIT

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 operating spaces 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 robot operation area 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 pinched 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 (R-30*i*B Plus, R-30*i*B Mate Plus)

There are following three types of Stop Category.

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

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.
"**Stop Category 0**" performs following processing.

- An alarm is generated, and then the servo power turns off. Instantly the robot stops.
- Execution of the program is paused.

Frequent Category 0 Stop of the robot during operation can cause mechanical problems of the robot.
Avoid system designs that require routine or frequent Category 0 Stop conditions.

Stop Category 1 following IEC 60204-1 (Controlled Stop, Smooth Stop)

The robot is decelerated until it stops, and servo power is turned off.
"**Stop Category 1**" performs following processing.

- The alarm "**SRVO-199 Controlled stop**" or "**SRVO-289 Smooth Stop**" occurs along with a decelerated stop. The program execution is paused.
- An alarm is generated, and then the servo power turns off.

In Smooth stop, the robot decelerates until it stops with the deceleration time shorter than Controlled stop.
The stop type of Stop Category 1 is different according to the robot model or option configuration. Please refer to the operator's manual of a particular robot model.

Stop Category 2 following IEC 60204-1 (Hold)

The robot is decelerated until it stops, and servo power remains on.
"**Stop Category 2**" performs following processing.

- The robot operation is decelerated until it stops. Execution of the program is paused.

> ⚠ **WARNING**
> 1 The stopping distance and time of Stop Category 1 are longer than those of Stop Category 0. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time is necessary when Stop Category 1 is used. Please refer to the operator's manual of a particular robot model for the data of stopping distance and time.
> 2 In multi arm system, the longest stopping distance and time of Stop Category 1 among each robot are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the multi arm system.
> 3 In the system which has extended axis, the longer stopping distance and time of Stop Category 1 among robot and extended axis are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the system which has extended axis. Please refer to the extended axis setup procedure of the controller operator's manual for considering the stopping distance and time of the extended axis.
> 4 When Stop Category 1 occurs during deceleration by Stop Category 2, the stop type of robot is changed to Stop Category 0.
> 5 In case of Stop Category 1, motor power shutdown is delayed for a maximum of 2 seconds. In this case, a risk assessment for the whole robot system is necessary, including the 2 seconds delay.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Stop Category 0 or Stop Category 1. The configuration of stop type for each situation is called *stop pattern*. The stop pattern is different according to the option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Deadman switch (*)
A	AUTO	Category 0	Category 0	Category 1	Category 1	-
	T1	Category 0	Category 0	-	Category 1	Category 0
	T2	Category 0	Category 0	-	Category 1	Category 0
C	AUTO	Category 1	Category 1	Category 1	Category 1	-
	T1	Category 0	Category 0	-	Category 1	Category 0
	T2	Category 0	Category 0	-	Category 1	Category 0
D	AUTO	Category 1	Category 1	Category 1	Category 1	-
	T1	Category 1	Category 1	-	Category 1	Category 1
	T2	Category 1	Category 1	-	Category 1	Category 1

Category 0: Stop Category 0
Category 1: Stop Category 1
-: Disable

(*) The stop pattern of NTED input is same as Deadman switch.
The following table indicates the Stop pattern according to the controller type or option configuration.
The case R651 is specified.

Option	R-30*i*B Plus/ R-30*i*B Mate Plus
Standard	C(**)
Old Stop Function (A05B-2670-J680)	A(**)
All Smooth Stop Function (A05B-2670-J651)	D(**)

The case R650 is specified.

Option	R-30*i*B Plus/ R-30*i*B Mate Plus
Standard	A(**)
Stop Category 1 by E-Stop (A05B-2670-J521)	C(**)
All Smooth Stop Function (A05B-2670-J651)	D(**)

(**)R-30*i*B Mate Plus does not have SVOFF input.

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.

"Old Stop Function" option

When "**Old Stop Function**" (A05B-2670-J680) option is specified, the stop type of the following alarms becomes Stop Category 0 in AUTO mode.

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.
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.

Stop Category 0 is different from **Stop Category 1** as follows:

- In Stop Category 0, 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 stopping distance and time of Stop Category 0 is shorter than those of Stop Category 1, depending on the robot model and axis.

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.

"All Smooth Stop Function" option

When "**All Smooth Stop Function**" (A05B-2670-J651) option is specified, the stop type of the following alarms becomes Stop Category 1 in all operation modes (AUTO, T1 and T2 mode).

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-003 Deadman switch released	Both deadman switches on Teach pendant are released.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-037 IMSTP input (Group: %d)	IMSTP input (*IMSTP signal for a peripheral device interface) is ON.
SRVO-232 NTED input	NTED input (NTED1-NTED11, NTED2-NTED21) is open.
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.
SRVO-410 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[5] is OFF.
SRVO-419 DCS PROFIsafe comm. error	PROFINET Safety communication error occurs.

Stop Category 1 is different from **Stop Category 0** as follows:

- In Stop Category 1, the robot is stopped along 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 Stop Category 1, physical impact is less than Stop Category 0. 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 time of Stop Category 1 is longer than those of Stop Category 0, depending on the robot model and axis.

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 time of Stop Category 1 are longer than those of Stop Category 0. 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.

"Stop Category 1 by E-Stop" option

When "**Stop Category 1 by E-Stop**" (A05B-2670-J521) option is specified, the stop type of the following alarms become Category 1 Stop but only in AUTO mode. In T1 or T2 mode, the stop type is Category 0 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.
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.

Stop Category 1 is different from **Stop Category 0** as follows:

- In Stop Category 1, the robot is stopped along 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 Stop Category 1, physical impact is less than Stop Category 0. 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 time of Stop Category 1 is longer than those of Stop Category 0, depending on the robot model and axis.

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 time of Stop Category 1 are longer than those of Stop Category 0. 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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TABLE OF CONTENTS

Maintenance

Introduction

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

This manual is the reference manual for *i*RVision on the R-30*i*B Plus controller. This manual describes each function which is 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 uses *i*RVision, please refer to manuals which are introduced in "Introduction: 1.2 RELATED MANUALS".

> ⚠ **CAUTION**
> This manual is based on the R-30*i*B Plus system software version 7DF0/03. 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.

Series	Chapter	Chapter title	Main content
Introduction	Chapter 1	PREFACE	Gives an overview of and a guide to how to use this manual and related manuals.
	Chapter 2	ABOUT *i*RVision	Gives an overview of the functions of *i*RVision and the basic knowledge required to use the functions.
Setup	Chapter 1	BASIC OPERATIONS	Describes the preparation of a teaching PC and the basic operation of the teaching screen.
	Chapter 2	CAMERA DATA	Describes how to teach each *i*RVision camera data.
	Chapter 3	VISION PROCESSES	Describes how to teach each *i*RVision vision processes.
	Chapter 4	COMMAND TOOLS	Describes how to teach the command tools, which are the components of the vision processes.
	Chapter 5	APPLICATION DATA	Describes the application data, which is the supplementary function for the vision processes.
	Chapter 6	STARTING FROM A ROBOT PROGRAM	Describes how to start *i*RVision from a robot program.
	Chapter 7	UTILITY MENU	Describes the *i*RVision utility menu.
	Chapter 8	OTHER OPTIONS	Describes other options, which are occasionally used with *i*RVision.
Maintenance	Chapter 1	TEACH PENDANT FIRMWARE UPDATE	Describes how to update teach pendant firmware.
	Chapter 2	FREQUENTLY ASKED QUESTIONS	Describes problems which could happen while using *i*RVision and the solutions for them.

Indications in this Manual

The symbol below is used in this manual. Please refer to it when looking for information.

Symbol	Description
✎MEMO	Gives information that will provide hints for performing screen operations, and information that will provide a reference for function explanations and setting details.

Explanation of teach pendant operation

This manual explains each procedure on the assumption that teaching is performed using a teaching PC. However, some procedures include a description of operation of the teach pendant. The teach pendant can be operated through touch panel operation, but the procedures using key input, for which the operations are more complex, are described in this manual.

1.2 RELATED MANUALS

This section introduces related manual.

Manual	Spec. No.	Description
OPERATOR'S MANUAL (Basic Operation)	B-83284EN	This is the main manual of the 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.
MAINTENANCE MANUAL	B-83195EN	This manual describes the maintenance and connection of R-30*i*B/R-30*i*B Plus Controller.
OPERATOR'S MANUAL (Alarm Code List)	B-83284EN-1	This manual describes the error code listings, causes, and remedies.
Optional Function OPERATOR'S MANUAL	B-83284EN-2	This manual describes the software optional functions
Sensor Mechanical Unit / Control Unit OPERATOR'S MANUAL	B-83984EN	This manual describes the connection between sensors which is a camera or 3D Laser Sensor and R-30*i*B Plus/R-30*i*B Mate Plus Controller, and maintenance of sensors.
*i*RVision 2D Camera Application OPERATOR'S MANUAL	B-83914EN-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, response to several cases, and so on.
*i*RVision Inspection Application OPERATOR'S MANUAL	B-83914EN-5	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, response to several cases, and so on.
*i*RVision Bin Picking Application OPERATOR'S MANUAL	B-83914EN-6	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, response to several cases, and so on.
*i*RPickTool OPERATOR'S MANUAL	B-83924EN	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, response to several cases, and so on.
Ethernet Function OPERATOR'S MANUAL	B-82974EN	This manual describes the robot networking options such as FTP, RIPE, PC Share, and so on.

1.3 TRADEMARKS

Windows, Windows XP, Windows 7 Professional, Windows 8.1 Professional, Windows 10 Pro and Internet Explorer are registered trademarks or trademarks of Microsoft Corporation in the United States and in all other countries.

The abbreviations below are used in this manual
Microsoft® Windows® 10 Pro: Windows 10
Microsoft® Windows® 8.1 Professional: Windows 8.1
Microsoft® Windows® 7 Professional: Windows 7
Microsoft® Windows® XP: Windows XP
Windows® operating system: Windows

2 ABOUT *i*RVision

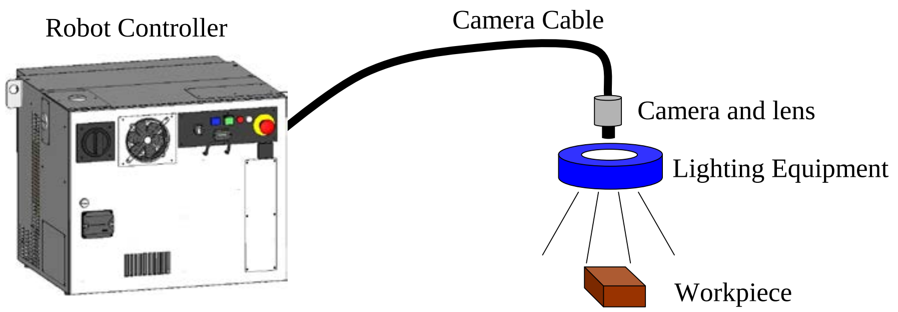
This chapter explains vision-guided robot motion using *i*RVision (*i*ntegral Robot Vision). *i*RVision is an image processing function integrated in a robot controller. It finds parts in an image snapped from a camera, offsets the robot motion and measures the features of the part. This chapter explains vision-guided robot motion using *i*RVision (integral Robot Vision).

2.1 BASIC CONFIGURATION

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
- Camera cable
- Lighting Equipment
- Camera multiplexer (used if needed)



BASIC CONFIGURATION of *i*RVision

For detailed information about the connection method between the Robot Controller and a camera, please refer to “R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER Sensor Mechanical Unit / Control Unit OPERATOR’S MANUAL B-83984EN”.

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*. *i*RVision adopts the latter approach - 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.

Reference position and actual position

With relative position offset, 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*.

Reference position setting

The operation of teaching the reference position to *i*RVision is called *reference position setting*. *i*RVision measures the reference position when a robot program is taught, and stores it internally.

Offset data

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.

2.3 FIXED FRAME OFFSET AND TOOL OFFSET

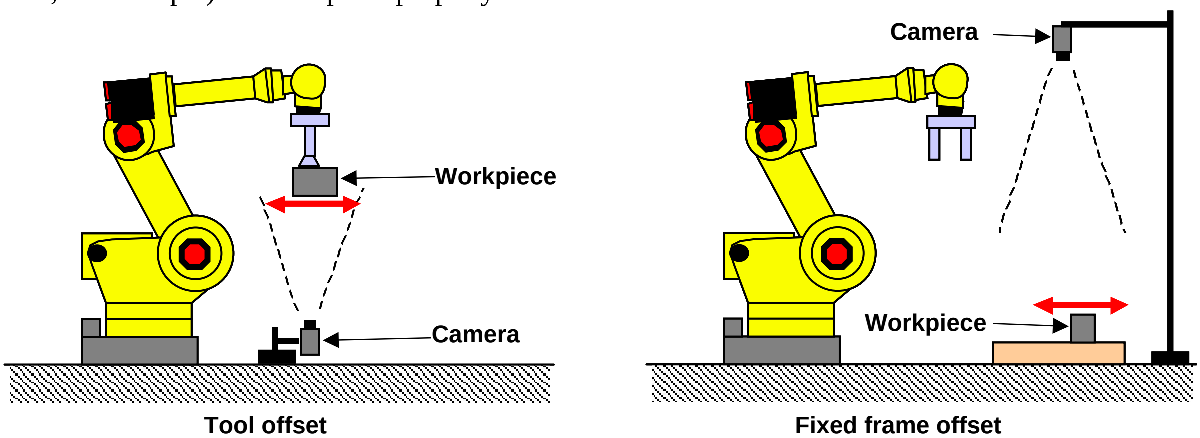
There are two kinds of robot position offset, *fixed frame offset* and *tool offset*. *i*RVision supports both kinds of robot position offset.

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.



***i*RVision vision-guided robot motion**

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

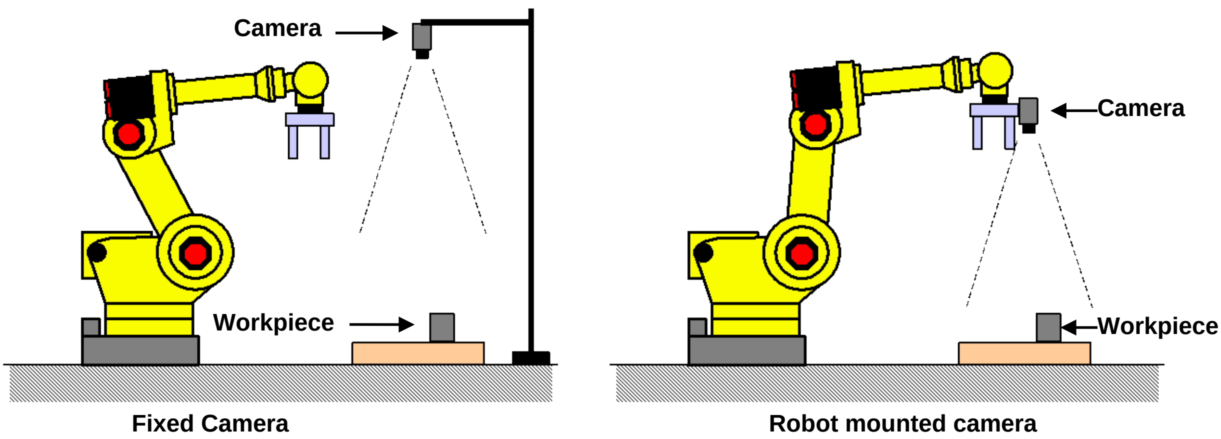
A fixed camera is attached to the top of the pedestal or another fixed structure. In this method, the camera always sees the same view from the same distance. An advantage of a fixed camera is that the robot cycle time can be reduced because *i*RVision can take and process a picture while the robot performs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

- The offset mode where a fixed camera takes a picture of a workpiece on a table and the visual sensor measures the error to grip the workpiece properly is 'Fixed Frame Offset'.
- The offset mode where a robot grips a workpiece to hold it up in front of a fixed camera which measures the tool offset to put the workpiece on a designated proper position is 'Tool Offset'.

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.

- The offset mode where a robot-mounted camera takes a picture of a workpiece on a table and the visual sensor measures the error to grip the workpiece properly is 'Fixed Frame Offset'.



Camera positioning methods with *i*RVision

2.5 CAMERA CALIBRATION

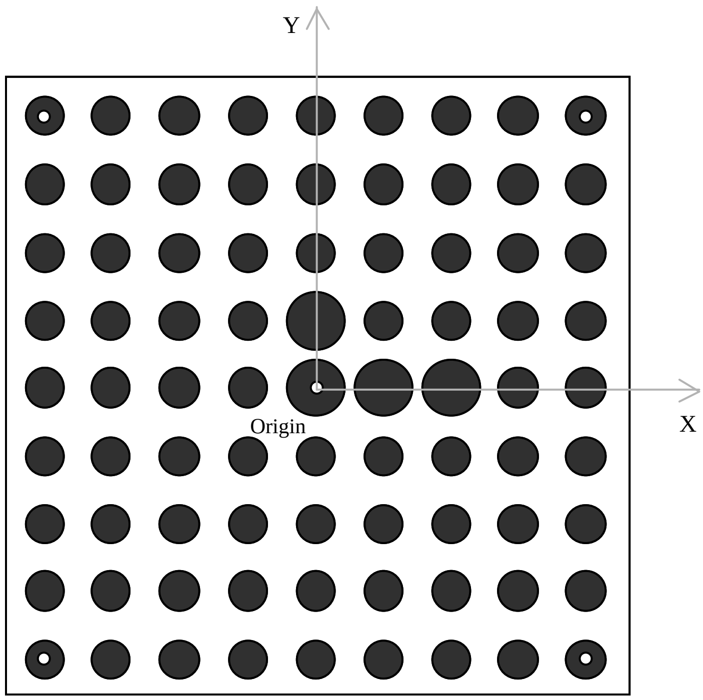
*i*RVision finds parts in an image snapped from a camera. The position of the part found is available as the positional information in the image. However, in order to compensate the robot based on the positional information that *i*RVision found, the positional information needs to be converted from the camera coordinate system to a robot coordinate system (user frame or tool frame). In order to perform such data conversion, data which describes where the camera is placed and where the camera is looking is required. The operation of setting up these data is called ‘camera calibration’.
Calibrating cameras accurately is very important so that your robot can be compensated accurately.
Calibrating cameras accurately is very important so that your robot can be compensated accurately.
There are roughly two kings of camera calibration - 'Grid Pattern Calibration' and 'Robot-Generated Grid Calibration'.

- Grid pattern calibration performs camera calibration using a calibration grid on which a predetermined pattern is drawn.
- Robot-generated grid calibration performs camera calibration moving the target, mounted on the robot end of arm tooling, in the camera's field of view in a grid to generate a virtual grid pattern.

For details on grid pattern calibration, refer to "Setup: 2.1.2 Grid Pattern Calibration".
For details on robot-generated grid calibration, refer to "Setup: 2.1.3 Robot-Generated Grid Calibration."

2.6 CALIBRATION GRID

A calibration grid is a multi-purpose fixture that is used for a variety of purposes, such as grid pattern calibration and grid frame setting.
*i*RVision uses a calibration grid on which a predetermined pattern is drawn for camera calibration and robot frame setting.



Calibration grid

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. This frame is called a 'grid frame'. 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.

2.7 VISION DATA

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

2.7.1 Types of Vision Data

There are four types of vision data:

Camera Data

Performs basic camera setup. Also, performs camera calibration. Creates one camera data for one camera.

Vision Process

Vision Process data is defining the image processing, location, and measurement to be performed by *i*RVision during production operation. Types of vision processes optimized for various application content are available.

Application Data

Application data are settings specific to an application.

2.7.2 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.

Data Path and Capacity

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 is.
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 latest two backups are saved by default.
You can check the available capacity of FROM module in your robot controller by following: The [MENU] key in the teach pendant → [Next] → [Status] → [Memory]. Of which, the capacity that can be used to store vision data is as follows.

One fourth of (free space of FROM – 1 MB)

Size of Vision Data

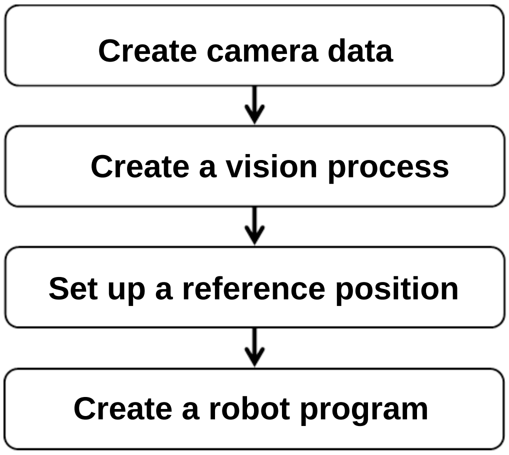
The maximum number of vision data that can be created also depends on the size of the vision data to be created. FANUC robots are teaching-playback robots. Robots of this method play back taught motion only. Therefore, in robot systems that do not use vision, you do not have to use frames because the robots just repeat the taught motion regardless of how accurate the frames are set up.

Example for Calculating the Number of Vision Data That can be Created

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

2.8 FLOW OF TEACHING

This chapter explains overview of flow of creating robot systems using *i*RVision.



Flow of creating robot systems

Create camera data

Create camera data on the *i*RVision [Vision Setup] screen.
For details, refer to "Setup: 2 CAMERA DATA."

Create a vision process

Create a vision process on the *i*RVision [Vision Setup] screen.
For details of vision processes, refer to "Setup: 3 VISION PROCESSES ", and "Setup: 4 COMMAND TOOLS".

Set up a reference position

Set up a reference position. After setting up a reference position, do not move the workpiece until the next step, "Create a robot program" is complete.
For details of setting up a reference position, refer to each section in "Setup: 3 VISION PROCESSES ".

Create a robot program

Create a robot program using a teach pendant. Create the robot program running the vision process so that it will offset the robot motion based on the vision result.
When creating a robot program, it is important to place the workpiece on the same position as when the reference position was set.
For details of robot programs, refer to "Setup: 6 STARTING FROM A ROBOT PROGRAM".

2.9 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 *i*RVision, frames are very important. For instance, when the *i*RVision 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 *i*RVision, (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 *i*RVision 2D view vision process, 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 “OPERATOR’S MANUAL (Basic Operation) B-83284EN” for information regarding detailed user frame setup procedures.

> **MEMO**
> 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.
In the case of fixed frame offset, it is very important to teach an accurate TCP 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. When setting up a user frame, touch up the origin, an X direction point and an Y direction point with the TCP of the robot. If the TCP is less accurate, the taught user frame will also be less accurate.

In the case of tool-offset, the offset calculated by *i*RVision, such as "Move 10 mm to X-direction" and "Rotate 30 degrees around Z-axis", is represented based on this tool frame.

See also the “OPERATOR’S MANUAL (Basic Operation) B-83284EN” 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 A needs to be physically the same as user frame 5 of robot B.

> ⚠ **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.

Dynamic UFrame

When performing coordinated motion control of two or more robots with one robot controller, you can teach the position of following group by coordinated motion frame relativity of the leading group with the Dynamic UFrame. *i*RVision can offset the robot on Dynamic UFrame. But there are the following limitations.

- Select Dynamic UFrame for [Offset Frame] of Vision Process.
- Generally, don't select Dynamic UFrame for [Application Frame] of Camera Calibration.
  However, when the camera moves with Dynamic UFrame, for example when the camera is fixed on the positioner, select Dynamic UFrame for [Application Frame] of Camera Calibration.
- Dynamic UFrame must be at the same position after RUN_FIND is called until GET_OFFSET is called.

For details of the Dynamic UFrame function, refer to "R-30*i*B/R-30*i*B Mate CONTROLLER Coordinated Motion Function OPERATOR'S MANUAL B-83484EN".

2.10 SENSORS USED IN *i*RVision

*i*RVision finds a part from an image using the following camera and offsets robot motion.

2D Camera

Camera to snap 2D images.

3D Area Sensor

3D Area Sensor which is composed of two camera units and one projector unit. The projector unit projects some grid patterns and two camera units snap their images, and then 3D information within the view is calculated.

2.11 TERMINOLOGIES

This section explains the terms specific for *i*RVision functions.

Application Data

One type of vision data. For details, refer to "Introduction: 2.7.1 Types of Vision Data" and "Setup: 5 APPLICATION DATA".

Camera Calibration

Information to translate the position of parts found from the camera frame to robot frame. For details, refer to "Introduction: 2.5 CAMERA CALIBRATION" and "Setup: 2 CAMERA DATA".

Camera Data

One type of vision data. For details, refer to "Introduction: 2.7.1 Types of Vision Data" and "Setup: 2 CAMERA DATA".

Optical axis of the camera

The axis passing through the center of the light receiving element of the camera and vertical to the light receiving element face is called the 'optical axis of the camera'.

Camera View

The vision tool which is placed right under the vision process when finding several points of a part with one vision process to calculate the offset data. Place the number of camera view same as that of the measuring points. You can run and test the vision process per camera view.

Measurement Tool

One type of command tools. Performs image processing to measure intensity and dimension and so on.

Locator Tool

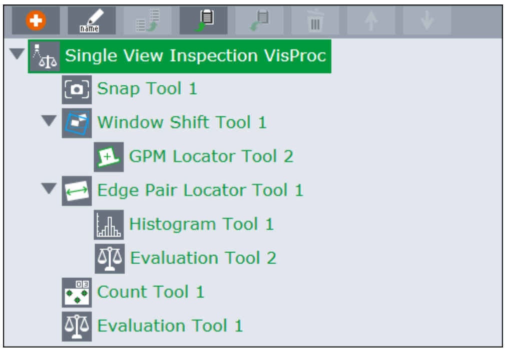
One type of command tools. Performs image processing to find parts and output the found positional information.

Fixed Camera

Using a camera installed on a mount is called a 'fixed camera'. For details, refer to "Introduction: 2.4 FIXED CAMERA AND ROBOT-MOUNTED CAMERA".

Parent Tool, Child Tool

In the tree view, vision tools are not all lined up in one column. Rather, some have their level offset to the right. The relationships between vision tools are represented by the level structure.
The upper tools on the left side of the level are called the 'Parent Tools'. The lower tools under the Parent Tools are called the 'Child Tools'. For details, refer to "Setup: 1.8.2 Tree View."



Command Tool

A component to compose a vision process. For details, refer to "Setup: 4 COMMAND TOOLS"

Snap

To snap an image.

Dynamic Window

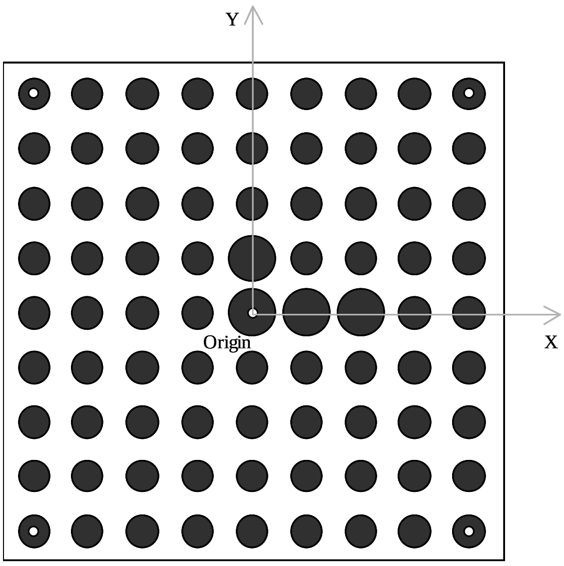
If a locator tool has detected multiple targets, a command tool that has been positioned as a child tool of the locator tool will be executed repeatedly as many times as the number of targets that have been detected by the parent locator tool. This action is called the 'Dynamic Window'. For details, refer to "Setup: 1.8.2 Tree View."

Calibration Grid Frame

A frame defined by grid pattern drawn on a calibration grid. For details, refer to "Introduction: 2.6 CALIBRATION GRID".

Calibration Grid

A multi-purpose fixture that is used for a variety of purposes, such as grid pattern calibration and grid frame setting. The following pattern is drawn. For details, refer to "Introduction: 2.6 CALIBRATION GRID".



Calibration Grid

Robot-mounted Camera

Using a camera installed on a robot hand is called a 'robot-mounted camera'. For details, refer to "Introduction: 2.4 FIXED CAMERA AND ROBOT-MOUNTED CAMERA".

Vision Tool

Camera view and command tools are called 'Vision Tools' collectively.

Vision Data

Teaching data of *i*RVision. For details, refer to "Introduction: 2.7 VISION DATA."

Vision Process

One type of vision data. For details, refer to "Introduction: 2.7.1 Types of Vision Data" and "Setup: 3 VISION PROCESSES ".

Vision Offset

To offset the robot motion using the results of *i*RVision measurement (offset data). For details, refer to "Introduction: 2.2 VISION-GUIDED ROBOT MOTION".

Vision Register

Area to store the *i*RVision results. The results stored in the vision register can be checked on the teach pendant. For details, refer to "Setup: 1.9 VISION REGISTERS"

Offset Data

'Offset data' is data to offset robots. For details, refer to "Introduction: 2.2 VISION-GUIDED ROBOT MOTION"

Live

To display images which are consecutively snapped. It is used when adjusting the direction of camera, lens focus and diaphragms. It is called 'live image display' as well.

Setup

1 BASIC OPEARATIONS

This chapter describes how to setup a PC for *i*RVision and how to operate *i*RVision on the PC.

> **MEMO**
> You can set up the *i*RVision by using the teach pendant or the PC. This manual is written on the assumption that it is operated using a PC. For the difference between operation with a PC and operation on the teach pendant, refer to "Setup: 1.8.16 Teaching from Teach Pendant."

1.1 CONNECTING A SETUP PC

When preparing a teaching PC, operations such as setting IP address and changing PC setting are required.
The operation may vary depending on the environment you use. For details, please contact the in-house network manager or the system manager.

1.1.1 Preparing 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.

> ⚠ **CAUTION**
> This section explains only the setting items that need to be changed based on the assumption that your Windows and IE are in a typical configuration. Therefore, when setting items which are not described here are set differently from the typical, it may cause the *i*RVision setup not working properly.

Refer to the following table for the tested OS and browser.

OS	Windows 7 Professional (32bit) Windows 7 Professional (64bit) Windows 8.1 Professional (64bit) Windows 10 Pro (64bit)
Browser	Internet Explorer 9 (32bit) Internet Explorer 10 Internet Explorer 11

> ⚠ **CAUTION**
> 1 The tested languages of Windows are Japanese and US English.
> 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.
> 4 Windows8.1 contains two types of Internet Explorer, Desktop mode and Metro mode. Only Desktop mode is compatible to *i*RVision setup. Metro mode cannot be used for *i*RVision setup.

1.1.2 Connecting a Communication Cable

Connect the robot controller and the PC using an Ethernet cable.

Cable	Twisted pair
Shield	Shielded

- On the robot controller side, plug the cable into the CD38A port on the front of the MAIN board.
- On the PC side, plug the cable into the network connector, usually marked .

1.1.3 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. For details, contact the network administrator of your organization.

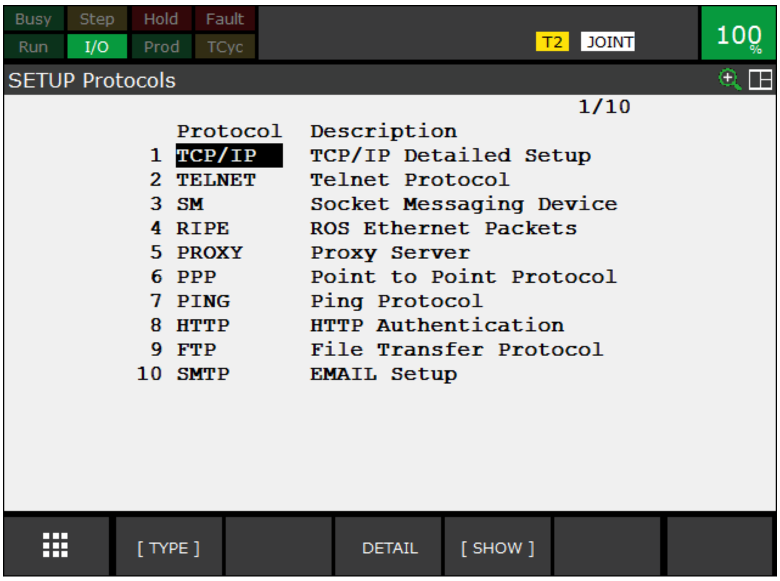
When the robot controller and the PC are connected on a one-on-one basis and not connected to any other network device, the IP addresses can be set as shown below.

Robot controller	192.168.0.1
PC	192.168.0.2
Default gateway	192.168.0.3
Subnet mask	255.255.0.0

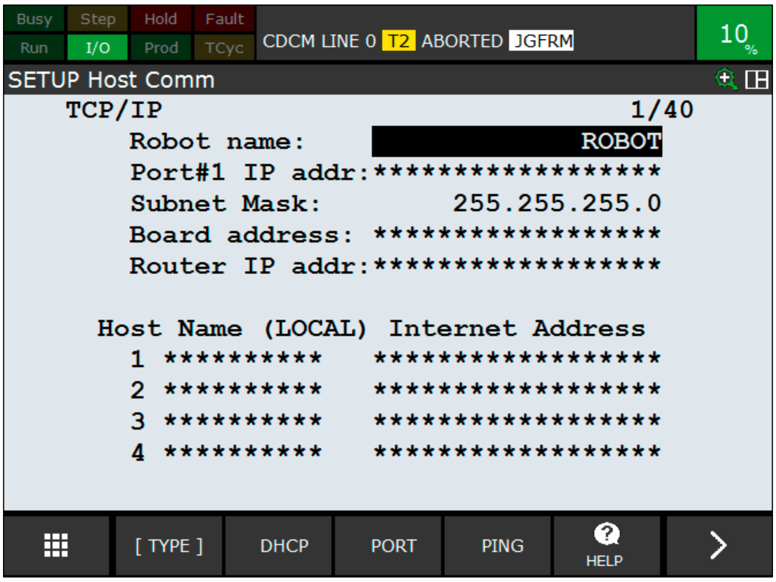
1.1.3.1 Setting the IP address of the robot controller

Set the IP address of the robot controller.

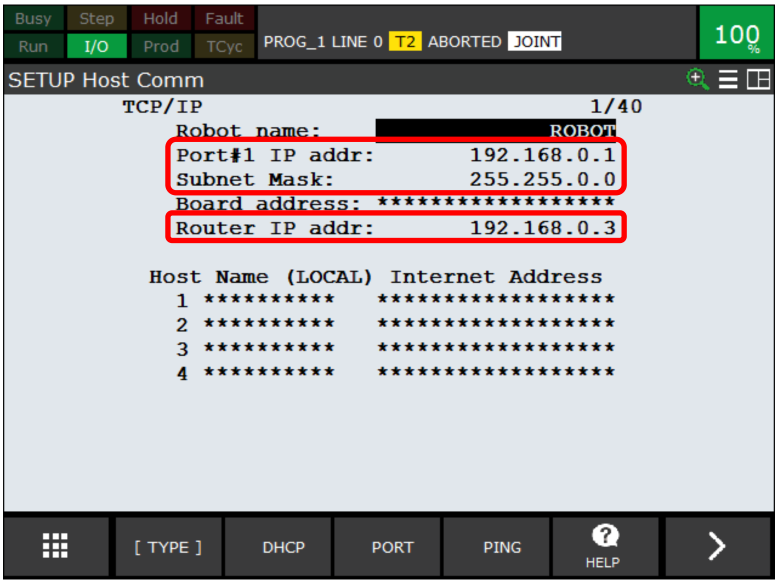
1 On the teach pendant of the robot controller, after selecting the [MENU] key – place the cursor over [SETUP], and press the [ENTER] key.
2 Select F1 [TYPE] – place the cursor over [Host Comm] and press the [ENTER] key.
The [SETUP Protocols] screen will appear.
3 On the [SETUP Protocols] screen, place the cursor over [TCP/IP] and press the [ENTER] key.



4 You can change the robot name in [Robot Name] on the [SETUP Host Comm] screen. 'ROBOT' is entered as default. The change is optional.



5 Enter the IP address of the robot controller in [Port#1 IP addr].
6 Enter the subnet mask in [Subnet mask].
7 Enter the IP address of the default gateway in [Router IP addr].



8 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.

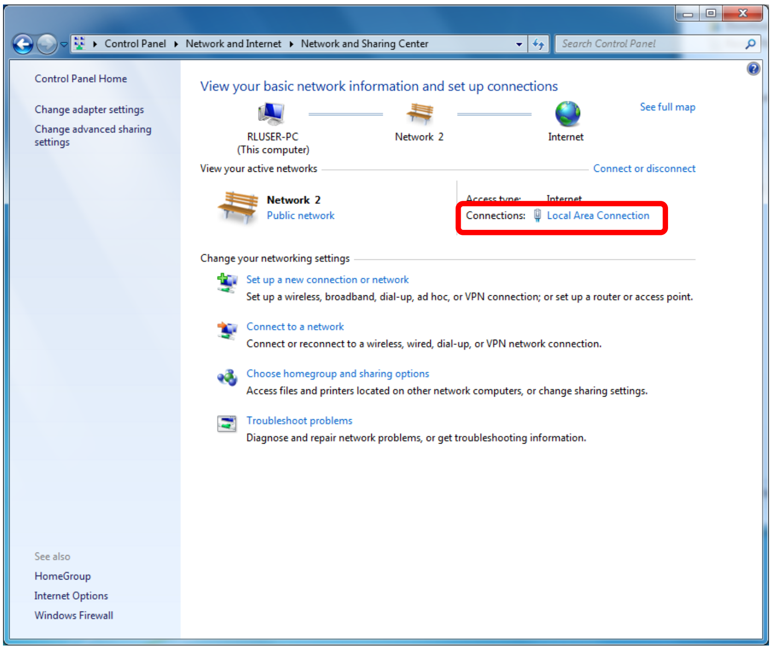
2 When setting the Robot Name, do not insert any spaces in the name.

1.1.3.2 Setting the IP address of the PC

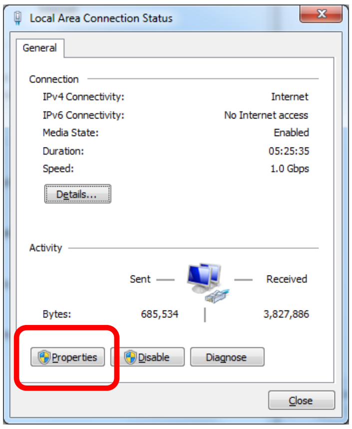
Set the IP address of the PC.

This procedure is explained using the Windows 7 screen as an example.

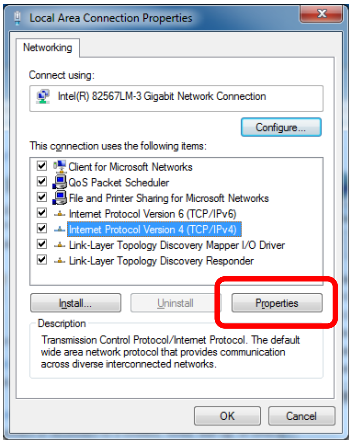
1 Select the [Start] button of your PC – [Control Panel] – click [Network and Sharing Center].
2 Click [Local Area Connections] in [View your active networks].



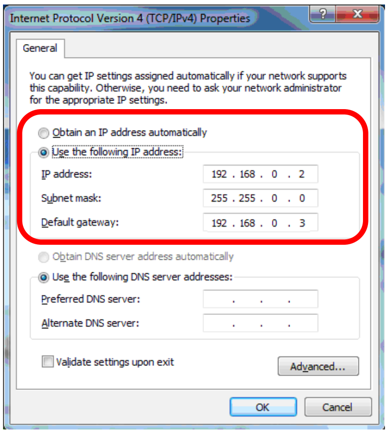
3 Click the [Properties] button in the [Local Area Connection Status] screen.



4 In the [Local Area Connection Properties] screen, 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].



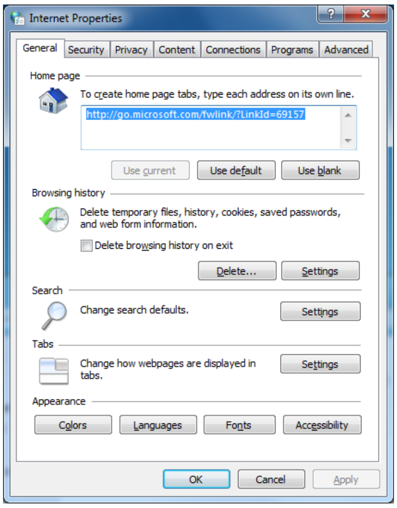
6 Click the [OK] button.

1.1.4 Modifying Settings of Internet Explorer

Set Internet Explorer to prevent Windows from blocking communication with the robot controller. The operation may vary depending on the environment you use. For details, please contact the in-house system manager.

This procedure is explained using the Windows 7 screen as an example.

1 Select the [Start] button of your PC – [Control Panel] – click [Internet Options].
The [Internet Properties] screen will appear.

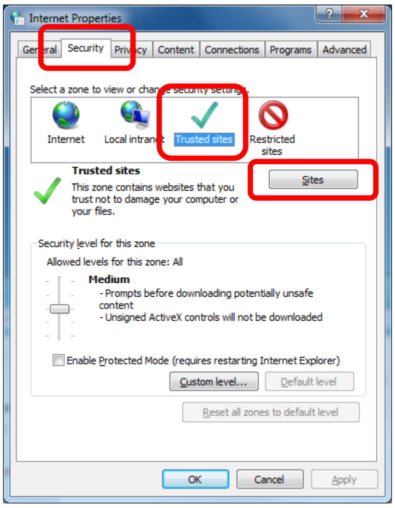


Register in Trusted Sites

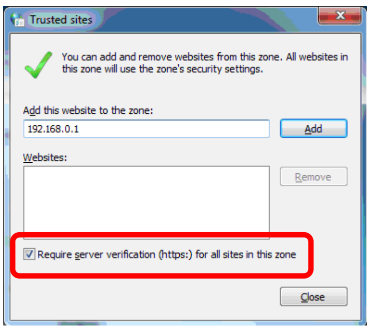
Register the robot controller as a trusted site.

1 On the [Internet Properties] screen, click the [Security] tab.
The [Security] tab screen will appear:

2 Select [Trusted Site], and then click the [Sites] button.



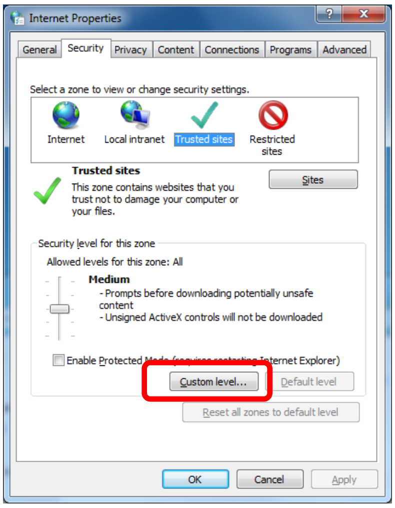
3 In the [Trusted sites] screen, uncheck the [Require server verification (https:) for all the sites in this zone] box.



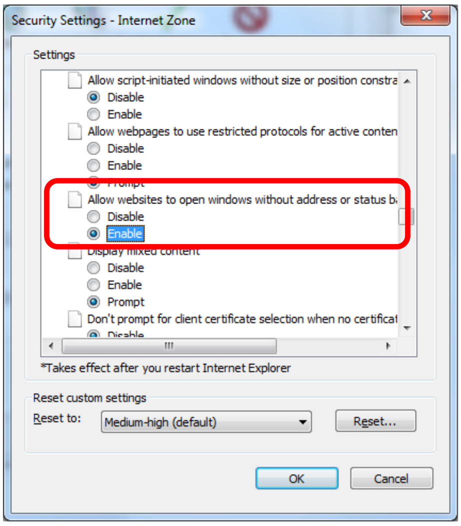
4 In the [Add this Web site to the zone] textbox, enter the IP address of the robot controller (or the last digit of the IP address can be replaced by *). Then, click the [Add] button.

5 Click the [Close] button to move to the [Security] tab.

6 Click the [Custom level] button.



7 In the [Security Settings – Internet Zone] screen, enable “Allow websites to open windows without address or status bars” in “Miscellaneous”.

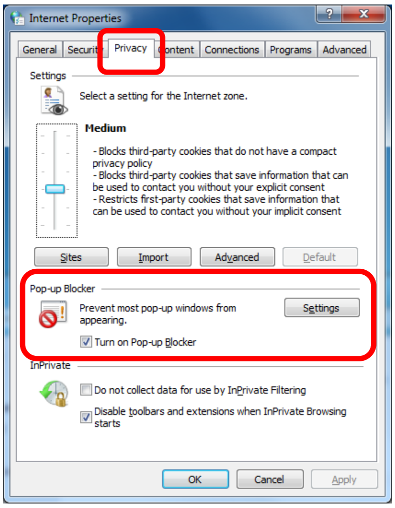


8 Click the [OK] button.
9 Once returned on the [Security] tab screen, click the [OK] button of the [Internet Properties] screen.
10 Re–open the Internet Explorer.

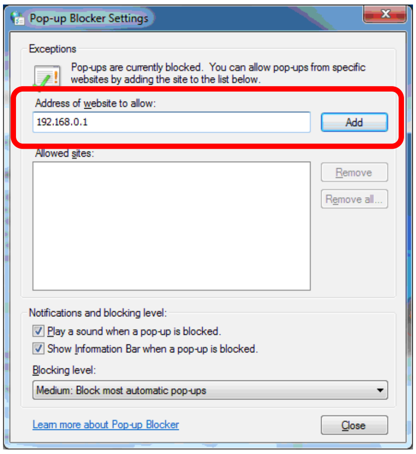
Popup Blockers

Modify so that the pop ups will not be blocked when accessing the homepage in the robot controller.

1 In the [Internet Properties] screen, click the [Privacy] tab.
The [Privacy] tab screen will appear.
2 Click the [Settings] button of [Pop-up Blocker].



3 In the [Pop-up Blocker Settings] screen, enter the IP address of the robot controller in the [Address of Web site to allow] textbox, and click the [Add] button.

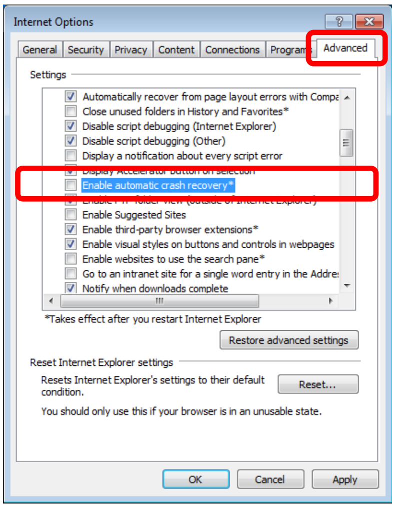


4 Click the [Close] button.
5 Once returned on the [Privacy] tab screen, click the [OK] button of the [Internet Properties] screen.
6 Re–open the Internet Explorer.

Disable Automatic Crash Recovery

Automatic Crash Recovery should be disabled in Internet Explorer. This setting is necessary to install Vision Controls properly.

1 In the [Internet Properties] screen, click the [Advanced] tab.
The [Advanced] tab screen will appear.
2 If the [Enable automatic crash recovery] box is checked, uncheck it.

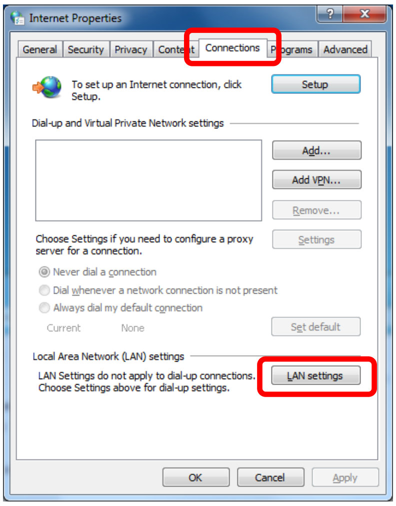


3 In the [Internet Properties] screen, click [OK].
4 Restart your PC.

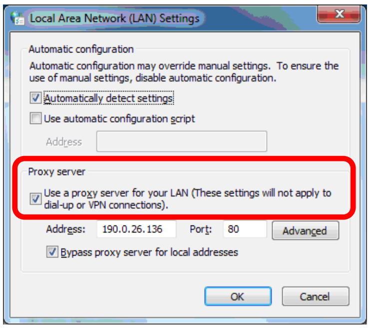
Proxy Setting

Register the robot controller as a local address so that the proxy server will not be used for communication with the robot controller.

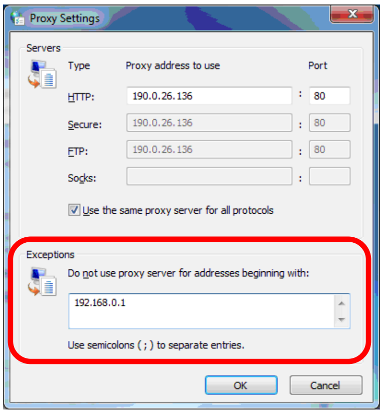
1 In the [Internet Properties] screen, click the [Connections] tab.
The [Connection] tab screen will appear.
2 Click the [LAN Settings] button.



3 In the [Local Area Network (LAN) Settings] screen, when the [Use a proxy server for your LAN] check box is not checked, proceed to the step 8.
When it is checked, perform the steps 4 to 7.



4 Click the [Advanced…] button of [Proxy server].
5 In the [Proxy Settings] screen, enter the IP address of the robot controller in the text box under [Exceptions].

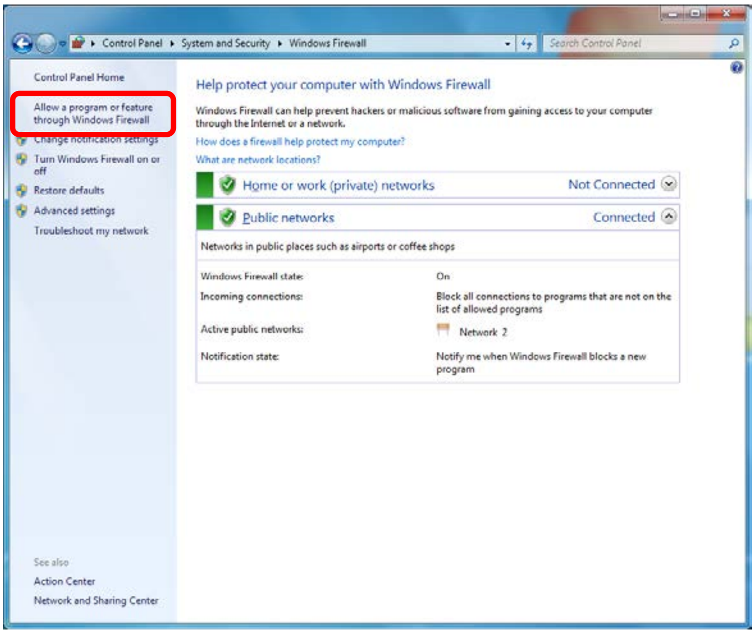


6 Click the [OK] button.
7 Once returned on the [Local Area Network (LAN) Settings] screen, click the [OK] button.
8 In the [Internet Properties] screen, click the [OK] button.
9 Re-open the Internet Explorer.

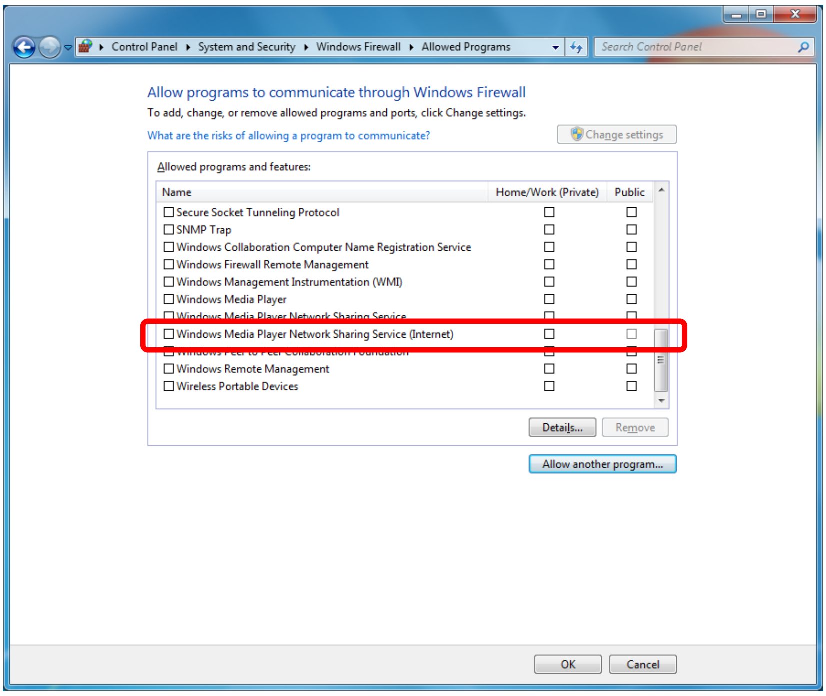
1.1.5 Modifying Setting of Windows Firewall

Modify the settings of Windows Firewall to prevent Windows Firewall from blocking communication with the robot controller.
The operation may vary depending on the environment you use. For details, please contact the in-house system manager.

1 Select [Start] button of your PC – [Control Panel] – click [Windows Firewall].
2 Click [Allow a program or feature through Windows Firewall].
The allowed programs screen will appear.



3 On the allowed programs screen, check whether the [Internet Explorer] of the [Allowed programs and features] is checked.

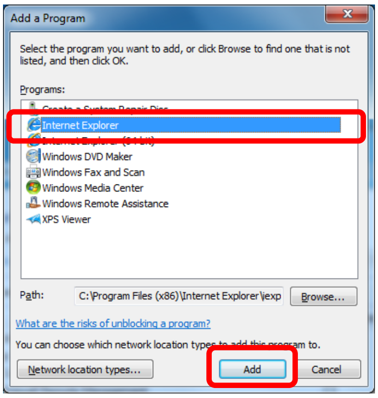


When it is checked, go to step 7.
When it is not checked, go to step 4.
When [Internet Explorer] is not in the list, go to step 5.

4 When [Internet Explorer] is unchecked, click the [Change settings] button and check it.
Go to step 7.

5 When [Internet Explorer] is not in the list, click the [Change settings] button and click [Allow another program].

6 Select [Internet Explorer] in the [Add a Program] screen list, and click the [Add] button.



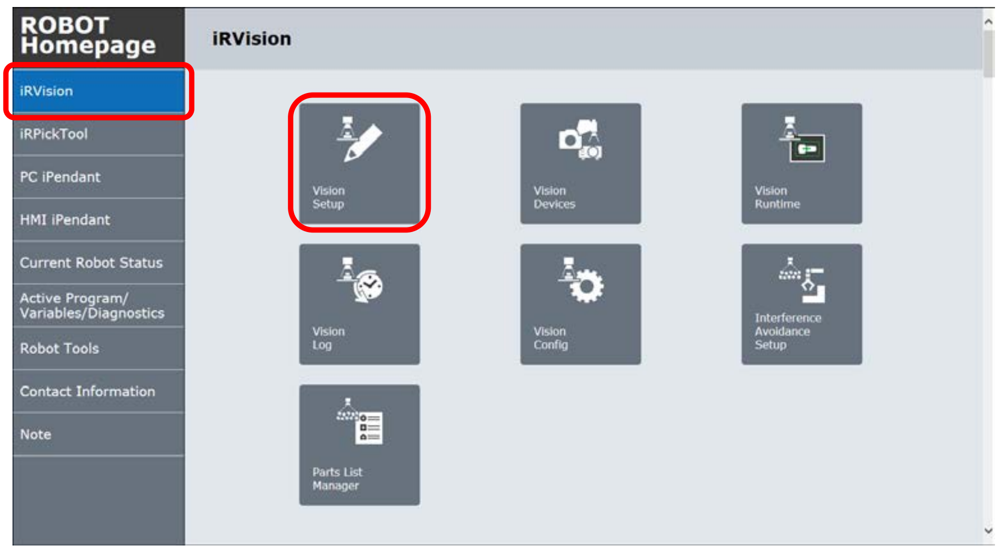
7 Once returned on the allowed programs screen, click the [OK] button.
8 Restart your PC.

MEMO
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, refer to "Maintenance: 2 FREQUENTLY ASKED QUESTIONS".

1.1.6 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 Select [Start] button of your PC － [Programs] － click [Internet Explorer].
2 Enter the IP address of the robot controller in the [Address].
The homepage of the robot will be displayed.



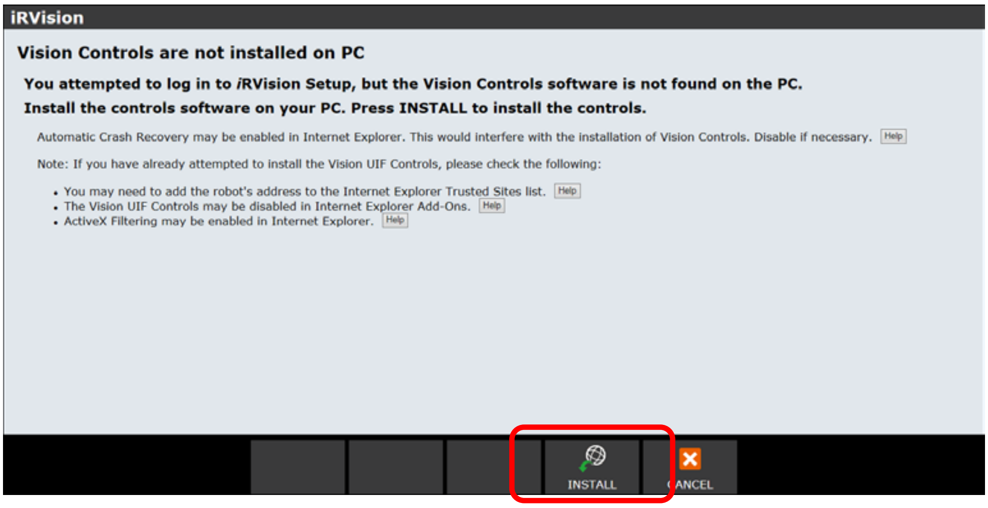
3 Click [iRVision] in the menu area on the robot homepage.
*i*RVision content will appear in the content display area.

MEMO

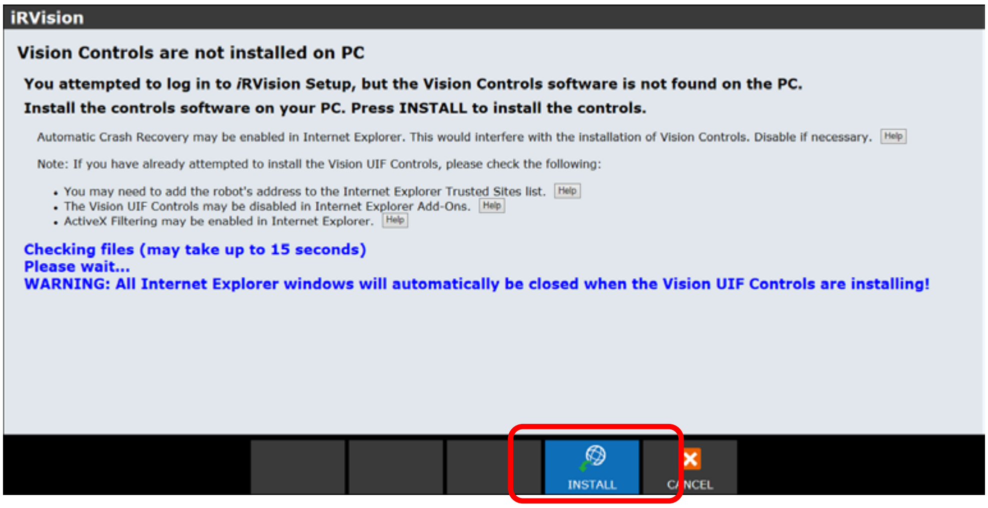
The robot homepage is not dedicated to *i*RVision but also is provided for every robot controller. When the robot controller has the *i*RVision option, the following three links for *i*RVision appear on the homepage of the robot:

4 Click [Vision Setup] in the *i*RVision section.
When the vision setup screen of the vision system opens, you do not need to install Vision UIF Controls, which has been installed on your PC.

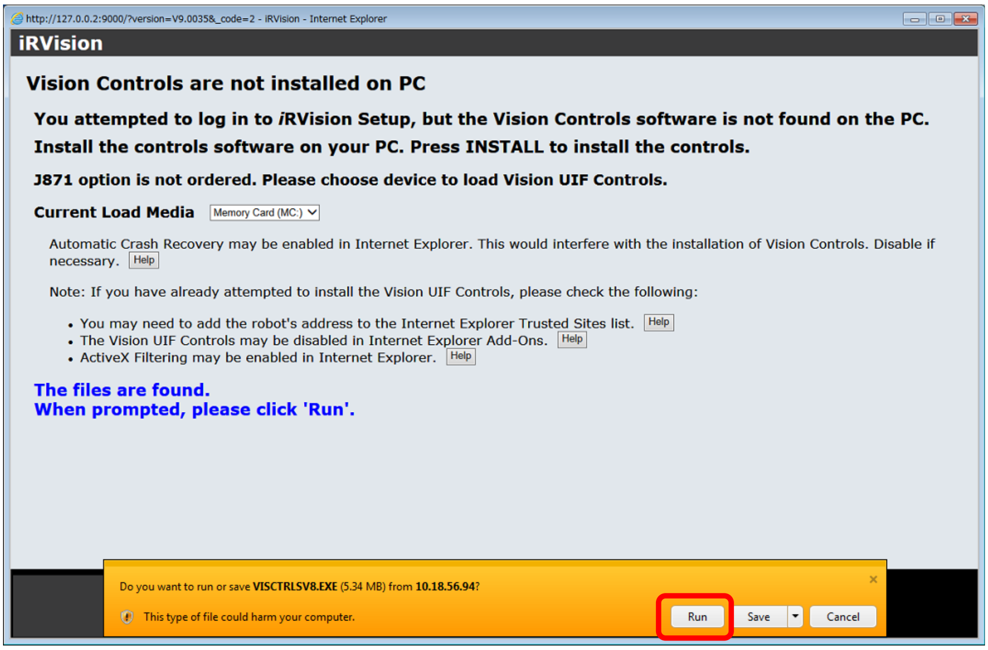
If Vision UIF Controls are not installed in the PC, the following screen appears:



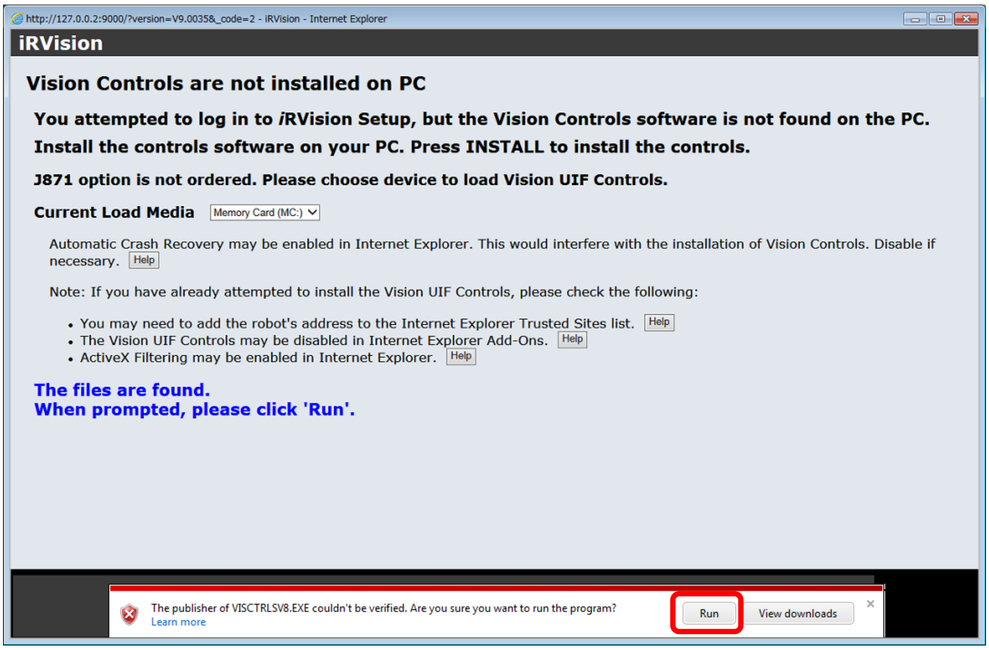
5 Click the [INSTALL] button.



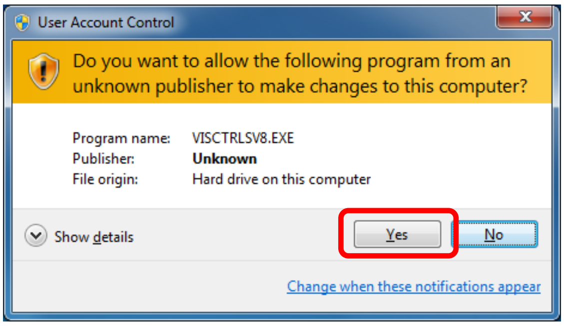
6 The following dialog appears. Click the [Run] button in the pop up.



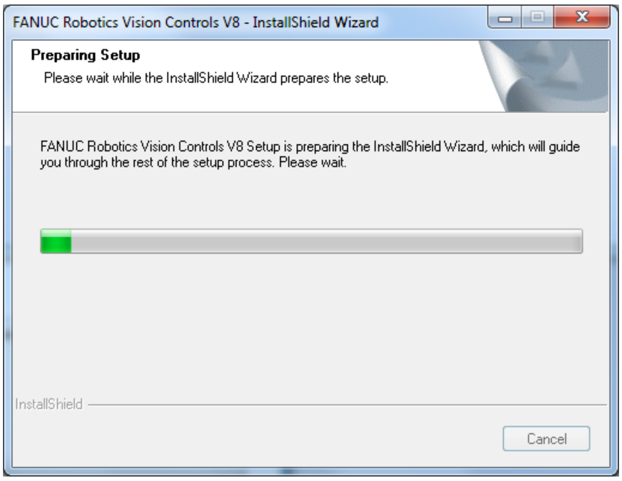
7 The following dialog appears. Click the [Run] button in the pop up.



8 The following dialog box appears. Click the [Yes] button.



9 Installation of Vision UIF Controls starts.



10 When the installation is completed, all Internet Explorer windows are closed.
11 Start Internet Explorer again, and open the homepage of the robot.

1.1.7 Restricting Login to Vision Setup

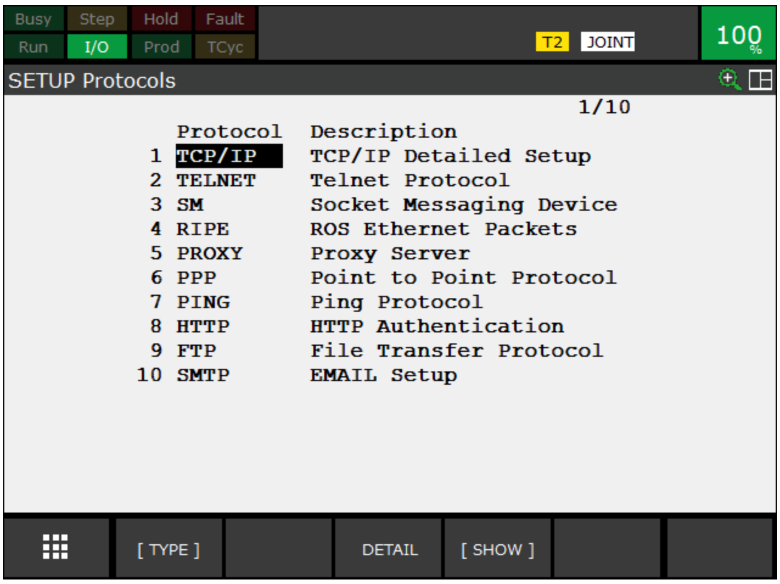
Login to [Vision Setup] of *i*RVision can be protected by password. Password protection prevents setup data for *i*RVision from being modified by unauthorized users.

> **MEMO**
> 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.

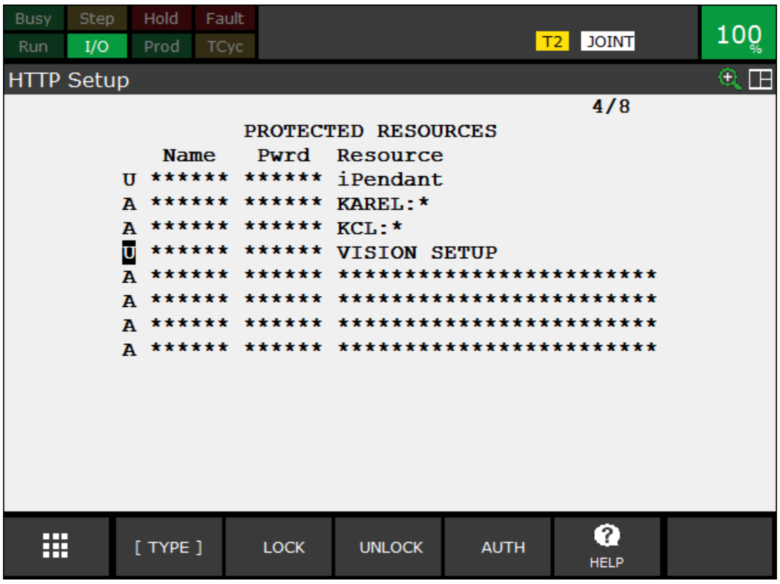
1.1.7.1 Setting password protection

The procedures to protect the log-ins to [Vision Setup] of *i*RVision with a password is as follows.

1 On the teach pendant, after selecting the [MENU] key – place the cursor over [SETUP] and press the [ENTER] key.
2 Select F1 [TYPE] – place the cursor over [Host Comm] and press the [ENTER] key.
The [SETUP Protocols] screen will appear.



3 Move the cursor to [HTTP] and press ENTER.
The [HTTP Setup] screen will appear.



4 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.

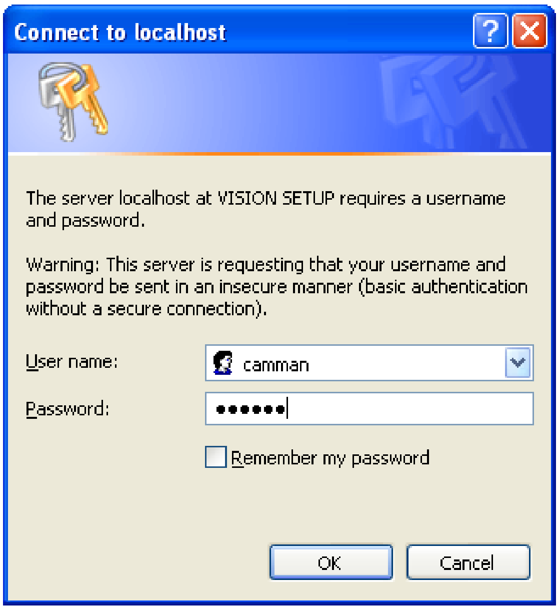
5 Move the cursor to the [Pwrd] field in the [VISION SETUP] line, press ENTER, and enter a password that is up to six characters.

> ⚠ **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.

6 Move the cursor to [U] in the [VISION SETUP] line, and press F4 [AUTH].
This protects the log-ins to [Vision Setup] with a password.

> ⚠ **CAUTION**
> HTTP setup screen is a default function of R-30*i*B Plus Controller. For details of HTTP setup screen, refer to "R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate CONTROLLER Ethernet Function OPERATOR'S MANUAL"

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.

> **MEMO**
> 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.

1.1.7.2 Canceling a password

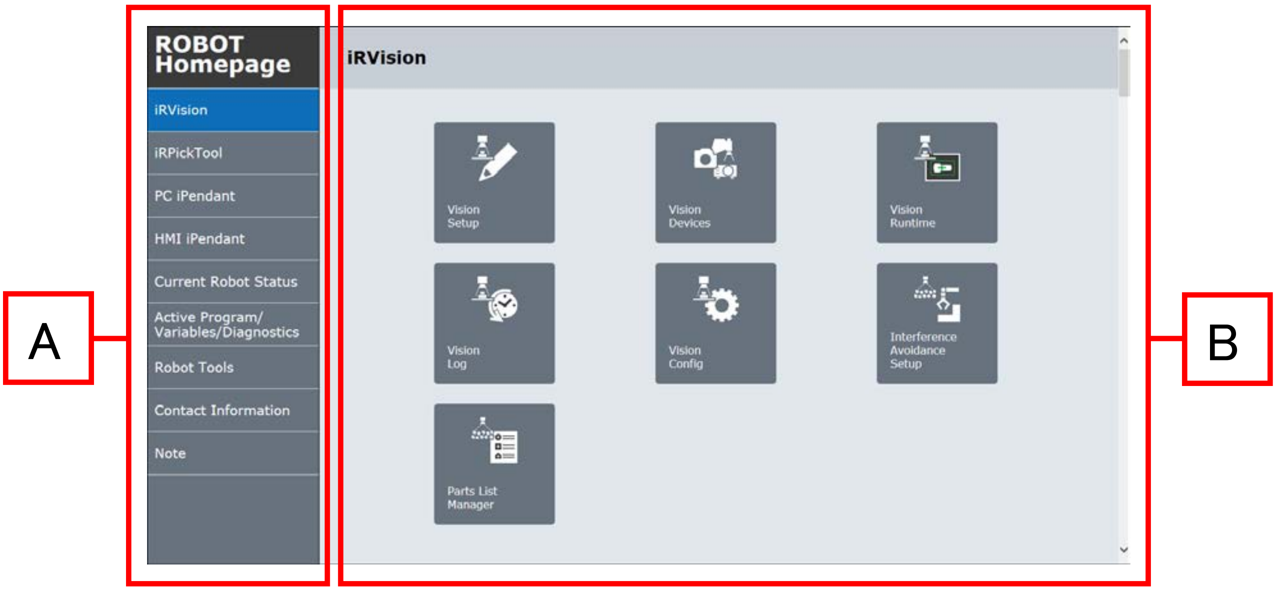
1 On the HTTP authentication screen, move the cursor to [A] in the [VISION SETUP] line, and press F3 [UNLOCK].

1.2 ROBOT HOMEPAGE

First, display the robot homepage by following the steps below.

1 Select [Start] button of your PC – [Programs] – click [Internet Explorer].
2 Enter the IP address or the host name of the robot controller in [Address].
The robot homepage will appear.

The content of the robot homepage is as below.



A Menu Area

The content of the function selected here will appear in B, content display area. The menu items displayed depend on the options of the robot controller.

B Content Display Area

The content of the function selected in A, menu area, will appear. The content displayed depend on the options of the robot controller.

When you select [iRVision] in the menu area, the following content will appear in the content display area.

[Vision Setup]

Displays the *i*RVision vision setup screen. For details, refer to "Setup: 1.3 VISION SETUP".

[Vision Devices]

Displays the *i*RVision vision device screen. For details, refer to "Setup: 1.4 VISION DEVICES".

[Vision Runtime]

Displays the Vision Runtime screen. For details, refer to "Setup: 1.5 VISION RUNTIME".

[Vision Log]

Displays the Vision Log screen. For details, refer to "Setup: 1.6 VISION LOG".

[Vision Config]

Displays the Vision Config screen. For details, refer to "Setup: 1.7 VISION CONFIG".

[Interference Avoidance Setup]

Displays the *i*RVision interference avoidance list screen. For details, refer to the description of interference avoidance setup in "*i*RVision Bin Picking Application OPERATOR’S MANUAL B-83914EN-6".

[Parts List Manager]

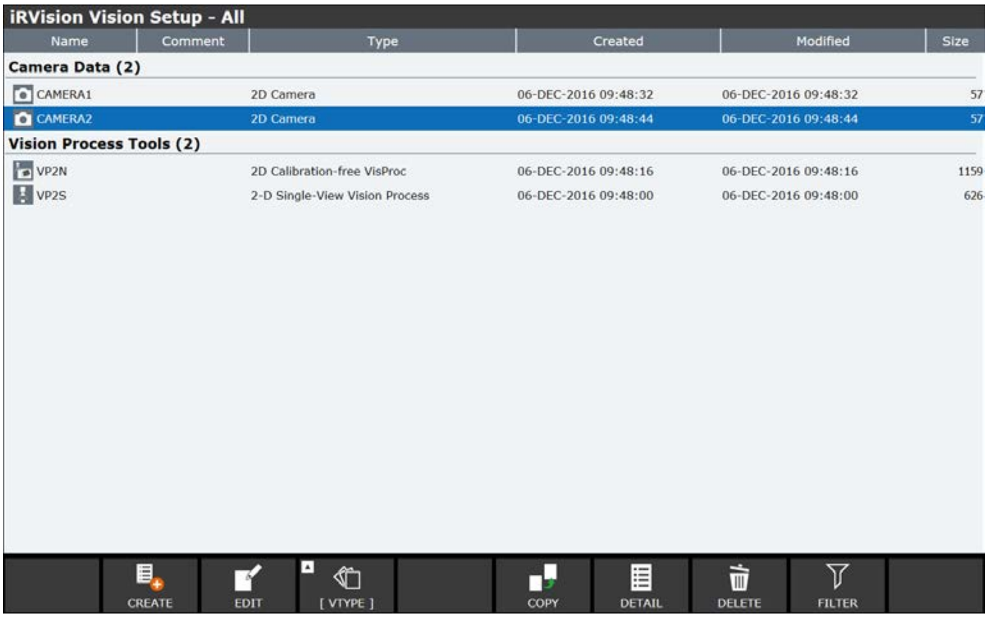
Displays the *i*RVision parts list manager list screen. For details, refer to the description of parts list manager in "*i*RVision Bin Picking Application OPERATOR’S MANUAL B-83914EN-6".

1.3 VISION SETUP

On the Vision Setup screen, you can create, teach and test vision data.

1.3.1 Operating Vision Data List Screen

1 On the homepage of the robot, select [iRVision] - click [Vision Setup].
The Vision Setup screen shows the list of vision data.



The following items can be displayed in the list.
Those displayed in bold in the list are the vision data categories. Created vision data will appear in categories.

[Name]
The name of vision data is displayed.

[Comment]
The comment of vision data is displayed. The operator may enter arbitrary character strings.

[Type]
The type of vision data is displayed.

[Created]
The time and date at which corresponding vision data was created 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. There is a limit to the size of a vision data file, and this limit is 2 MB by default.

Function key

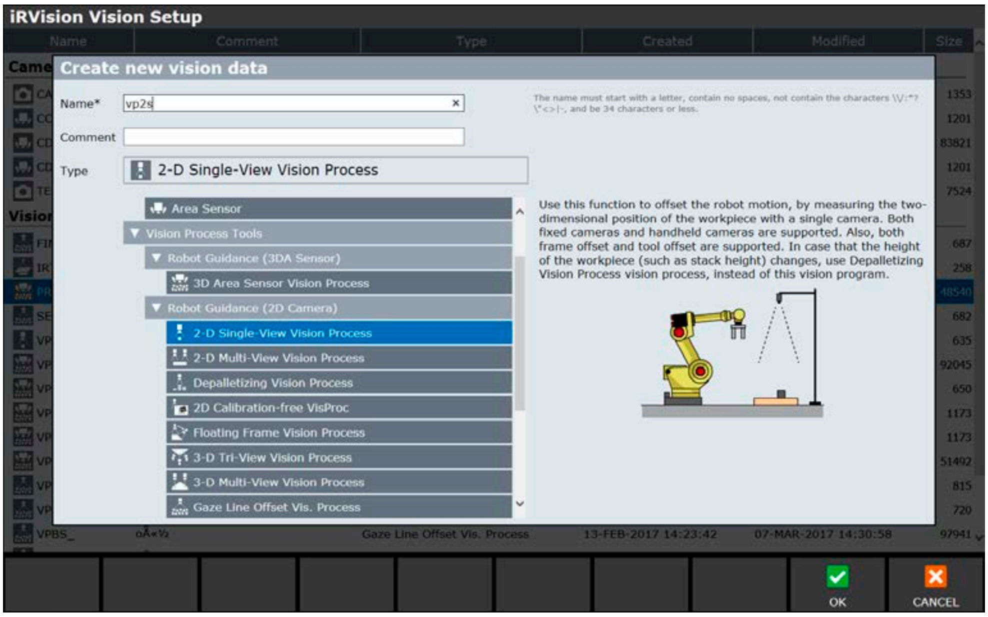
The following function keys will appear on the vision data list screen.

Icons	Name	Function
	CREATE	Creates a new vision data. For details, refer to "Setup: 1.3.1.1 Creating New Vision Data".
	EDIT	Opens the vision data edit screen. For details, refer to "Setup: 1.3.2 Editing Vsion Data".
	COPY	Makes a copy of the vision data. For details, refer to "Setup: 1.3.1.3 Copying Vision Data".
	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, refer to "Setup: 1.3.1.4 Verifying Vision Data Detail Information".
	DELETE	Deletes the vision data. For details, refer to "Setup: 1.3.1.2 Deleting Vision Data".
	FILTER	Sets a filter to the list of vision data. For details, refer to "Setup: 1.3.1.5 Setting a Filter to List of Vision Data".

1.3.1.1 Creating new vision data

To create new vision data, perform the following steps.

1 Click [CREATE].
A pop up to select the types of vision data will appear.
2 Click the type of vision data to create.
A pop up of creating a new vision data will appear.



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. The name must contain no spaces, not contain the symbol other than underscore, and start with start with a letter.
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.

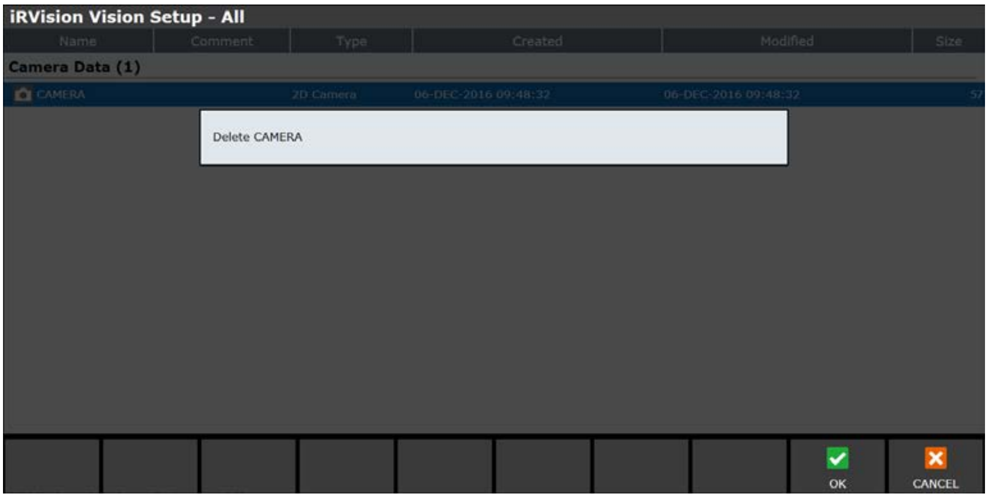
4 Click [OK].
A new vision data will be created.
Clicking [CANCEL] will cancel create.

⚠ CAUTION
The following names are not usable as the name of the vision data:
CON, PRN, AUX, NUL, COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9, LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, LPT9.

1.3.1.2 Deleting vision data

To delete vision data, perform the following steps.

1 In the list, select the vision data to be deleted.
2 Click [DELETE].
A pop up to confirm delete will appear.



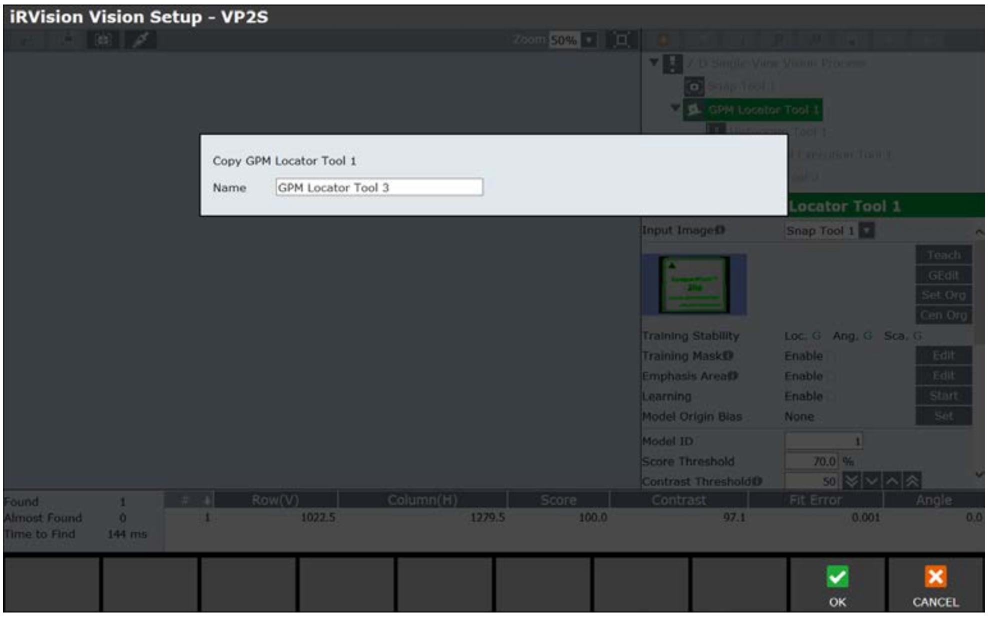
3 Click [OK].
The selected vision data will be deleted.
Clicking [CANCEL] will cancel delete.

1.3.1.3 Copying vision data

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

1 In the list, select the vision data to be copied.

2 Click [COPY].
A pop up to enter the [Name] of the copy destination will appear.

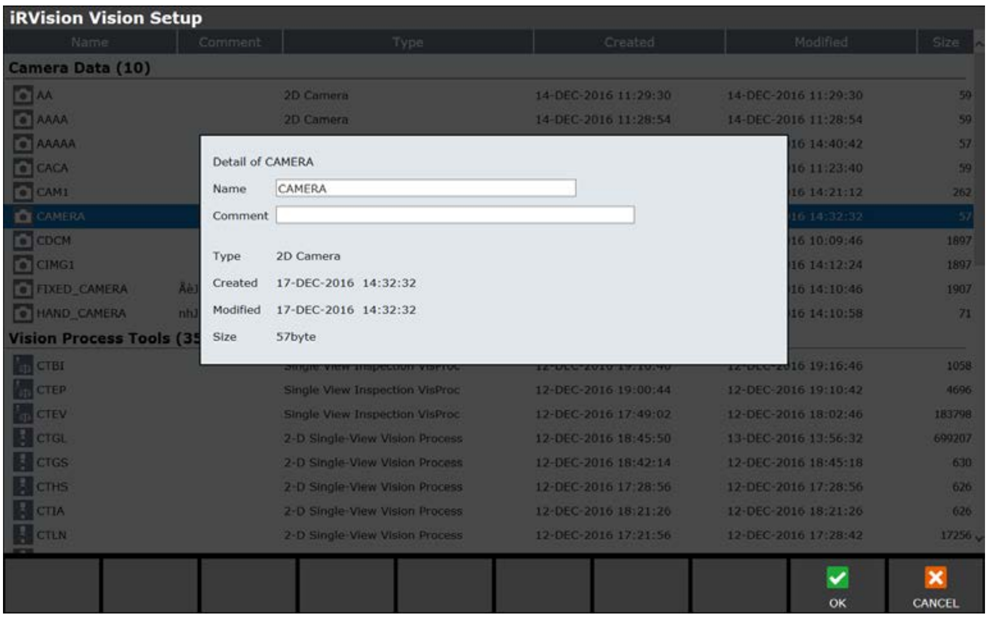


3 In [Name], enter the vision data name of the copy destination.
4 Click [OK].
A copy will be created.
Clicking [CANCEL] will cancel copy.

1.3.1.4 Verifying vision data detail information

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

1 In the list, select the vision data to be verified.
2 Click [DETAIL].
A pop up of detail information will appear.
In [Name], enter a new vision data name if you want to rename the vision data. In [Comment], enter a new comment string if you want to change the comment.

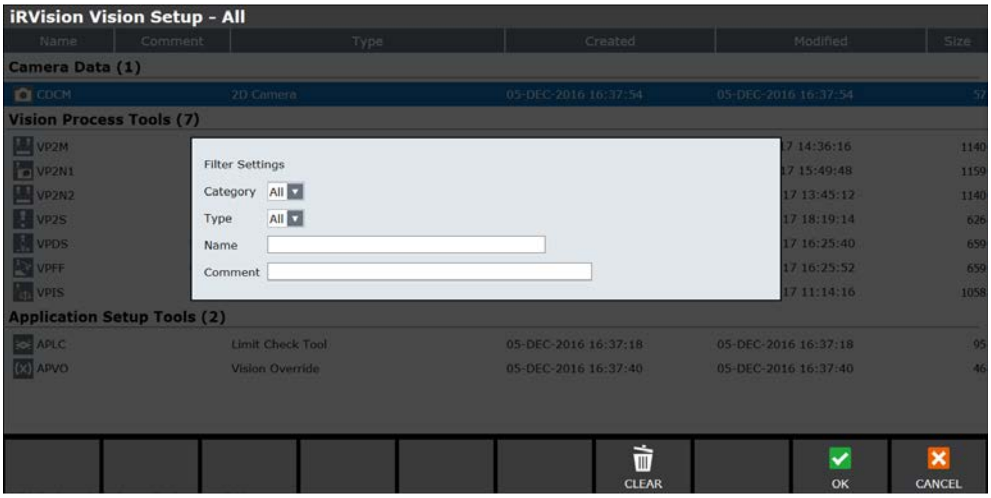


3 Click [OK].
Returns to the vision data list screen. The changes of [Name] and [Comment] will be reflected. Clicking [CANCEL] will cancel changes of [Name] and [Comment].

1.3.1.5 Setting a filter to list of vision data

Set a filter on the vision data list screen to display specific vision data.

1 Click [FILTER] in the list screen of vision data.
The filter setting pop up will appear.
2 Set up at least one of [Category], [Type], [Name] and [Comment].



3 Click [OK].
The filter will be applied.
Clicking [CANCEL] will cancel setting a filter and returns to the original screen.

The following items appear in the filter setting pop up.

[Category]

Select a category of vision data that you want to display on the list screen of vision data. For example, if [Camera Data] is selected as the category, only Camera Data is displayed on the list screen. If [ALL] is selected as the category, all categories of vision data are displayed on the list.

[Type]

Select a type of vision data that you want to display on the list screen of vision data. For example, if [2-D Single-View Vision Process] is selected as the type, only '2D Single View Vision Process' is displayed on the list screen. If [ALL] is selected as the type, all types of vision data are displayed on the list.

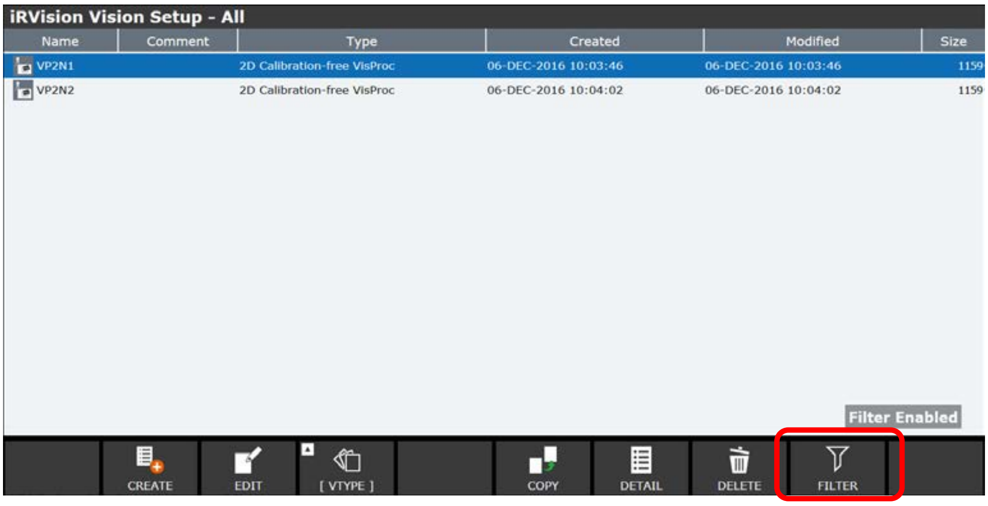
[Name]

Specify a text string that should be included in the vision data name. Only vision data with the name including the specified text string are displayed on the list screen. When not specified, filtering is not performed with the vision data name.

[Comment]

Specify a text string that should be included in the comment of vision data. Only the vision data with the comment including the specified text string are displayed on the list screen. When not specified, the filtering is not performed with the vision data comment.

While a filter is enabled, “Filter Enabled” is displayed on the list screen of vision data.



Clear the filter

1 While the filter is enabled, click [FILTER] on the vision data list screen.
The filter setting pop up will appear.

2 Select [CLEAR] – click [OK].
Filter setting will be cleared.

1.3.2 Editing Vision Data

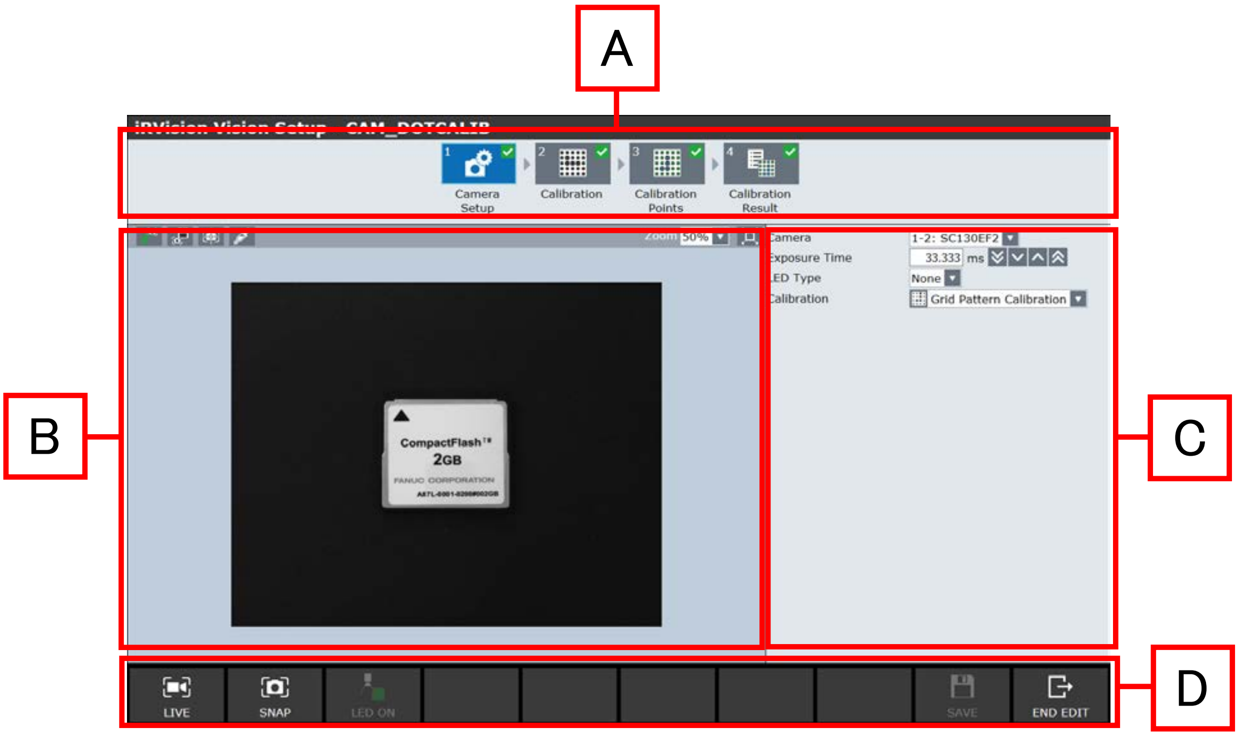
Edits the created vision data. The structure of vision data edit screen depends on the vision data category.

1.3.2.1 Editing camera data

Select camera data from the vision data list screen to edit.

1 On the vision data list screen, select the camera data to edit – click [Edit].
The camera data edit screen will appear. The selected camera data name will be displayed in the title.

The camera data edit screen has the following structure.



A Navigation Area

On the camera data edit screen, navigate the setup steps with the button displays.
Blue buttons represent the current step, and steps that setup is completed will have ✓ displayed.
When teaching, start setup from the steps on the left. You cannot proceed to the next step without completing the setup of the previous step. The buttons of steps you cannot proceed will be displayed in pale gray.
When editing camera data, you can switch the steps by clicking the buttons.
The steps displayed will vary depending on the types of camera and camera calibration.

B Image View Area

Displays the image snapped by the selected camera.

C Setup Items Area

Displays the setup items corresponding to the steps selected in the navigation area.

D Function Key Area

Displays the function keys that are usable in the displayed screen. The function key display will change depending on the setup condition and so on

For the details of teaching each camera data, refer to "Setup: 2 CAMERA DATA".

Function key

The following function keys will appear on the camera data edit screen.

Icons	Name	Function
	LIVE	Starts the camera live image display.
	SNAP	Snaps a new camera image.

Icons	Name	Function
	LED ON	Switch between the LED Type On (LED ON) and Off (LED OFF). You cannot use it when [LED Type] is [None] on the Camera Setup. For details, refer to "Setup: 2.1.1 Camera Setup"
	SAVE	Saves the camera data.
	END EDIT	Ends the camera data edit screen, and returns to the vision data list screen. If you click [END EDIT] when the changes are not saved, a message to confirm whether to save the changes will appear. Click [SAVE AND EXIT] to save the changes, and [EXIT W/O SAVE] to undo the inappropriate changes. Clicking [CANCEL] will return to the vision process edit screen. The camera data edit screen will remain internally open until you click [END EDIT]. When you display other main screen and display the camera data edit screen again, you can continue to edit the camera data.

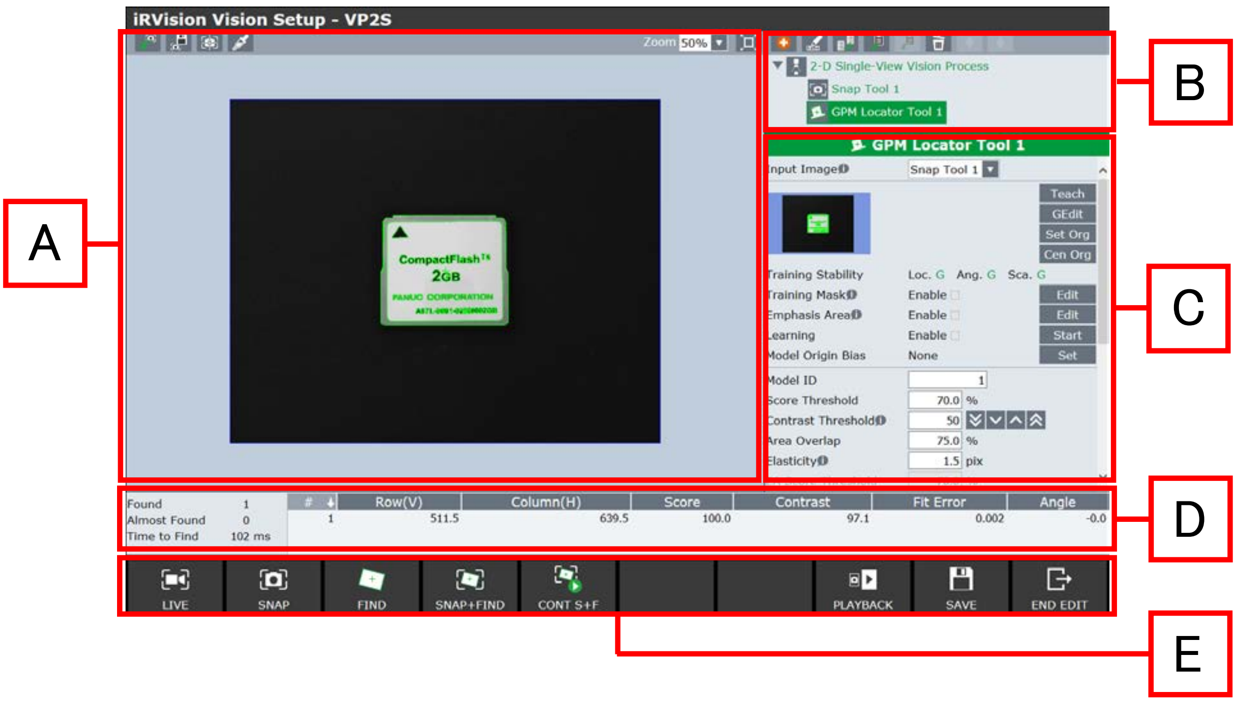
⚠ CAUTION
Do not turn off the robot controller while saving camera data. Doing so may corrupt the memory in the robot controller and may interfere with normal robot operation.

1.3.2.2 Editing vision process

Select a vision process from the vision data list screen to edit.

1 On the vision data list screen, select the vision process to edit and click [EDIT].
The edit screen for vision processes will appear. The selected vision process name will be displayed in the title.

The vision process edit screen has the following structure.



A Image View Area

Displays the image snapped by the selected camera.

B Tree View Area

Displays the vision tools composing the vision process in tree format.
The setup items of vision tool selected here will appear in C, setup items area, and the execution results such as FIND in D, result display area.
The display size of the tree view area may be changed by dragging the border line between the tree view area and the setup items area.

C Setup Items Area

Displays the setup items of vision tool selected in B, tree view area.
The vision tool name will appear in the title of the setup items area (the top of the area). The background of the title will be displayed in green when the edited vision tool is setup correctly. The background of the title will be displayed in red when there is a not set item or items in inappropriate status.
When there are many setup items, you can display the hidden parts by dragging the scroll bar in the setup items area.

D Result Display Area

Displays the results of test executed on the vision tool selected in B, tree view area.
Clicking a row on the list view of found results will highlight the selected row. Then the graphics of the selected results will be plotted on the image. Clicking the selected row again will clear select.
Clicking the header item on the table of found results will display , and clicking again will display . Sort and display in the ascending/descending order of the value of the selected item.
The display size of the result display area may be changed by dragging the upper border line of the results display area.

E Function Key Area

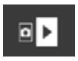
Displays the function keys that are usable in the displayed screen. The function key display will change depending on the setup condition and so on

For details of teaching each vision processes, refer to "Setup: 3 VISION PROCESSES” .

Function key

The following function keys will appear on the vision process edit screen.

Icons	Name	Function
	LIVE	Starts the camera live image display.
	SNAP	Snaps a new camera image.
	FIND	Performs a test detection of the vision tool selected in the tree view. For details, refer to "Setup: 3 VISION PROCESSES" and "Setup: 4 COMMAND TOOLS".
	SNAP+FIND	Performs a new image snapping and test detection.
	CONT S+F	Continuously performs image snapping and test detection.
	2-3D SNAP	An image is snapped and a 3D map is acquired.

Icons	Name	Function
	PLAYBACK	Brings you to the image playback mode. About the image playback mode, refer to "Setup: 1.6.4 Image Playback".
	SAVE	Saves the vision process.
	END EDIT	Ends the vision process edit screen, and returns to the vision data list screen. If you click [END EDIT] when the changes are not saved, a message to confirm whether to save the changes will appear. Click [SAVE AND EXIT] to save the changes, and [EXIT W/O SAVE] to undo the inappropriate changes. Clicking [CANCEL] will return to the vision process edit screen. The vision process edit screen will remain internally open until you click [END EDIT]. When you display other main screen and display the vision process edit screen again, you can continue to edit the vision process.

⚠ **CAUTION**

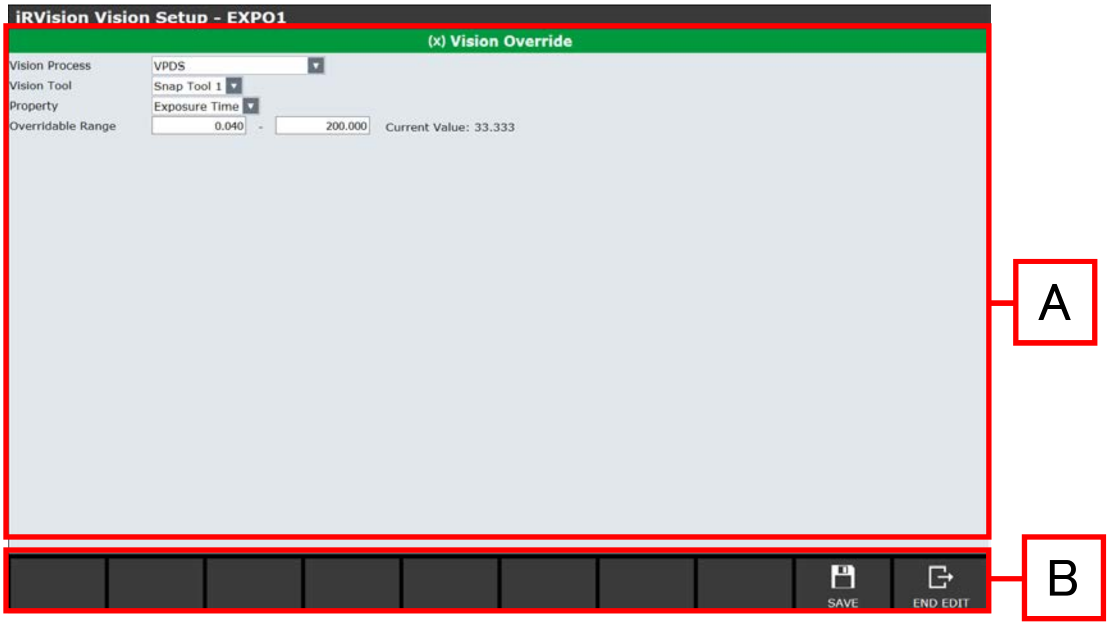
1. Do not turn off the robot controller while saving vision processes. Doing so may corrupt the memory in the robot controller and may interfere with normal robot operation.
2. The new settings made by modifying the contents of the vision process edit screen are not saved until [SAVE] or [END EDIT]-[SAVE AND EXIT] is clicked. You need to save the vision process so that the new settings are effective to the production operation.
3. 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.
4. The maximum number of vision data edit screen that you can open at the same time is limited to 1.

1.3.2.3 Editing application data

Select application data from the vision data list screen to edit.

1. On the vision data list screen, select the application data to edit and click [EDIT].
   Displays the application data edit screen. The selected application data name will be displayed in the title.

The application data edit screen has the following structure.



A Setup Items Area

Displays the setup items of selected application data.

B Function Key Area

Displays the function keys that are usable in the displayed screen. The function key display will change depending on the setup condition and so on

For details of setting up application data, refer to "Setup: 5 APPLICATION DATA".

Function key

The following function keys will appear on the application data t screen.

Icons	Name	Function
	SAVE	Saves the application data.
	END EDIT	Ends the application data edit screen, and returns to the vision data list screen. If you click [END EDIT] when the changes are not saved, a message to confirm whether to save the changes will appear. Click [SAVE AND EXIT] to save the changes, and [EXIT W/O SAVE] to undo the inappropriate changes. Clicking [CANCEL] will return to the application data edit screen. The application data edit screen will remain internally open until you click [END EDIT]. When you display other main screen and display the application data edit screen again, you can continue to edit the application data.

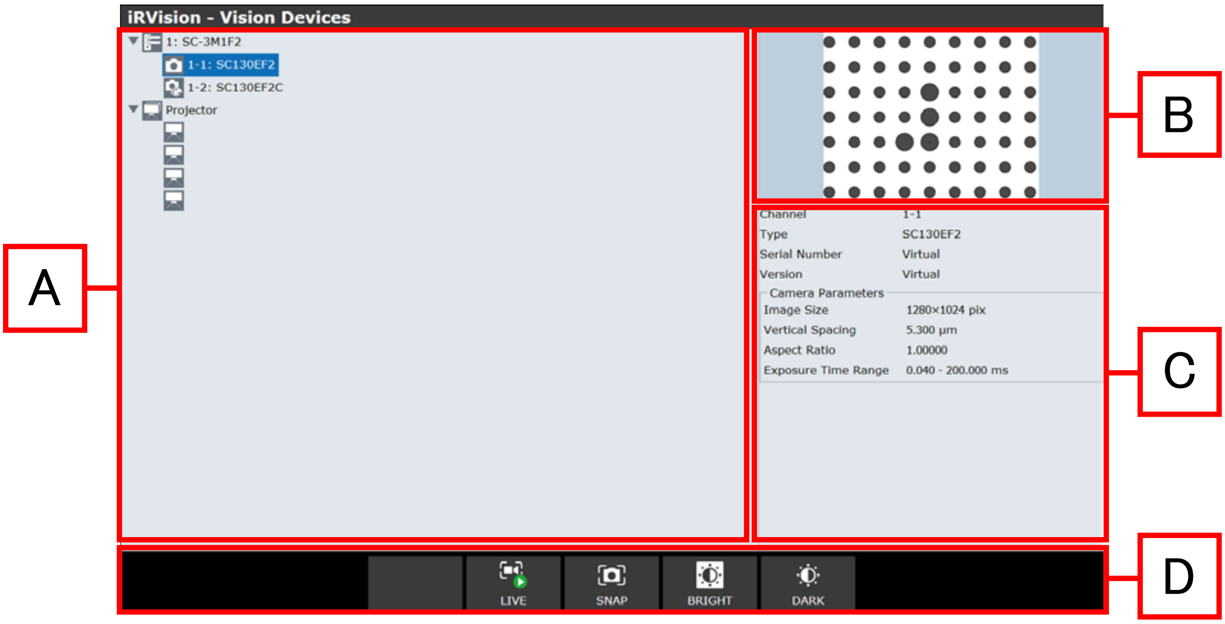
⚠ CAUTION

Do not turn off the robot controller while saving application data. Doing so may corrupt the memory in the robot controller and may interfere with normal robot operation.

1.4 VISION DEVICES

You can check the connection information of *i*RVision devices (such as camera and projector) connected to the robot controller.

1 On the homepage of the robot, select [iRVision] – click [Vision Devices].
Displays the vision device screen.



Vision device screen has the following structure.

A Device List Area

Displays the camera and projector connected to the robot controller as elements.

B Image View Area

If the device selected in A, device list area, is a camera, a camera image will appear in the image view area.

C Detail Information Area

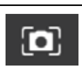
Displays the information of the device selected in A, device list area.

D Function Key Area

Displays the function keys that are usable in the displayed screen. The function key display will change depending on the setup condition and so on

Function key

The following function keys will appear on the vision device screen.

Icons	Name	Function
	LIVE	Starts the camera live image display.
	SNAP	Snaps a new camera image.

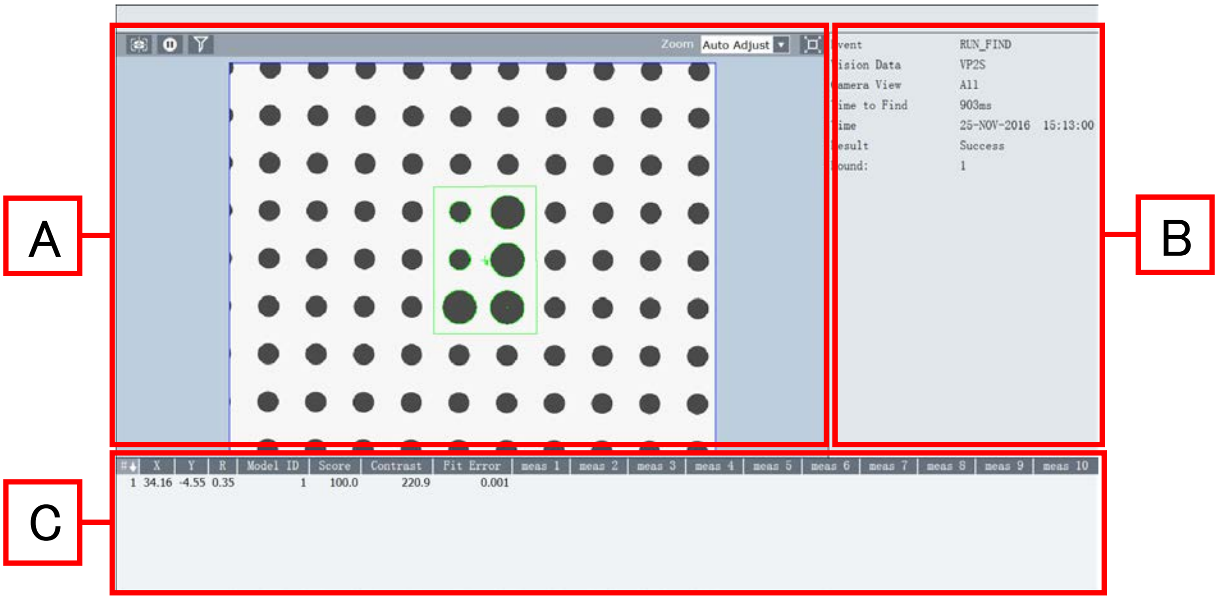
Icons	Name	Function
	BRIGHT	Make the image in the image view brighter.
	DARK	Make the image in the image view darker.

1.5 VISION RUNTIME

You can check the found results of vision process when RUN_FIND is executed from TP program on the vision runtime.

1 On the homepage of the robot, select [iRVision] – click [Vision Runtime].
Displays the vision runtime screen.

The Vision Runtime screen has the following structure.



A Image View Area

Displays the found results image of vision process when RUN_FIND is executed from TP program.

B Execution Information Area

Displays the information such as executed vision process name, time of execution and time to find.

C Result Display Area

Displays the detail of found results of executed vision process in a list view format.

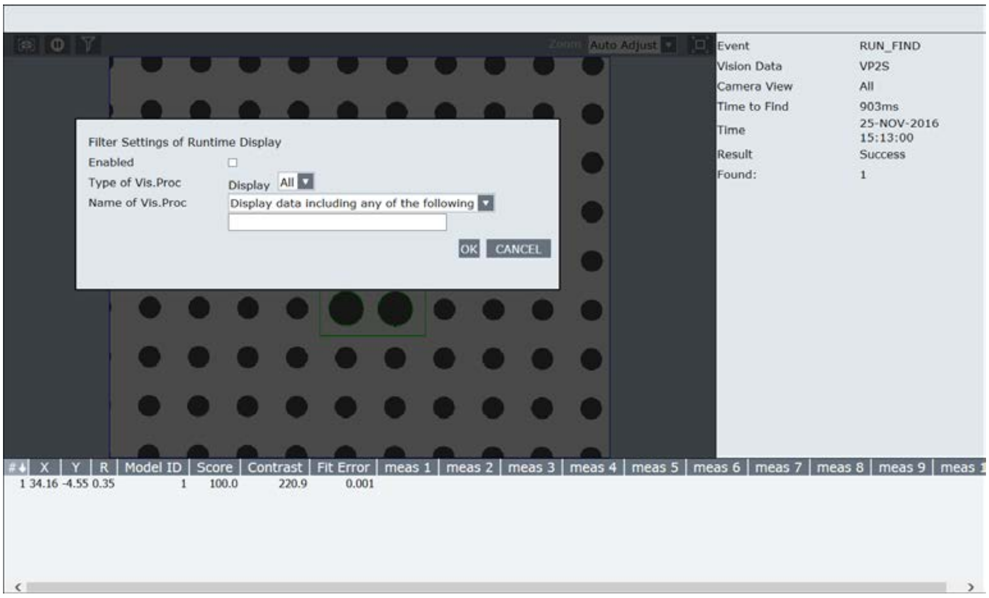
The following buttons will appear on this screen.

: Displays blue center lines in top-bottom and left-right directions of the image.
: Suspends the image display on the vision runtime.
: Displays the image in full on the vision runtime screen.
: Returns to the original display when clicked during magnified display.

1.5.1 Setting Filter to Vision Runtime

The filter setting enables to show only the specified vision processes on the Vision Runtime screen.

1 On the image view of the vision runtime screen, click button.
The filter setting pop up will appear.



2 Specify the filter setting conditions.
3 Click [OK].
The filter will be applied.
Clicking [CANCEL] will cancel setting a filter and returns to the original screen.

The following items appear in the filter setting pop up. The filter setting can be done individually for teach pendant and PC. The filter setting is kept even after rebooting the controller.

[Enabled]
Check this item to enable the filter. By default, it is not checked.

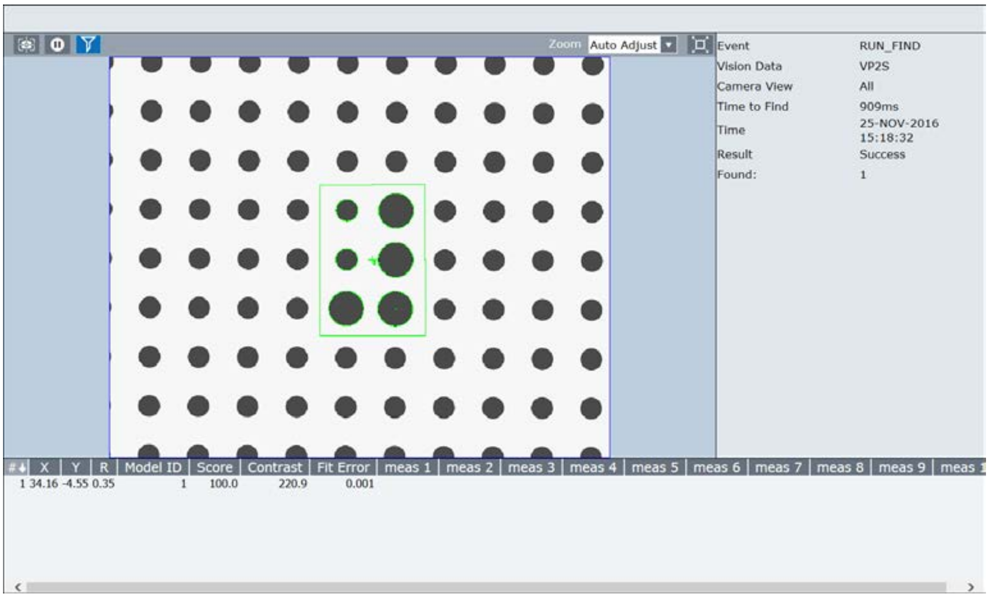
[Type of Vis.Proc]
Select the type of vision process to be displayed in the drop-down-box. Only the specified type of vision process is displayed. By default, all types of vision process are displayed.

[Name of Vis.Proc]
Specify text strings that should be included in the vision process name and select whether the vision processes should be displayed or not in the drop-down-box. You don’t have to specify entire name of the vision processes. You can specify multiple text strings by separating them with a white space.

[Display data including any of the following]
Vision Runtime displays vision processes only when the vision process name includes any of the specified text strings.

[Display data not including any of the following]
Vision Runtime displays vision processes when the vision process name does not include any of the specified text strings. In other words, it does not display vision processes when the vision process name includes any of the specified text strings.

When the filter is enabled,  is displayed in the image view of the vision runtime screen.



Clear the filter

1 While the filter is enabled, click  button on the vision runtime screen.
The filter setting pop up will appear.

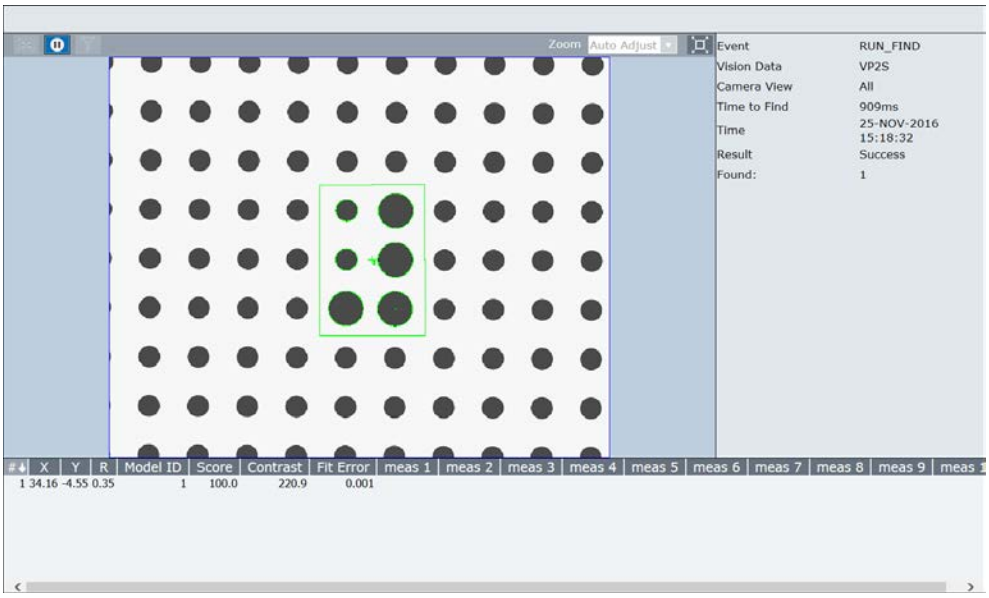
2 Select [CLEAR] – click [OK].
Filter setting will be cleared.

1.5.2 Freezing Vision Runtime

You can temporarily freeze the Vision Runtime screen. While being frozen, the Vision Runtime screen is not updated even if the controller runs a vision process.

1 On the vision runtime screen, click  button.
Refreshing the vision runtime will be stopped.

While refreshing the vision runtime is stopped,  is displayed in the image view of the vision runtime screen.



Resuming Refresh

1 While refreshing is stopped, click  button on the vision runtime screen.
Refreshing the vision runtime will resume.

1.6 VISION LOG

Vision log is a function to record loggings of vision processes. Images snapped by vision processes can be recorded as logged images.
By default, however, the vision log is disabled. You need to change the setting in order to record the vision log and logged images

1.6.1 Recording the Vision Log

To record the vision log, check [Enable Logging] on the *i*RVision vision config screen. For details of *i*RVision vision config, refer to "Setup: 1.7 VISION CONFIG".

The vision log is recorded in the external memory device (MC: for R-30*i*B Plus controller). If no memory device is inserted, the vision log is not recorded even when *i*RVision is configured to record the vision log.

When the free space of the memory device is less than the specified value (1 MB 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 the memory device 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 device has enough free space. For information about how to export vision logs to an external device or how to delete them, refer to "Setup: 7.3 VISION LOG MENU".
2 If the free space of a memory device falls below the specified value as a result of other files being written to the memory device, 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.
4 Be sure to format Memory Card or USB memory with FAT16.

1.6.2 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, refer to "Setup: 1.6.4 Image Playback".
Images are saved as a part of the vision log on a memory device. Whether to save images to the vision

log is specified for each vision process.
Set whether to record the logged images or not on the vision process edit screen. For details, refer to each section in "Setup: 3 VISION PROCESSES" .

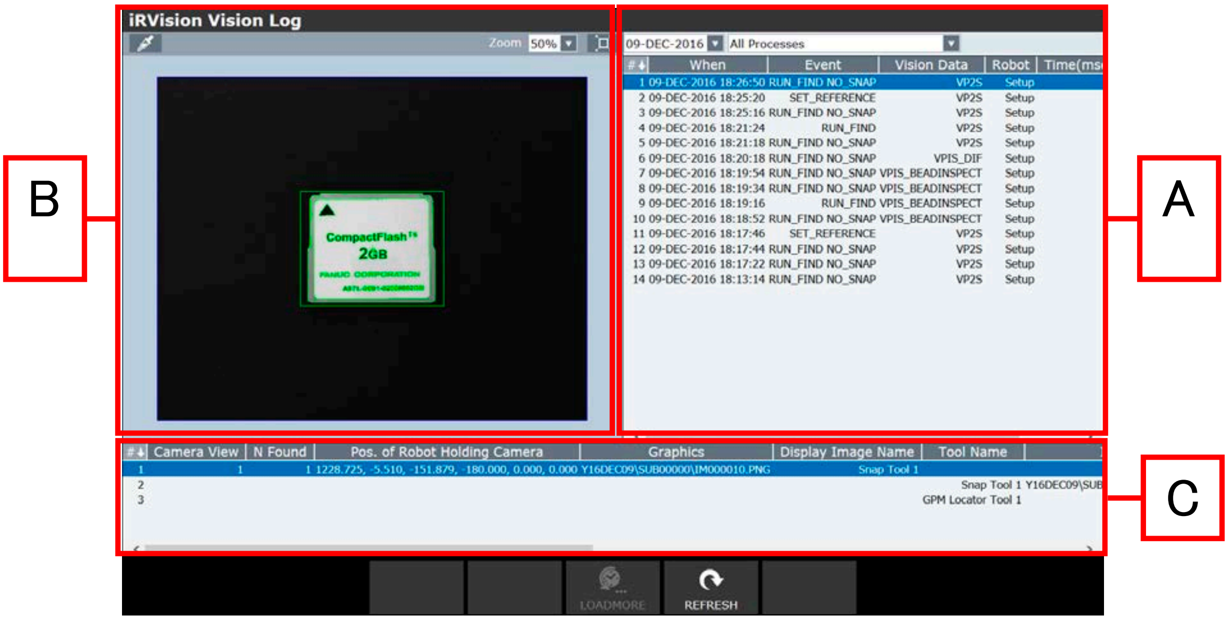
> **MEMO**
> If you have the vision log disabled in the Vision Config screen, logged images are not saved even when you set the vision process to save logged images.

1.6.3 Viewing the Vision Log

On the *i*RVision Vision Log screen, you can view recorded vision logs.

1 On the homepage of the robot, select [iRVision] – click [Vision Log].
The vision log screen will appear.

The vision log screen has the following structure.



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 vision logs of all existing vision data, select [All Processes].

A Log Display Area

Displays the list of recorded logs in a list view format.

B Image View Area

When an image is recorded on the log selected in A, the image will appear in the image view.

C Result Display Area

Selecting a log in A will display the detail information in the result display area.

Function key

The following function keys will appear on the vision log screen.

Icons	Name	Function
	LOADMORE	When the vision log screen appears, 500 most recent logs will be displayed in the log display area. Click it when viewing logs older than them. One click displays additional 500 logs.
	REFRESH	Refreshes the display of the vision log.

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/Y16APR10/

is the sub-folder for April 10, 2016.

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

.VL Logged data file
.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.

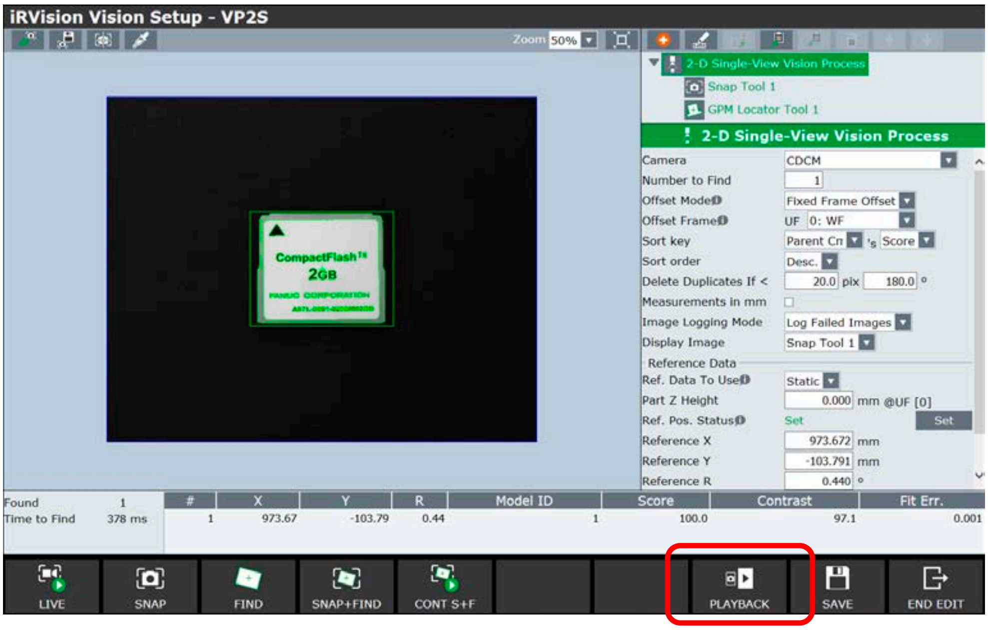
The kinds of results that are displayed on the setup page are recorded in the Logged data file.
For detail of the log pass of the vision log, refer to "Setup: 1.7 VISION CONFIG".

1.6.4 Image Playback

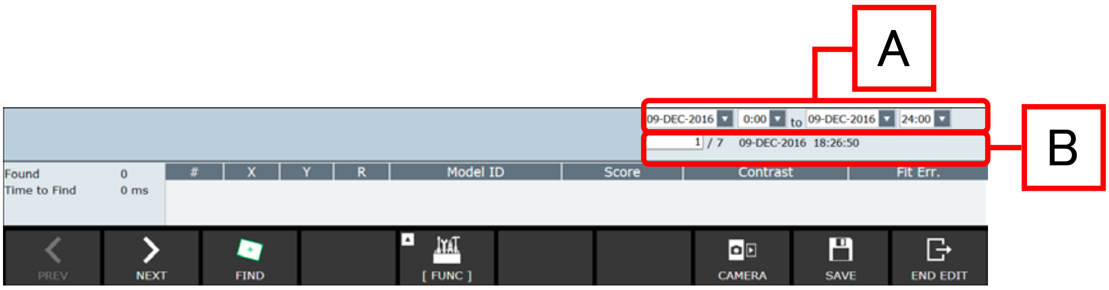
Performing test using the logs is called 'Playback'. Images logged during production operation can be used to test and adjust location parameters. When location parameters have been changed, for example, this function is useful to use past images to check for any problem.
When the camera is mounted on 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, refer to "Setup: 1.6.2 Logging Images".

Below are the steps for image playback,

1 Click [PLAYBACK] on the vision process edit screen.



Turns to playback mode.
The bottom of the setup item area and the function key labels change as follows.



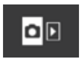
A Select the time zone which logged image was saved. When you first start image playback mode, all logged image which can use on the vision process are selected. If you want to use the image which is saved on the specified time zone, select the specified time zone. Such as the above example, the image which is saved from 0:00 to 24:00 on December 9 of 2016.

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 7 images which are saved from 0:00 to 24:00 on December 9 of 2016, and the first image of these images is displayed.

Function key

The function key labels change as follows in the playback mode.

Icons	Name	Function
	PREV	Loads the previous image.
	NEXT	Loads the next image.
	FIND	Performs a test detection by using the image displayed on the image display.

Icons	Name	Function
	[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.
	CAMERA	Finish the image playback mode.

⚠ CAUTION

In the image playback mode, SAVE IMAGE, LOAD IMAGE, LIVE, SNAP, LASER ON/OFF, 2D SNAP, CONT S and SNAPIND buttons are not available.

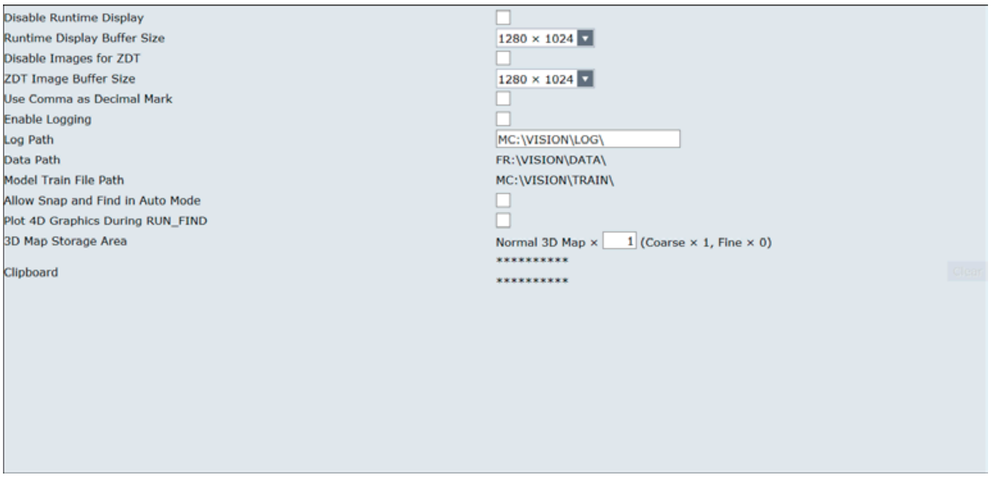
MEMO

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

1.7 VISION CONFIG

On the Vision Config screen, you can set the system variables related to *i*RVision.

1 On the homepage of the robot, select [iRVision] – click [Vision Config]. 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.

[Runtime Display Buffer Size]

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

[1280×1024]

By default, this size is selected.

[640×512]

The buffer size is configured 1/4 of the default size.
The resolution of the image displayed on the PC vision runtime will become lower, but it will reduce the network traffic. The image displayed on the vision runtime of the teach pendant will not be affected because it will not be more than the resolution of the teach pendant screen

⚠ **CAUTION**

Changing the size of Runtime Display Buffer requires rebooting the controller.

[Disable Images for ZDT]

When this item is checked, the system does not perform any processing related to saving images for ZDT function and images are not sent to your mobile device.

[ZDT Image Buffer Size]

The maximum size of images to be sent to your mobile device with the ZDT function is selected from the following items.

[640×512]

When the camera image is larger than this size, the image will be shrunk to be smaller than this size, and then sent to your mobile device. It will reduce the network traffic and the capacity load of the ZDT server.

[1280×1024]

By default, this size is selected.

[Use Comma as Decimal Mark]

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.

[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. 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 available storage units for the vision log is Memory Card (MC:) and USB memory (UD1:) and PC Share (C1:).
The default path is “UD1:/VISION/LOG” for R-30*i*B Plus.

[Data Path]

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

[Model Train File Path]

This item is used to specify the destination folder for storing model train files and image files used with External Model Train function. This item is read-only and cannot be changed. Refer to "Setup: 6.2.3 IRVTRAIN" for External Model Train function.

[Allow Snap and Find in Auto Mode]

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.

[Plot 4D Graphics during RUN_FIND]

When this item is checked, the calibration data and found results are displayed on the 4D Display screen when calling RUN_FIND from an application program. This item is disabled by default because it can affect cycle time.

[3D Map Storage Area]

This item is used to specify the size of 3D Map Storage Area in DRAM. The size of 3D Map Storage Ares is specified by the number of blocks, instead of in bytes. A block can store one normal-density 3D map. The item also shows number of coarse-density 3D maps and fine-density 3D maps that can be stored on the right for your reference. Storing a coarse-density 3D map requires one block, and storing a fine-density 3D map requires four blocks. Determine densities and number of 3D maps that you need to have simultaneously, and then calculate number of blocks for them. For example, when storing one coarse-density 3D map and one fine-3D map simultaneously requires 5 blocks. If you don't have them simultaneously, and you use them one after another, required number of blocks is 4.

> ⚠ **CAUTION**
> 1 Changing the size of 3D Map Storage Area requires rebooting the controller.
> 2 3D maps consume a large amount of memory. Increasing the size of 3D Map Storage Area will decrease the free space of the temporary memory pool. When you increase the size of 3D Map Storage Area, be sure to confirm the free space of the temporary memory pool after restarting the controller. If the free space of the pool is less than 3 MB, decrease the size of 3D Map Storage Area.

[Clipboard]

This item shows the name of vision data and vision tool in the clipboard. The clipboard is used for the copy/paste operation. Contents of a vision tool can be copied to the clipboard and pasted from the clipboard tool to another tool in the same vision process or another vision process. Press [Clear] to clear the clipboard. Cycling power will also clear the clipboard.

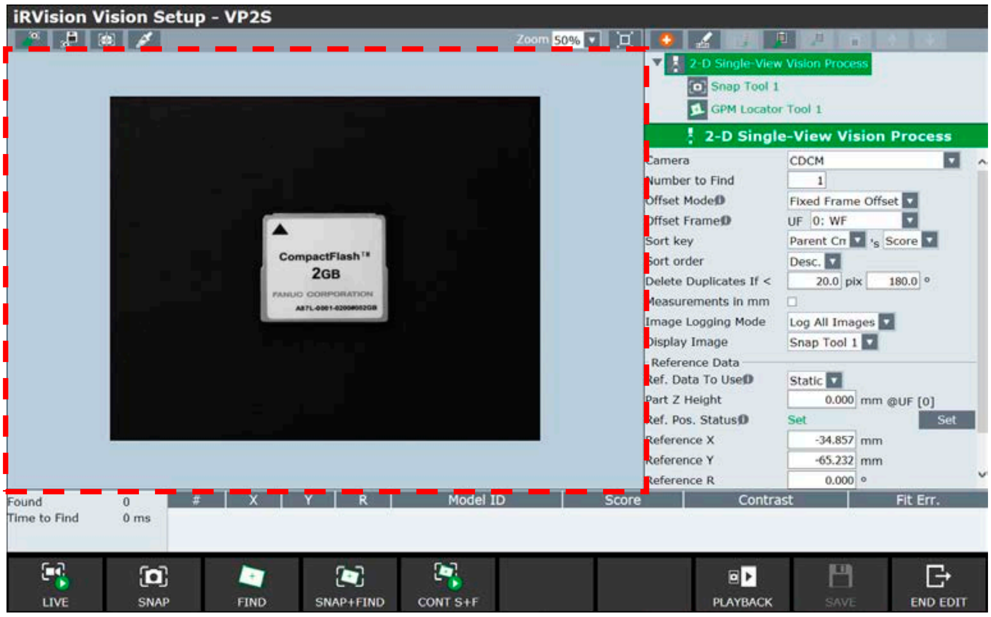
For details of copy and paste of the teaching content of vision tools using the clipboard, refer to "Setup: 1.8.2 Tree view".

1.8 FREQUENTLY-USED OPERATIONS

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

1.8.1 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 Click [LIVE].
  Displaying the live image is started.
2 Click [STOP] while the live image is being displayed.
  Displaying the live image is stopped.

> ⚠ **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.

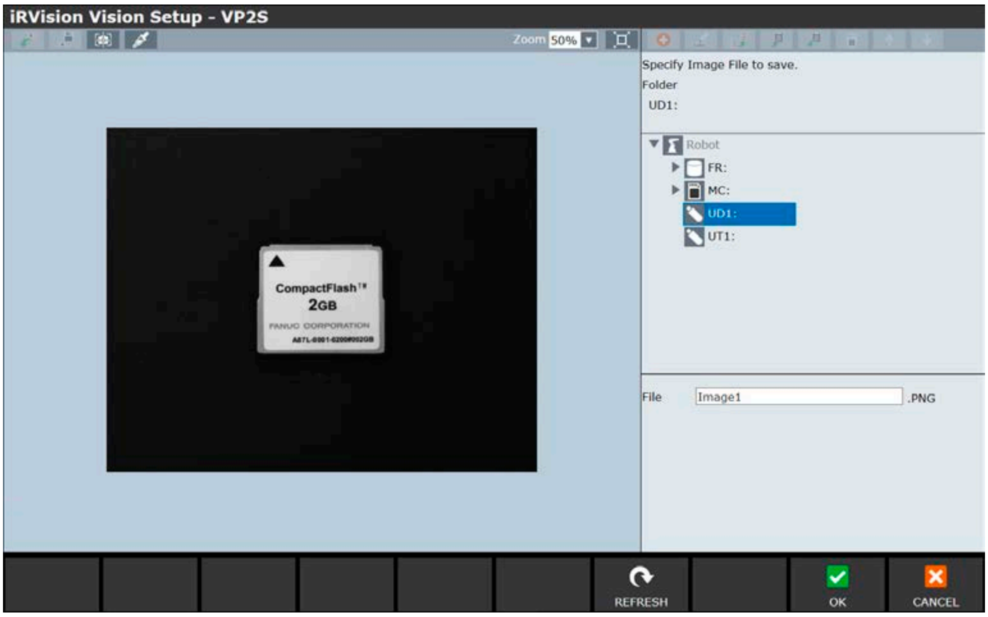
1 Click [SNAP].
  One image is snapped, and the image is displayed in the image display control.

Saving an image to a file

An image currently displayed in the image display control is saved to a memory card or a USB memory in the robot controller.

Images are saved in the PNG format. A PNG formatted image can be viewed using Windows Photo Viewer.

1 click  button.
The following dialog is displayed.



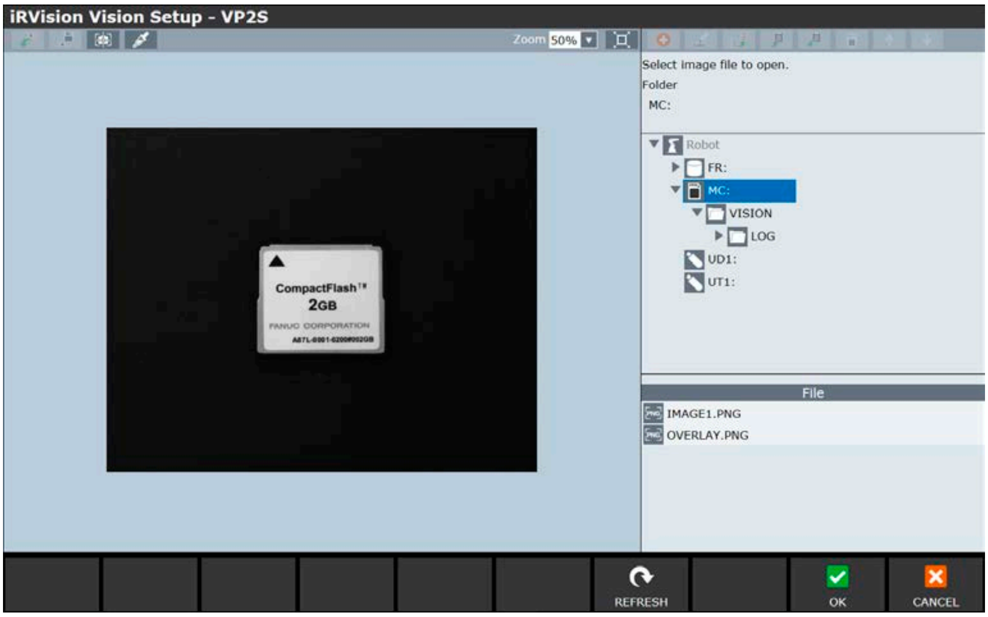
2 Select the destination drive and folder in the folder tree.
3 Enter the file name of the destination in the [File] text box.
4 Click [OK].
The image is saved.
Clicking [CANCEL] will cancel saving.

> ⚠ **CAUTION**
> An image currently displayed in the image display control is saved. The image with Graphics cannot be saved.

Loading an image file

An image file in a memory card or a USB memory of the robot controller is loaded. After it is loaded, the image can be used for vision process setup and testing. Image Files in the BMP or PNG format can be loaded.

1 Click  button.
The following dialog is displayed.

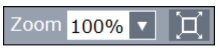


2 Select the drive and folder that contains the image file to load in the folder tree.
3 Select a file to load in the [File] list.
4 Click [OK].
The loaded image file appears in the image display control.
Clicking [CANCEL] will cancel loading.

MEMO
Depending on settings of your vision process, test detection may not be available with an image loaded from an image file when additional information is required, for example position of robot holding the camera, laser images for 3DL sensor and so no). In those cases, an alarm indicating that test detection is not available will be posted. To test such a vision process, use logged images. For details, refer to "Setup: 1.6.4 Image Playback".

Zoom Level

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

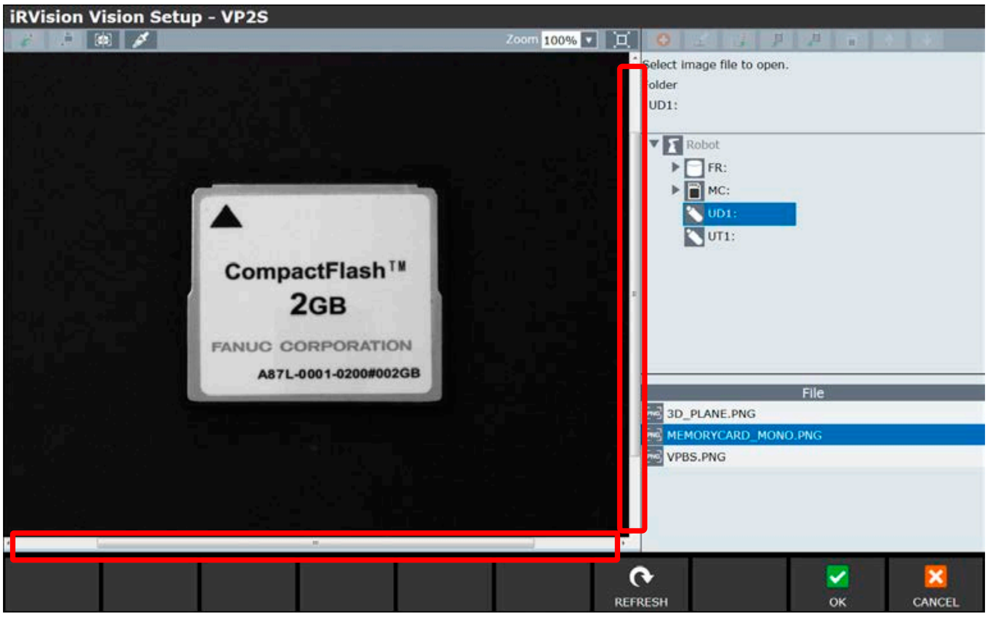


The following zoom levels are available.

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

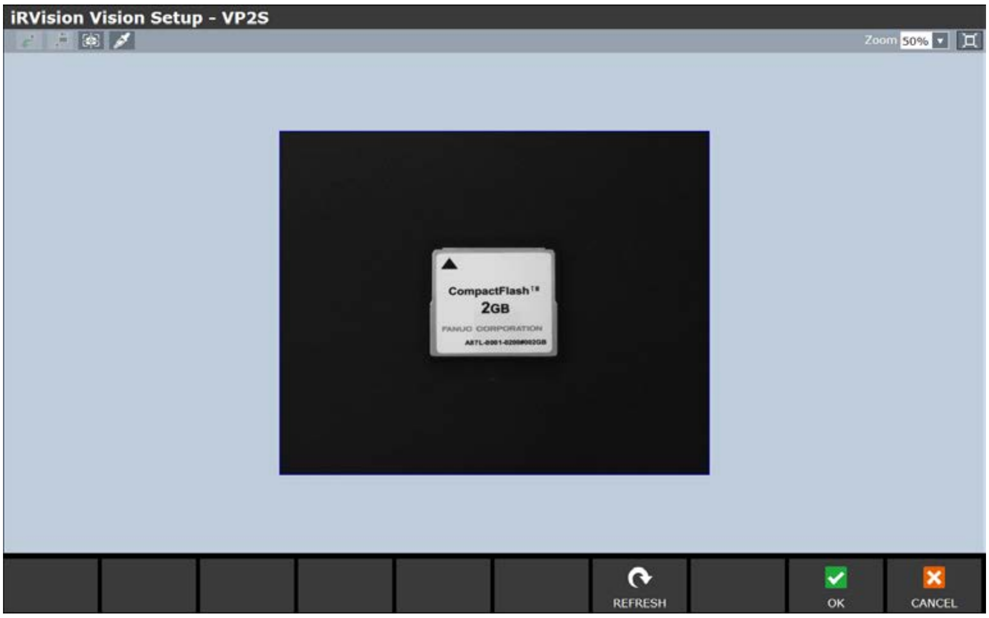
Scrolling an image

When an image cannot fit in the display area, you can move the image vertically or horizontally, by using scroll bars displayed on the image display control.



Maximizing the Image Display Control

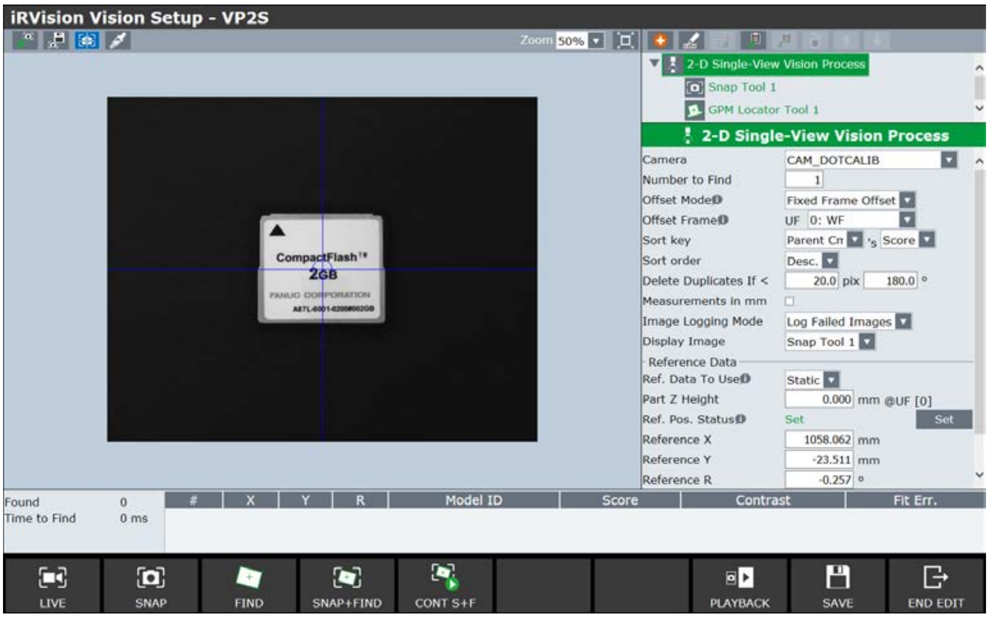
The size of the image display control can be maximized.



1 Click button.
Displays the displayed image in full.
2 Click button while displayed in full image.
Return to the original layout

Displaying Center Line

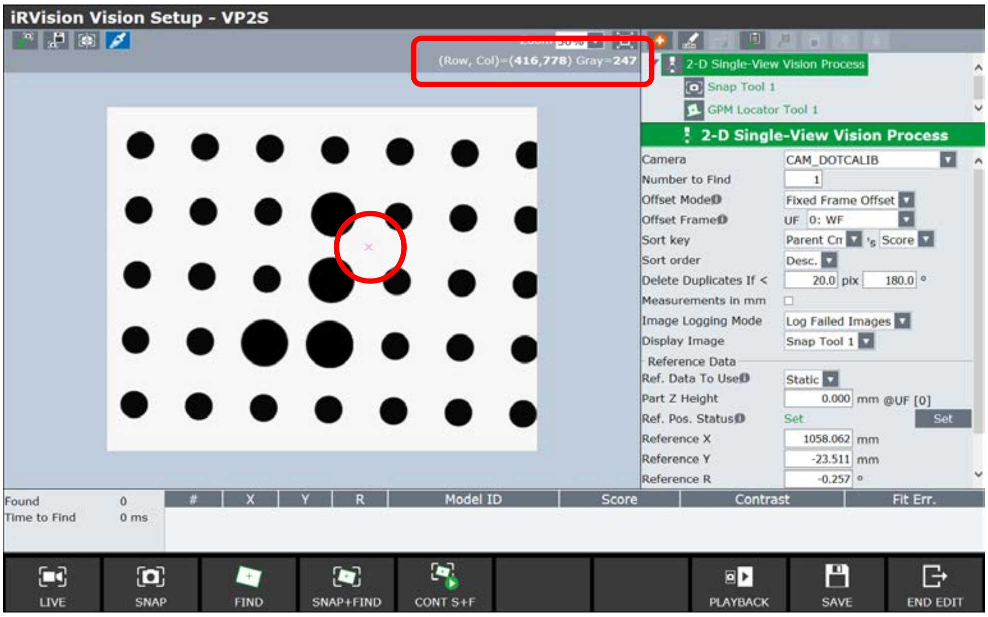
Image center line can be displayed on the image display control.



1 Click button.
Displays the center lines of the displayed image.
2 Click button while displaying the center lines.
The center lines disappear.

Check the grayscaleGB value

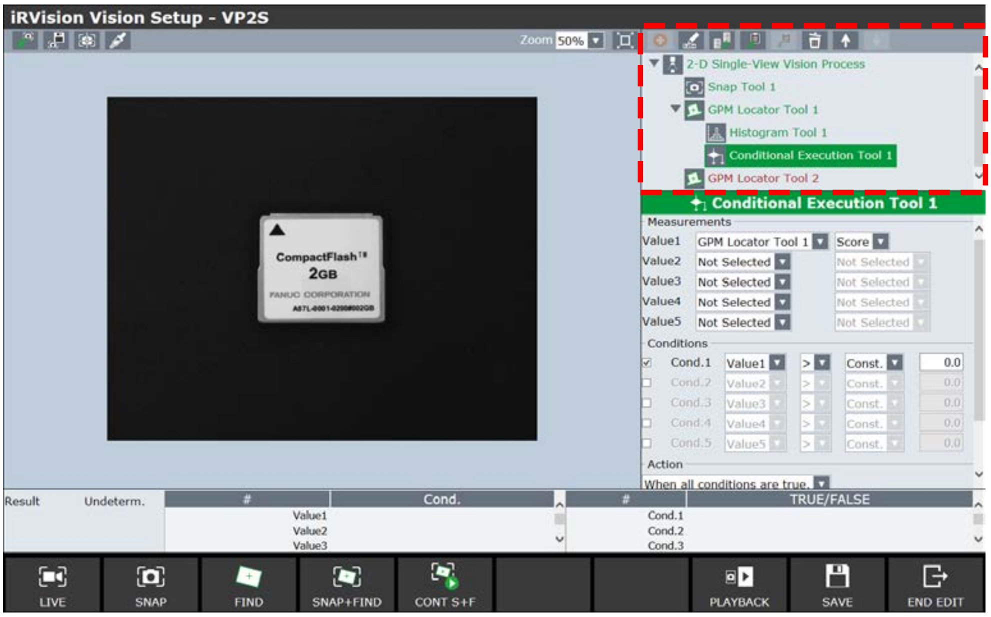
The sampling tool shows the location and grayscale/RGB values of the selected pixel on the image.



1 Click button.
The sampling tool will be enabled. will appear in the upper left of the image.
2 Click an arbitrary pixel on the image.
The location and grayscale of the pixel that is shown by mark are indicated. If a color camera is used, the values of RGB are indicated.
3 Click button to disenable the sampling tool.
The sampling tool will be disabled.

1.8.2 Tree View

In the following figure, the surrounded area by the dot line on the *i*RVision setup screen is called a tree view. The tree view is displayed if the tree tab is selected. The tree view indicates the structure of vision data.



Tree View content

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*.

If you look at the tree view carefully, you will find that the vision tools are not arranged in a row and some vision tools are indented. Relationships among vision tools are represented by a tree structure.

- Histogram Tool 1 is displayed one level right of GPM Locator Tool 1. Histogram Tool 1 is referred to as a 'Child Tool' of GPM Locator Tool 1, and GPM Locator Tool 1 is referred to as a 'Parent Tool' of Histogram Tool 1.
- Conditional Execution Tool 1 is displayed one level right of GPM Locator Tool 1. Therefore, Conditional Execution Tool 1 is a 'Child Tool' of GPM Locator Tool 1, and GPM Locator Tool 1 is a 'Parent Tool' of Conditional Execution Tool 1.
- will be displayed on the row top of a parent tool with a child tool. Click button to display the child tool. When turned to , the child tool will appear.
- Histogram Tool 1 and Conditional Execution Tool are referred to as 'Brother Tools' of same parent tool because they are on the same level.
- '2-D Single-View Vision Process' has 3 child tools; Snap Tool 1, GPM Locator Tool 1 and GPM Locator Tool 2. Snap Tool 1, GPM Locator Tool 1 and GPM Locator Tool 2 are brother tools of 2-D Single-View Vision Process as the parent tool.

Tree View Rules

- 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. The measurement window which dynamically shifts depending on the found results of the parent tool like this is called the 'Dynamic Window'.

- When GPM Locator Tool 1 found several results, the child tool of GPM Locator Tool 1 will be executed for the amount of results found by 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

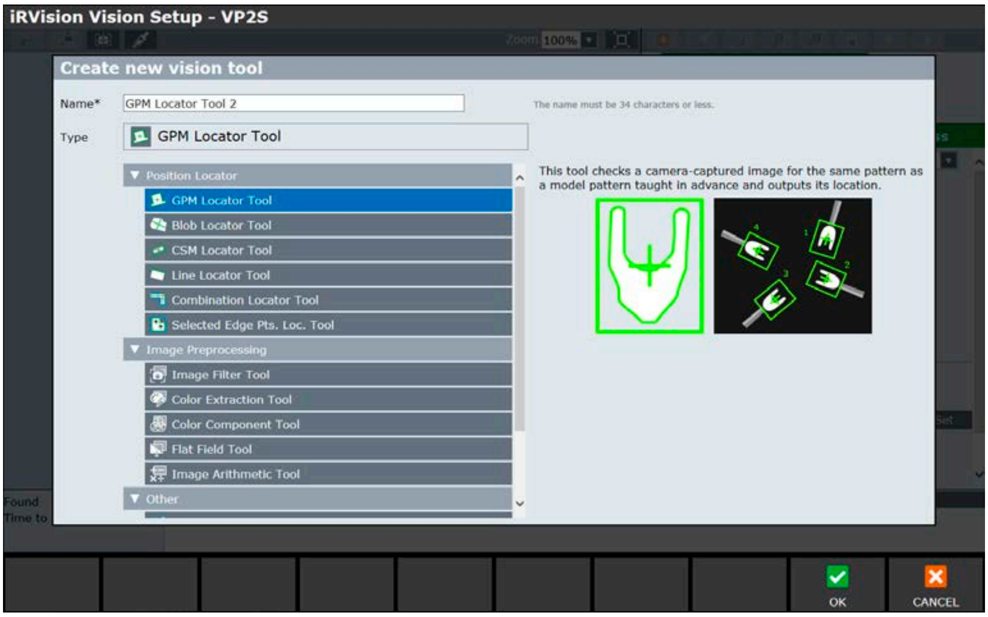
Select the tool to be set up.

1 Click the icon or the name of a tool in the tree view.
The clicked tool is highlighted.
Displays the setup items corresponding to the setup items area.
Click when selecting a vision tool in deeper level.

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 Click button.
A pop up to select the types of vision tool will appear.
3 Click the type of the command tool to add.
A pop up of creating a new command tool will appear.

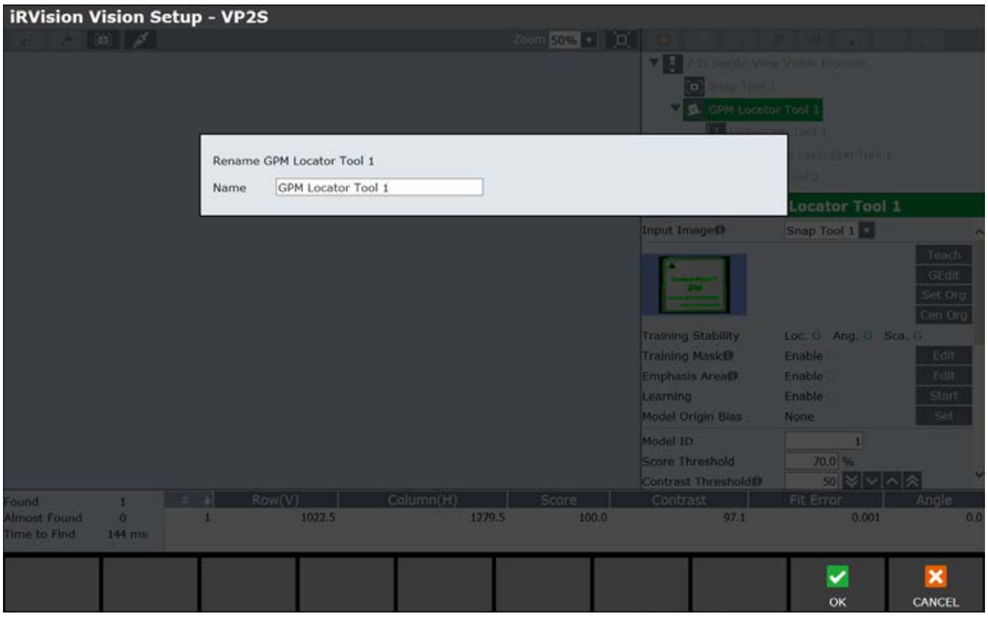


4 In [Name], enter the name of the command tool to be inserted. By default, it is the same name as the selected command tool. You can enter up to 34 letters in half-width alphanumeric characters and half-width katakana or 16 letters in full-width.
5 Click [OK].
The new command tool will be added under the selected parent tool.
Clicking [CANCEL] will cancel adding the command tool.

Renaming a tool

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

1 Select the tool to be renamed.
2 Click button.
The setup items area changes as below.

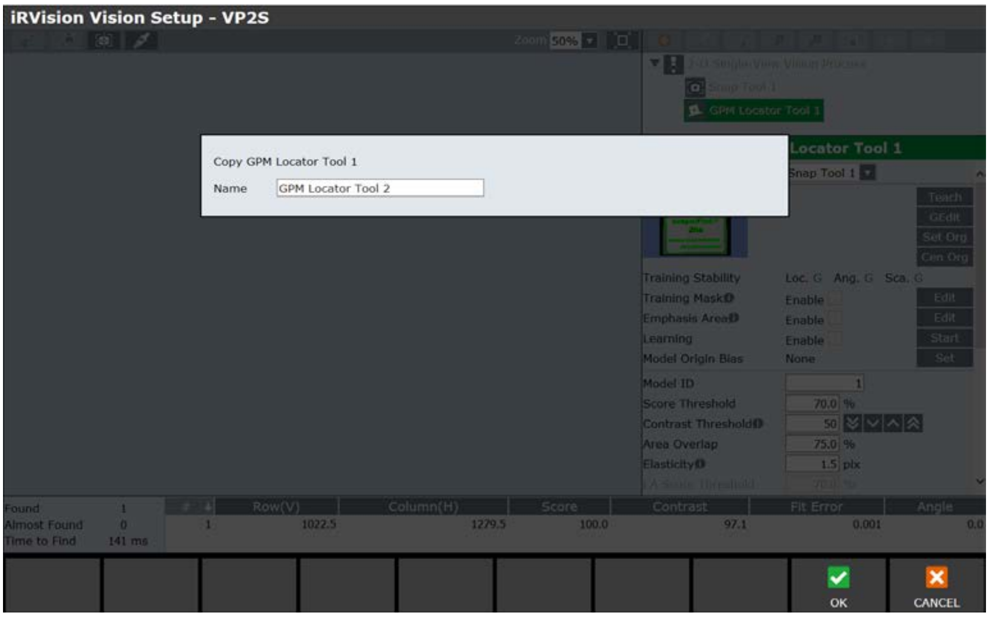


3 In [Name], enter a new tool name.
4 Click [OK].
The name of the command tool will be changed.
Clicking [CANCEL] will cancel changes of name.

Copying a tool

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

1 Select the command tool to be copied.
2 Click button.
The setup items area changes as below.



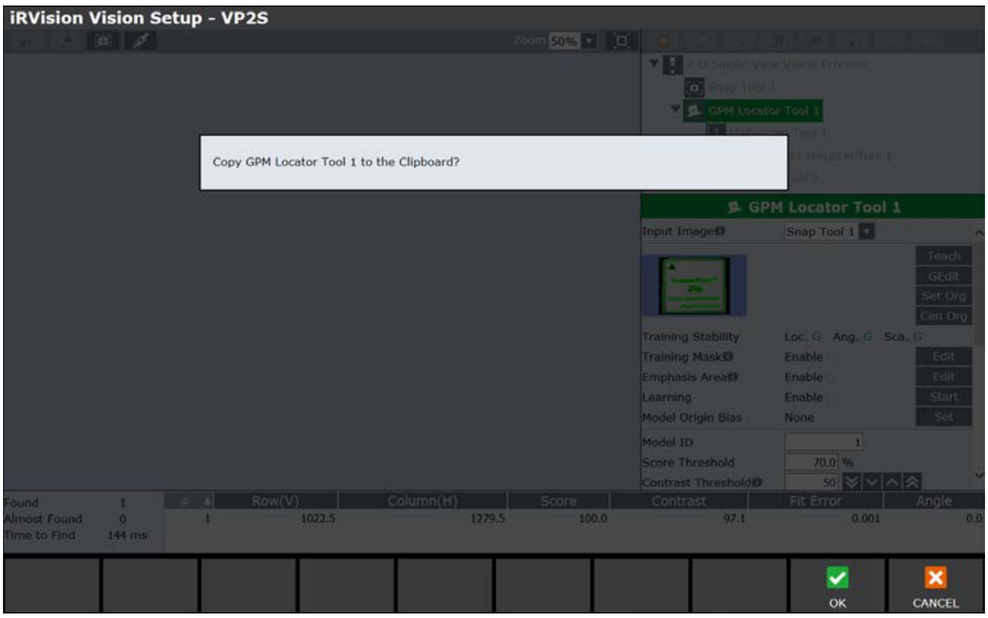
3 In [Name], enter the copy destination name.
4 Click [OK].
A copy of the command tool will be created.
Clicking [CANCEL] will cancel creating the copy.

MEMO
The copied command tool will be inserted into the tree view as a brother tool of the original command tool. At that time, the child tools of the original tool will be copied as well.

Copying a tool to the clipboard

This operation copies the contents of the selected vision process or command tool to the clipboard.

1 Select the tool to be copied to the clipboard.
2 Click  button.
The setup items area changes as below.



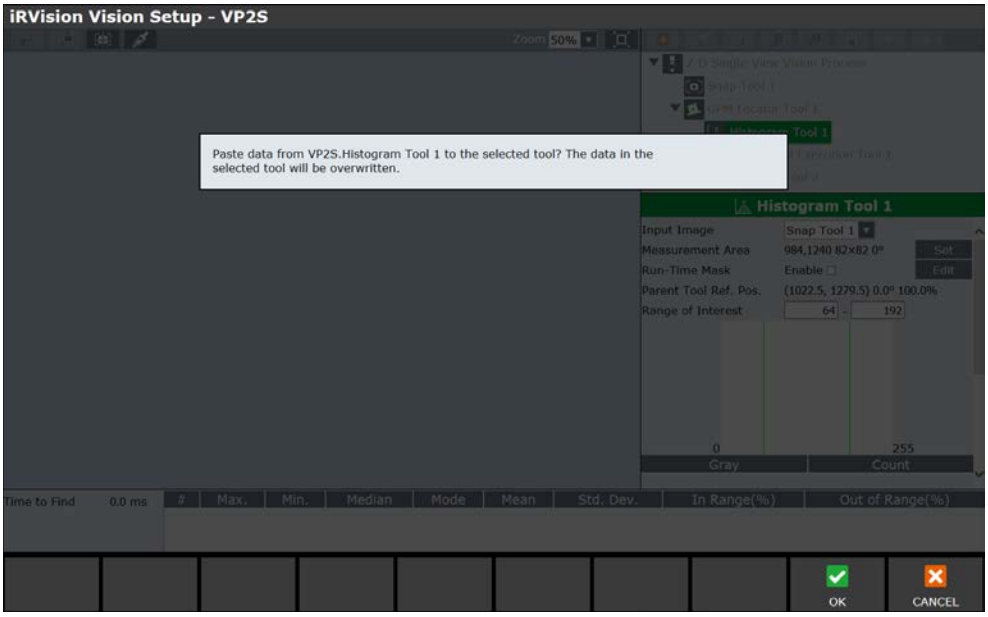
3 Click [OK].
The teaching content of the command tool will be copied on the clipboard.
Clicking [CANCEL] will cancel copying to the clipboard.

MEMO
1 This function does not copy the selected tool's children. Only the contents of the selected tool are copied. Copying the children must be done separately.
2 You can only copy one on the clipboard. If you copy other command tools, the content will be overwritten.
3 The name of the tool in the clipboard and the name of the vision data that it was copied from are displayed on the [Vision Config] page.

Pasting a tool from the clipboard

This operation replaces the contents of the selected tool with the ones in the clipboard.

1 Select the tool to be pasted from the clipboard.
2 Click button.
The setup items area changes as below.



3 Click [OK].
The content copied on the clipboard will be pasted on the selected command tool.
Clicking [CANCEL] will cancel pasting from the clipboard.

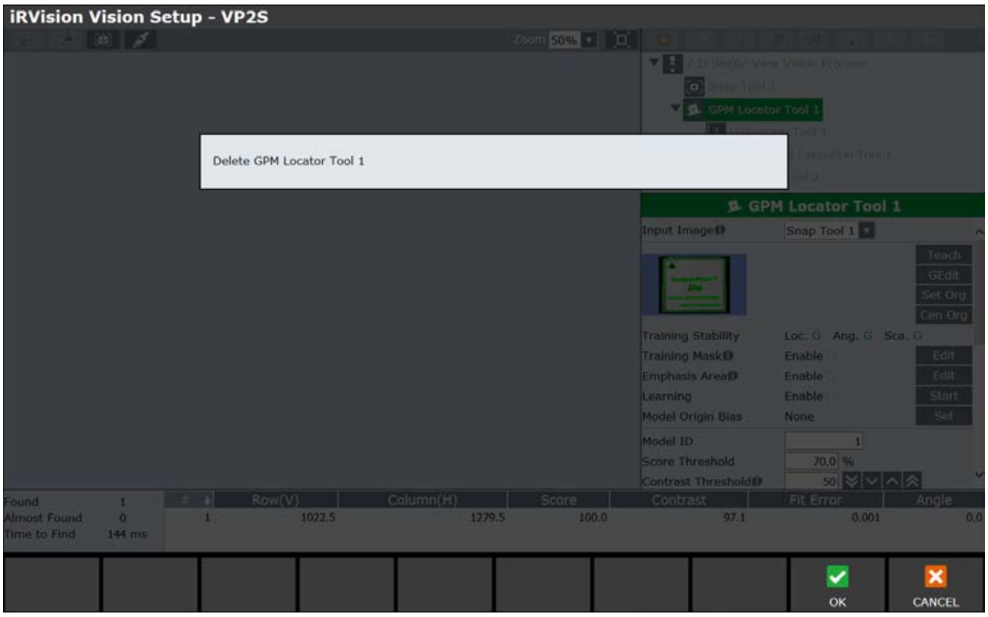
MEMO
1 The Paste From Clipboard operation is only allowed if the tool in the clipboard is the same type as the selected tool. For example; if a GPM locator tool is in the clipboard, button will be grayed out unless the selected tool is a GPM locator tool.
2 The Paste From Clipboard operation is not allowed if the tool in the clipboard is not dynamically located but the selected tool is dynamically located. For example; if a parent GPM locator tool is in the clipboard, it cannot be pasted to a child GPM locator because the parent does not have a dynamically located search window but the child does. button will be grayed out if the selected tool is dynamically located and the tool in the clipboard is not.

Deleting a tool

A command tool is deleted from a vision process.

1 Select the command tool to be deleted.

2 Click button.
The setup items area changes as below.



3 Click [OK].
The selected command tool will be deleted.
Clicking [CANCEL] will cancel delete.

> ⚠ **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.

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, click the button.

3 To move the command tool downward, click the button.

Depending on the types of the command tools, changing order may fail. In that case, the button will be hidden and cannot be selected.

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

1.8.3 List View

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

#	Vt	Hz	X	Y	Z	Err
1	502.4	529.7	0.0	0.0	0.0	0.063
2	502.4	646.7	30.0	0.0	0.0	0.074
3	385.3	529.7	0.0	30.0	0.0	0.060
4	502.4	763.8	60.0	0.0	0.0	0.071
5	34.1	529.7	0.0	120.0	0.0	0.083
6	34.1	646.7	30.0	120.0	0.0	0.072
7	34.1	763.8	60.0	120.0	0.0	0.070
8	34.1	880.9	90.0	120.0	0.0	0.064
9	34.1	998.0	120.0	120.0	0.0	0.091
10	34.1	1115.0	150.0	120.0	0.0	0.118
11	34.1	1232.1	180.0	120.0	0.0	0.139
12	151.1	61.4	-120.0	90.0	0.0	0.154
13	151.1	178.5	-90.0	90.0	0.0	0.101

When a row of a table is clicked, the selected line is highlighted. Clicking again will clear the select. Clicking the header item on the table will display , and clicking again will display . Sort and display in the ascending/descending order of the value of the selected item.

1.8.4 Text Box

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

1 Click a text box.
2 Enter anything.

1.8.5 Drop-Down Box

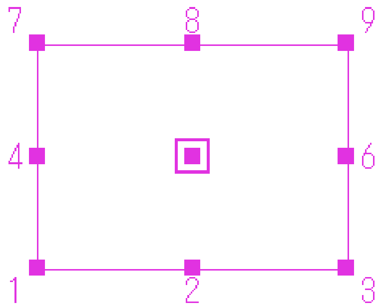
An item is selected from options.

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

1.8.6 Control Points

When setting a window such as a search area and adding diagrams and masks on an image, manipulate the position and size by moving the points that the diagram has (hereinafter called 'control points').

This section explains the operation of editing windows such as a search area as an example.
The position and size of the window is controlled by moving the control points.
A non-rotatable rectangular window has 9 control points as shown below. A control point is displayed as a small solid square. The midair square is displayed around the selected control point. In this figure, the control point 5 is selected.



Control points of a non-rotatable rectangular window

The following buttons will appear on this screen.

: You can add numbers to each control point.

Select the control point

Select a control point by clicking the control point or clicking [PREV_VTX] or [NEXT_VTX] to move the midair square.

Click and move the control point

Move the control point in the following steps.

1 On the screen in a status to edit control points, select the control point to move.
2 Click the destination.
The control point will be moved.

Drag and move the control point

Move the control point in the following steps.

1 On the screen in a status to edit control points, select the control point to move and drag to the destination.

Move the control points with the cursor

Move the control point in the following steps.

1 On the screen in a status to edit control points, select the control point to move.
2 Every time you press the cursor, it moves by one pixel toward that direction.
Every time you press the cursor while holding down SHIFT, it moves by ten pixels toward that direction.

1.8.7 Point Setup

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

1 Click the button for setting a point in the setup window for a tool.
 will appear in the center of the image, and be in a status to edit points.

2 Click the position of the point which you want to configure on the image.
is moved.
To change the position of back to the default, click [RESET].
To cancel the previous operation, click [UNDO].

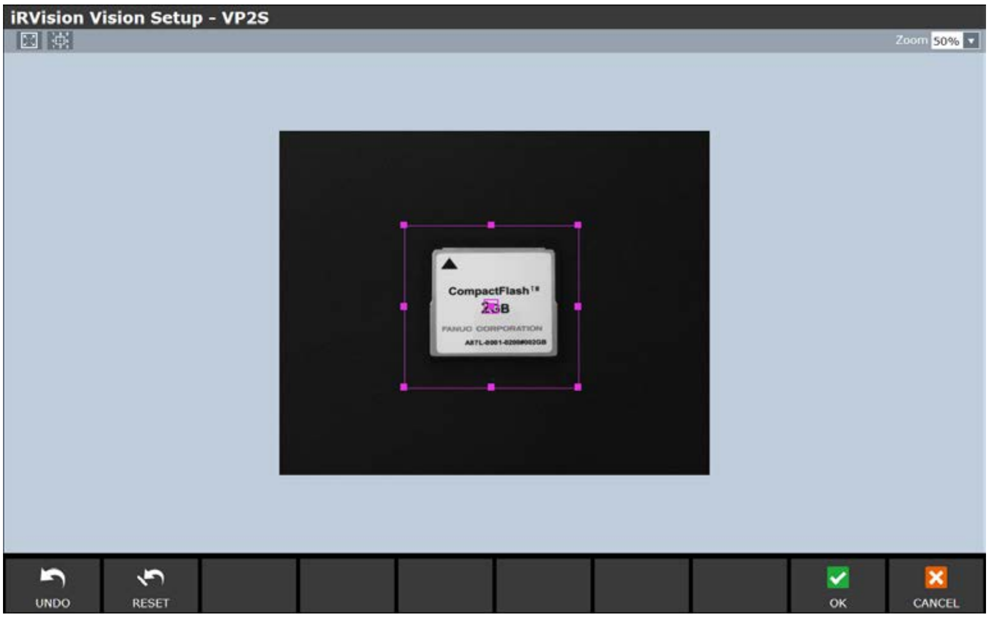
3 Click [OK].
The point setup is complete.
To cancel the setting, click [CANCEL].

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

1.8.8 Window Setup

Set up a rectangular window on the image. It is an operation used in model teaching of GPM locator tool and setting up of search windows/measurement windows of various vision tools.
The rectangular window may be rotatable and not depending on the vision tool used.

1 Click the button to set up the area on the tool edit screen.
The display of the image view will be as shown below and in a status to edit windows.



The following buttons will appear on this screen.

: The window becomes the same size as the image.

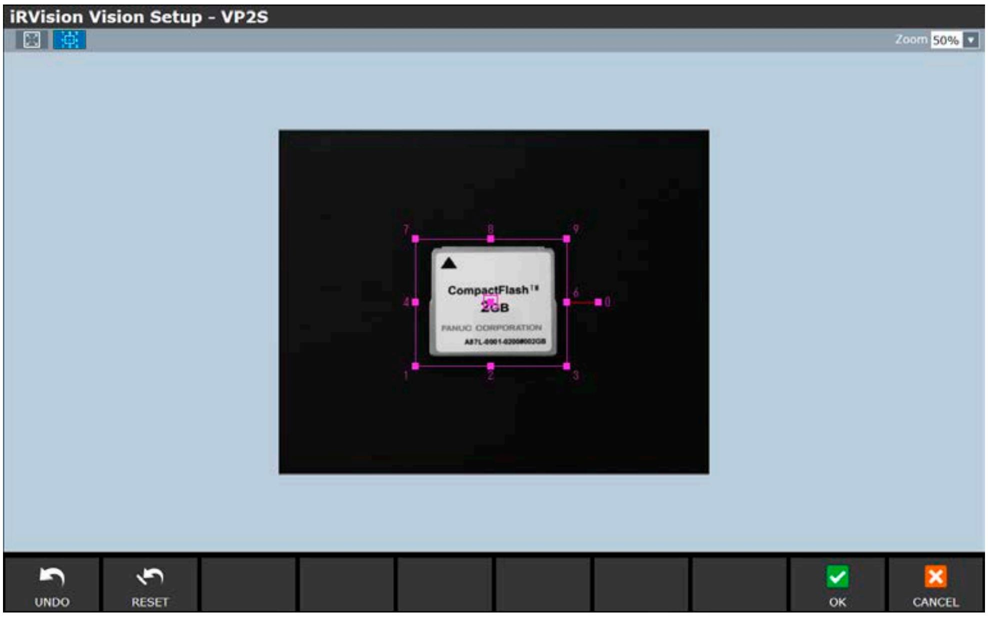
2 Manipulate the control points of a rectangular window on the image to determine the position and size of the rectangular window.
When moving the position of the window, select and move the center control point.
When changing the size of the window, select and move any control point other than the center control point.
Click the [RESET] button to return the window edits back to the original status.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".

3 Click [OK].
Window setup is complete.
Clicking [CANCEL] will cancel setup.

MEMO

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

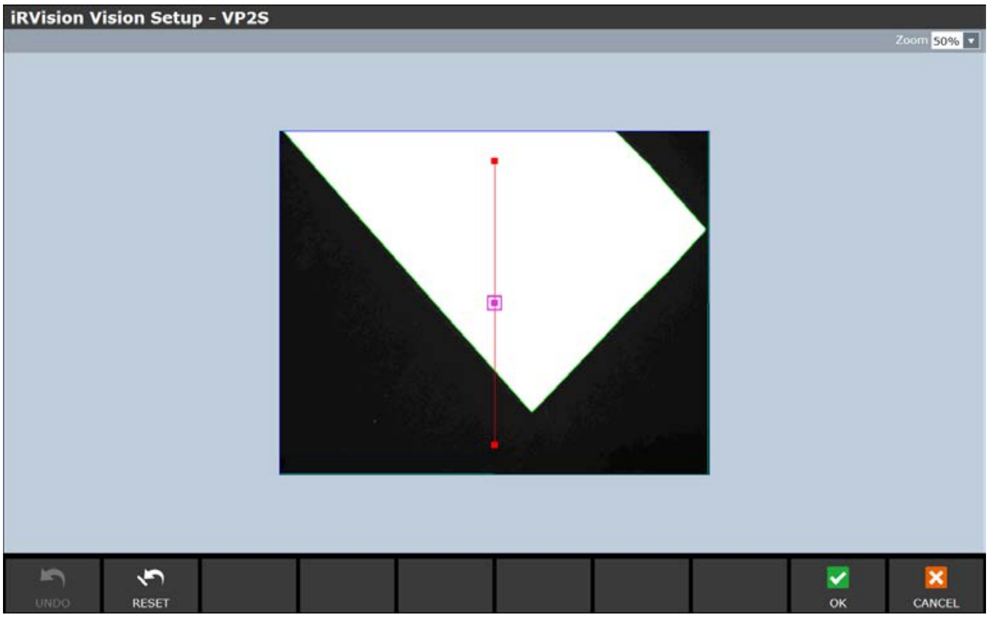
Some tools such as the histogram tool and the edge pair locator tool allow you to rotate the rectangular window. In this case, you will see an additional horizontal line from the rectangular window as shown below. An additional line has the control point for rotation on the tip. You can rotate the rectangular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



1.8.9 Singe Line Setup

A single line is set graphically on the image. It is an operation used in line teaching to the line locator tool and so on.

1 Click the button to set up a single line on the tool setup screen.
The display of the image view will be as shown below and in a status to edit a single line.



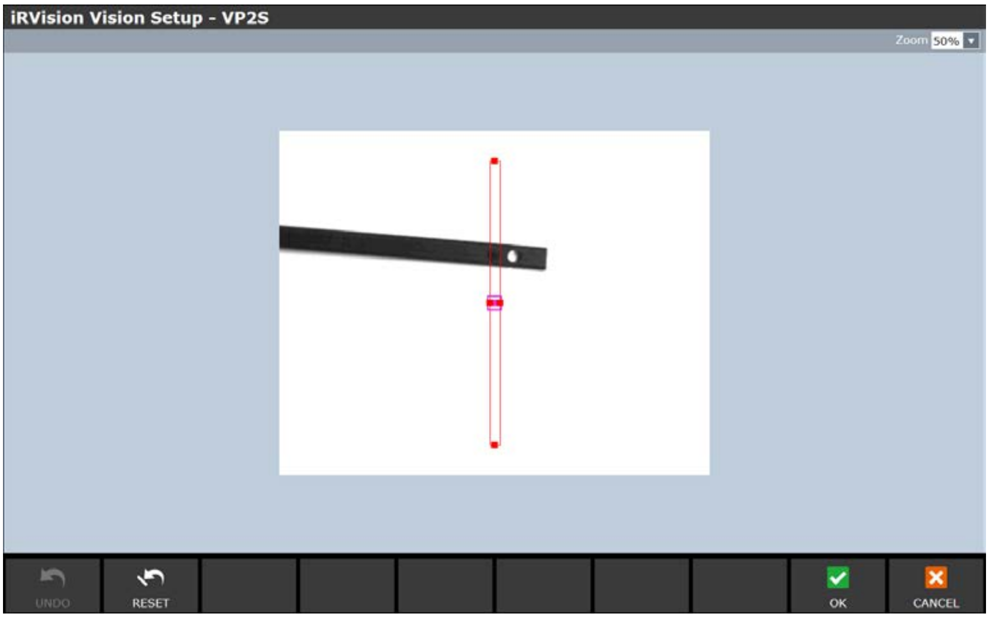
2 Manipulate the control points of the single line on the image to determine the area to teach.
When moving the position of the single line, select and move the center control point. It only changes the position of the single line, and does not change the length or angle.
When changing the length and angle of the single line, select and move either of the control points on the both ends.
Click the [RESET] button to return the single line edits back to the original status.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".

3 Click [OK].
The single line setup is complete.
Clicking [CANCEL] will cancel setup.

1.8.10 Double Line Setup

A double line is set graphically on the image. It is an operation used in double line teaching to the line locator tool and so on.

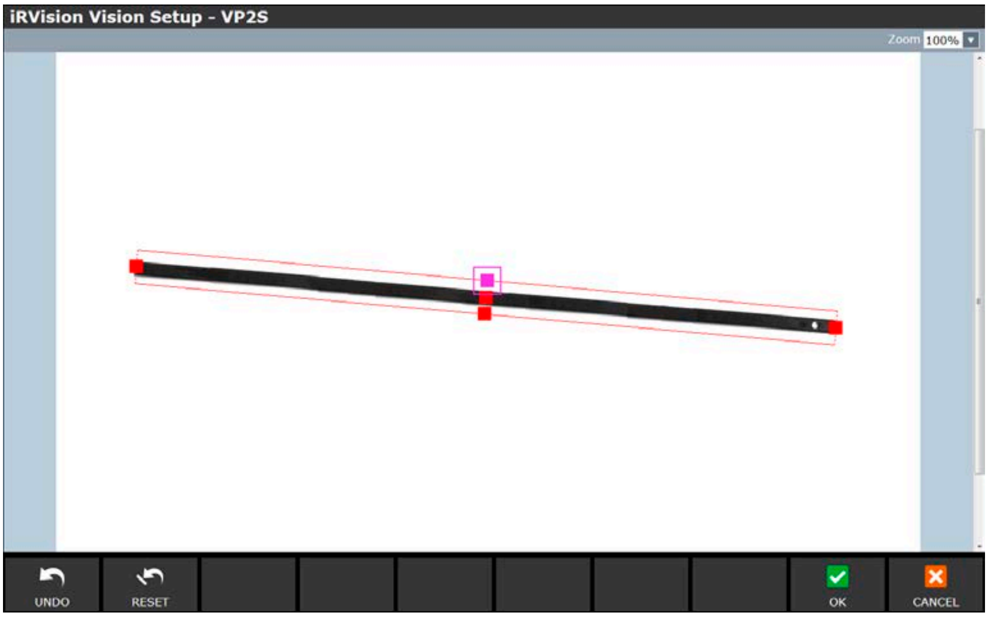
1 Click the button to set up a double line on the tool setup screen.
The display of the image view will be as shown below and in a status to edit a double line.



2 Manipulate the control points of the double line on the image to determine the area to teach.
When moving the position of the double line, select and move the center control point.
When changing the length and angle of the double line, select and move either of the control points on the dotted line.
Click the [RESET] button to return the double line edits back to the original status.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".
3 Click [OK].
The double line setup is complete.
Clicking [CANCEL] will cancel setup.

Change the width of the double line in the following steps. In the following figure, the dotted lines indicate the width direction of the double line. Teach so that two solid lines overlap with the lines on the image.

1 Select and move either of the control points on the solid line on the screen in a status to edit the double line.
It changes the position of the control points and changes the width of the double line.



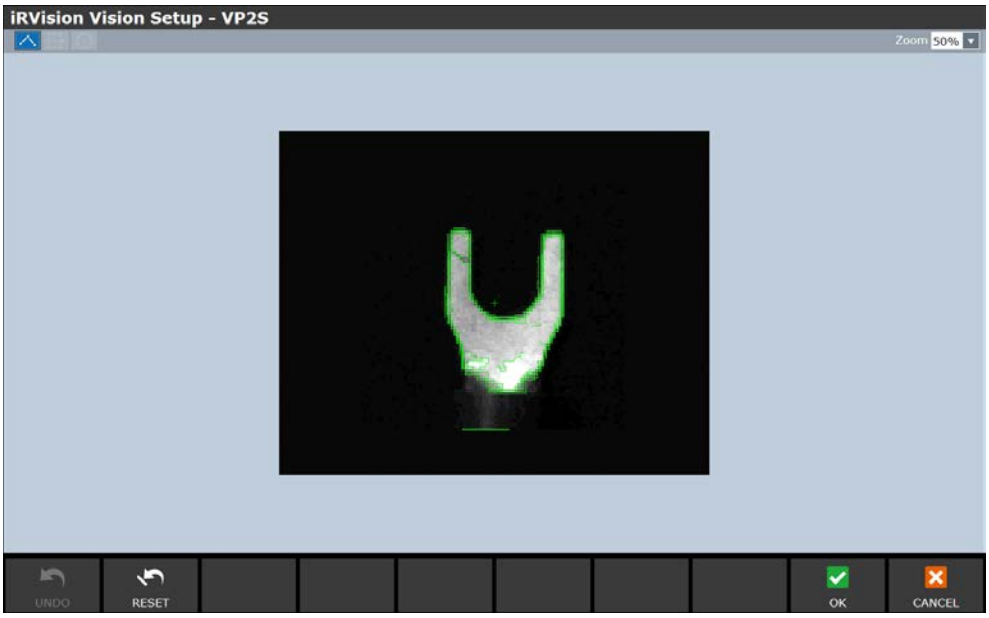
1.8.11 Segmented-Line Setup

A segmented-line is set graphically on the image. It is an operation used in inspection line teaching to the bead inspection tool, etc.

Creating Segmented-Line

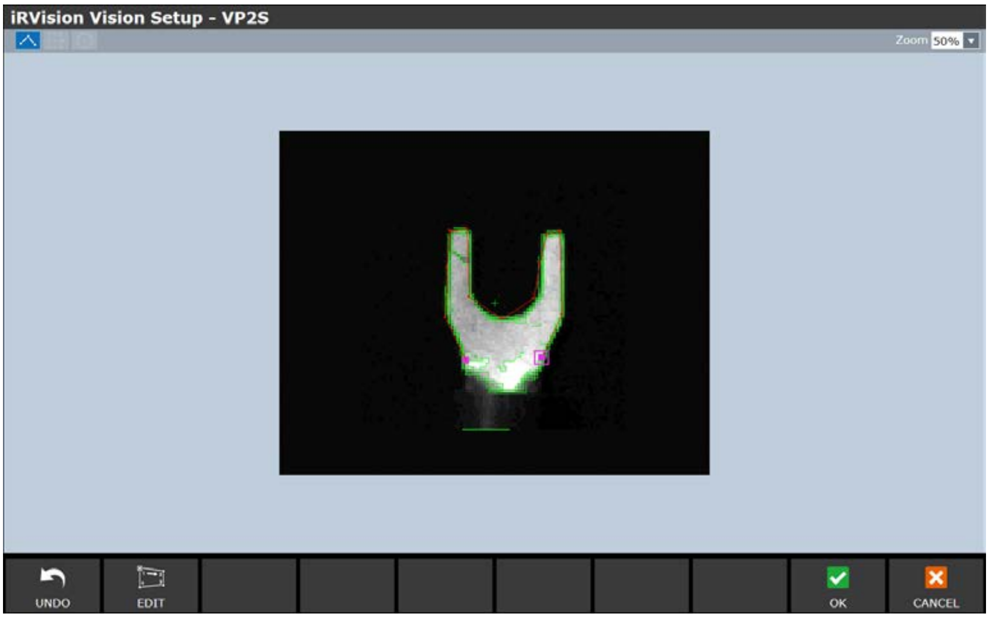
Perform the following steps to create a new segmented-line.

1 Click the button to add a segmented-line on the tool edit screen.
The display of the image view will be as shown below and in a status to allow inputting a segmented-line.



2 Click where you want to place a vertex of the segmented-line in turn on the image.
A vertex is created where you clicked, and a straight line is drawn between a control points.

3 Draw the necessary segmented-line by moving the position of the vertex of the segmented-line and changing the length and shape of the line.
Click the [RESET] button to return the segmented-line edits back to the original status.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".

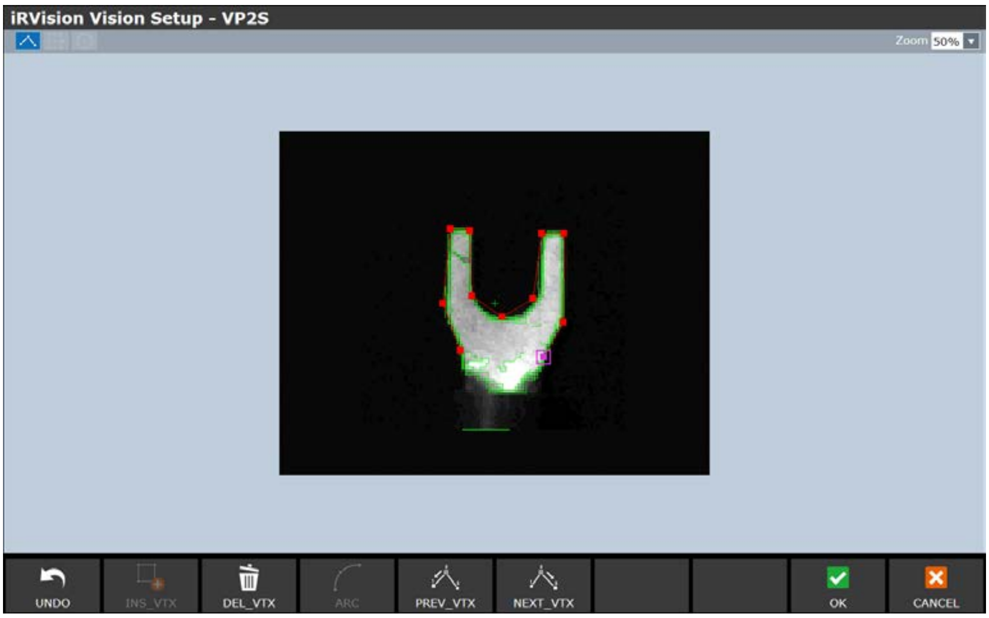


4 Click [OK].
Ends adding segmented-lines.
Clicking [CANCEL] will cancel adding segmented-line.

Editing Segmented-Line

Perform the following steps to edit a segmented-line.

1 Click the button to edit a segmented-line on the tool edit screen.
The display of the image view will be as shown below and in a status to edit a segmented-line.



You can perform the same operation by clicking [EDIT] while adding a segmented-line as well.

On this screen, you can move, add, delete vertices of the segmented-line. And you can also make a part of the segmented-line an arc.

Move vertex

Perform the following steps to move a vertex.

1. Select the vertex you want to move by clicking [PREV_VTX] and [NEXT_VTX] or clicking the vertex itself on the image.
2. Move the vertex.
   The vertex is moved.

Add vertex

Perform the following steps to add a vertex. The new vertex is added between the selected vertex and the following vertex.

1. Select the start vertex of the segment on which you want to add a vertex by clicking [PREV_VTX] and [NEXT_VTX] or clicking the vertex itself on the image.
2. Click [INS_VTX].
   A vertex will be added on the selected side.

Delete vertex

Perform the following steps to delete the vertex.

1. Select the vertex you want to delete by clicking [PREV_VTX] and [NEXT_VTX] or clicking the vertex itself on the image.
2. Click [DEL_VTX].
   Slected vertex is deleted.

Make arc

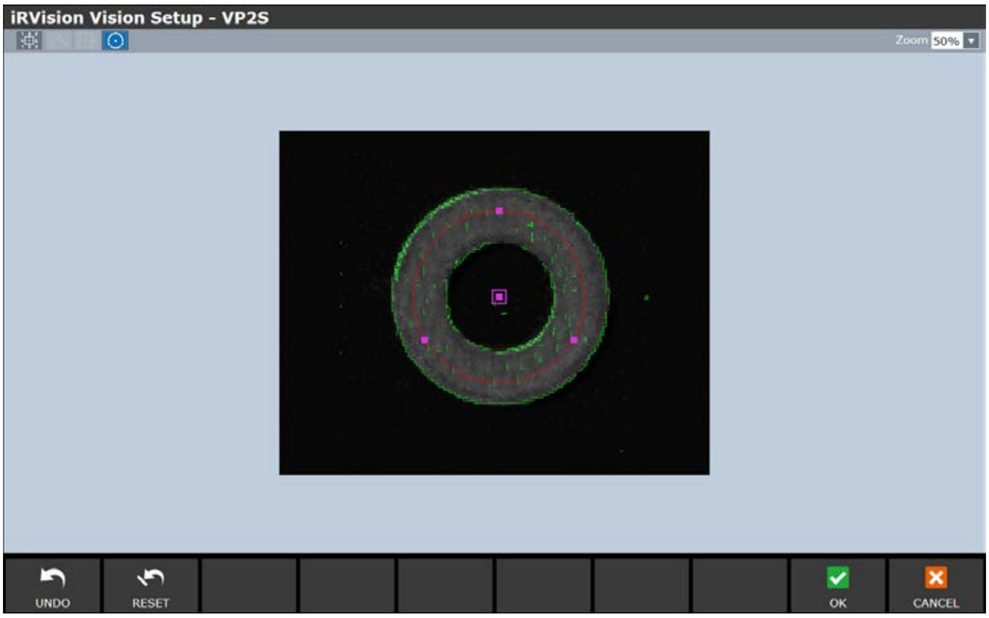
Perform the following steps to make a part of the segmented-line an arc.
An arc is composed of three vertices and specifying a vertex as an arc point creates an arc using the vertex and vertices in front and behind.

1. Select the vertex you change to make an arc point by clicking [PREV_VTX] and [NEXT_VTX] or clicking the vertex itself on the image.
2. Click [ARC].
   An arc will be created with a selected vertex as an arc point.
   If you want to make an arc back to lines, click [UN-ARC] after selecting the arc point.

1.8.12 Circle Setup

A circle is set graphically on the image. It is an operation used in inspection line teaching to the bead inspection tool and so on.

1. Click the button to set up a circle on the tool setup screen.
   The display of the image view will be as shown below and in a status to edit a circle.



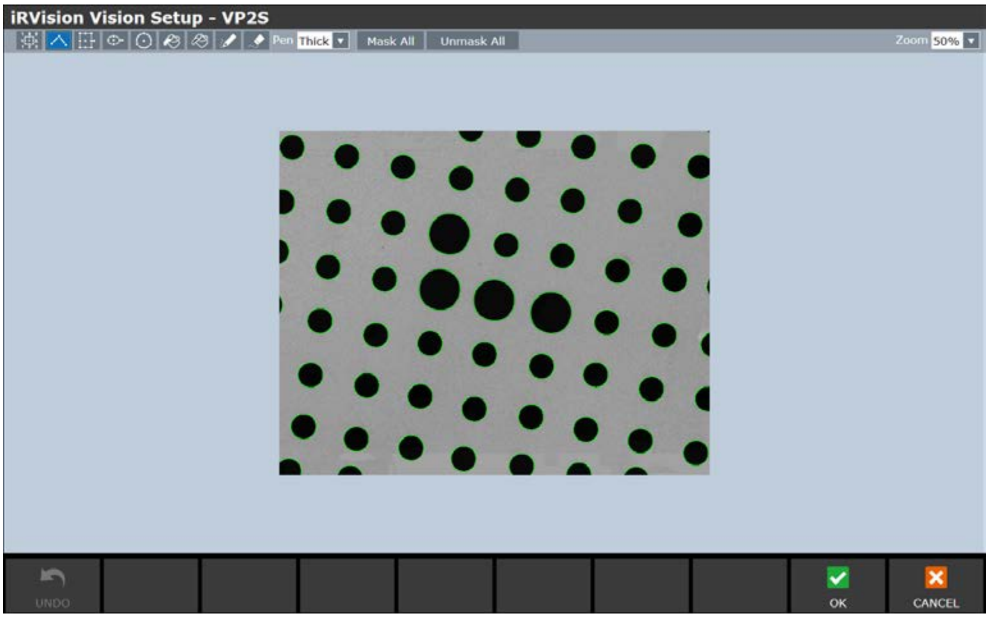
2 Manipulate the control points on the image to determine the position and size of the circle.
When moving the position of the circle, select and move the center control point.
When changing the size of the circle, select and move any control point on the circle.
Click the [RESET] button to return the position and size of the circle back to the original status.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".

3 Click [OK].
The circle setup is complete.
Clicking [CANCEL] will cancel setup.

1.8.13 Editing Masks

Masks are edited on the image graphically. It is an operation used in editing locator tool masks such as the GPM locator tool and run-time mask.

1 Click the button to edit a mask on the tool edit screen.
The display of the image view will be as shown below and in a status to edit a mask.



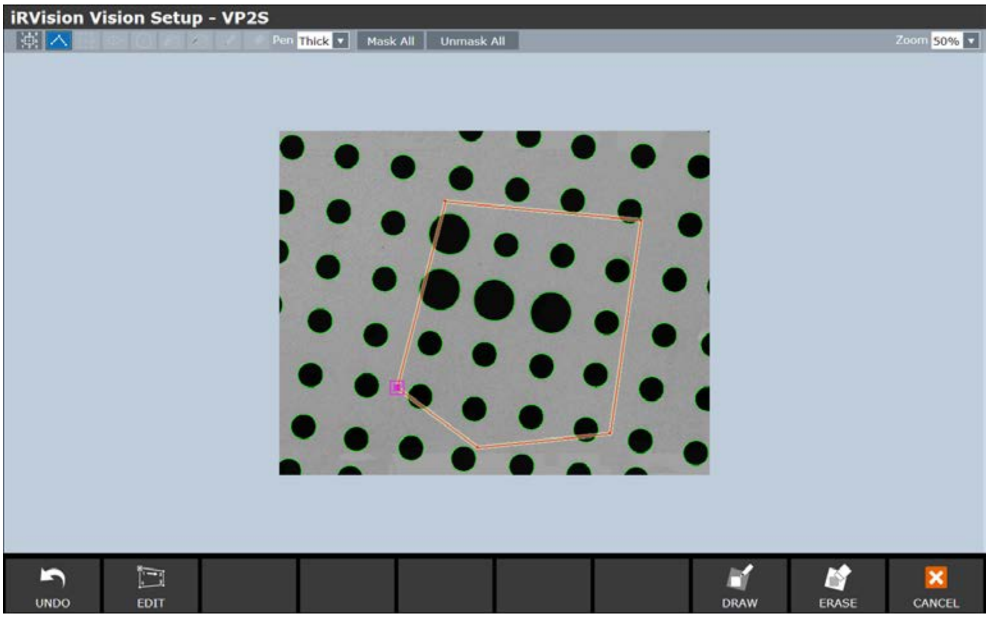
MEMO

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.

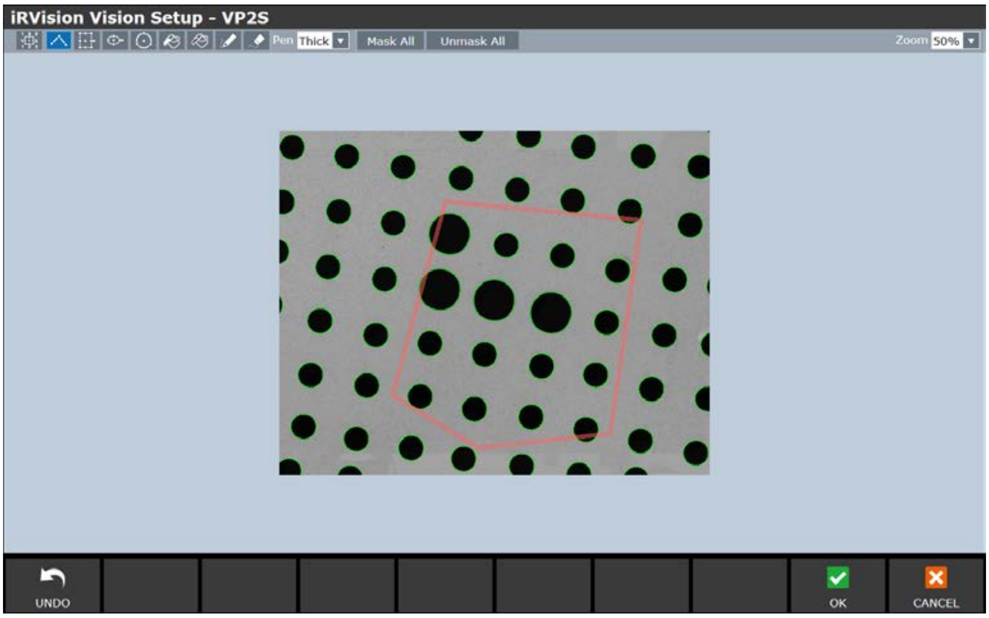
Drawing polygonal lines

A mask is drawn with polygonal lines.

1 On the screen in a status to edit a mask, click  button.
2 Select the thickness of pen from three items [Thin], [Medium] and [Thick] by using the drop-down box of [Pen].
3 Click vertex of polygonal lines in turn on the image.
A control point will be created on the place you clicked and a straight line will be drawn between the control points.
4 Draw the necessary segmented-line by moving the position of the vertex of the segmented-line and changing the length and shape of the line.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".
5 Click the starting point of the segmented-line.
Creating control points is complete. The segmented-line will be a closed polygon.



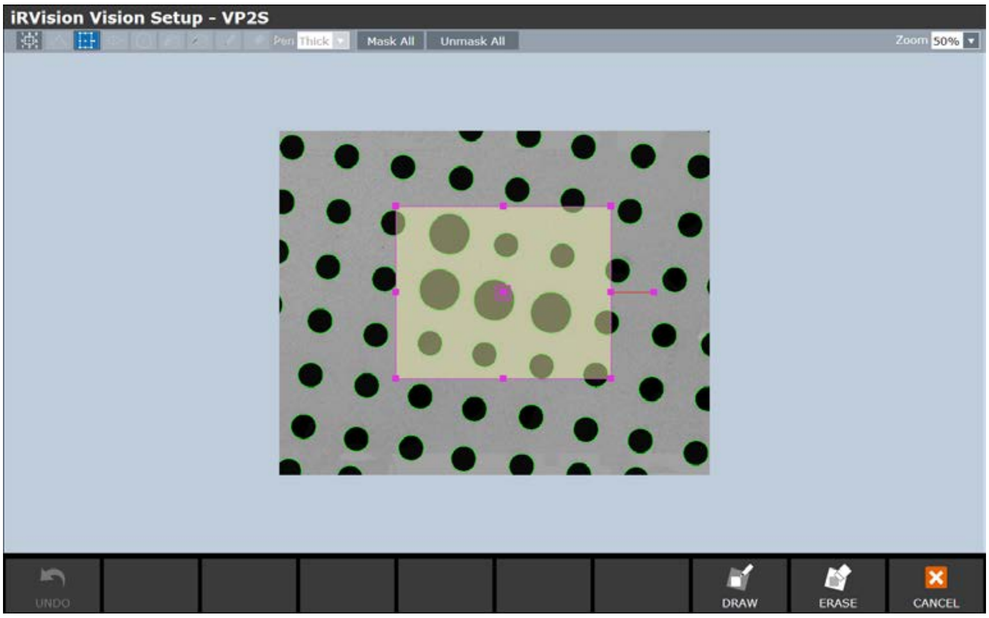
6 Click [DRAW].
The mask in the shape of the configured polygonal lines is drawn.
If you click [ERASE], the mask is erased along the configured polygonal lines.
7 Click [OK].
The mask setup is complete.
Clicking [CANCEL] will cancel setup.



Drawing an rectangle

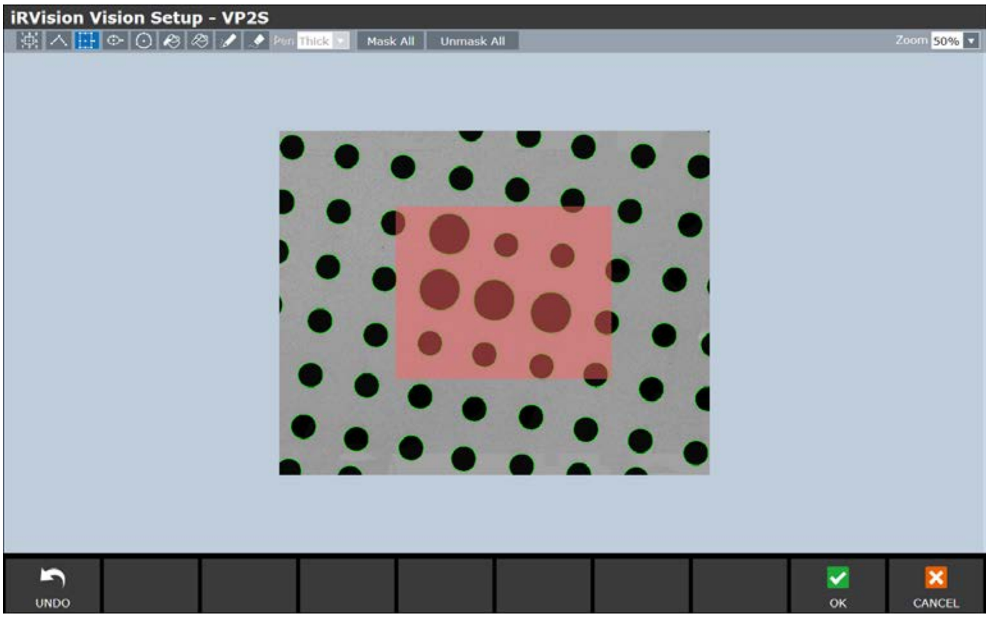
A filled rectangle is drawn.

1 On the screen in a status to edit a mask, click  button.
2 Click an arbitrary position on the image.
A rotatable rectangular window centered on that position will appear.



3 Manipulate the control points of the window on the image to adjust the position and size of the rectangular mask.
Click the [RESET] button to return the position and size of the rectangle back to the original status.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".
4 Click [DRAW].
The mask in the shape of the rectangle is drawn.
If you click [ERASE], the mask in the shape of the rectangle is erased.

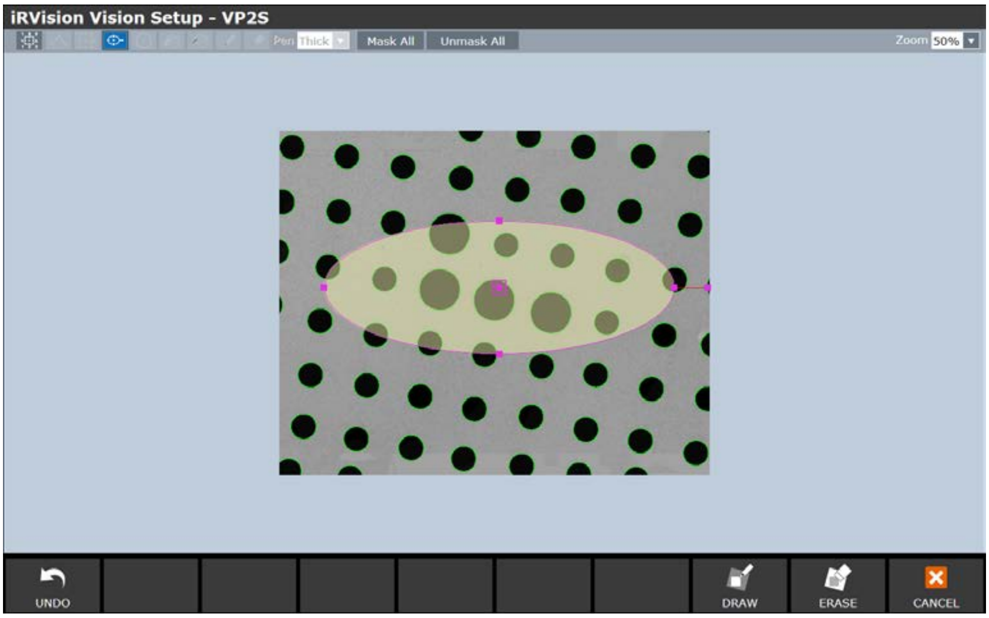
5 Click [OK].
The rectangle setup is complete.
Clicking [CANCEL] will cancel setup.



Drawing an ellipse

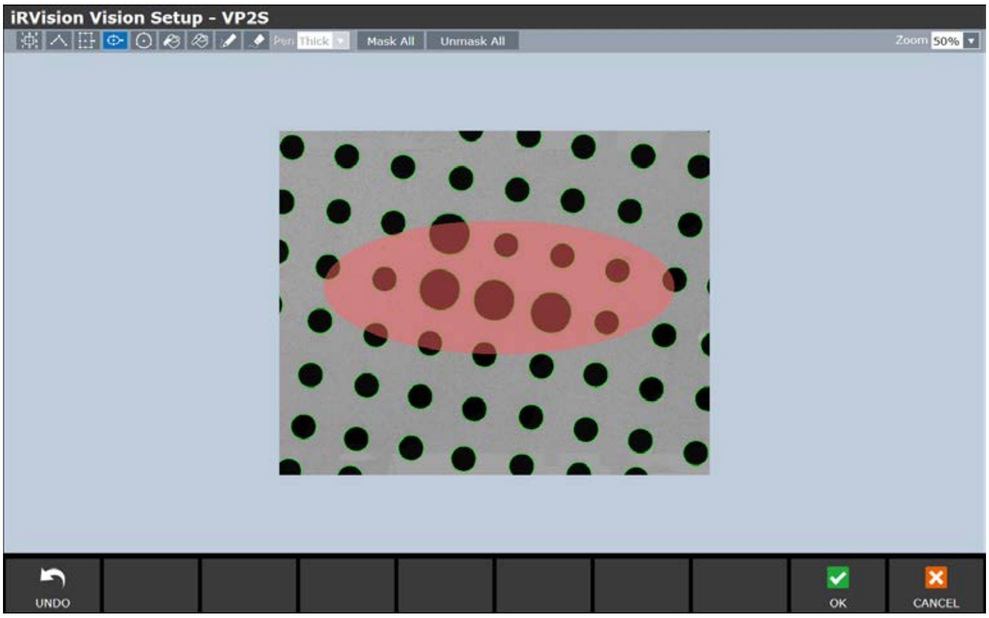
A filled ellipse is drawn.

1 On the screen in a status to edit a mask, click button.
2 Click an arbitrary position on the image.
A rotatable ellipsoidal window centered on that position will appear.



3 Manipulate the control points of the window to adjust the position and size of the ellipsoidal mask.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".
4 Click [DRAW].
The mask in the shape of the ellipse is drawn.
If you click [ERASE], the mask in the shape of the ellipse is erased.

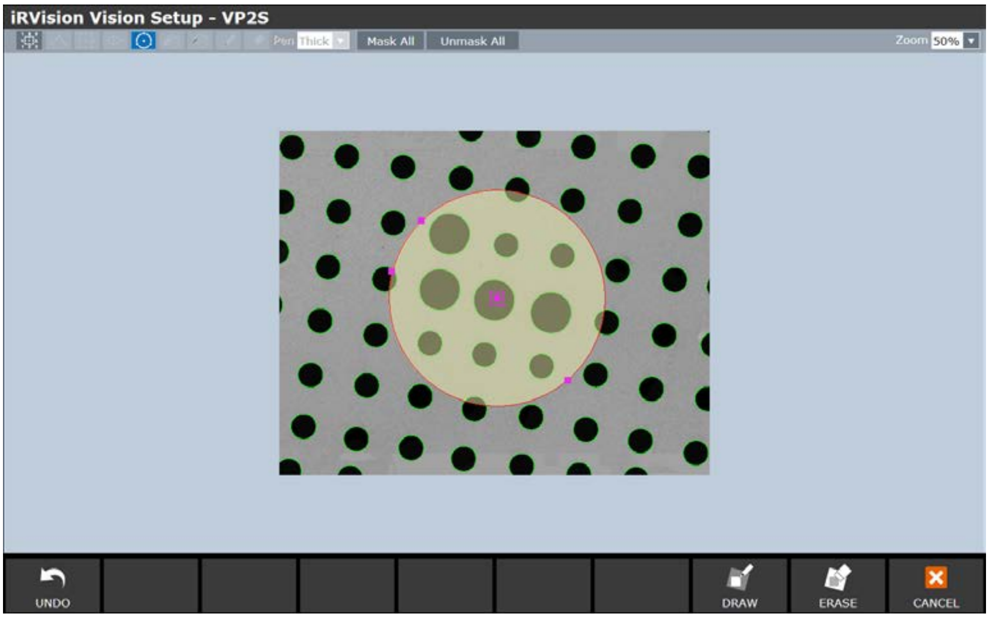
5 Click [OK].
The mask setup is complete.
Clicking [CANCEL] will cancel setup.



Drawing a circle

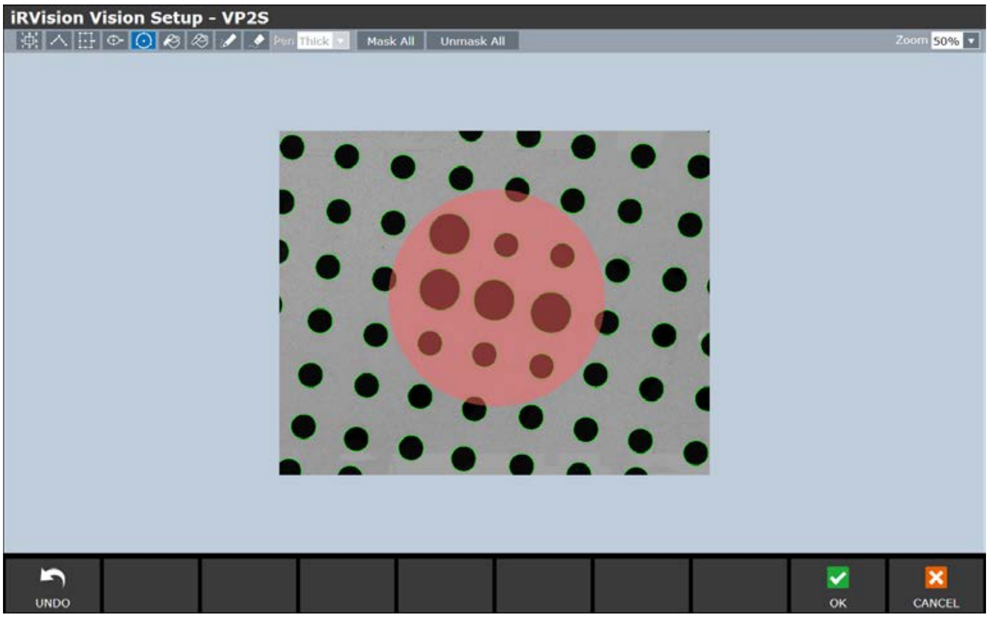
A filled circle is drawn.

1 On the screen in a status to edit a mask, click  button.
2 Click an arbitrary position on the image.
A circular window centered on that position will appear.



3 Manipulate the control points of the circle on the image to adjust the position and size of the circular mask.
Click [UNDO] to cancel the previous operation.
For how to move the control points, refer to "Setup: 1.8.6 Control Points".

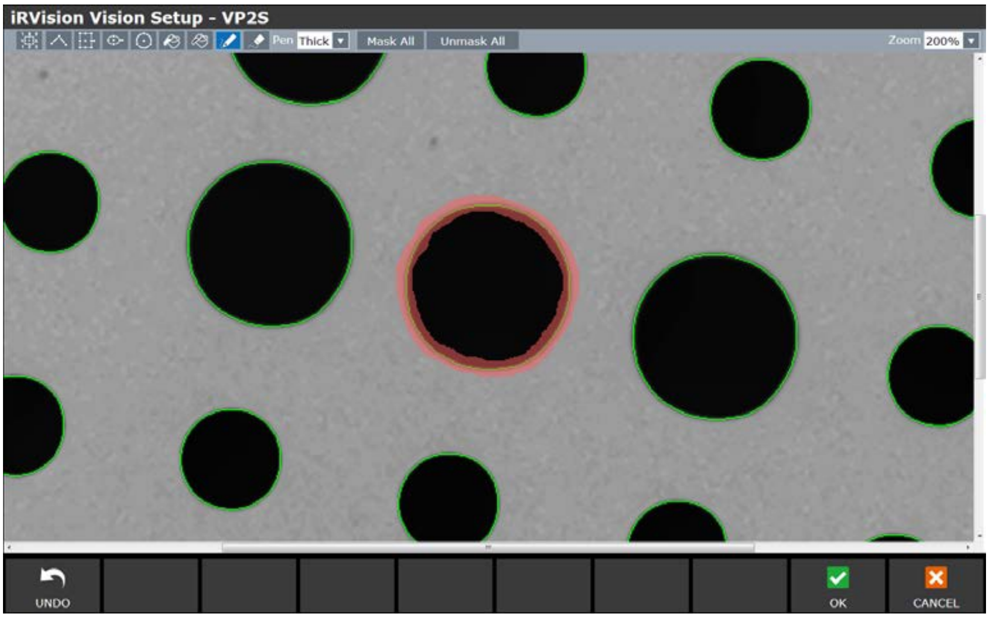
4 Click [DRAW].
The mask in the shape of the circle is drawn.
If you click [ERASE], the mask in the shape of the circle is erased.
5 Click [OK].
The mask setup is complete.
Clicking [CANCEL] will cancel setup.



Draw a mask freehand

Draw a mask in the following steps.

1 On the screen in a status to edit a mask, click  button.
2 Select the thickness of pen from three items [Thin], [Medium] and [Thick] by using the drop-down box of [Pen].
3 Place the cursor over the starting point of the line segment and drag.
Mask is drawn as the mouse moves.
4 Click [OK].
The mask setup is complete.
Clicking [CANCEL] will cancel setup.

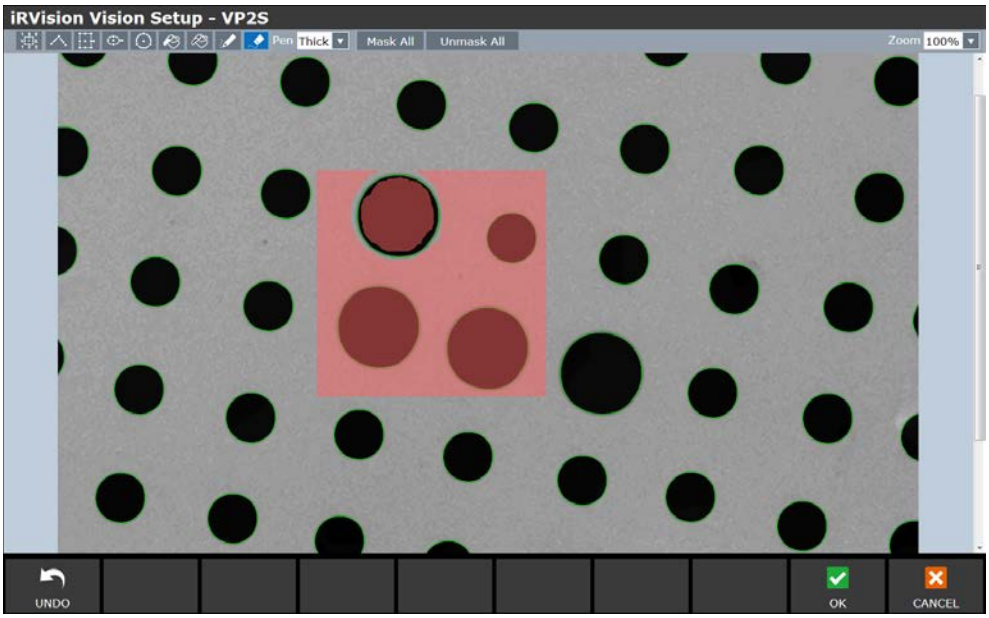


> **MEMO**
> The Drawing Freehand function and the Erasing Freehand function can be used only when a PC is used for editing mask.

Erase a mask freehand

Erase a mask in the following steps.

1 On the screen in a status to edit a mask, click button.
2 Select the thickness of pen from three items [Thin], [Medium] and [Thick] by using the drop-down box of [Pen].
3 Place the cursor over the starting point of the line segment and drag.
Mask is erased as the mouse moves.
4 Click [OK].
The mask setup is complete.
Clicking [CANCEL] will cancel setup.



Filling in a closed area

An enclosed area is filled.

1 On the screen in a status to edit a mask, click button.
2 Click the position which you want to fill on the image.
 The selected area will be filled in.
3 Click [OK].
 The mask setup is complete.
 Clicking [CANCEL] will cancel setup.

> **MEMO**
> If the selected 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 On the screen in a status to edit a mask, click button.
2 Click the position which you want to erase on the image.
 The selected area will be erased.
3 Click [OK].
 The mask setup is complete.
 Clicking [CANCEL] will cancel setup.

Filling the entire image

The entire image is filled.

1 On the screen in a status to edit a mask, click the [Mask All] button.
 The entire image will be filled.
2 Click [OK].
 The mask setup is complete.
 Clicking [CANCEL] will cancel setup.

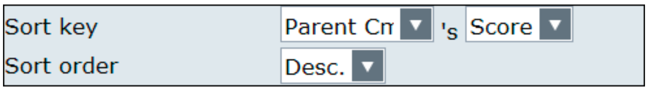
Clearing the entire image

The entire image is unmasked.

1 On the screen in a status to edit a mask, click the [Unmask All] button.
 The entire image will be unmasked.
2 Click [OK].
 The mask setup is complete.
 Clicking [CANCEL] will cancel setup.

1.8.14 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 measurement value used as the sort key in the [Sort Key] drop-down box.
2 Select an order of sort in the [Sort Order] drop-down box.

[Sort key]

The following items are provided for the [Sort key] first 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.

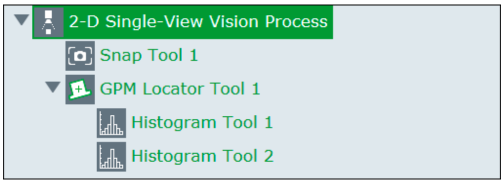
[Parent Cmd. Tool Level]

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

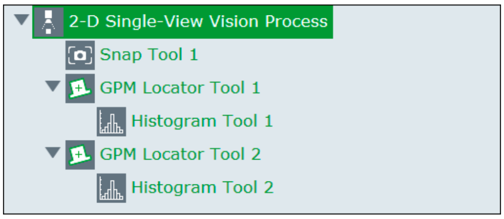
[Child Cmd. Tool Level]

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

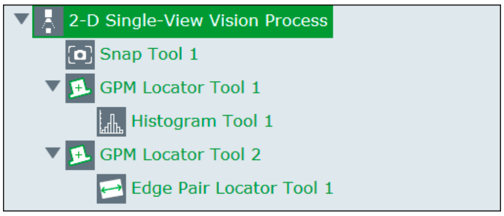
When found results are to be sorted by the measurement results of a child tool added to a locator tool, such as a histogram, the child tool must be placed as the first child tool. In the configuration shown below, for example, when sorting by the results of Histogram 2 is to be performed, change the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

[Min 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.

[Min Path Angle]

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.

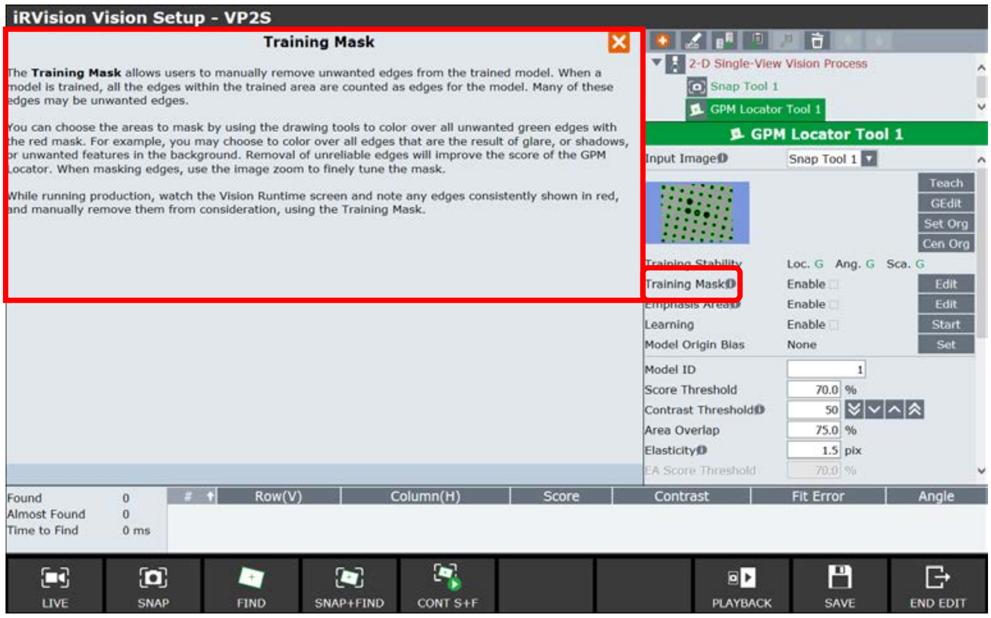
[Model ID]

Change the order by the Model ID for with which locator tool the found parts were found.

1.8.15 Contextual Help

Among the setup items of vision tools, you can check the Help for the ones frequently asked.

1 Click which appears next to the item in the setup items area on the vision tool edit screen. The Help will appear in the image view area.



Clicking will end the Help and return to the original screen.

1.8.16 Teaching from Teach Pendant

You can perform *i*RVision teaching from the teach pendant as well. There are following differences from operation with a PC.

> ⚠ **CAUTION**
> You need to use the *i*Pendant with touch panel, when you teach vision data on the teach pendant.

1.8.16.1 *i*RVision menu

Display the *i*RVision screen on the teach pendant.

1 On the teach pendant, select the [MENU] key – press [iRVision].
*i*RVision sub-menu will appear.
2 Select the function to operate in the sub-menu.
The screen for the selected function will appear.

*i*RVision sub-menu is as follows

[Vision Setup]
Perform *i*RVision teaching and manual override.

[Vision Runtime]
Displays the *i*RVision vision runtime screen.

[Vision Log]
Displays the *i*RVision vision log screen.

[Vision Config]
Displays the *i*RVision vision config screen.

[Vision Utilities]
Displays the *i*RVision utilities screen.

[Vision Devices]
You can check the connection information of *i*RVision devices (such as camera and projector) connected to the robot controller.

[Bin Picking IA]
Displays the *i*RVision interference avoidance list screen. For details, refer to the description of interference avoidance setup in "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR’S MANUAL".

[Bin Picking PM]
Displays the *i*RVision parts list manager list screen. For details, refer to the description of bin-pick search vision process setup function in "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR’S MANUAL".

[Bin Picking Cfg]
Displays the *i*RVision bin-pick config main screen. For details, refer to the description of bin-pick search vision process setup function in "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR’S MANUAL".

1.8.16.2 Function keys

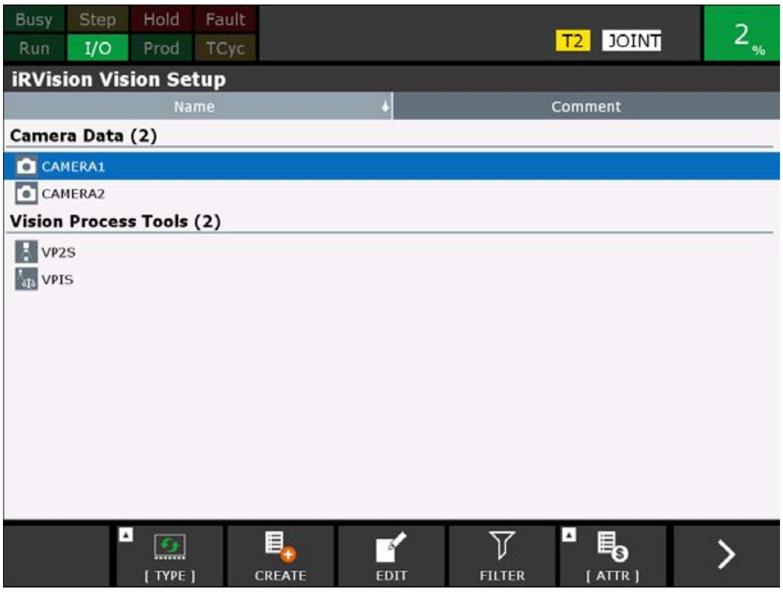
The function keys are displayed on teach pendant as follows.

- Menu of five function keys will appear.

- Function key menu is allocated to from F1 to F5 of the teach pendant key switch.
  You can change the function key menu page by next page key (>).
- More frequently used function keys will be displayed on the first page.

1.8.16.3 Vision data list screen

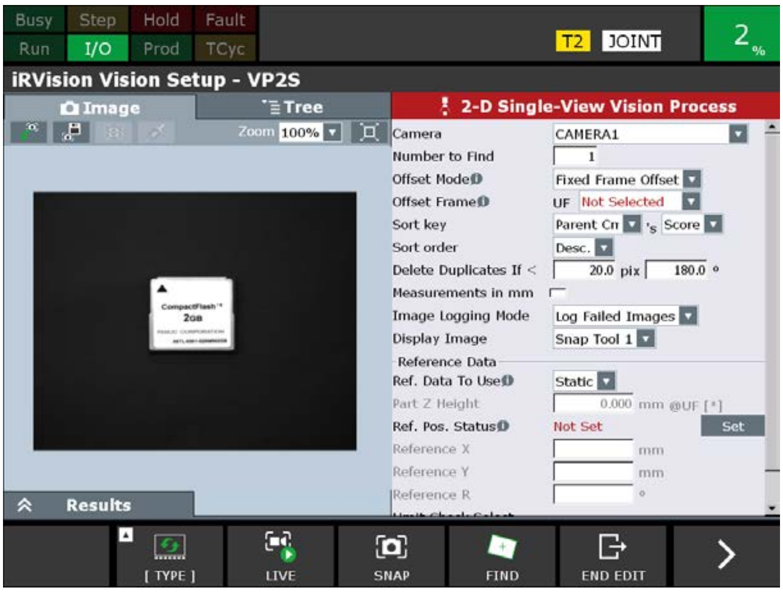
The Vision Data List Screen is displayed on teach pendant as follows.



- Place the cursor over F1 [TYPE] and press the [ENTER] key to display *i*RVision menu. Once a menu is selected, it moves to the screen of the selected menu.
- Select the items (comment, type, date created, date updated, size) to display in the right column of the list screen with F5 [ATTR].

1.8.16.4 Vision data edit screen

On teach pendant, the vision data edit screen has the following structure.



The difference between the operations with a PC and with the teach pendant is as follows.

Screen operation content	PC	Teach pendant
Image view and tree view	Displayed at the same time. You can change the view size as you like.	Press tab to switch. Not displayed on the same screen. The view size is fixed.
Result teach view	Displayed on the same screen.	Hidden by default. It will appear when you tap the result tab or perform FIND.
Switching function key pages	Displayed on the same screen. No switching pages.	F7 [PLAYBACK], F8 [CONT S+F], F9 [SNAP] and F10 [SAVE] will appear when you switch pages with the next page key ( ).
*i*RVision menu	*i*RVision menu is displayed in the function content displayed on the homepage of the robot.	*i*RVision menu will appear when you place the cursor over F1 [TYPE] and press the [ENTER] key.

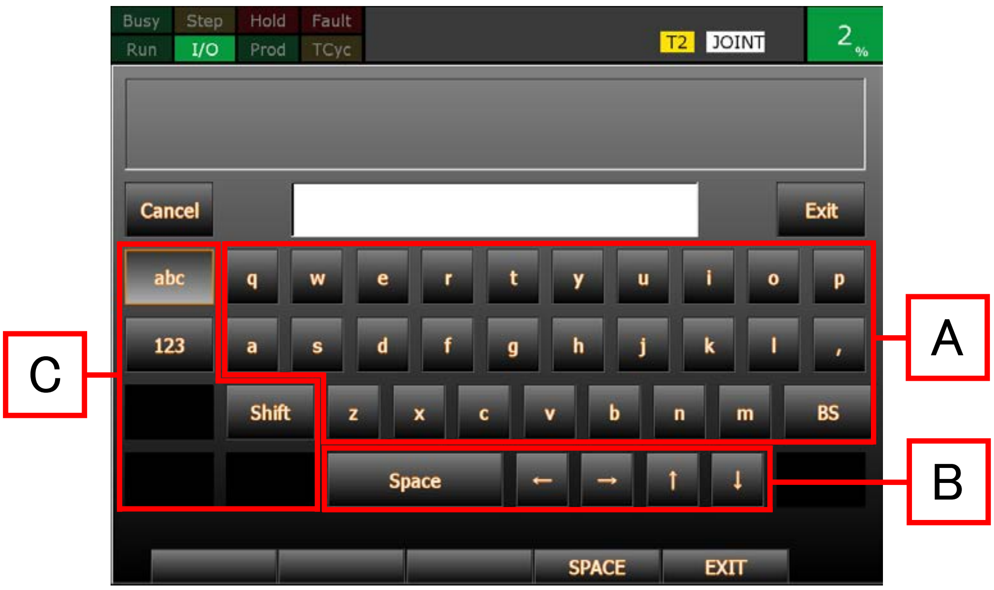
The function key menu is different depending on the selected function.

1.8.16.5 Text box

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

1 On the teach pendant screen, place the cursor over a text box and press the [ENTER] key.
2 Numeric values are inputted by using value hardkeys of teach pendant.
3 Text strings are inputted by using software keyboard.

If a text box for a text string is selected, the software keyboard automatically appears on the screen of teach pendant as follows.



A Inputting keys. Pressing the keys in the area C will change the characters you may input.
B Cursor keys and Space key.
C Exchanging keys of inputting keys. You can input one byte character if [abc] is pressed. You can input numeric number and special symbol (e.g., @, #, $, %) if [123] is pressed.

1.8.16.6 Control points

When editing a diagram such as a search window on the teach pendant, you cannot move the control points by dragging. Press the destination or use the cursor key to move.

1.8.16.7 Editing mask

When editing a mask on the teach pendant, you cannot draw or erase a mask freehand.

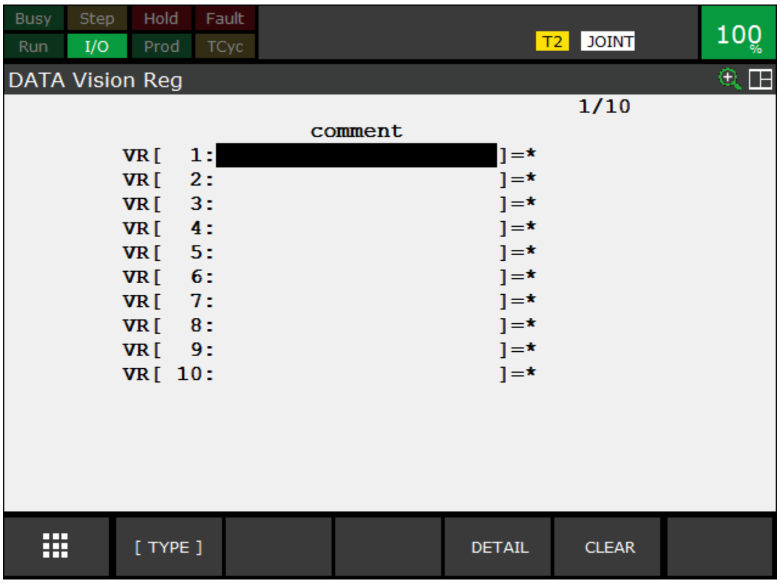
1.9 VISION REGISTERS

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.

1.9.1 Vision Register List Screen

Perform the following steps to display the vision register list screen.
Check the values on the detail 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

Comment for a vision register is voluntary.
The steps to add a comment to a vision register are as follows.

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.

1

Erasing a value

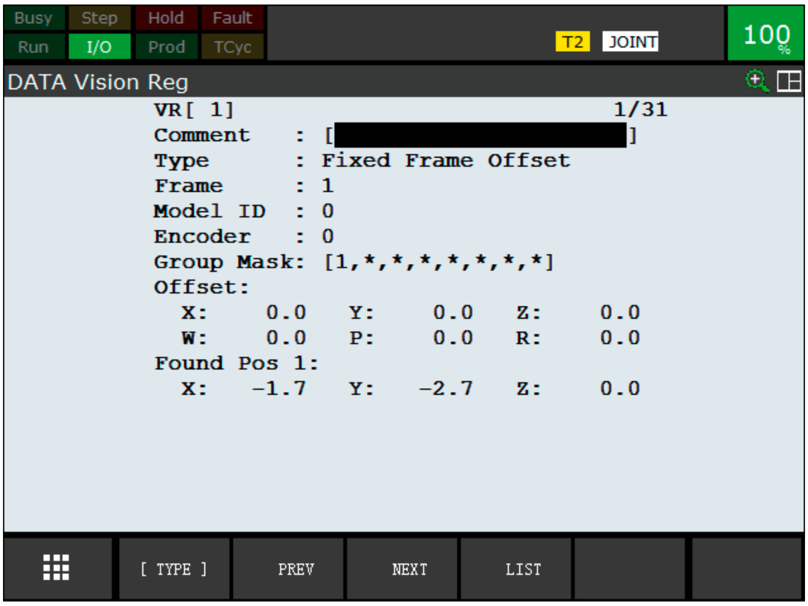
Erase the data from the vision register to which a value is set.
The steps to erase a value from a vision register are as follows.

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.
The value will be erased from the selected register, and [R] on the right of the comment will change to [*].

1.9.2 Vision Register Detail Screen

The steps to display the vision register detail screen are as follows.

1 On the vision register list screen, move the cursor to the line of a vision register to which the value is refereed.
2 Pressing F4 [DETAIL] will display the vision register detail screen like below.



⚠ **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.

There are the following items on the vision register detail screen.

[Type]

Type of offset data stored in the vision register. Clicking F4 [CHOICE] will display the following choices.

[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 Pos (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 Pos (TOOL)], it is the user tool number. It is the frame number specified in [Offset Frame] on the vision process setup page.

[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. Specify the motion groups of the robot to be offset.

> ⚠ **CAUTION**
> GET_OFFSET command does not change Group Mask. Manually set Group Mask in advance so that the necessary robots are offset. By default, Group Mask is set to offset only the robot of motion group 1, so you don't have to change it in most cases.

[Offset]

Offset data in the XYZWPR format. It is represented in the user frame or the tool frame of [Frame].

[Found Pos]

Actual position of each camera view. It is represented in the user frame or the tool frame of [Frame].

[Meas]

Measurement values that Measurement Output Tool outputs.

Function key

On this screen, the function keys below can be used.

Key number	Item Name	Function
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.

1.9.3 Changing the Number of Vision Registers

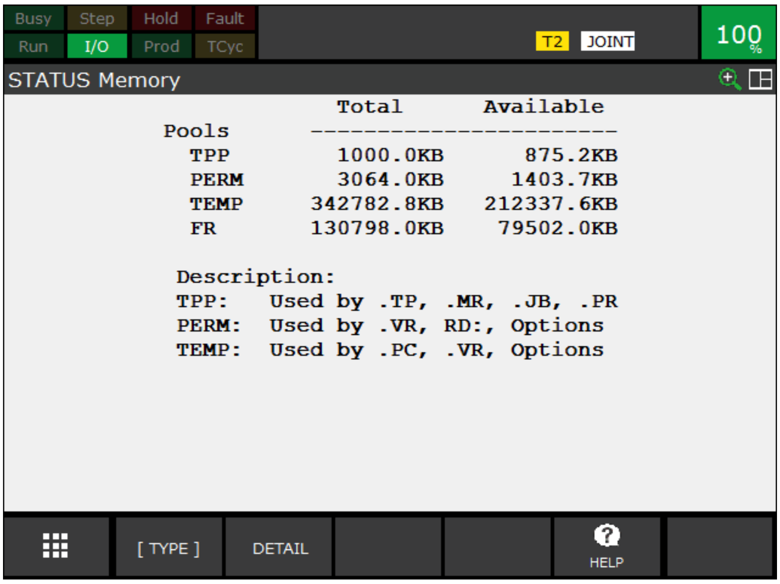
You can change the number of vision registers at Controlled Start in the Program Limits menu. The default number is 10. You can have a maximum of 100 vision registers, or as few as 1.

> ⚠ **CAUTION**
> The size of a vision register is 288 byte per one. When the number of vision registers are increased, the use of the temporary memory will increase.
> Before increasing the number of vision registers, check the remaining capacity of the temporary memory.

Checking the temporary memory capacity

The steps to check the remaining capacity of the temporary memory are as follows.

1 After selecting the [MENU] key – [NEXT] – [Status] – place the cursor over [Memory] and press the [ENTER] key.
A screen like the following one will appear.

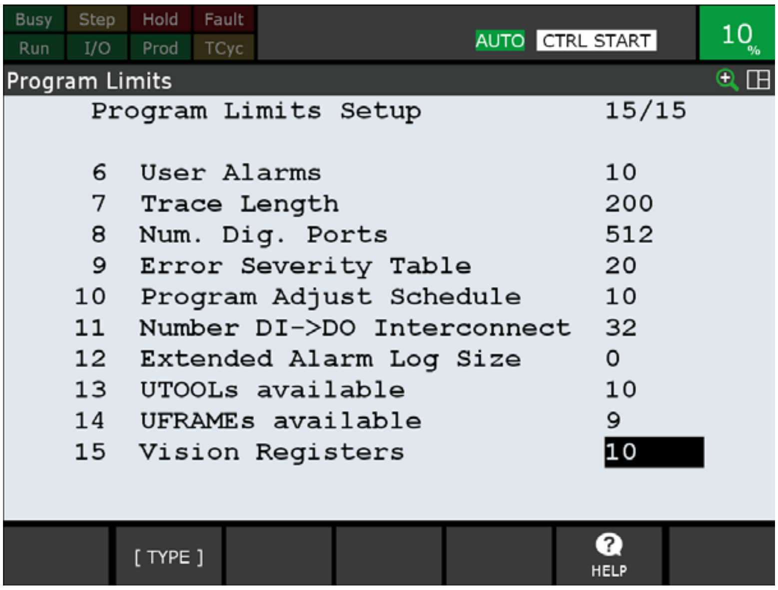


2 Check the remaining capacity on the [TEMP] line.

Changing the Number of Vision Registers

Change the number of vision registers after confirming that the memory capacity is sufficient.
The steps to change the number of vision registers are as follows.

1 Perform a Controlled Start.
Refer to R-30*i*B and R-30*i*B Mate CONTROLLER OPERATOR'S Manual (Basic Operation).
2 Press MENU.
3 Press 0, NEXT, and select Program Setup.
The following screen is shown.



4 Move the cursor to Vision Registers, type the desired number of vision registers (1 - 100), and press ENTER.
5 Press FCTN.
6 Select Start (Cold).
Executes the cold start will be executed.

1.10 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.

Designate the number of image registers by the system variable $VISION_CFG.$NUM_IMREGS. The default value is 1. The maximum value is 10.

Designate the total capacity of image registers by the system variable $VISION_CFG.$IMREG_SIZE.
The default value is 1500000 byte, which is a capacity to allow storing one 1280 x 1024 image (one full-size image with reduction ratio 1 on a monochrome camera).
When the total capacity of the image sizes to store in the image register at the same time exceeds the default value, enlarge the size of the system variable $VISION_CFG.$IMREG_SIZE.

The capacity required to store images can be calculated as follows depending on the camera type and the snap window/reduction ratio designated in the snap tool.
In the case of a monochrome camera, add 'length x width + 500' to the default value for each one image to store additionally.
In the case of a color camera, add 'length x width x 3 + 500' to the default value for each one image to store additionally.

> **⚠ CAUTION**
> 1 After changing the value of the system variables $VISION_CFG.$NUM_IMREGS and $VISION_CFG.$IMREG_SIZE, restart the robot controller to re-create the image register.
> 2 When the total capacity of the image registers is increased, the use of the temporary memory will increase. Before increasing the total capacity of image registers, check the remaining capacity of the temporary memory.

> **MEMO**
> The length and width size of an image can be calculated by 'the length of the snap window divided by the reduction ratio' and 'the width of the snap window divided by the reduction ratio' respectively.

1.11 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.

Backing up Vision Data

To back up vision data, on the teach pendant, after selecting the [MENU] key - place the cursor over [FILE] and press the [ENTER] key to open the file screen, and select F4 [BACKUP] - place the cursor over [All of above] and press the [ENTER] key. For details of the operation, refer to "R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR'S MANUAL (Basic Operation)".

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 "OPERATOR’S MANUAL (Basic Operation) B-83284EN".

1.12 PASSWORD PROTECTION OF VISION DATA

You can restrict the operations to *i*RVision by using the password function. As shown in the following table, the operations can be restricted according to the level of password. As for the password function, refer to "9.10 PASSWORD FUNCTION" in the " OPERATOR’SMANUAL (Basic Operation) B-83284EN".

Level	Restricted operation and edit
Install Setup	Operations to *i*RVision are not restricted.
Program Operator	• In the Vision Setup page, the following operations to vision data are restricted: Creating new vision data, deleting vision data, saving vision data, changing vision data name, and changing vision data comment. • In the Vision Config page, any item can be not changed. • In the Vision Utilities page, the following operations are restricted; LIVE, FIND, EXECUTE, Log Export, and changing items.

1.13 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 controller (Connect the camera cable to a controller with which *i*RVision option is installed)
- Robot system in which a camera calibration plate is held by a robot connected to another controller

For these inter-controller communications, ROS Interface Packet over Ethernet (RIPE) function is used. For details about the RIPE function, please refer to "Ethernet Function OPERATOR’S MANUAL B-82974EN".

2 CAMERA DATA

This chapter describes how to set up camera tools.
In the camera data, basic camera setup is performed. Camera calibration is also performed, if necessary.
In *i*RVision, the following visual sensors are supported.

- 2D Camera
- 3D Area Sensor

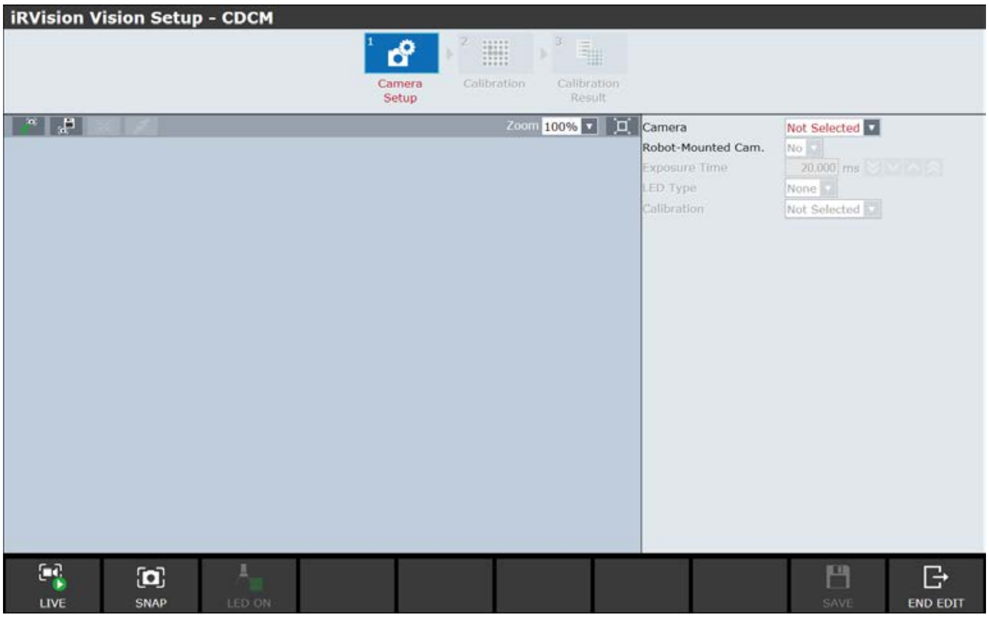
2.1 2D CAMERA

This chapter describes how to set up 2D CAMERA tools.
To set camera data, follow the steps in the navigation area.
After performing basic setup in the first 'Camera Setup', calibration is performed, if necessary.

2.1.1 Camera Setup

Set the camera to use and the type of camera calibration for the camera data that has been created.

If [Camera Setup] is selected in the navigation area, the following screen appears in the setting items area.



The setting items area has the following parameters in it.

[Camera]

A list of the cameras connected to the robot controller is displayed by clicking the drop-down box. Select the camera to be used.

[Robot-Mounted Cam.]

Select whether the camera is mounted on a robot or not.

[No]
The camera is fixed.

[Yes]

The camera is mounted on the robot end of arm tooling.

[Robot Holding Cam.]

When [Yes] is selected for [Robot-Mounted Cam.] drop-down box, specify the controller name and the motion group number of the robot holding the camera.

[Exposure Time]

It is so called the electronic shutter speed. The units are millisecond. The larger the value is, the brighter a snapped image is.

MEMO

The exposure time specified here is used for snapping an image in this screen and performing camera calibration. Although the exposure time for executing the vision process is separately set in snap tools inserted in the vision process, the value specified here will be used as the default value of the exposure time for snap tools.

[LED Type]

Select a LED type for snapping a 2D Image from the drop-down box. Setting items are added according to the selected item.

[None]

Disable LED light.

[Integrated]

Use the LED light integrated in the camera package. Selecting this will display setting items of the [LED Intensity]. When selecting the [Integrated], the LED light performs strobe light emission.

[External]

Use an external LED light. Selecting this will display setting items of the [LED Signal], [Use Strobe] and [LED Delay].

⚠ CAUTION

When selecting the [External] for the [LED Type], an LED light, power of an LED light, signal cable, etc. should be arranged by a customer.

MEMO

The LED light parameters specified here are used for snapping an image in this screen and when calibrating the camera. Although the LED light parameters for executing the vision process are separately set in snap tools in the vision process, the parameters specified here will be used as the default ones for snap tools.

[LED Intensity]

This item is displayed when [Integrated] is selected for the [LED Type] drop-down box. Set a value between 1 and 16. The larger the value is, the brighter a snapped image is. The default value is 8.

[LED Signal]

These items are displayed when [External] is selected for [LED Type].

Select the type of signal and the on/off relationship between the signal and the LED light from the [LED Type] drop-down box.

If [DO] or [RO] is selected, a signal number needs to be entered. Enter a signal number in the displayed text box.

First drop-down box

[MUX]
Use the signal from the MUX.

[DO]
Use a DO signal of the robot controller.

[RO]
Use a RO signal of the robot controller.

Second drop-down box

[Normal]
Turn on the LED light when turning on the signal.

[Reverse]
Turn on the LED light when turning off the signal.

Select [Normal] to turn on the LED light when the signal is turned on, or [Reverse] to turn off the LED light when the signal is turned on.

[Use Strobe]

This item is displayed when [External] is selected for the [LED Type] drop-down box and [MUX] is selected for the [LED Signal] drop-down box.
Check this check box when a stroboscopic light is used for the LED light. When this item is checked, the LED light flashes synchronously with the image acquisition by the camera.

[LED Delay]

This item is displayed when [External] is selected for the [LED Type] drop-down box. The unit is millisecond. Set the amount of delay taken until the LED light becomes stable after the signal is output. It varies depending on the LED light and the LED power supply unit to be used. *i*RVision waits for the time period specified here and then starts exposure of the camera.

[White Balance]

Setting items displayed when [Camera] is a color camera.
Adjust the proportion of RGB gains to capture a white object as white pixels on an image. The default values for [R], [G] and [B] are all 1.00.
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.

[Calibration]

Select the camera calibration method from the drop-down box.

[Grid Pattern Calibration]
Camera calibration is performed by using a calibration grid on which the predetermined pattern is drawn. For details, refer to "Setup: 2.1.2 Grid Pattern Calibration".

[Robot-Generated Grid Cal.]

The camera calibration is performed by moving a target mounted on the robot end of arm tooling along a grid, within the camera's field of view. For details, refer to "Setup: 2.1.3 Robot-Generated Grid Calibration".

[Camera Calib. For Vis. Track]
Camera calibration dedicated to the visual tracking. Perform camera calibration by using a calibration grid in the wizard form. For details, refer to "Setup: 2.1.4 Visual Tracking Calibration".

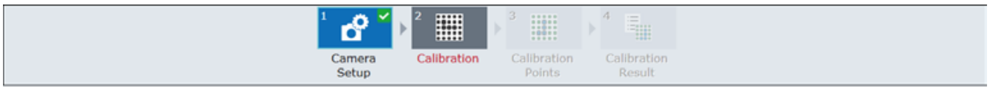
[No Calibration]
When using this camera only for the inspection vision process and the 2D calibration-free vision process, camera calibration is not required. In such cases, select [No Calibration].

When selecting a calibration method, necessary steps are added in the navigation area in accordance with the selected method.

2.1.2 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. By snapping the pattern drawn on the calibration grid, *i*RVision automatically recognizes the positional relationship between the calibration grid and the camera, the lens distortion, the focal distance, etc. For information about the calibration grid, refer to "Introduction: 2.6 CALIBRATION GRID".

When selecting [Grid Pattern Calibration] for [Calibration] in [Camera Setup], the following steps for the grid pattern calibration are displayed in the navigation area.



[Calibration]
Finds the grid pattern and perform camera calibration.

[Calibration Points]
Check the calibration points that have been found.

[Calibration Result]
Check the calculated calibration data.

2.1.2.1 Setting fixture position

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

Depending on the application, the calibration grid is either secured on a fixed surface or mounted on the robot end of arm tooling. In either case, it is necessary to set the arrangement position and direction (mounting information) of the calibration grid when performing calibration for the camera.

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.
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.

There are following two ways to set the calibration grid frame.

- Setting by physically touching-up with a pointer tool, etc.
- Setting automatically without contact by using a grid frame set

For details of the grid frame setting, refer to "Setup: 7.2 GRID FRAME SETTING".
Setting with a touch-up pin is described here.

Setting the calibration grid frame by touch-up

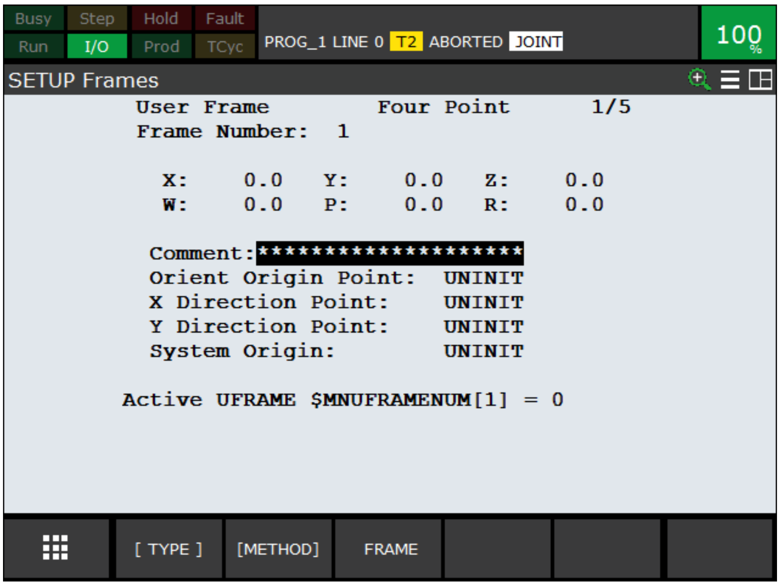
Set the calibration grid frame by physically touching-up with a pointer tool.
Setting methods vary depending on cases, namely, whether the calibration grid is secured on a fixed surface or where a calibration grid is mounted on the robot end of arm tooling.

When the calibration grid is secured to a fixed surface such as a table

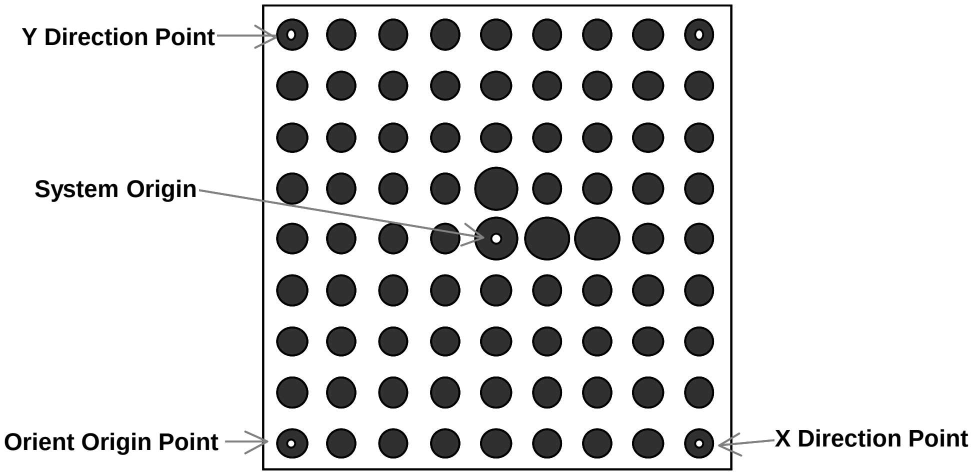
When the calibration grid is secured on a fixed surface, the position of the calibration grid frame relative to the robot world frame should be set as the robot user frame.

Setting operation is the same as that of a normal user frame. For details, refer to "R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR'S MANUAL (Basic Operation)". This section mainly describes where to touch up a calibration grid.

1 Prepare a pointer tool for touch-up and set TCP to the tip of the pointer tool.
2 Set a user frame by the [Four Point] teaching method.



3 Perform frame setting by touching up four points described in the drawing below with the TCP of the robot.



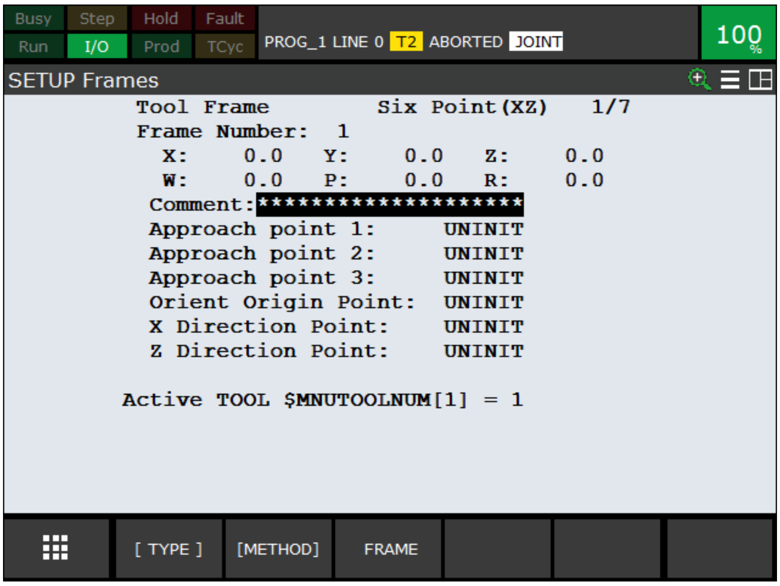
Four point teaching method touch-up points for a calibration grid

When the calibration grid is mounted on the robot end of arm tooling

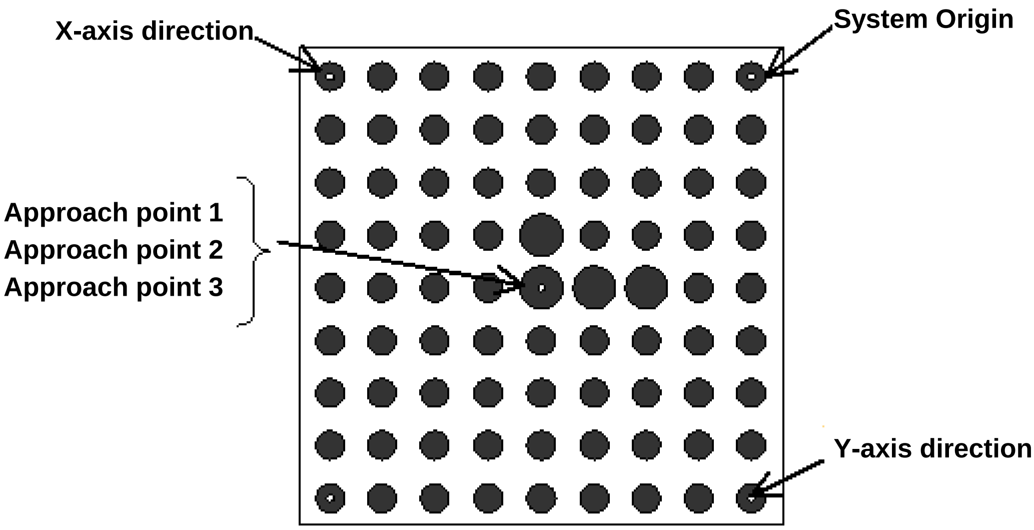
When the calibration grid is mounted on a robot, the position of the calibration grid frame relative to the robot mechanical interface frame (wrist flange) should be set as a robot tool frame.

The setting procedures are as follows. For details, refer to "OPERATOR'S MANUAL (Basic Operation) B-83284EN". This section mainly describes where to touch up a calibration grid.

1 Fix a pointer for touch-up on a secured table, etc.
2 Set a tool frame by the [Six Point (XY)] teaching method.



3 Perform frame setting by touching up four points described in the drawing below with the TCP of the robot.

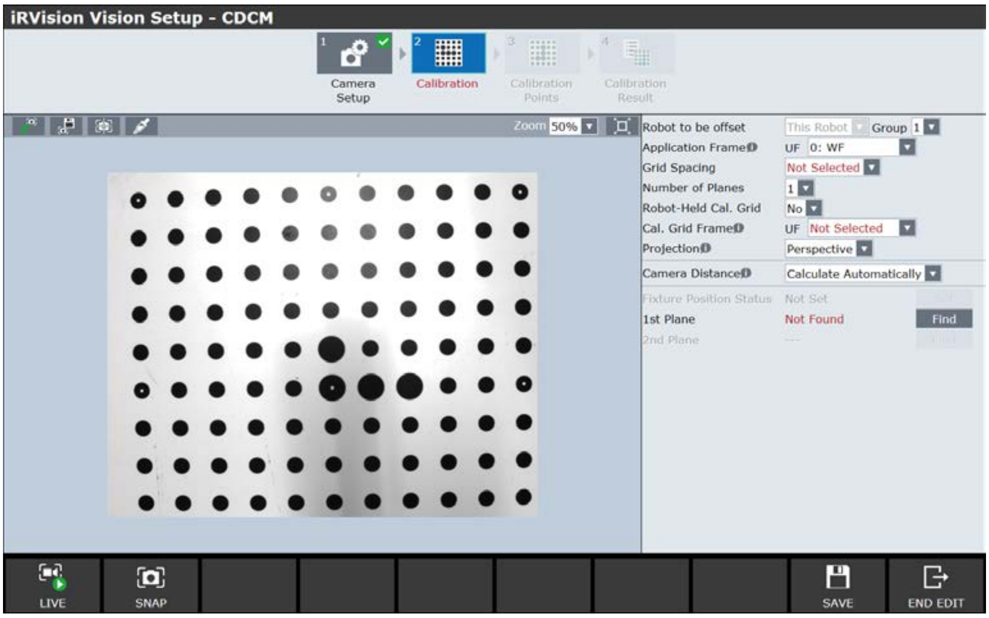


Six point teaching method touch-up points for a calibration grid

2.1.2.2 Calibration

Finds the grid pattern and perform camera calibration.

If you select [Calibration] in the navigation area, the following screen appears.



The setting items area has the following parameters.

[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.

[Grid Spacing]

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

[Number of Planes]

Select the number of planes to be calibrated from the drop-down box.

[1 (Plane Calibration)]

When using a fixed camera + a fixed calibration grid, select [1 (Plane Calibration)].

[2 (Plane Calibration)]

When using a robot-mounted camera or using a robot-held calibration grid, [2 (Plane Calibration)] is recommended.

[Robot-Held Cal. Grid]

Select the installation status of the calibration grid.

[No]

Select if the calibration grid is not moved with respect to the user frame.

[Yes]

Select if the calibration grid is mounted on the robot.

[Robot Holding Grid]

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

[Cal. Grid Frame]

Select the user frame number or the tool frame number where the calibration grid frame is recorded, from the drop-down box.
When the calibration grid is secured on a fixed surface, select the user frame number.
When the calibration grid is mounted on the robot end of arm tooling, select the tool frame number.

[Projection]

[Perspective] is selected.

[Perspective]

Normally, select [Perspective].

[Orthogonal]

When using a telecentric lens, select [Orthogonal].

[Camera Distance]

Select a method to setup the camera distance from the drop-down box.

[Calculate Automatically]

Normally, select [Calculate Automatically].

Once the grid pattern is found, the camera distance is calculated automatically.
When calibration is performed using two planes, the value close to the nominal focal distance of the lens is calculated (e.g. 11.8 mm for a lens of nominal f = 12 mm, etc.). Also, this value being close to the nominal value is the indication that the calibration has been properly performed.

[Override Focal Distance]

When calibration is performed using one plane by installing the grid pattern perpendicular to the camera's optical axis, the correct focal distance cannot be calculated in principle, so select [Override Focal Distance] and input the nominal focal distance of the lens in the text box.

[Override Standoff Distance]

Similarly as [Override Focal Distance], select this option when calibration is performed using one plane by installing the calibration grid perpendicular to the camera's optical axis. The focal distance is calculated on the basis of the inputted standoff distance. Selecting this will display setting items of the [Standoff Distance].

[Standoff Distance]

This item is displayed when [Override Standoff Distance] is selected in [Camera Distance]. Enter the actual standoff distance in the text box by measuring the distance between the center of length direction of the lens and the grid pattern surface along the camera's optical axis.

[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 clicked, 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 clicking 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]

The status of the grid pattern on the 1st plane is displayed.

- When the grid pattern has been found, [Set] is displayed in green.
- When the grid pattern has not been found, [Not Found] is displayed in red.

Click the [Find] button on [1st Plane] to find the grid pattern.

[2nd Plane]

The status of the grid pattern on the 2nd plane is displayed.

- When the grid pattern has been found, [Set] is displayed in green.
- When the grid pattern has not been found, [Not Found] is displayed in red.

Click the [Find] button on [2nd Plane] to find the grid pattern.

[Finding the grid pattern]

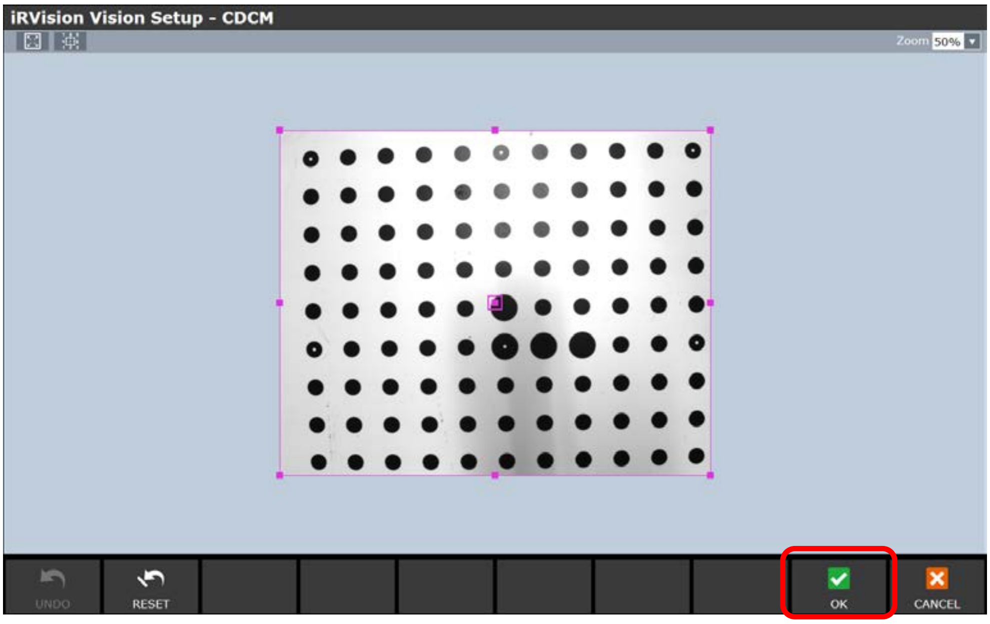
The grid pattern is found to calculate calibration data.

1 To capture the image of the calibration grid, click F3 [SNAP].

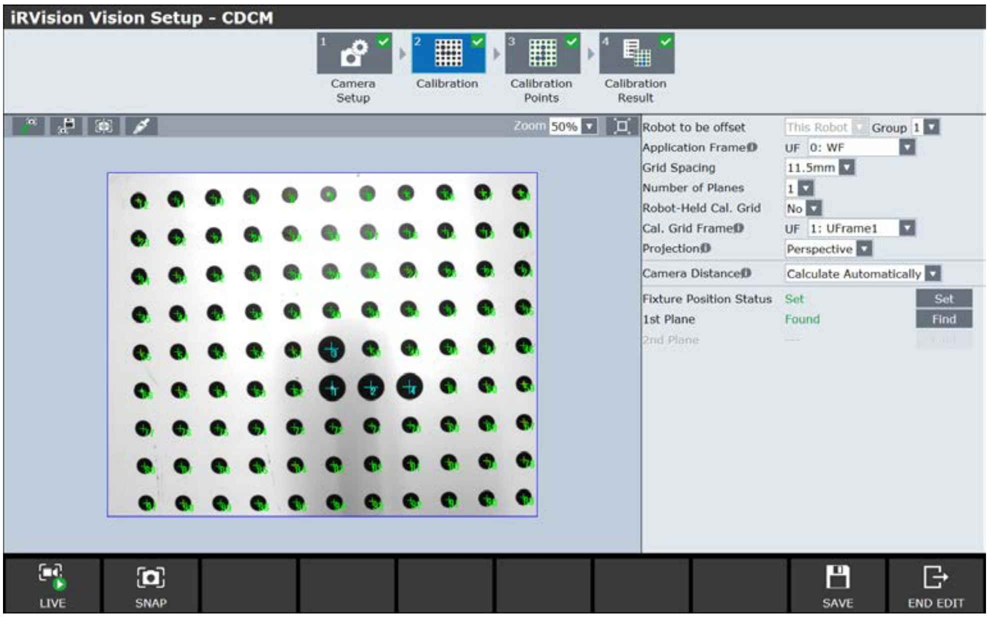
> ⚠ **CAUTION**
> The calibration grid does not have to fill the field of view, but the calibration will be less accurate if circles of the grid pattern appear only a part in the image. Make sure that the image is filled with circles of the grid pattern; do not care about some of the circles appearing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

2 Click the [Find] button of [1st Plane].

3 Specify the grid range with the displayed red rectangle. Click [OK] to find the grid pattern. If you want to quit, click [Cancel].



When the grid pattern is found successfully, crosshairs (+) appear at the center of each of the found circles.



4 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.

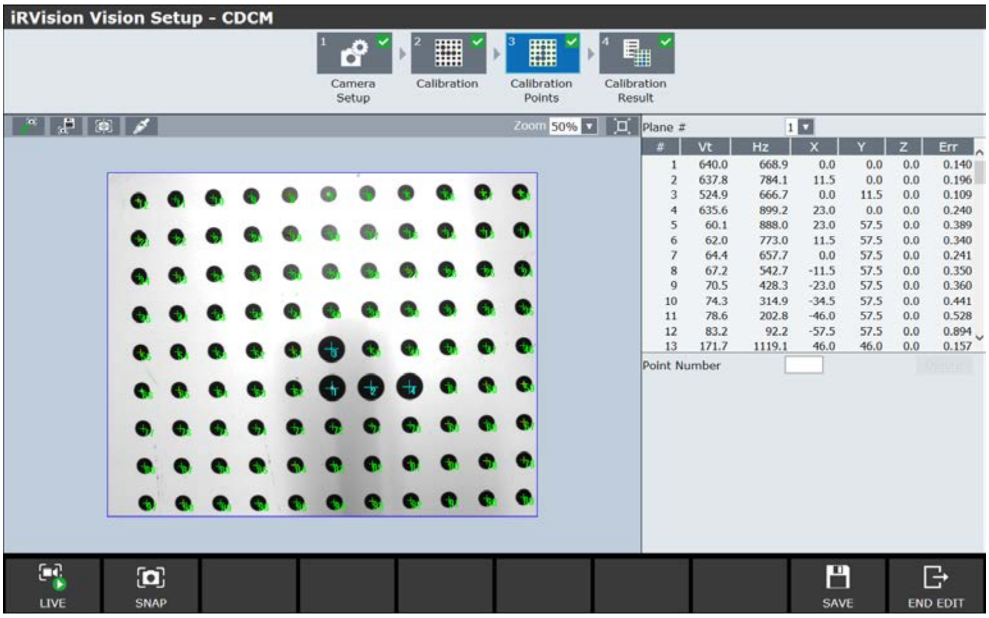
For 1-plane calibration, this completes the procedure for calibration.
For 2-plane calibration, continue to perform the following steps.

5 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 about 150 mm. If the plane does not come into focus, decrease the travel distance.
6 Click the [Find] button of [2nd Plane].
7 Similar to 1st plane, check the calibration points that have been found.

2.1.2.3 Checking calibration points

Check the calibration points that have been found.

If you select [Calibration Points] in the navigation area, the following screen 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.

The calibration point information is displayed in the setting items area.

[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]

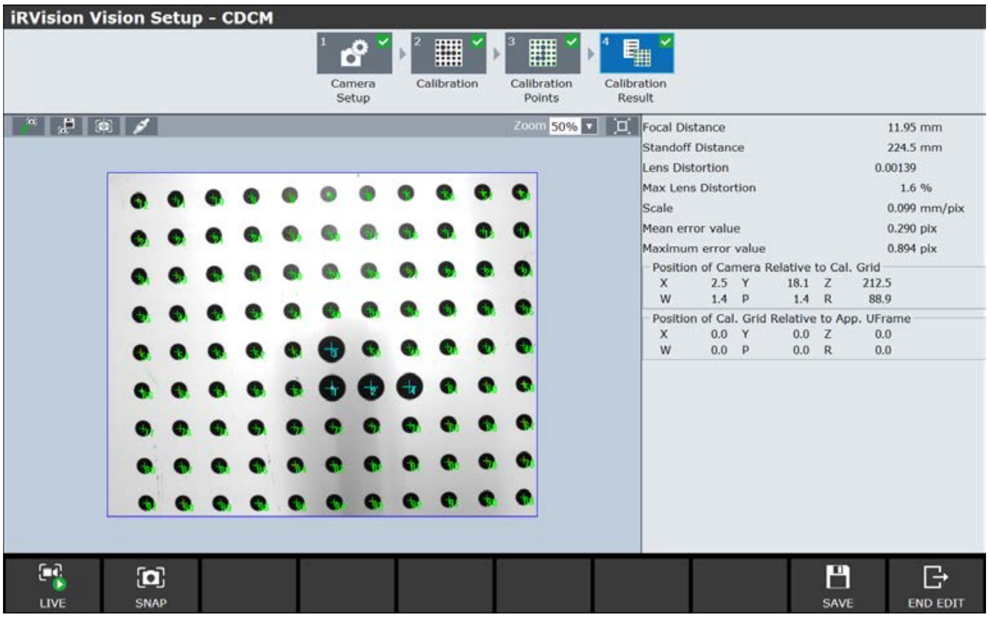
The distance between the centers of the green crosshairs and red crosshairs plotted on the image is displayed. A smaller value indicates more accurate calibration.

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 click the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated.

2.1.2.4 Checking calibration result

Check the calculated calibration data. If you select [Calibration Result] in the navigation area, the following screen appears.



The calculated calibration results are displayed in the setting items area.

[Focal Distance]

The calculated focal distance of the lens is displayed. Check if the value is appropriate for the lens in use. The nominal focal distance is labeled 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 [Calibration], set [Camera Distance] to [Override Focal Distance] 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.

[Standoff Distance]

The distance between the center of the length direction of the lens and the top surface of the grid pattern along the camera's optical axis.
Check if the value is appropriate for the standoff 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.

[Max Lens Distortion]

Expresses in pixels the size of the distortion at the location where the lens distortion is greatest.

[Scale]

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 value]

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

[Position of Camera Relative to Cal. Grid]

The position of the camera relative to the calibration grid frame is displayed. For the calibration grid frame, refer to "Introduction: 2.6 CALIBRATION GRID". In the case of 2-plane calibration, it is relative to the calibration grid frame of the 1st plane.

[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 [Calibration] 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 [Calibration]. The value is displayed only for a robot-mounted camera. In the case of 2-plane calibration, it is the robot position at the time of finding calibration grid for the 1st plane.

2.1.2.5 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 18 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:! Find plane-1
 13:   PR[99,3]=0
 14:J P[1] 100% FINE OFFSET,PR[99]
 15:   CALL IRVBKLSH(1)
 16:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1
 17:
 18:! Find plane-2
 19:   PR[99,3]=100
 20:J P[1] 100% FINE OFFSET,PR[99]
 21:   CALL IRVBKLSH(1)
 22:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
 23:   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.

2.1.3 Robot-Generated Grid Calibration

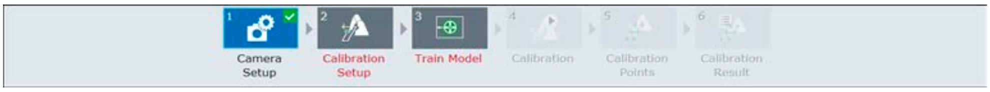
Robot-generated grid calibration is a general-purpose camera calibration function suitable for the calibration of a wide-view-angle camera.

The procedure for the operation of robot-generated grid calibration is as follows.

1. Select and mount the target on the robot end of arm tooling.
2. Perform [Calibration Setup] on the camera data edit screen.
3. Perform [Train Model] on the camera data edit screen.
4. Select the camera data to calibrate in the *i*RVision utility menu.
5. Set up the target position in the *i*RVision utility menu.
6. Generate a calibration program in the *i*RVision utility menu.
7. Run the calibration program.
8. Check [Calibration Points] on the camera data edit screen.
9. Check [Calibration Results] on the camera data edit screen.

MEMO
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 "Setup: 7 UTILITY MENU".

When selecting [Robot-Generated Grid Cal.] for [Calibration] in [Camera Setup], the following steps for the robot-generated grid calibration are displayed in the navigation area.



[Calibration Setup]
Perform setup necessary for robot-generated grid calibration.

[Train Model]
Teach the shape of a target as a model pattern.

[Calibration]
Perform camera calibration.
For actual operation, perform the followings on the *i*RVision utility menu of the teach pendant.

- Setting Target Position
- Generating Calibration Program
- Executing Calibration Program

[Calibration Points]
Check the calibration points that have been found.

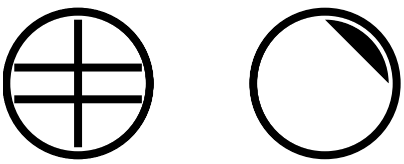
[Calibration Result]
Check the calculated calibration data.

2.1.3.1 Selecting 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.

The following figure shows examples of appropriate / inappropriate geometries for the target.



Examples of appropriate target geometries:

The rotation angle cannot be identified. The size cannot be identified.

Examples of inappropriate target geometries:

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 targe

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.

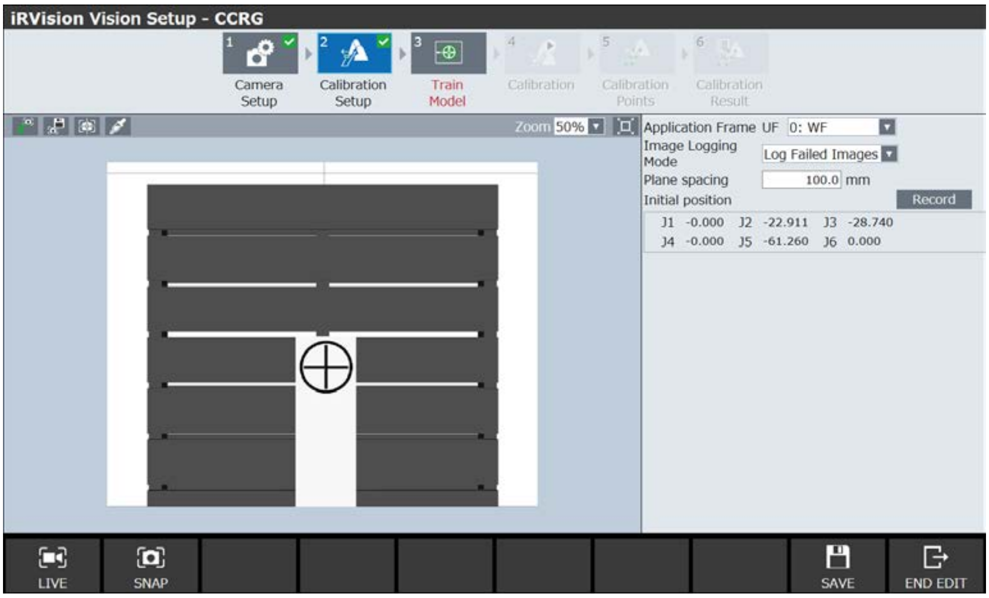
> **MEMO**
> 1 Normally, the robot position and posture are set so that the range of robot motion becomes maximal when the robot actually operates. Therefore, mounting the target so that it can be captured by the camera when the robot is in a posture that it takes during operation makes it easier to 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

2.1.3.2 Calibration setup

Perform the necessary setup for robot-generated grid calibration on the calibration setup screen.

> **MEMO**
> [Calibration Setup] is performed on the camera data edit screen.

If you select [Calibration Setup] in the navigation area, the following screen appears.



The setting items area has the following parameters.

[Application Frame]

Select the robot frame to be used as the reference frame for calibration from the drop-down box. The camera will be calibrated with respect to the selected frame.

When the camera is almost facing upward or downward, you don't have to change this setting, as you can use the world frame as the application frame. But when the camera is facing sideways, set a user frame so that its XY plane is almost perpendicular to the camera's optical axis and select it as the application frame.

MEMO

In the robot-generated grid calibration, it is premised that the camera's optical axis is generally horizontal with the Z axis of the application frame, and the robot is operated horizontally to the XY plane of the application frame when executing calibration.

⚠ 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.

[Image Logging Mode]

From the drop-down box, select whether to save images in the vision log. However, if you have the vision log disabled in the system variable, logged images are not saved.

[Do Not Log]

Do not record logged images.

[Log Failed Images]

Record logged images only in the case of target not found.

[Log All Images]

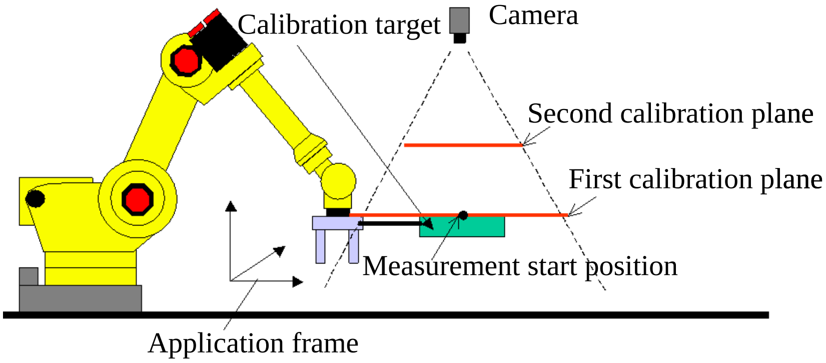
Record logged images every time.

[Plane spacing]

Specify the spacing between calibration planes 1 and 2. A calibration plane spacing is enlarged as much as possible within the range which the focus of lens suits. When the spacing is too close, the accuracy of calibration may not be acquired. 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 click the RECORD button.



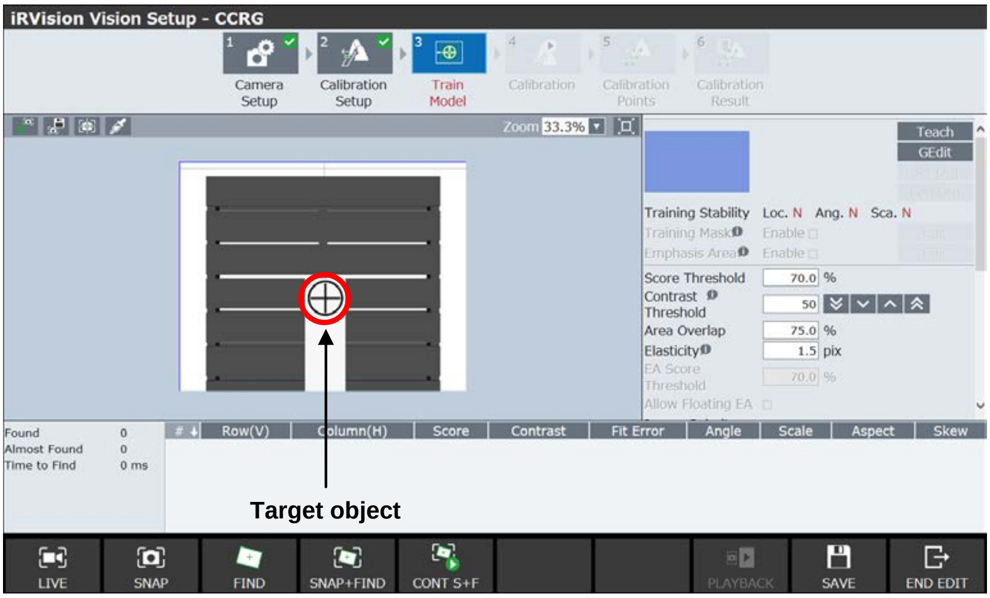
Start Position

2.1.3.3 Teaching model

Teach the model pattern for finding the target.

> **MEMO**
> [Train Model] is performed on the camera data edit screen.

If you select [Train Model] in the navigation area, the following screen appears.

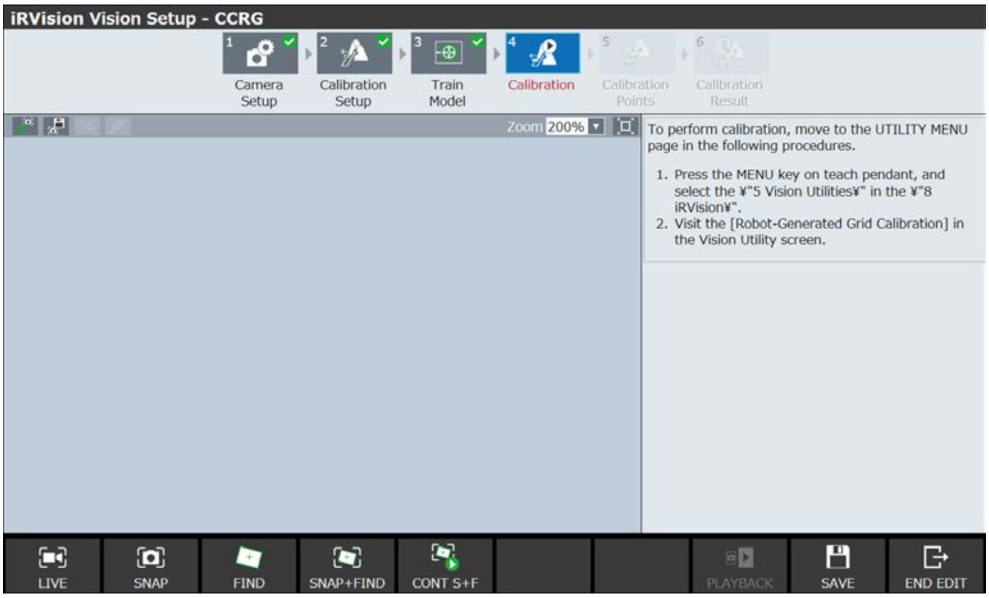


The procedure to teach the model pattern is the same as the GPM locator tool. For details, refer to "Setup: 4.2 GPM LOCATOR TOOL"

2.1.3.4 Calibrating camera

Perform camera calibration.
Leave the camera data edit screen on the PC and go to the *i*RVision utility menu on the teach pendant.

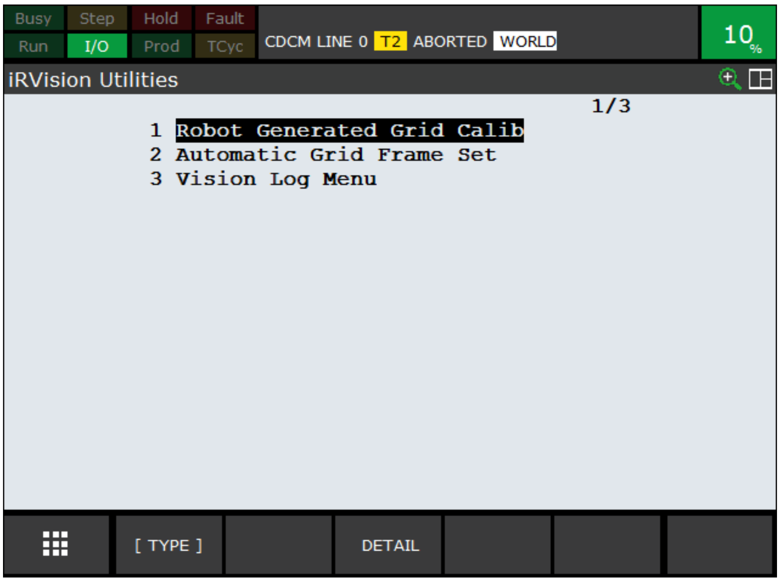
If you select [Calibration] in the navigation area, the following screen appears.



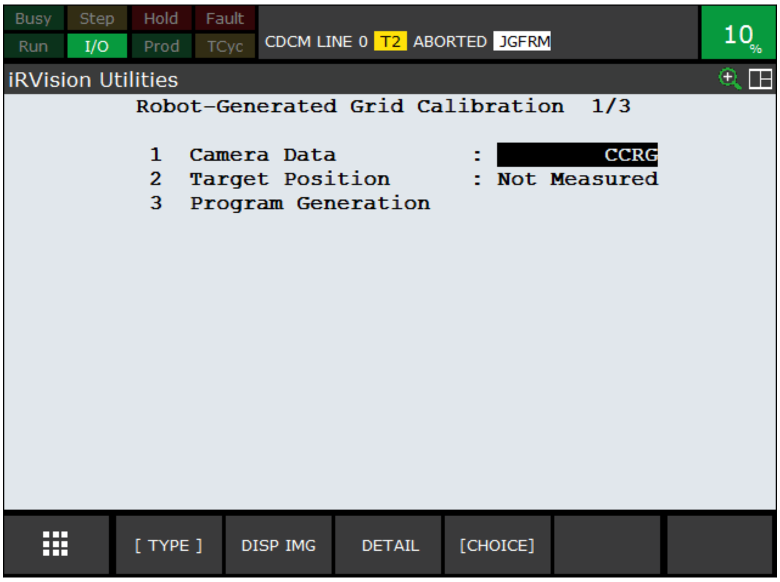
1 After clicking [SAVE] on the camera data edit screen to save the changes, click [END EDIT] to close the camera data edit screen.

> ⚠ **CAUTION**
> The camera data edit screen must be closed. Calibration cannot be performed on the utility menu if the camera edit screen remains open.

2 On the teach pendant, press the [MENU] key.
3 After selecting [iRVision] → place the cursor over [Vision Utilities] and press the [ENTER] key to display the *i*RVision utility menu.



4 Place the cursor over [Robot-Generated Grid Calib] and press the [ENTER] key.
The main screen for robot-generated grid calibration will appear.



MEMO
Robot-generated grid calibration main screen cannot be opened in more than one window at a time.

There are the following items on the robot-generated grid calibration main screen.

[Camera Data]

Select camera data to calibrate.

Furthermore, if you place the cursor over this line and press F3 [DETAIL], you can check the detail of the selected camera data. For details of the screen, refer to "Setup: 2.1.3.11 Camera Data Menu".

[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, [Measured] is displayed. Otherwise, [Not Measured] is displayed. For the steps to set the target position, refer to "Setup: 2.1.3.5 Setting Target Position".

Furthermore, if you place the cursor over this line and press F3 [Position], you can check the values of the target position. For details of the screen, refer to "Setup: 2.1.3.12 Target Position Menu".

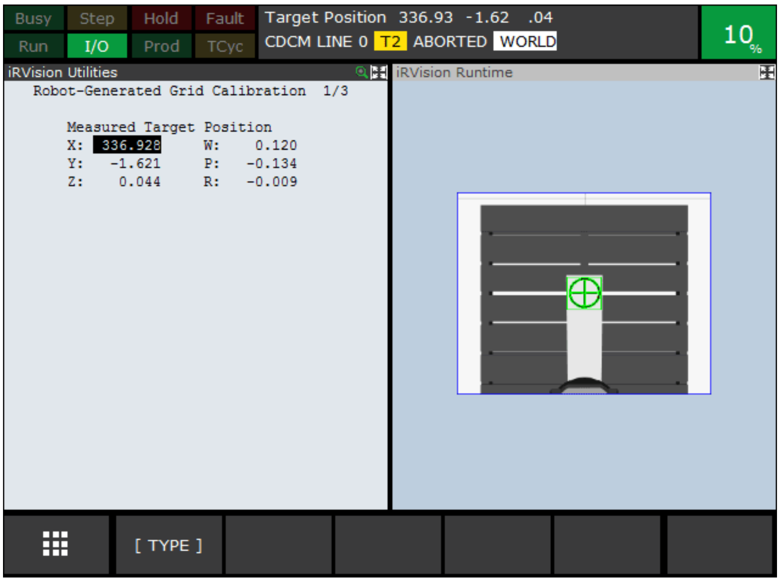
[Program Generation]

Generate a calibration program to perform robot-generated grid calibration.
For program generation, refer to "Setup: 2.1.3.6 Generating Calibration Program".

Function Keys

The following function keys are displayed on the robot-generated grid calibration main screen as common functions.

Key number	Item Name	Function
F1	TYPE	Jumps to another *i*RVision menu screen.
F2	DISP IMG	Two screens will appear; robot-generated grid calibration main screen and [iRVision Runtime] (refer to the following).



2.1.3.5 Setting target position

Measures the position of the target mounted on the robot end of arm tooling.

> **MEMO**
> Set the target position in the *i*RVision utility menu.

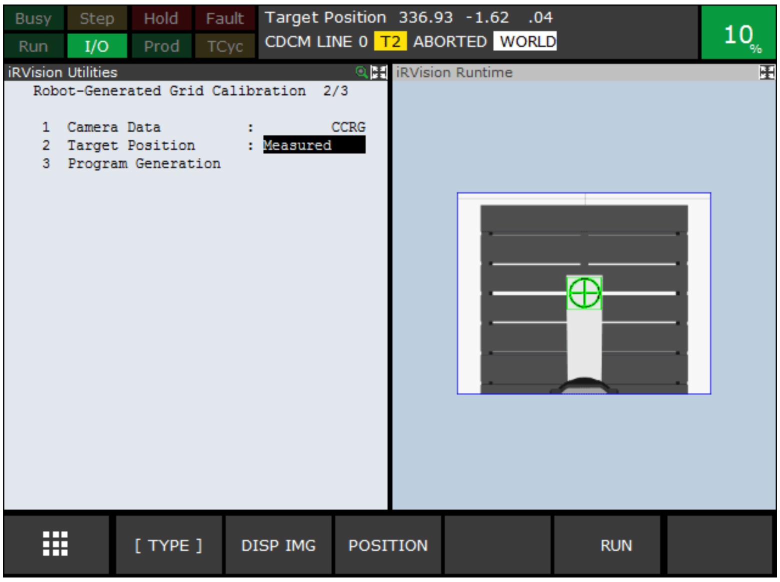
6-axis robots and 4-axis/5-axis robots vary in setting methods for the target position.
You can set target positions for 6-axis robots by measuring targets with cameras.

- For 6-axis robots, target positions are automatically set by measuring targets with cameras.

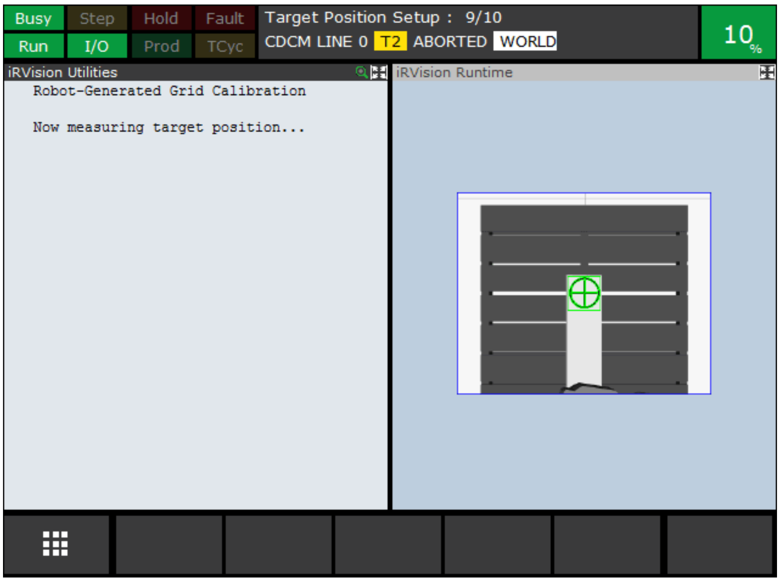
- For 4- and 5-axis robots, the target position cannot be measured automatically. Calculate the coordinate values of the target position relative to the robot wrist flange from the drawing, and set them manually.

[6-axis robot]

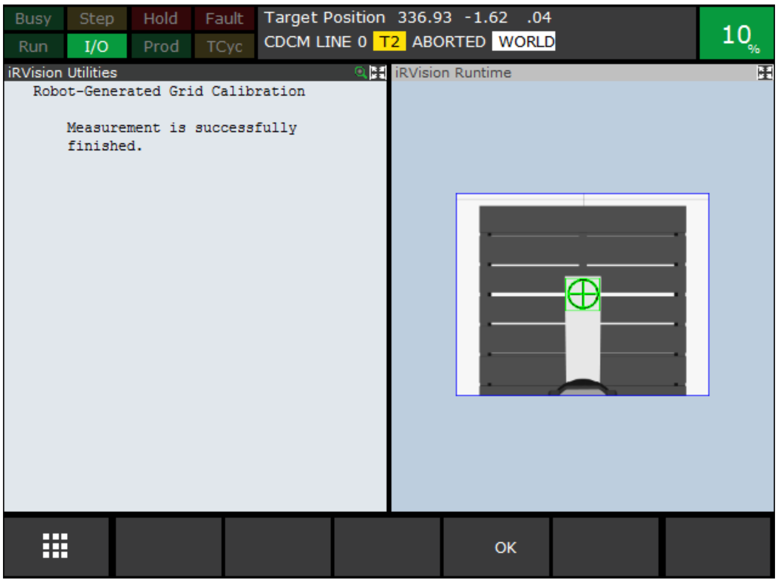
A 6-axis robot can measure the position of robot-mounted target mark by vision.



1 Verify whether the calibration data which is selected [1 Calibration Data] is proper.
2 Check the name of the camera data selected in [Camera Data].
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.



When the measurement is complete, the robot stops and the message [Measurement is successfully finished.] appears on the screen.



5 Press F4 OK to return to the main menu.
[Target Position] will be indicated as [Measured].

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].

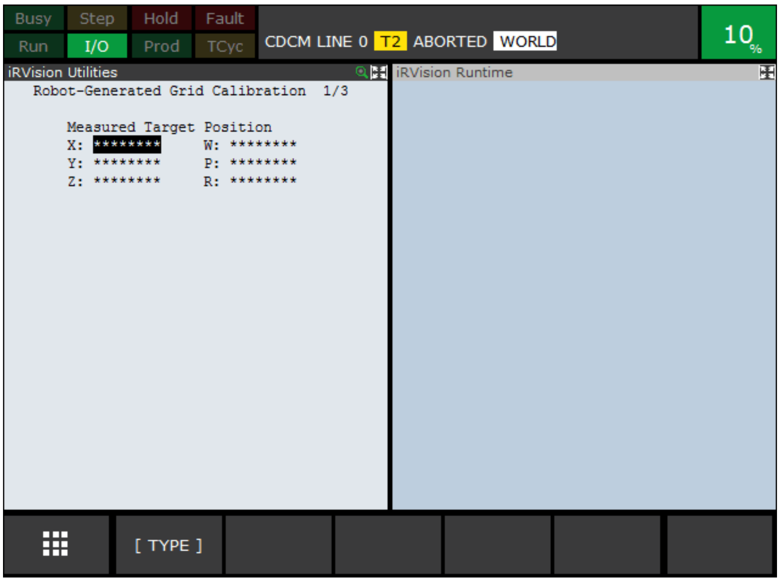
> ⚠ **CAUTION**
> If the camera calibration setup page is opened in the Vision Setup screen, Robot-Generated Grid Calibration cannot perform the measurement. Make sure that the setup page is closed. You can see the status of the measurement on the Vision Runtime screen.

> **MEMO**
> 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 Calculate coordinate values of the target mask (refer to "Setup: 2.1.3.3 Teaching Model") relative to the robot wrist flange.
2 Place the cursor on [2 Target Position], and press F3 [POSITION] to visit the target position menu.
Target position details are shown on the screen.



3 Enter the coordinate values in [X], [Y], and [Z].
Enter 0 in [W], [P], and [R].

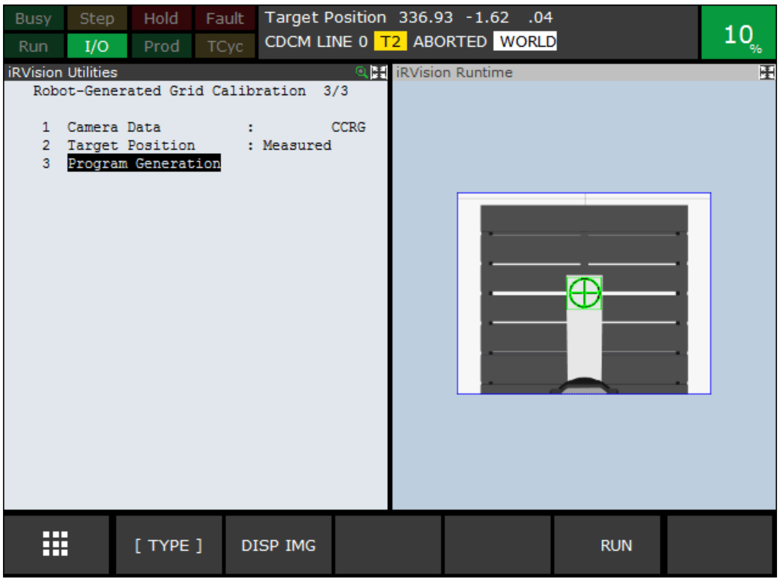
4 Press the [PREV] key to return to the main menu.
[Target Position] will be indicated as [Measured].

> ⚠ **CAUTION**
> Make sure the target position should correspond to the model origin trained in "Setup: 2.1.3.3 Teaching Model". If the positions are different, the camera cannot be calibrated properly.

2.1.3.6 Generating calibration program

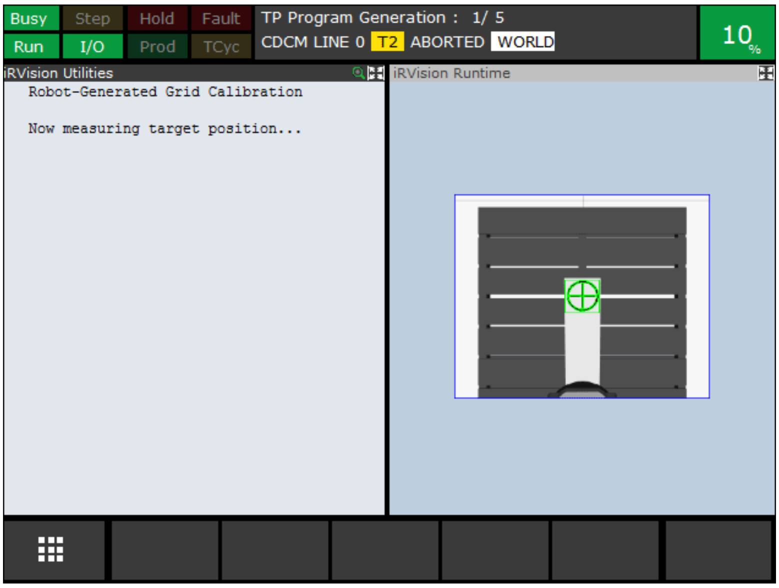
Measures the size of the camera's field of view, and generates a robot program for camera calibration.

> **MEMO**
> Generate a calibration program in the *i*RVision utility menu.



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. 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 on the target camera data edit screen.
2 Click [Train Model] in the navigation area.
3 Click the [Set] button in the search window.
4 Make the search window smaller to exclude sections where you do not want the robot to operate. Click [OK].
5 Check the changes and click [SAVE].
6 Click [END EDIT].
7 Close the camera data edit screen.
8 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 CAMERA_CALIB 'CAMERA1' REQUEST=1
  5:L P[1001] 1000mm/sec FINE
  6:   CALL IRVBKLSH(1)
  7:   VISION CAMERA_CALIB 'CAMERA1' REQUEST=1001
  8:L P[1002] 1000mm/sec FINE
  9:   CALL IRVBKLSH(1)
 10:   VISION CAMERA_CALIB 'CAMERA1' 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 'CAMERA1' REQUEST=2048
296:L P[2049] 1000mm/sec FINE
297:   CALL IRVBKLSH(1)
298:   VISION CAMERA_CALIB 'CAMERA1' REQUEST=2049
299:L P[2] 1000mm/sec FINE
300:   VISION CAMERA_CALIB 'CAMERA1' 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 'CAMERA1' REQUEST=1001
```

Each command in the program is briefly explained below.

```
  4:   VISION CAMERA_CALIB 'CAMERA1' 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 'CAMERA1' 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 'CAMERA1' 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.

2.1.3.7 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.

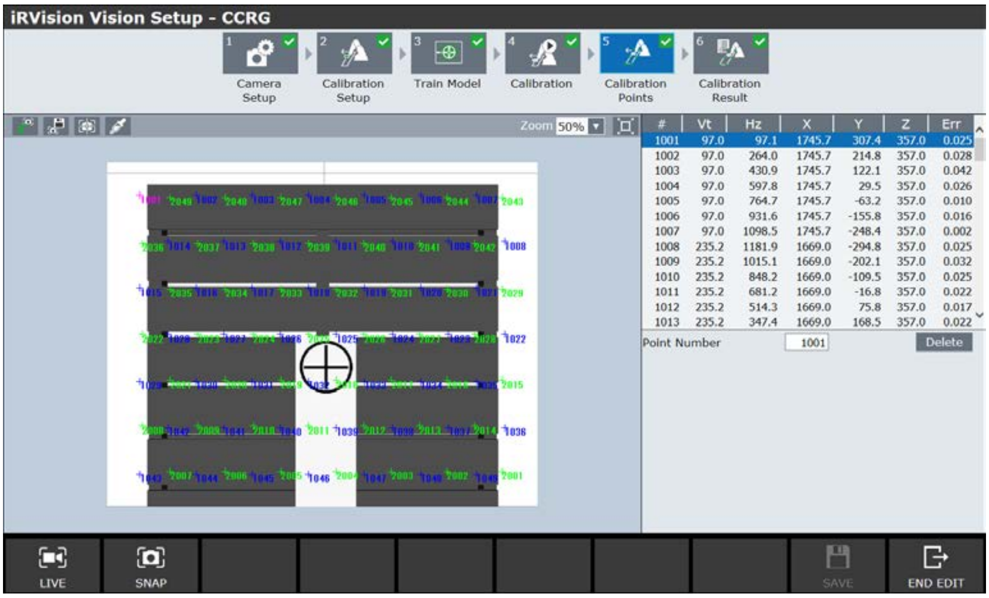
> **MEMO**
> As long as the position where the target is mounted remains unchanged, you can re-calibrate the camera simply by executing the generated calibration program.

After executing the calibration program to the last, camera calibration is complete.

2.1.3.8 Checking calibration points

Check the calibration points found after performing the robot-generated grid calibration.

> **MEMO**
> Checking [Calibration Points] is performed on the camera data edit screen.



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.

The following calibration point information is displayed in the setting items area.

[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.

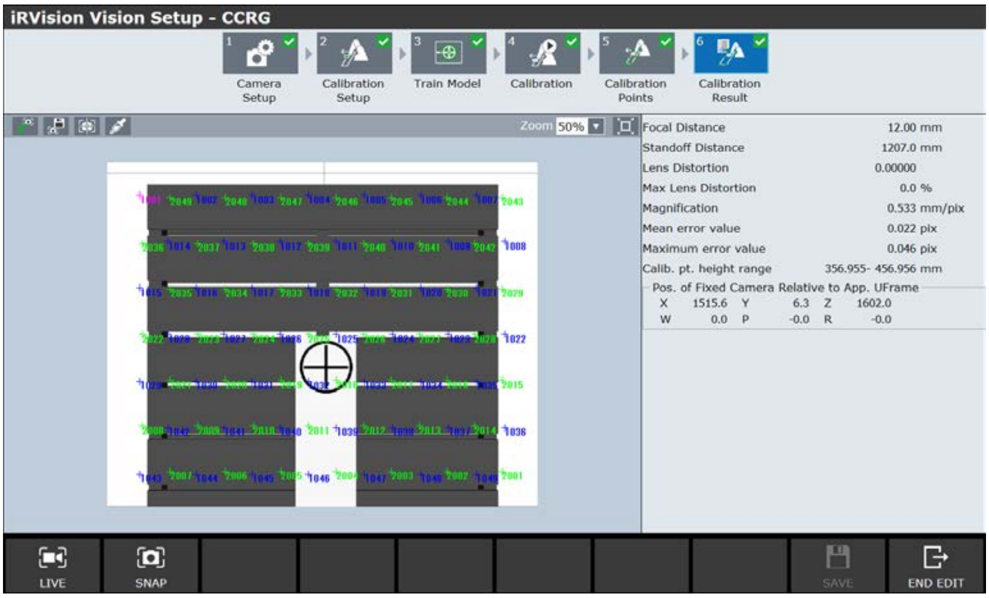
Deleting a calibration point

If a crosshair is displayed at a location where no calibration point is present, select that point by selecting 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 click the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated.

2.1.3.9 Checking calibration result

Check the calculated calibration data.

MEMO
Checking [Calibration Results] is performed on the camera data edit screen.



The following information of calculated calibration results is displayed in the setting items area.

[Focal Distance]

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

[Standoff Distance]

The distance from the center of the length direction of the lens to the top surface of the grid pattern along the camera's optical axis.
Check if the value is appropriate for the standoff in use.

[Lens Distortion]

The calculated lens distortion coefficient is displayed.

[Max Lens Distortion]

Expresses in pixels the size of the distortion at the location where the lens distortion is greatest.

[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.

[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 value]

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

[Calib. pt. height range]

The range of Z height of the calibration points that have been found on the application frame.

[Pos. of Fixed Camera Relative to App. UFrame]

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

2.1.3.10 Automatic re-calibration

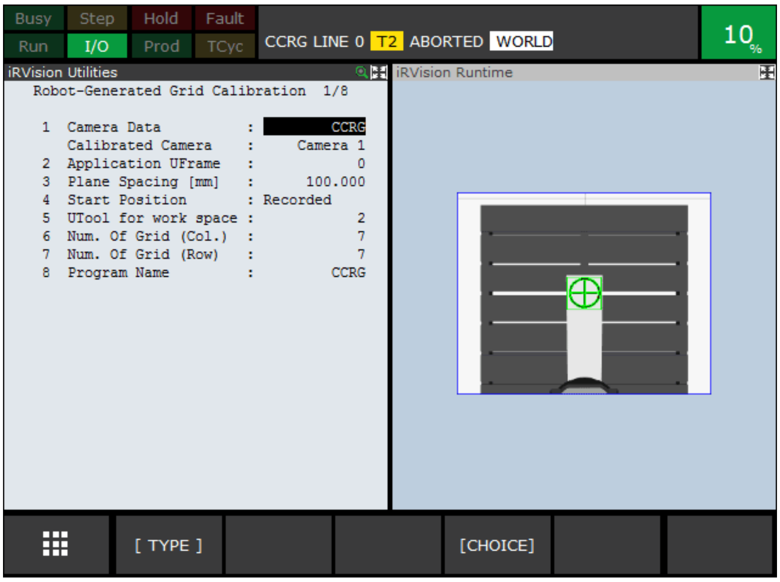
If the position of the camera is changed or the camera is replaced for some reason after the system is put into operation, the camera needs to be re-calibrated. In such a case, the use of automatic re-calibration allows you to restore the camera to its proper position with ease. Since no manual operation 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.

2.1.3.11 Camera data menu

You can check the camera data settings on the [iRVision Utilities] screen.

If you press F3 [DETAIL] with the cursor placed on [Camera Data] in the main menu for Robot-Generated Grid Calibration, a menu like the one shown below appears.



The following items will be displayed on the detailed screen of camera data.

[Camera Data]

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

[Calibrated Camera]

When the selected camera is a 3D area sensor and you want to calibrate two cameras individually, select the camera to calibrate.

[Application UFrame]

The number of the application user frame specified in the selected camera calibration is displayed.

[Plane spacing]

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]

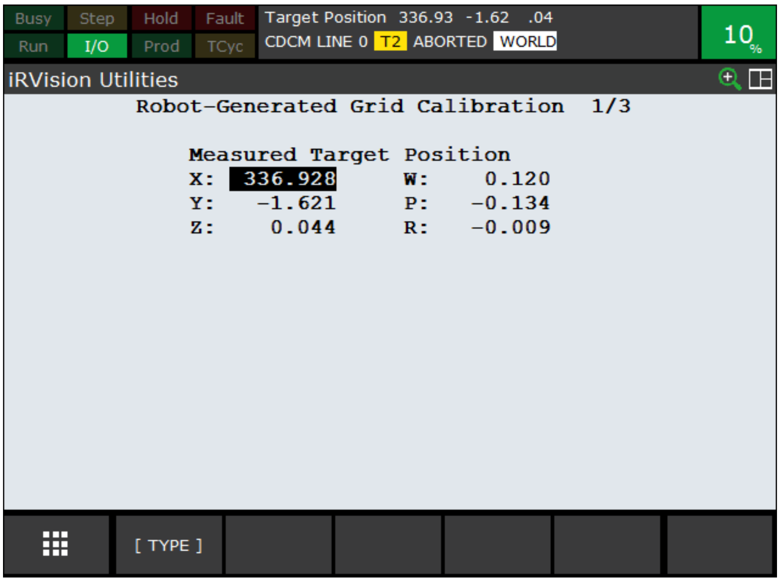
Specify the name of the calibration program to be generated. By default, this program name is the same as the name of the selected camera calibration. Normally, you do not need to change the default name.

2.1.3.12 Target position menu

You can check the target position currently set on the detailed screen of the target position. It is the position of the target with respect to the robot mechanical interface frame (wrist flange).

On the detailed screen of target position, the results of target position setting (refer to "Setup: 2.1.3.5 Setting Target Position") are shown.

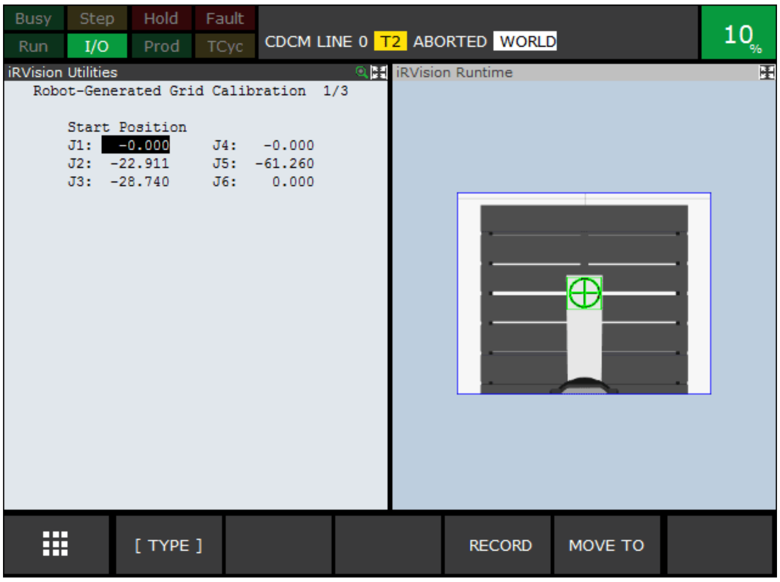
If you press F3 [DETAIL] with the cursor placed on [Target Position] in the main menu for Robot-Generated Grid Calibration, the following screen appears.



2.1.3.13 Start position menu

You can check the start position currently set on the detailed screen of measurement start position.

If you press F3 [POSITION] with the cursor placed on [Start Position] in the calibration data menu, the following screen appears.



Function Keys

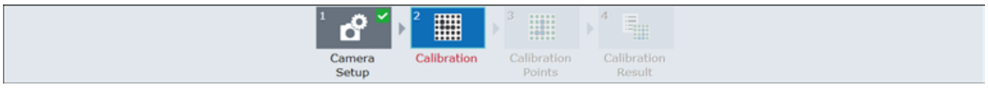
The following function keys will appear on the detailed screen of measurement start position.

Key number	Item Name	Function
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.

2.1.4 Visual Tracking Calibration

The visual tracking calibration is the camera calibration method dedicated to the visual tracking application.
For the calibration grid, refer to "Introduction: 2.6 CALIBRATION GRID".

When camera calibration of visual tracking is selected, the following is displayed:



[Calibration]

Execute the guide on the calibration screen to perform the visual tracking camera calibration.

[Calibration Points]

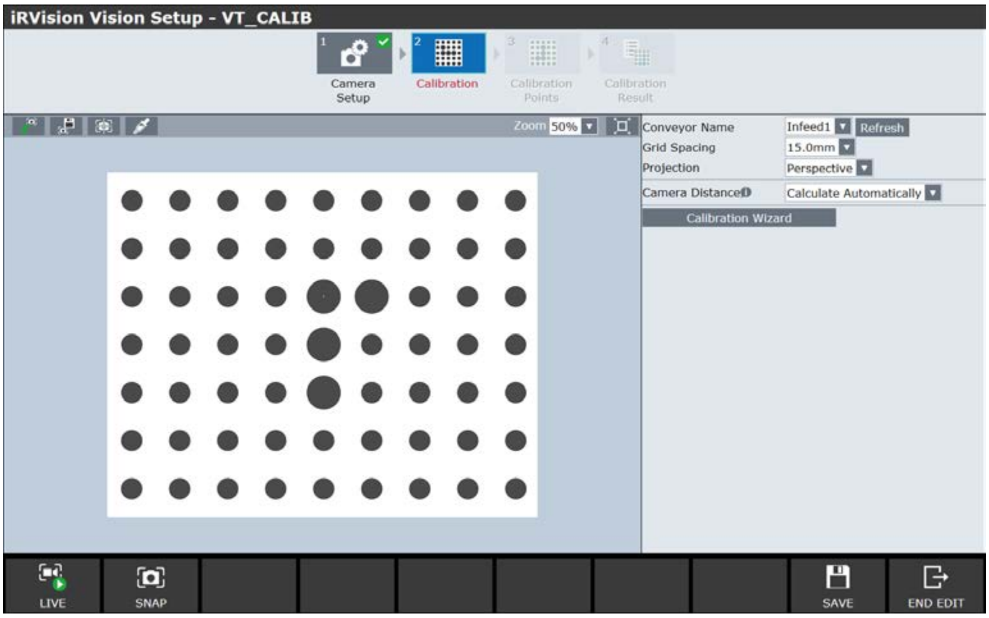
Check the calibration points that have been found in visual tracking calibration.

[Calibration Result]

Check the calculated calibration data.

2.1.4.1 Calibrating camera

Calibrate the camera.
If you select [Calibration] in the navigation area, the following screen appears.



The setting items area has the following parameters.

[Conveyor Name]

Select a Conveyor of visual tracking to be used.

MEMO

- If you add or delete a conveyor on the *i*RPickTool setup screen after you open this screen, click the [Refresh] button to refresh options of the [Conveyor Name] dropdown box.
- About the Conveyors, refer to "R-30*i*B Plus CONTROLLER *i*RPickTool OPERATOR'S MANUAL".

[Grid Spacing]

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

[Projection]

Select [Perspective].

[Perspective]

Normally, select [Perspective].

[Orthogonal]

When using a telecentric lens, select [Orthogonal].

[Camera Distance]

Select a setup method for the camera distance from the drop-down box.
Normally, select [Override Focal Distance].

⚠ **CAUTION**

With regard to the calculation method for [Camera Distance], when [Calculate Automatically] is selected, it is in principal possible that the focal distance might not be calculated accurately, because the calibration grid on the conveyor and the camera's imaging surface are nearly parallel.

[Calibration Wizard]

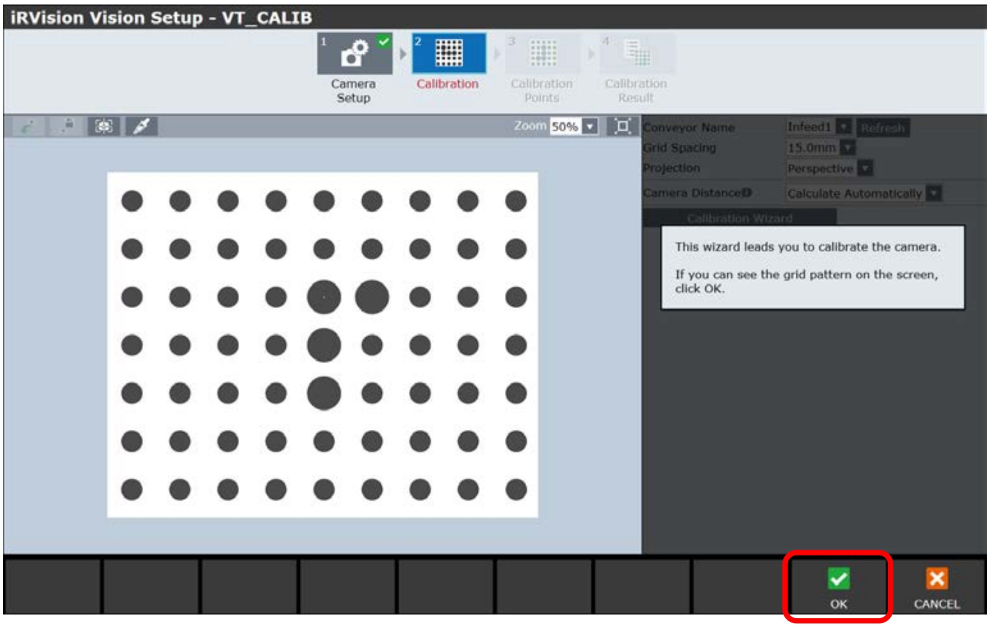
Perform the following steps in the wizard to perform camera calibration:

⚠ **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.

The steps to execute calibration are as follows.

1 Click 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 click F4 [OK].

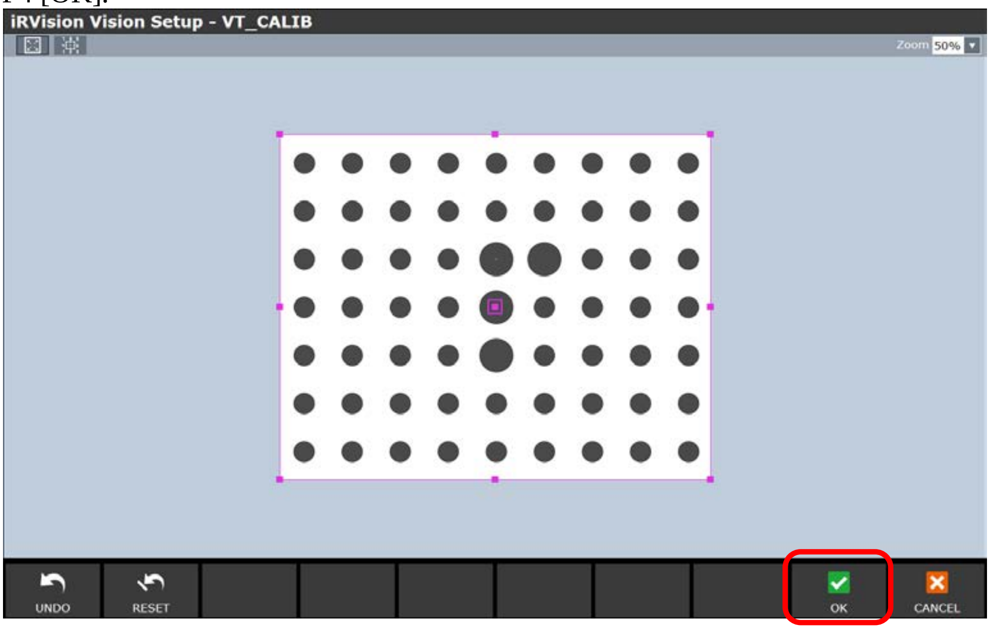


⚠ CAUTION

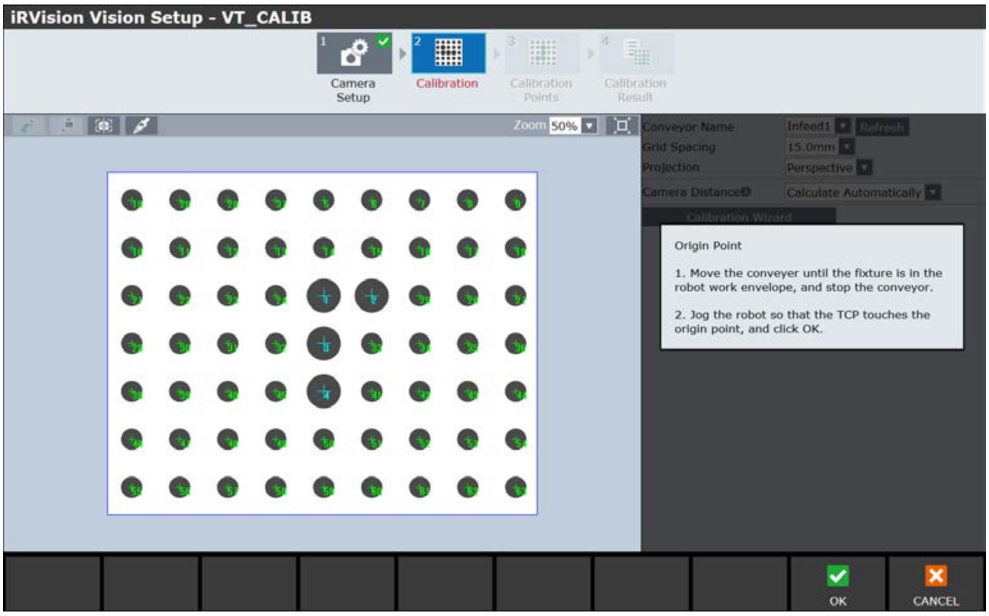
The calibration grid does not have to fill the field of view, but the calibration will be less accurate if circles of the grid pattern appear only a part in the image. Make sure that the image is filled with circles of the grid pattern; do not care about some of the circles appearing outside the image.

3 Enclose the grid pattern with a red rectangular window.

4 Click F4 [OK].



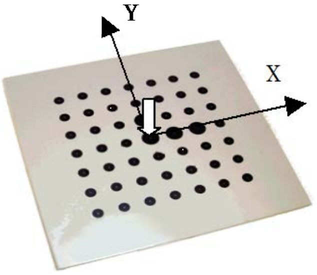
Upon completion of grid pattern location, the screen shown below is displayed.



5 Move the conveyor so that the calibration grid comes in front of a robot connected to the controller on which the *i*RVision setup screen is opened.

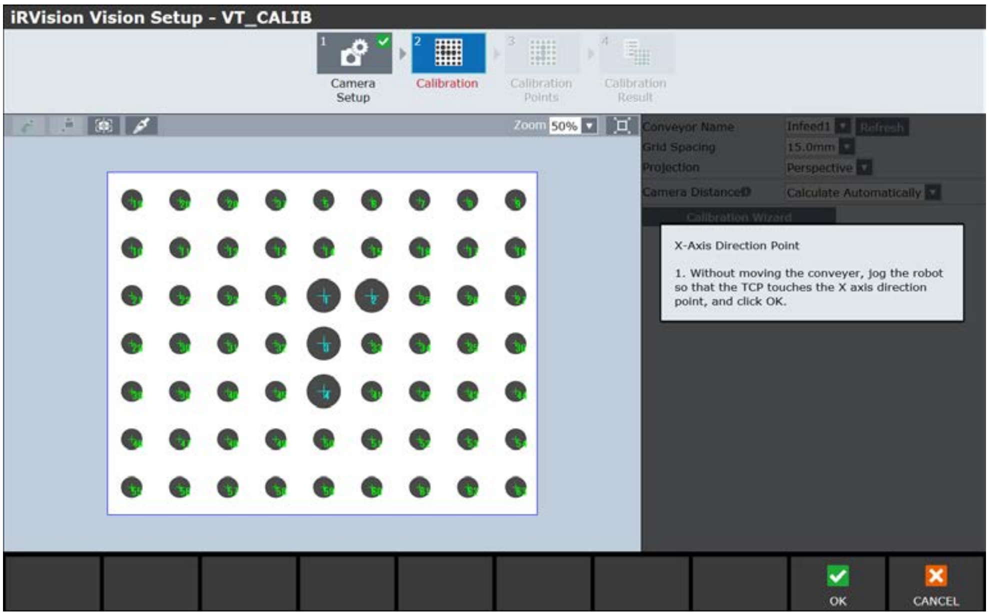
⚠ CAUTION
Be careful not to move the calibration plate.

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

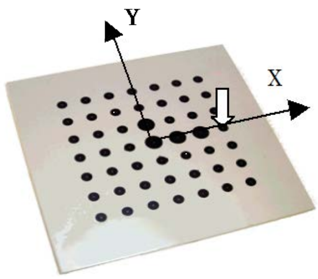


Origin of the calibration grid

The following screen will appear:

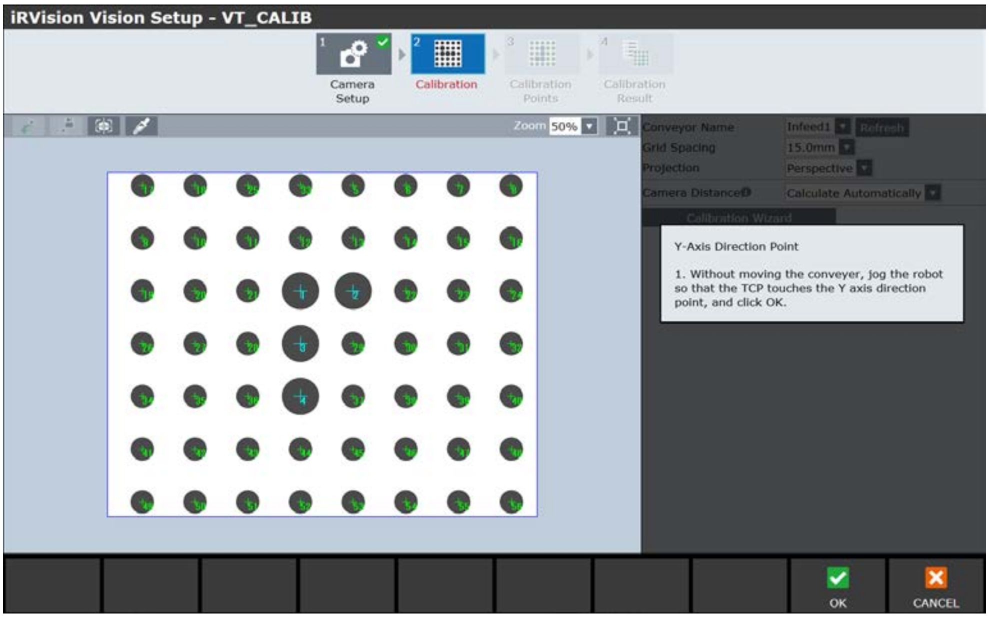


7 Jog the robot so the TCP is on a point on the positive X-axis of the calibration grid, then click F4 [OK].

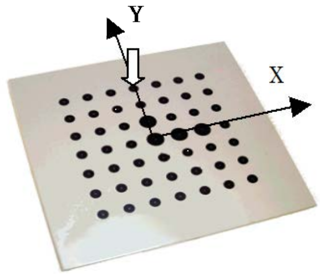


Point on the positive X-axis of the calibration grid

The following screen will appear:



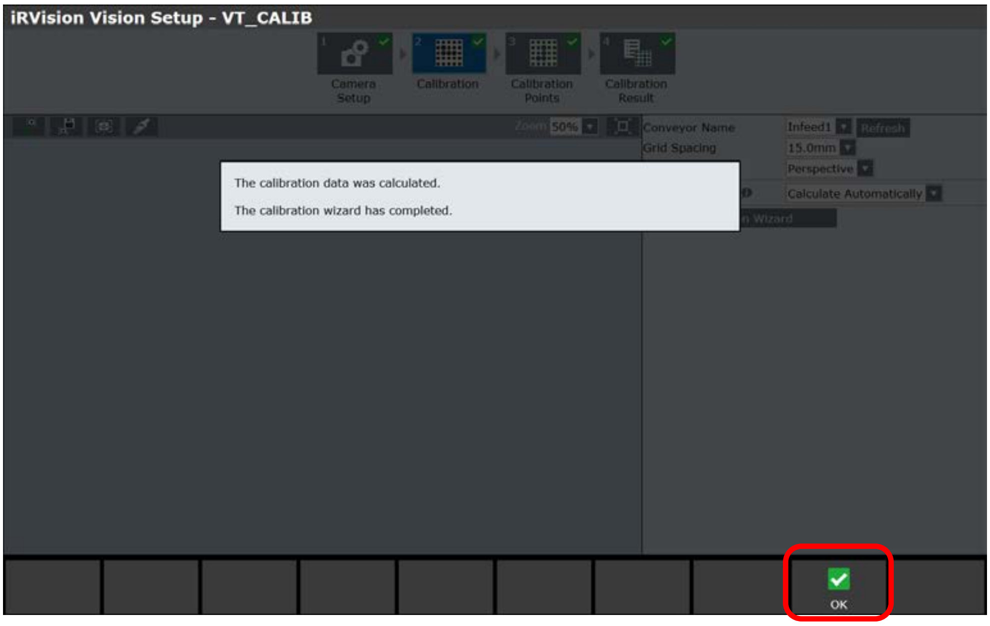
8 Jog the robot so that the TCP is on a point on the positive Y-axis of the calibration grid, then click F4 [OK].



Point on the positive Y-axis of the calibration grid

Once the calibration data is calculated, the screen to confirm finish will appear.

9 Click F4 [OK].
Ends the wizard and returns to the calibration screen.



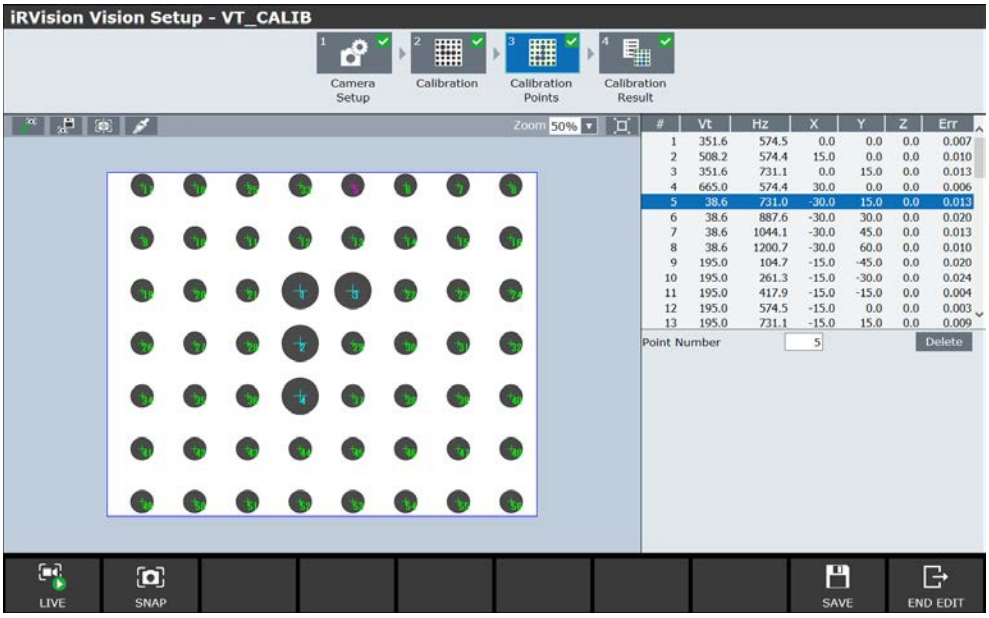
When the grid pattern is found successfully, '+' appear at the center of each of the found grid points.

10 Check that the '+' is displayed in light blue on four large grid points on the image.
Check that the '+' is displayed in green on small grid points on the image.
It does not matter if there are one or two small grid points which cannot be found.

2.1.4.2 Checking calibration points

Check the calibration points that have been found.

When the [Calibration Points] is selected, 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.

The following calibration point information will be displayed in the setting items area.

[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.

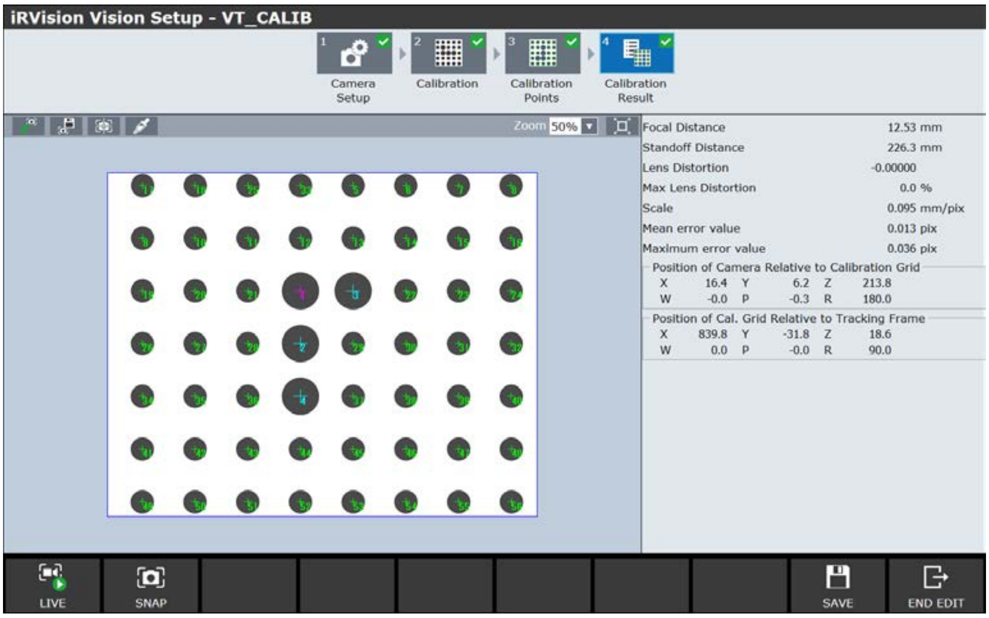
Deleting a calibration point

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 click the [Delete] button. The specified point is deleted from the list, and the calibration data is automatically recalculated.

2.1.4.3 Checking calibration result

Check the calculated calibration data.

Select [Calibration Result] in the navigation area to show a screen like the one shown below.



The following information of calculated calibration results will be displayed in the setting items area.

[Focal Distance]

The calculated focal distance of the lens is displayed.
Check if 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 ± 5 degrees, the focal distance cannot be measured accurately. Therefore, in the [Calibration], set [Camera Distance] to [Override Focal Distance] and enter the nominal focal distance of the lens in use. If you enter the focal distance, the calibration data is automatically recalculated.

[Standoff Distance]

The distance from the center of the length direction of the lens to the top surface of the grid pattern along the camera's optical axis.
Check if the value is appropriate for the standoff 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. Visual tracking calibration returns accurate coordinates by using this calculated lens distortion when accurately converting the image frame to the robot frame.

[Max Lens Distortion]

Expresses in pixels the size of the distortion at the location where the lens distortion is greatest.

[Scale]

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 [Calibration Points] 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, refer to "Setup: 7.2 GRID FRAME SETTING".

[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, refer to "R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RPickTool OPERATOR'S MANUAL" for V8.20P and later versions of controller, or "R-30*i*B CONTROLLER *i*RVision Visual Tracking OPERATOR'S MANUAL" for V8.10P and V8.13P of controllers. Refer to " R-30*i*B Plus CONTROLLER *i*RPickTool OPERATOR'S MANUAL".

2.2 3D AREA SENSOR

This vision process acquires a 3D map with 3D Area Sensor.
To set 3D area sensor data, follow the steps in the navigation area.
After performing basic setup for the sensor in the first 'Sensor Config', perform calibration. Lastly, set and adjust the 3D map acquisition conditions in 'Sensor Setup'.

2.2.1 3D Area Sensor Guidance

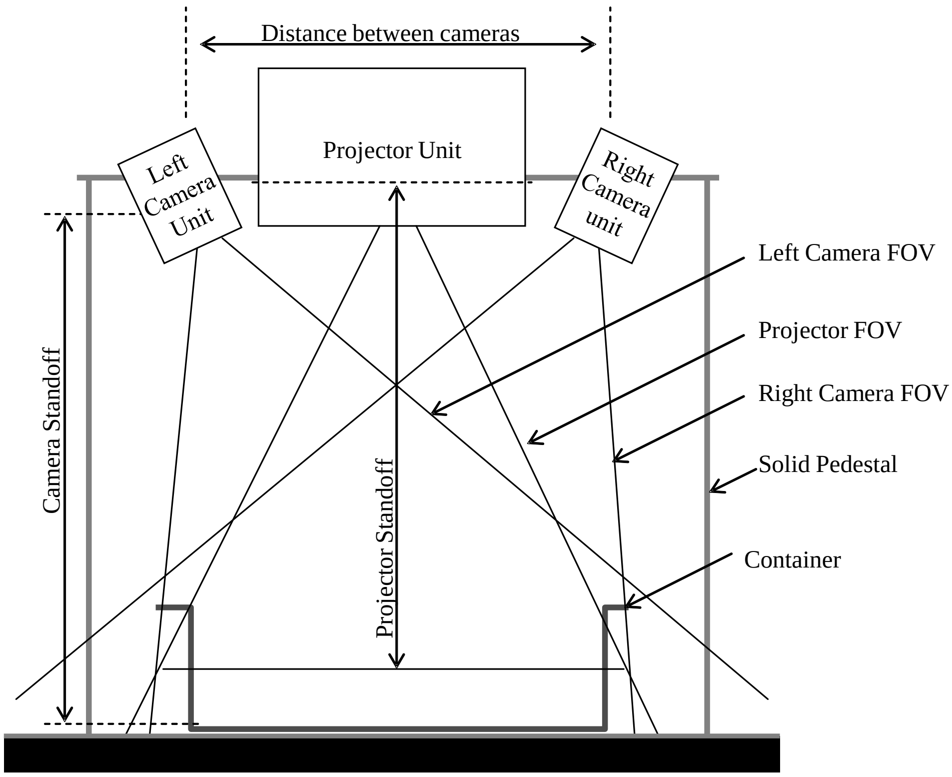
3D Area Sensor is composed of three units, two camera units and one projector unit. The projector unit projects stripe patterns very quickly and two camera units snap their images, and then 3D information in a wide area is calculated at once. In this document, one element of the acquired 3D information is referred to as “3D point”, and a whole set of the 3D information is referred to as “3D map”.

The camera units and the projector unit of 3D Area Sensor should be mounted on a solid pedestal. Each unit of 3D Area Sensor needs to be settled properly with reference to the target container so that 3D Area Sensor comes into its own.

> ⚠ **CAUTION**
> 3D Area Sensor cannot be mounted on a robot.

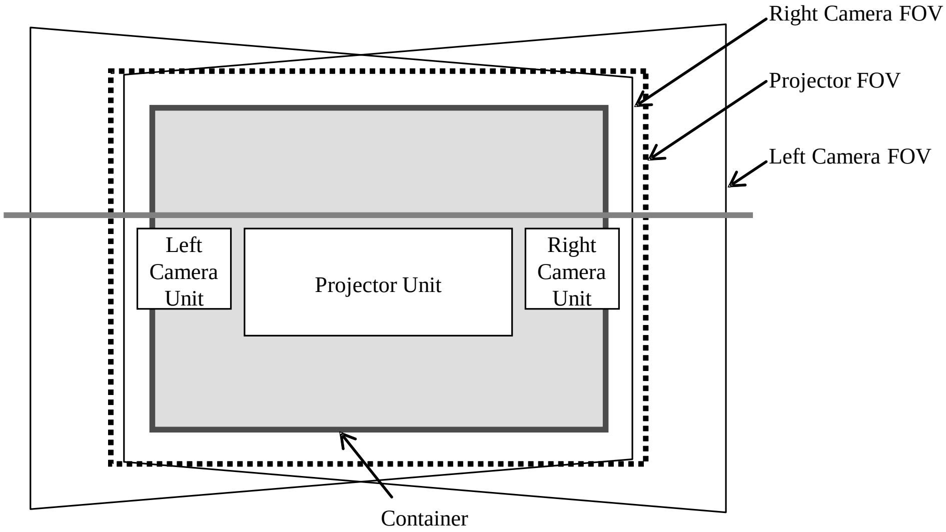
Standard Layout

The figure below shows the side view of the standard layout of 3D Area Sensor. Two camera units and a projector unit are mounted on the same upper beam.



Example of standard layout of the 3D Area Sensor (front)

And the figure below shows the overhead view of the standard layout.



Example of standard layout of the 3D Area Sensor (top)

As you can see in the figures above, two camera units and a projector unit should be located roughly on a line. When the camera standoff is constant, the longer the distance between cameras is, the more accurate the Z depth information you will get, but the more blind area, in other words area where one camera can see but another camera cannot, you will be likely to have. Therefore, in order to avoid workpieces being behind the sidewall of the container, camera units should be located above the container area.

The distance between cameras, the camera standoff and the Z accuracy of a 3D point have the following relationship.

$$\text{Z accuracy of 3D point} = \pm \frac{\text{Longer Side of Camera FOV} \times \text{Camera Standoff}}{\text{Number of Pixels of Longer Side of the Image} \times \text{Distance Between Cameras}}$$

> ⚠ **CAUTION**
> The calculated Z accuracy is a theoretical value. The actual value of Z accuracy is affected by focus of projected pattern, camera focus, ambient light, accuracy of each camera calibration, etc.

The following table shows typical examples of measurement area, layout, and Z accuracy of a 3D point when a 3D map is acquired for a flat surface.

Table 2.2.1 Typical measurement area, layout, Z accuracy

Measurement Area (Container Size)			Distance Between Cameras	Standoff		Z Accuracy	
Long Side	Short Side	Depth		3DA/1300	3DA/400	3DA/1300	3DA/400
1340 mm	1000 mm	1000 mm	1340 mm	2438 mm		±2.0 mm	
1200 mm	900 mm	896 mm	1200 mm	2200 mm			
1100 mm	825 mm	821 mm	1100 mm	2030 mm			
1000 mm	750 mm	746 mm	1000 mm	1860 mm			
900 mm	675 mm	672 mm	900 mm	1691 mm			
800 mm	600 mm	597 mm	800 mm	1521 mm			
700 mm	525 mm	522 mm	700 mm	1351 mm			
600 mm	450 mm	448 mm	600 mm	1181 mm			
500 mm	375 mm	373 mm	500 mm	1011 mm			
400 mm	300 mm	299 mm	400 mm		880 mm		±1.0 mm
300 mm	225 mm	224 mm	300 mm		675 mm		
200 mm	150 mm	149 mm	200 mm		470 mm		

> ⚠ **CAUTION**
> 1 Select a somewhat larger layout so that the container is seen in the field of view even if the container position is shifted a little.
> 2 Make sure that there is enough space between 3D Area Sensor and the container for the robot to move around.
> 3 The standoff of the two camera units should be the same.
> 4 Depending on the size of container and the required Z accuracy, there is a case that mounting the camera units and the projector unit at different heights is preferable.
> 5 Ex ante testing is recommended, because the ambient light, material of the workpiece and the setting of 3D Area Sensor can affect the actual measurement area and the actual Z accuracy.

[Camera Calibration]

Grid Pattern Calibration and Robot-Generated Grid Calibration are available to calibrate the camera units of 3D Area Sensor. Two camera units need to be calibrated in respect to the same application frame.

[Projection FOV and Standoff of Projector Unit]

The FOV of the projector unit should cover the upper opening of the container.

For normal density mode, 3D Area Sensor calculates 239 x 192 points in the projector FOV. So the spatial density of measured 3D points depends on the projector FOV size. Therefore, the larger the projector FOV is, the longer the spatial distance of measured 3D points is.

Illumination power of the projector unit is limited. Therefore, the larger the projector FOV is, the lower the intensity of the pattern projected over workpieces is. In order to get a good contrast between bright stripes and dark stripes of the projected patterns and eventually to acquire a 3D map as stably as possible, the projector FOV should be as narrow as possible. Especially it is important when the color of the workpiece is similar to that of the projector light and/or the reflection ratio of the workpiece surface is low.

Determine the projector FOV size based on the above advices first, and determine the projector standoff based on the selected projector FOV then.

[FOV of Cameras]

The FOV of the camera units should cover the upper opening of the container too. The camera FOV size affects the detection accuracy of the projected patterns. For example, if the camera FOV was too wide in comparison with the projector FOV, it would be difficult to detect the patterns accurately, because each pattern that appears on a camera image would not be clear enough. Settle the camera unit so that their FOV and the FOV of the projector unit are almost the same as possible. The optical axis of each camera unit should roughly pass through the center point of the upper opening of the container.

[Ambient Lights]

Ambient lights can affect the robustness of 3D Area Sensor. The stronger the ambient lights are, the less stable the measurement results of 3D Area Sensor can be. If the intensity of ambient lights is too strong, shade the container from the ambient lights.

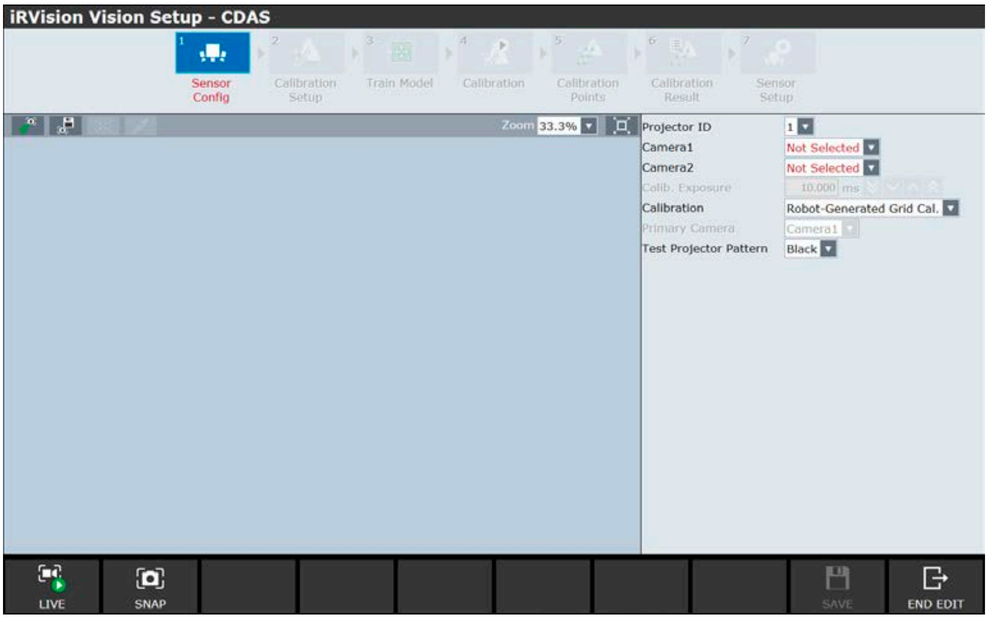
MEMO
Empirically 3D Area Sensor can acquire a 3D map stably when the intensity of ambient lights is less than a half of that of the projector.

⚠ CAUTION
The lighting interfered with the pattern projected by the projector should be turned off while 3D Area Sensor is acquiring.

2.2.2 3D Area Sensor Configuration

Perform a basic setup for the created camera data of the 3D area sensor, such as projector, camera and type of calibration to use.

If you select [Sensor Config] in the navigation area of the 3D area sensor data edit screen, the following screen appears in the setting items area.



The setting items area has the following parameters.

[Projector ID]

A list of projector units connected to the robot controller is displayed by clicking the drop-down box. Select [1] when only one projector unit is connected.

[Camera1]

A list of cameras connected to the robot controller is displayed by clicking the drop-down box. Select the camera to be used.

[Camera2]

A list of cameras connected to the robot controller is displayed by clicking the drop-down box. Select the camera to be used.

[Calib. Exposure]

Shutter speed of a camera when performing calibration. This value is shared with two camera units. The units are millisecond. Input a value or change the value with the buttons. The larger the value is, the brighter a snapped image is.

> **MEMO**
> The exposure time specified here is used for snapping an image displayed in this screen and performing camera calibration. Although the exposure time for executing the vision process is separately set with snap tools inserted in the vision process, the value specified here is the default value of the exposure time in snap tools.

[Calibration]

Select the camera calibration method from the drop-down box.

[Robot-Generated Grid Cal.]

Perform robot-generated grid calibration of both [Camera 1] and [Camera 2] at the same time. Robot-generated grid calibration is to perform camera calibration by using a target mounted on a robot end of arm tooling that moves on virtual grid patterns in the cameras' field of views. For details, refer to "Setup: 2.2.3 Robot-Generated Grid Calibration".

[Indivisual Robot-Generated Grid Cal.]

Perform robot-generated grid calibration on [Camera 1] and [Camera 2] individually. For details, refer to "Setup: 2.2.4 Individual Robot-Generated Grid Calibration".

MEMO

Basically, [Robot-Generated Grid Cal.] is recommended for [Calibration].
However, select [Individual Robot-Generated Grid Cal.] in the following cases..

(1) When you want to set different start positions of [Camera 1] and [Camera 2] individually
E.g. If a common start position is used for [Camera 1] and [Camera 2], a robot or its hand interfere with peripheral devices.

(2) When you want to set different targets used in calibration for [Camera 1] and [Camera 2] individually.
E.g. It is difficult to find the common target between [Camera 1] and [Camera 2].

[Grid Pattern Calibration]

Camera calibration is performed by using a calibration grid on which the predetermined pattern is drawn. For details, refer to "Setup: 2.2.5 Grid Pattern Calibration".

When selecting a calibration method, necessary steps are added in the navigation area in accordance with the selected method.

[Primary Camera]

From the drop-down box, select a camera used in cases where only one of the two camera units is used. By default, [Camera 1] is selected. For example, a camera selected as the primary camera is used in the following cases.

- Target setup for robot-generated grid calibration
- 2D vision processes where a 3D area sensor data is selected

⚠ CAUTION

When [Primary Camera] of the 3D area sensor data is changed, which changes the camera to be used, you need to re-set the 2D vision processes.

[Test Projector Pattern]

Select a projector pattern for adjusting the projector position from the drop-down box. Select other than [Black] and click [PRJ ON] to light the projector. In addition, the selected projector pattern is projected synchronicity with a camera snap, and you can check the projector pattern in the image.

[Black]

Light is off.
The projector light is off even if [PRJ ON] is clicked or a camera snapped.

[White]

Light is on with no pattern or flame.
The projector light is on when [PRJ ON] is clicked or a camera snaps.

[Stripe]

Stripe pattern.
The projector light is on when [PRJ ON] is clicked or a camera snaps.

[Frame]

Frame pattern.
The projector light is on when [PRJ ON] is clicked or a camera snaps.

2.2.3 Robot-Generated Grid Calibration

'Robot-Generated Grid Calibration' is a method to calibrate a camera by using a target mounted on an EOAT or a robot hand that moves on virtual grid patterns in the camera's field of view.

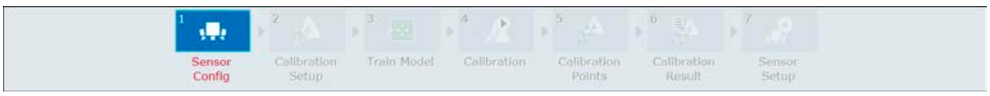
The procedure for the operation of robot-generated grid calibration in 3D area sensor is as follows.

1 Select and mount the target on the robot end of arm tooling.
2 Perform [Calibration Setup] on the camera data edit screen.
3 Perform [Train Model] on the camera data edit screen.
4 Select the camera data to calibrate in the *i*RVision utility menu.
5 Set up the target position in the *i*RVision utility menu.
6 Generate a calibration program in the *i*RVision utility menu.
7 Run the calibration program.
8 Check [Calibration Points] on the camera data edit screen (for each camera).
9 Check [Calibration Result] on the camera data edit screen (for each camera).

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. In this case, you may perform re-calibration of the camera by just going through the step 7.

MEMO
In robot-generated grid calibration, advance setup is performed on the camera data edit screen, and actual calibration work is performed from the *i*RVision utility menu.

If you select [Robot-Generated Grid Cal.] for [Calibration] in [Sensor Config], the following steps for the robot-generated grid calibration are displayed in the navigation area.



[Calibration Setup]

Perform setup necessary for robot-generated grid calibration.

[Train Model]

Teach the shape of a target as a model pattern.

[Calibration]

Perform camera calibration.
For actual operation, perform the followings on the iRVision utility menu of the teach pendant.

- Measuring target position
- Generating Calibration Program
- Executing Calibration Program

[Calibration Points]

Check the calibration points that have been found.

[Calibration Result]

Check the calculated calibration data.

2.2.3.1 Selecting the target

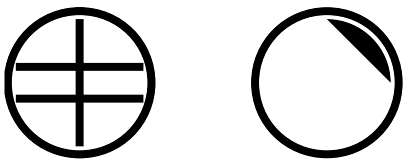
Select the target mark to be used for calibration.

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.

The following figure shows examples of appropriate/inappropriate geometries for the target.



Examples of appropriate target geometries

The rotation angle cannot be identified. The size cannot be identified.

Examples of inappropriate target geometries

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.

MEMO

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.

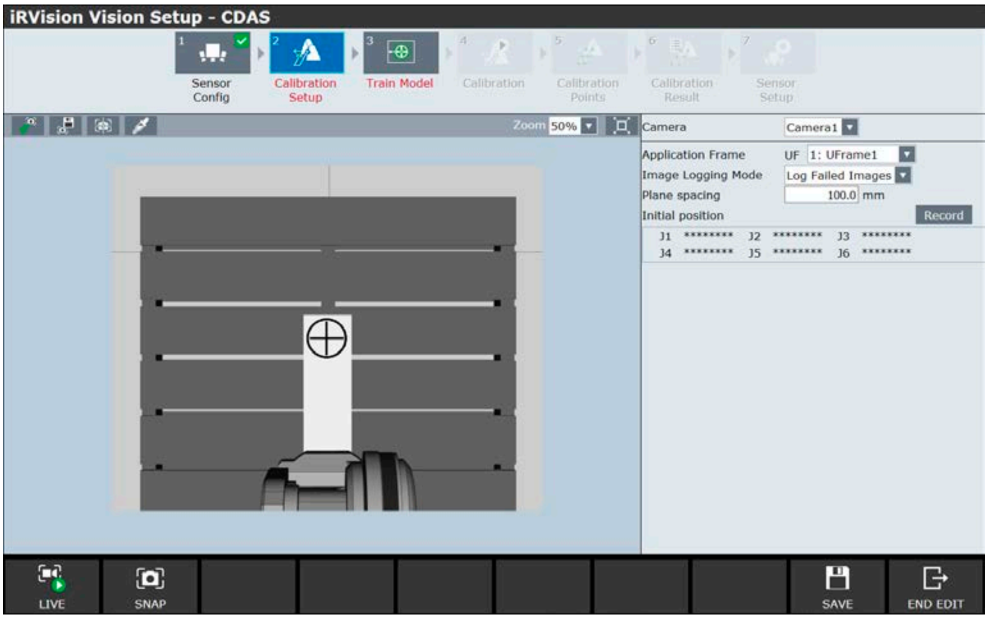
2.2.3.2 Calibration setup

Perform the necessary setup for robot-generated grid calibration on the calibration setup screen.

MEMO

[Calibration Setup] is performed on the camera data edit screen.

If you select [Calibration Setup] in the navigation area of the 3D area sensor data edit screen, the following screen appears.



The setting items area has the following parameters.

[Camera]

From the [Camera] drop-down box, select the camera to display in the camera view.

[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. The cameras on the left and the right need to be calibrated on the same application frame in the 3D area sensor.

When the camera is almost facing upward or downward, you don't have to change this setting, as you can use the world frame as the application frame. But when the camera is facing sideways, set a user frame so that its XY plane is almost perpendicular to the camera's optical axis and select it as the application frame.

> **MEMO**
> In the robot-generated grid calibration, it is premised that the camera's optical axis is generally horizontal with the Z axis of the application frame, and the robot is operated horizontally to the XY plane of the application frame when performing calibration.

> **⚠ 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.

[Image Logging Mode]

From the drop-down box, select whether to save images in the vision log. However, if you have the vision log disabled in the system variable, logged images are not saved.

[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.

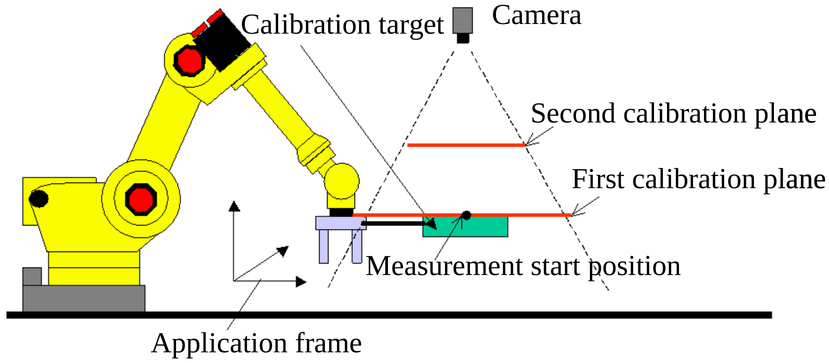
[Plane spacing]

Specify the spacing between calibration planes 1 and 2. About 10% of the space between the camera and 1st plane is suitable for the plane spacing.
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 click the RECORD button.



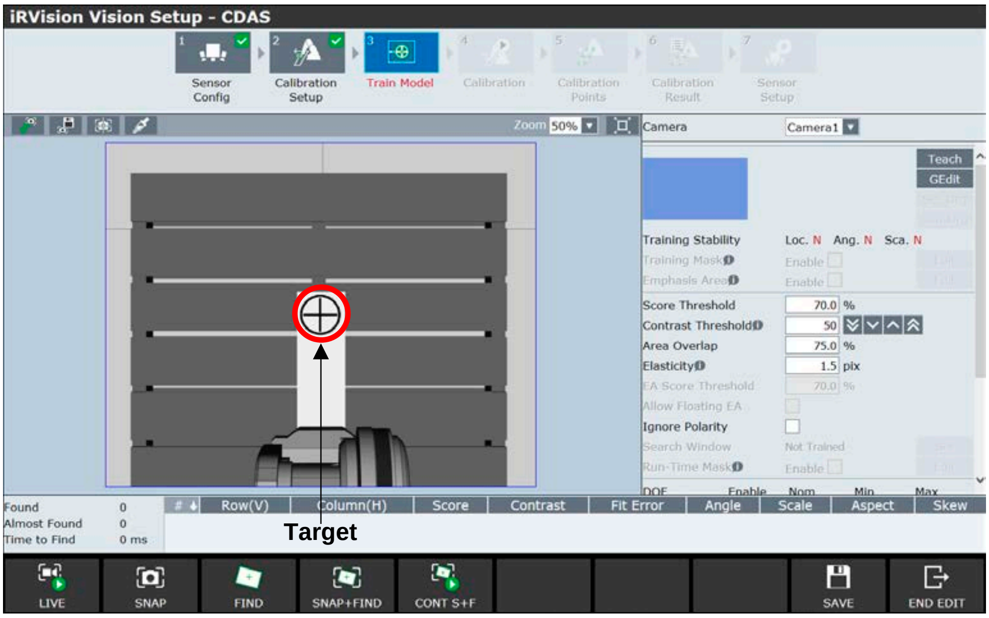
Initial position

2.2.3.3 Teaching model

Teach the model pattern of the workpiece you want to find.

> **MEMO**
> [Train Model] is performed on the camera data edit screen.

If you select [Train Model] in the navigation area of the 3D area sensor data edit screen, the following screen appears. Teach the shape of the target to use for calibration as a model pattern for the GPM locator tool. Teach a model after moving the robot to the recorded start position.



The parameters in the setting items area other than shown below and the steps to teach model patterns are same as the GPM locator tool. For details, refer to "Setup: 4.2 GPM LOCATOR TOOL"

[Camera]

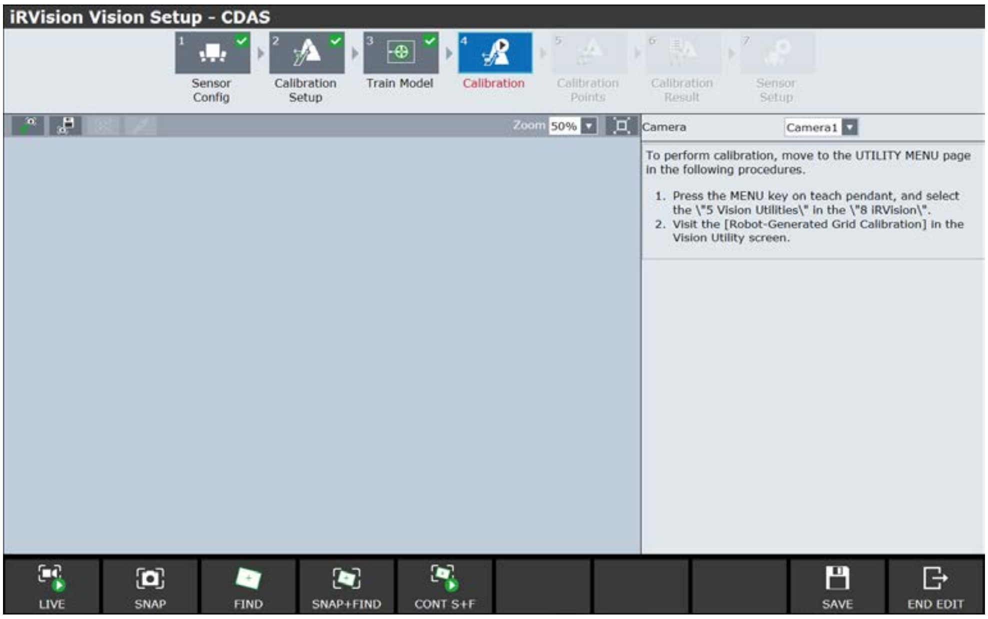
Select a camera from the drop-down box. The camera snaps an image to be used in model teaching.

MEMO
Set [Search Window] and [Run-Time Mask] for each camera. If you want to restrict the range to set the calibration points, make sure to select [Camera] you want to set before setting the window.

2.2.3.4 Calibrating camera

Perform camera calibration.
Calibrations of the two 3D area sensor camera units are performed at the same time in the following steps. Move from the 3D area sensor data edit screen of the PC to the *i*RVision utility menu of the teach pendant.

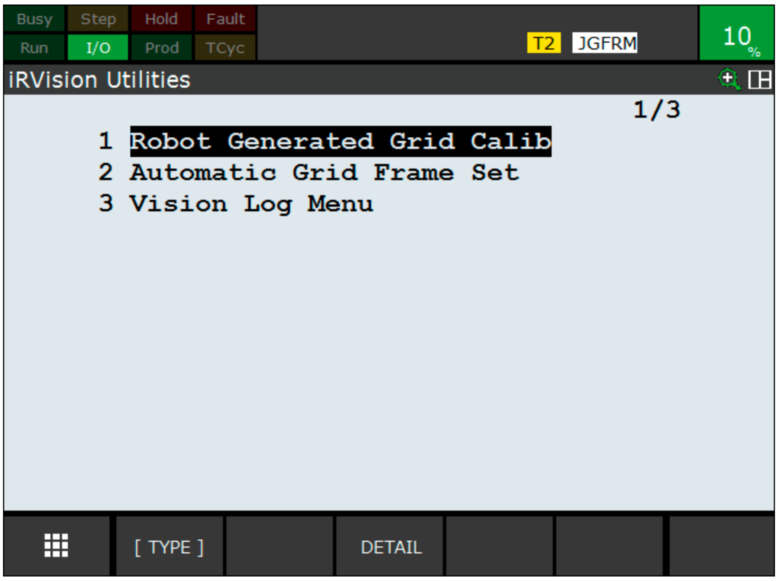
If you select [Calibration] in the navigation area of the 3D area sensor data edit screen, the following screen appears.



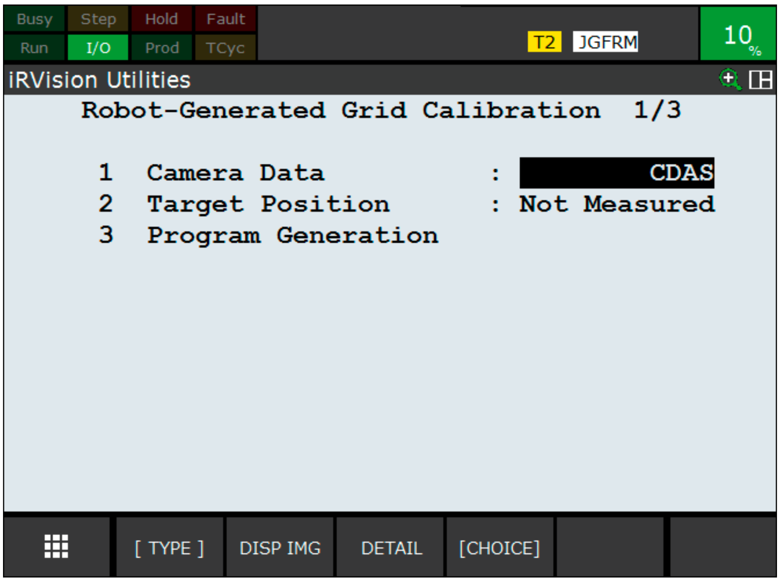
1 After clicking [SAVE] on the 3D area sensor data edit screen to save the changes, click [END EDIT] to close the 3D area sensor data edit screen.

⚠ CAUTION
The 3D area sensor data edit screen must be closed. Calibration cannot be performed on the utility menu if the 3D area sensor data edit screen remains open.

2 On the teach pendant, press the [MENU] key.
3 After selecting [iRVision] → place the cursor over [Vision Utilities] and press the [ENTER] key to display the [iRVision Utilities] screen.



4 Place the cursor over [Robot-Generated Grid Calib] and press the [ENTER] key.
The main screen for robot-generated grid calibration will appear.



MEMO
Robot-generated grid calibration main screen cannot be opened in more than one window at a time.

There are the following items on the robot-generated grid calibration main screen.

[Camera Data]

Select 3D area sensor data to calibrate.

1 Move the cursor over this line and press F4 [CHOICE].
A list of camera data will appear.
2 Place the cursor over the camera data name and press the [ENETER] key.
The selected camera data name will be displayed for [Camera Data].

Perform calibration of the selected camera and the calibration result will automatically be reflected to the other camera.

Furthermore, if you place the cursor over this line and press F3 [DETAIL], you can check the details of the selected 3D area sensor data. For details of the screen, refer to "Setup: 2.1.3.11 Camera Data Menu".

[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, [Measured] is displayed. Otherwise, [Not Measured] is displayed. For the steps to set the target position, refer to "Setup: 2.2.3.5 Setting Target Position".

Furthermore, if you place the cursor over this line and press F3 [POSITION], you can check the values of the target position. For details of the screen, refer to "Setup: 2.1.3.12 Target Position Menu".

[Program Generation]

Generate a calibration program to perform robot-generated grid calibration.
For program generation, refer to "Setup: 2.2.3.6 Generating Calibration Program".

Function Keys

The following function keys are displayed on the robot-generated grid calibration main screen as common functions.

Key number	Item Name	Function
F1	TYPE	Jumps to another *i*RVision menu screen.
F2	DISP IMG	Two screens will appear; robot-generated grid calibration main screen and [iRVision Runtime].

2.2.3.5 Setting target position

Measures the position of the target mounted on the robot end of arm tooling.

> **MEMO**
> Set the target position in the *i*RVision utility menu.

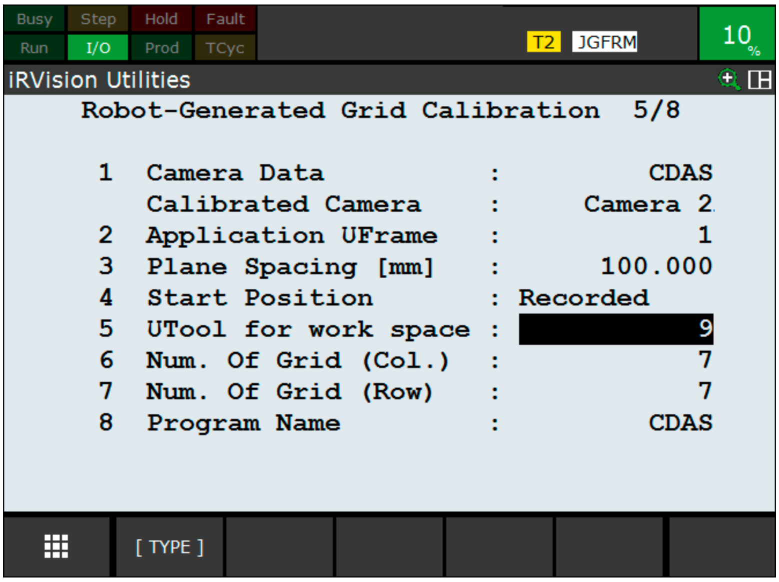
6-axis robots and 4-axis/5-axis robots vary in setting methods for the target position.

- For 6-axis robots, the position can be set automatically by measuring the target with a camera.
- For 4- and 5-axis robots, the target position cannot be measured. Calculate the coordinate values relative to the robot's wrist flange from the drawing, and set them manually.

[6-axis robot]

A 6-axis robot can measure the position of robot-mounted target mark by vision.

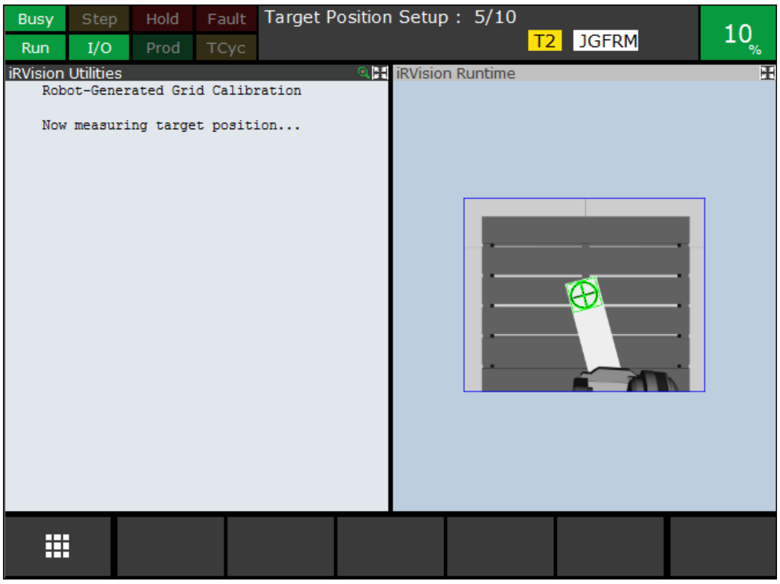
1 Go to the main screen for robot-generated grid calibration.
2 Place the cursor over [Camera Data] and after checking the camera data name, press F3 [DETAIL]. A detailed screen of camera data will appear.
3 Place the cursor over [UTool for work space], and enter the number of a tool frame whose values can be changed without causing any problem



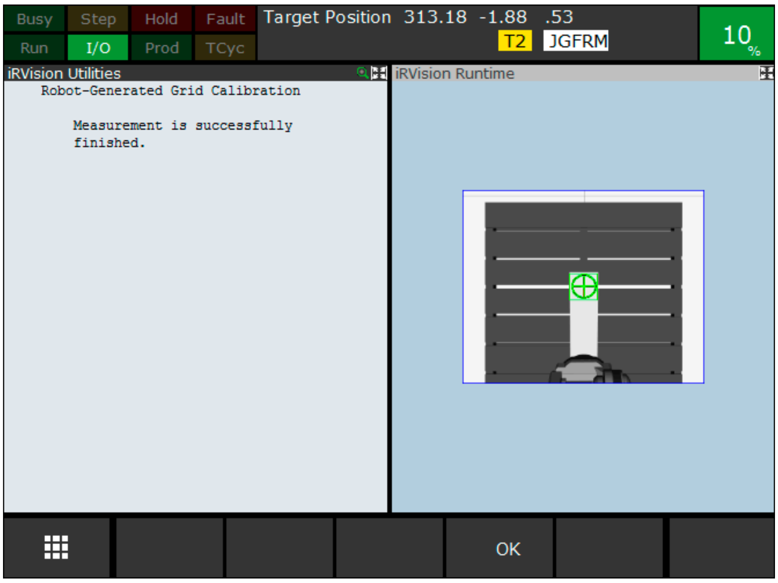
⚠ CAUTION

Robot-generated grid calibration uses one tool frame as a working frame for target position measurement and the creation of a program for the calibration. As measurement is performed by rewriting the values for the specified tool frame, specify the number of a tool frame which does not cause any problem even if its values are changed.

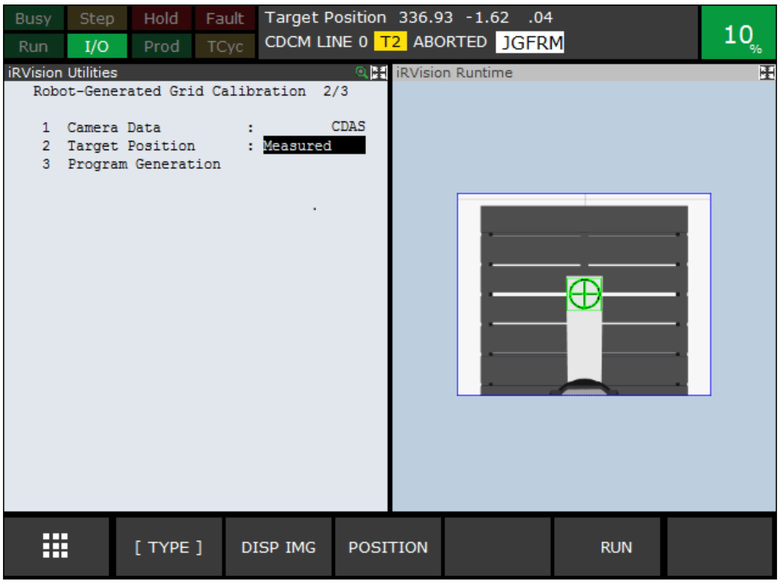
4 Press the [PREV] key.
The screen returns to the robot-generated grid calibration main screen.
5 Place the cursor on [2 Target Position].
6 Press F2 [DISP IMG] and display vision runtime.
7 Check the name of the camera data selected in [Camera Data].
8 Enable the teach pendant, and reset the alarm.
9 Press SHIFT + F5 [RUN] to start the measurement.
Keep holding down SHIFT while the measurement is in progress.



When the measurement is complete, the robot stops and the message [Measurement is successfully finished.] appears on the screen.



10 Press F4 [OK] to return to the main menu.
[Target Position] will be indicated as [Measured].



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 by pressing F2 [DISP IMG] on the teach pendant.

> ✎ **MEMO**
> 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 train the position of the target mark manually.

1 Calculate from the drawing the coordinate values of the position which corresponds to the model origin of the model pattern trained in camera data (Refer to "Setup: 2.1.3.3 Teaching Model), relative to the robot wrist flange.

2 Place the cursor on [2 Target Position], and press F3 [POSITION] to visit the target position menu.

3 Input X, Y and Z to the position of the target mark that relative to the robot mechanical interface frame (the robot wrist flange).
Input W, P and R to zero.

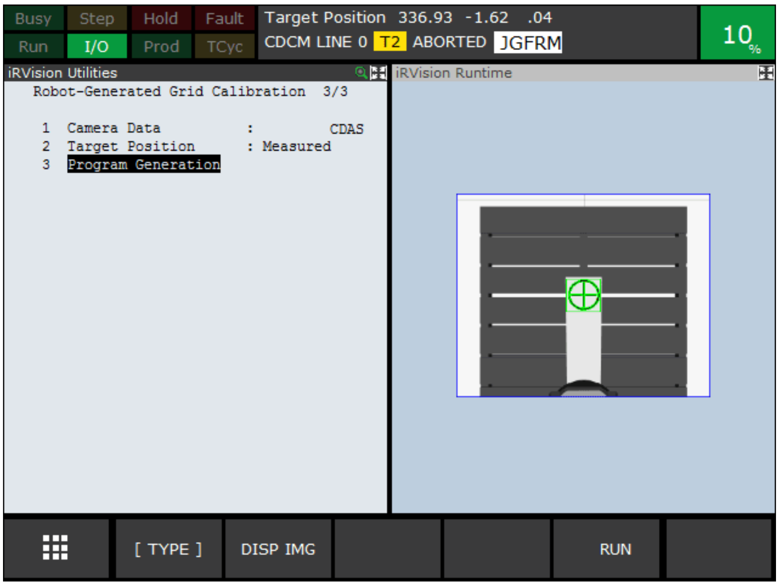
4 Press the [PREV] key to return to the main menu. [Target Position] will be indicated as [Measured].

> ⚠ **CAUTION**
> Make sure the target position corresponds to the model origin trained in section 2.2.3.3, "Teaching Model". If the positions are different, the camera cannot be calibrated properly.

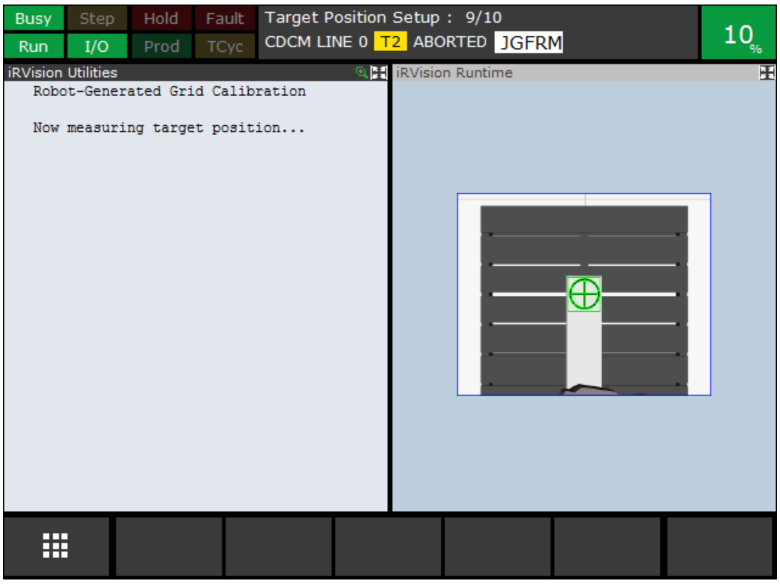
2.2.3.6 Generating calibration program

Measures the size of the camera's field of view, and generates a robot program for camera calibration.

> ✎ **MEMO**
> Generate a calibration program in the *i*RVision utility menu.



1 Go to the main screen for robot-generated grid calibration.
2 Check the name of the 3D area sensor data selected in [Camera Data].
3 Verify whether [2 Target Position] is Measured.
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.



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 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].

2

> ⚠ **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 Click [Train Model] in the navigation area.
3 Click the [Set] button in the search window.
4 Shrink the search window and omit the area that the interference occurred. Click [OK].
5 Click F10 [SAVE] to save the camera calibration.
6 Click F5 [END EDIT] to close the setup page.
7 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=1
  2:   UTOOL_NUM=9
  3:L P[1] 1000mm/sec FINE
  4:   VISION CAMERA_CALIB 'CAMERA1' REQUEST=1
  5:L P[1001] 1000mm/sec FINE
  6:   CALL IRVBKLSH(1)
  7:   VISION CAMERA_CALIB 'CAMERA1' REQUEST=1001
  8:L P[1002] 1000mm/sec FINE
  9:   CALL IRVBKLSH(1)
 10:   VISION CAMERA_CALIB 'CAMERA1' 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 'CAMERA1' REQUEST=2048
296:L P[2049] 1000mm/sec FINE
297:   CALL IRVBKLSH(1)
298:   VISION CAMERA_CALIB 'CAMERA1' REQUEST=2049
299:L P[2] 1000mm/sec FINE
300:   VISION CAMERA_CALIB 'CAMERA1' 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 'CAMERA1' REQUEST=1001
```

Each command in the program is briefly explained below.

```
4:    VISION CAMERA_CALIB 'CAMERA1' 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 'CAMERA1' 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 'CAMERA1' 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.

2.2.3.7 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.

> **MEMO**
> 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.

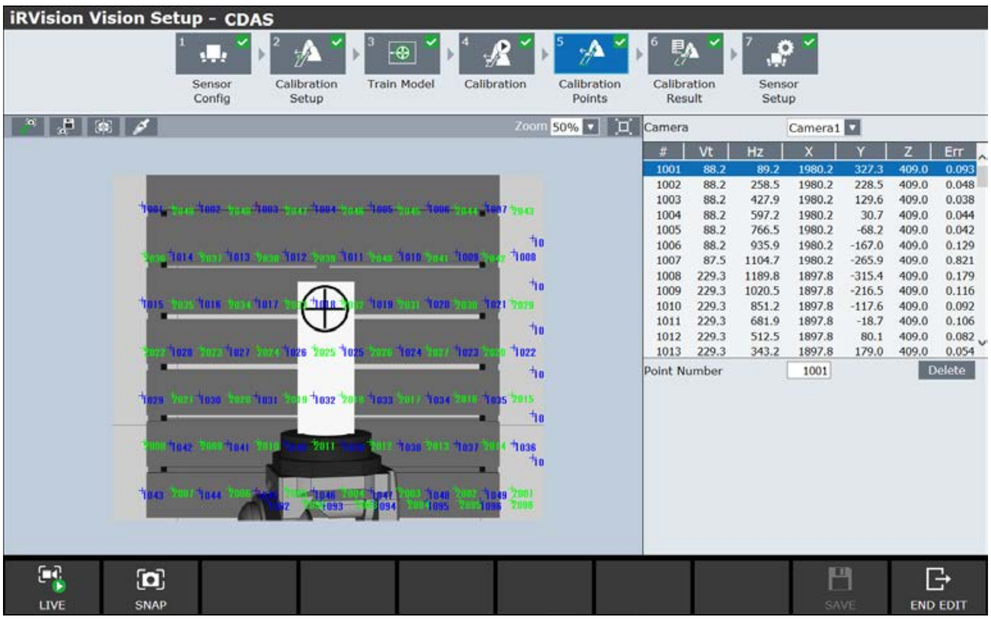
After executing the calibration program to the last, camera calibration is complete.

2.2.3.8 Checking calibration points

Check the calibration points found after performing the robot-generated grid calibration.

> **MEMO**
> Checking [Calibration Points] is performed on the 3D area sensor data edit screen.

If you select [Calibration Points] in the navigation area of the 3D area sensor data edit screen, the following screen 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.

The following calibration point information is displayed in the setting items area.

[Camera]

Select the camera whose calibration points you want to check from the drop-down box.

[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]

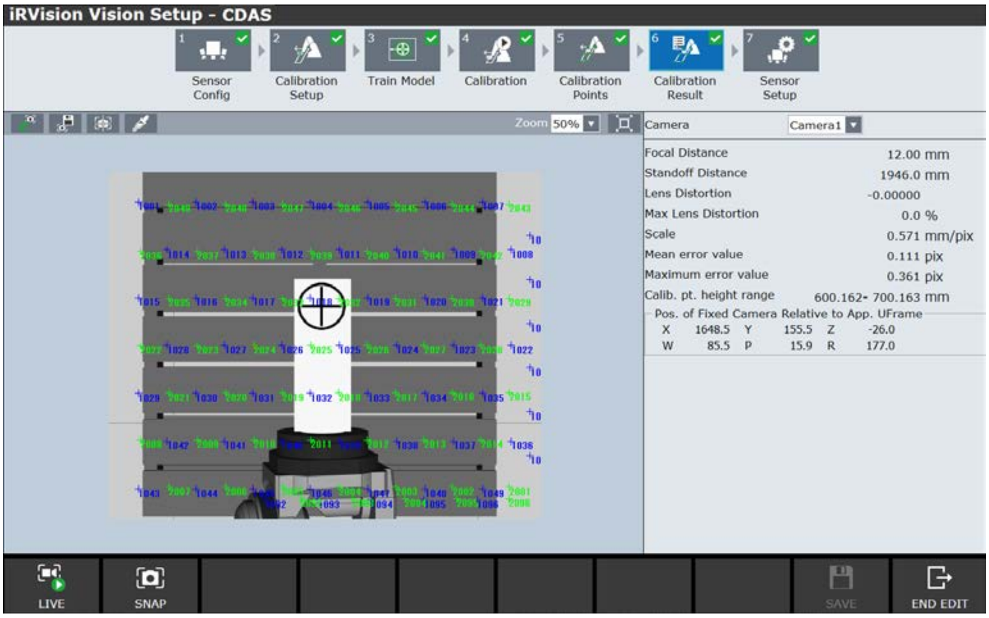
If a crosshair is displayed at a location where no calibration point is present, select that point by selecting it in the list or enter the index number of the point in the text box to the left of the [Delete] button, and then click the [Delete] button. The specified point is deleted from the list, and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

2.2.3.9 Checking calibration result

Check the calculated calibration data.

> **MEMO**
> Checking [Calibration Results] is performed on the camera data edit screen.

If you select [Calibration Result] on the 3D area sensor data edit screen, the following screen appears.



The following information of calculated calibration results is displayed in the setting items area.

[Camera]
Select the camera whose calibration results you want to check from the drop-down box.

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

[Standoff Distance]
The distance from the center of the length direction of the lens to the top surface of the grid pattern along the camera's optical axis.
Check that the value is appropriate for the standoff 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. Robot-generated grid calibration returns accurate coordinates by using this calculated lens distortion when accurately converting the image frame to the robot frame.

[Max Lens Distortion]
Expresses in pixels the size of the distortion at the location where the lens distortion is greatest.

[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.

[Maximum / Mean Error]
The average and maximum errors of all the calibration points shown in the [Calibration Points] table are displayed.

[Calib. pt. height range]
The range of Z height of the calibration points that have been found on the application frame.

[Pos. of Fixed Camera Relative to App. UFrame]

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

2.2.3.10 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.

2.2.4 Individual Robot-Generated Grid Calibration

Once you select [Individual Robot-Generated Grid Cal.] in [Calibration], the cameras on the left and the right in 3D area sensor will be calibrated individually based on their settings.

> **MEMO**
> Basically, [Robot-Generated Grid Cal.] is recommended for [Calibration]. However, select [Individual Robot-Generated Grid Cal.] in the following occasions.
> (1) When you want to set different start positions of [Camera 1] and [Camera 2] individually.
> E.g. If a common start position is used for [Camera 1] and [Camera 2], the robot or the hand interfere with the peripheral devices.
> (2) When you want to set different target to be used for calibration for [Camera 1] and [Camera 2].
> E.g. It is difficult to find the common target for [Camera 1] and [Camera 2].

Once you select [Individual Robot-Generated Grid Cal.] in [Calibration] of the camera Setup, buttons of the steps corresponding to the robot-generated grid calibration will appear in the navigation area. For steps and operation of robot-generated grid calibration, refer to "Setup: 2.2.3 Robot-Generated Grid Calibration."

For individual robot-generated grid calibration, the following setup will be performed individually for the cameras on the left and the right

- Recording Start Position
- Teaching a Model
- 'Setting Target Position', 'Generating Calibration Program', and 'Executing Calibration Program' on *i*RVision utility menu

'_1' or '_2' will be added to the end of the TP program name (camera data name) generated in individual robot-generated grid calibration.

2.2.5 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, refer to "Introduction: 2.6 CALIBRATION GRID".
For the setup procedures of a grid frame in 3D area sensor, refer to "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL".

If you select [Grid Pattern Calibration] for [Calibration] in [Sensor Config], the following steps for grid pattern calibration are displayed in the navigation area.

[Calibration]

Finds the grid pattern and perform camera calibration.

[Calibration Points]

Check the calibration points that have been found.

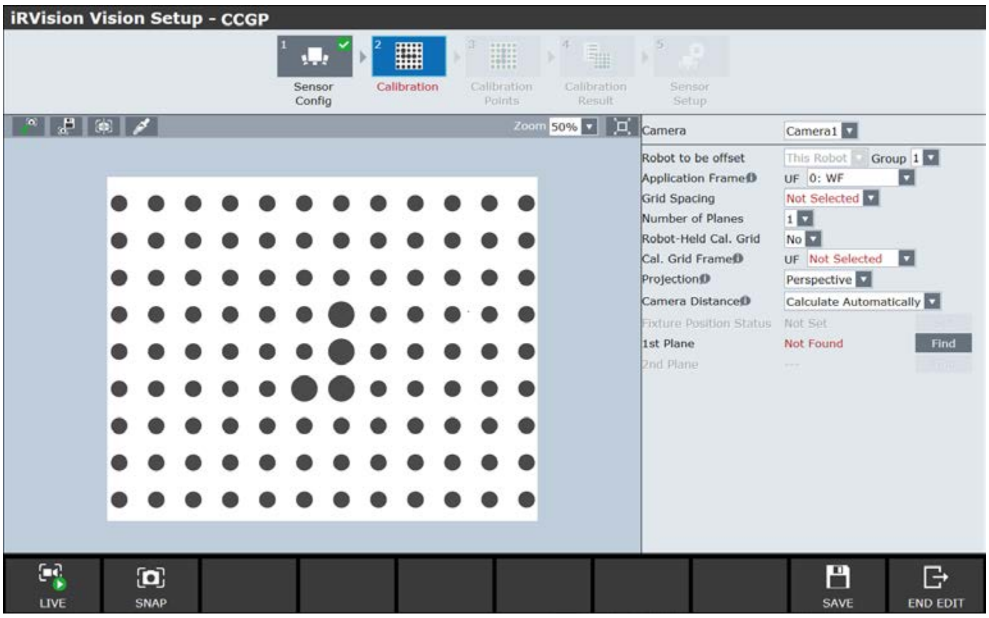
[Calibration Result]

Check the calculated calibration data.

2.2.5.1 Calibrating Camera

Calibrate the camera.

If you select [Calibration] in the navigation area of the 3D area sensor data edit screen, the following screen appears.



The parameters in the setting items area other than shown below and the steps to teach model patterns are same as 2D camera grid pattern calibration. For details, refer to "Setup: 2.1.2.2 Calibration".

[Camera]

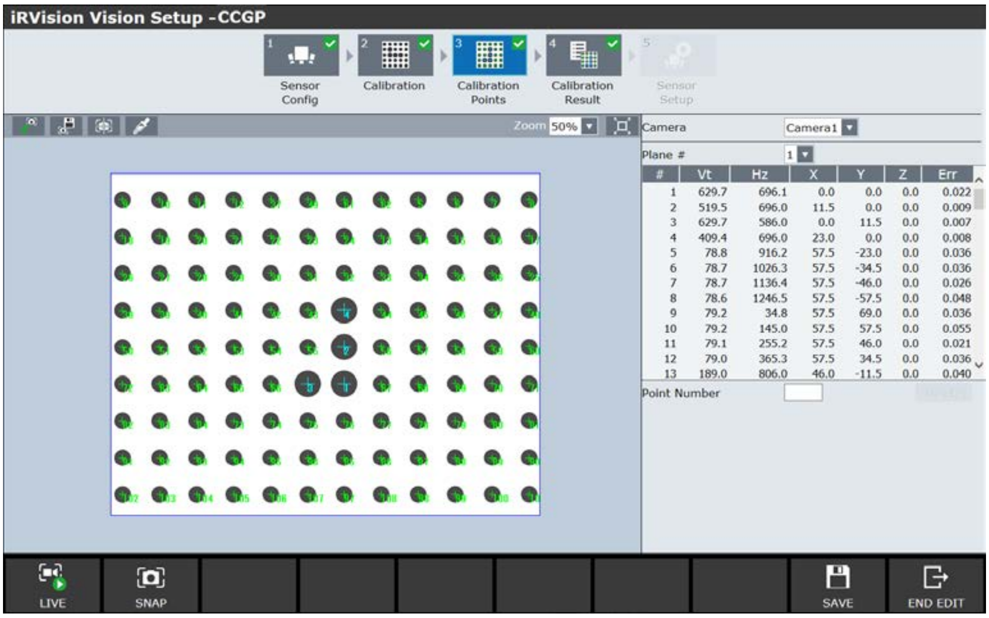
Select the camera which is the target of calibration setup from the drop-down box.

> ⚠ **CAUTION**
> In 3D area sensor data, grid pattern calibration needs to be performed on both cameras after selecting each camera from [Camera].

2.2.5.2 Checking calibration points

Check the calibration points that have been found in the grid pattern calibration.

If you select [Calibration Points] in the navigation area, the following screen 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.

The parameters in the setting items area other than shown below and the calibration point information are same as 2D camera grid pattern calibration. For details, refer to "Setup: 2.1.2.3 Checking Calibration Points".

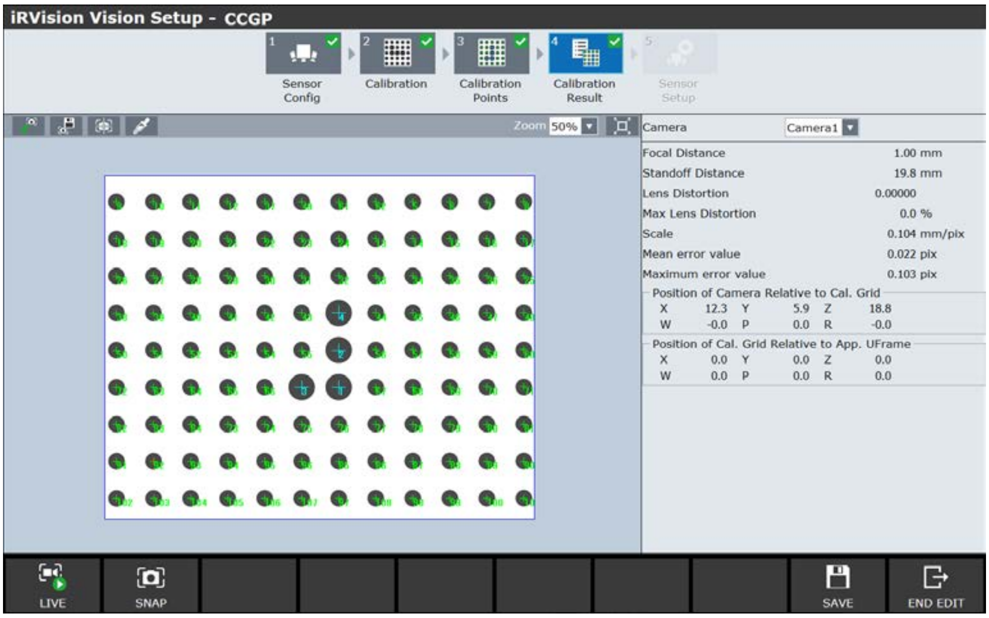
[Camera]

Select the camera whose calibration points you want to check from the drop-down box.

2.2.5.3 Checking calibration result

Check the calculated calibration data.

If you select [Calibration Result] in the navigation area of the 3D area sensor data edit screen, the following screen appears.



The information of setting items area other than shown below is same as 2D camera grid pattern calibration. For details, refer to "Setup: 2.1.2.4 Checking Calibration Result".

[Camera]

Select the camera whose calibration points you want to check from the drop-down box.

2.2.5.4 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.

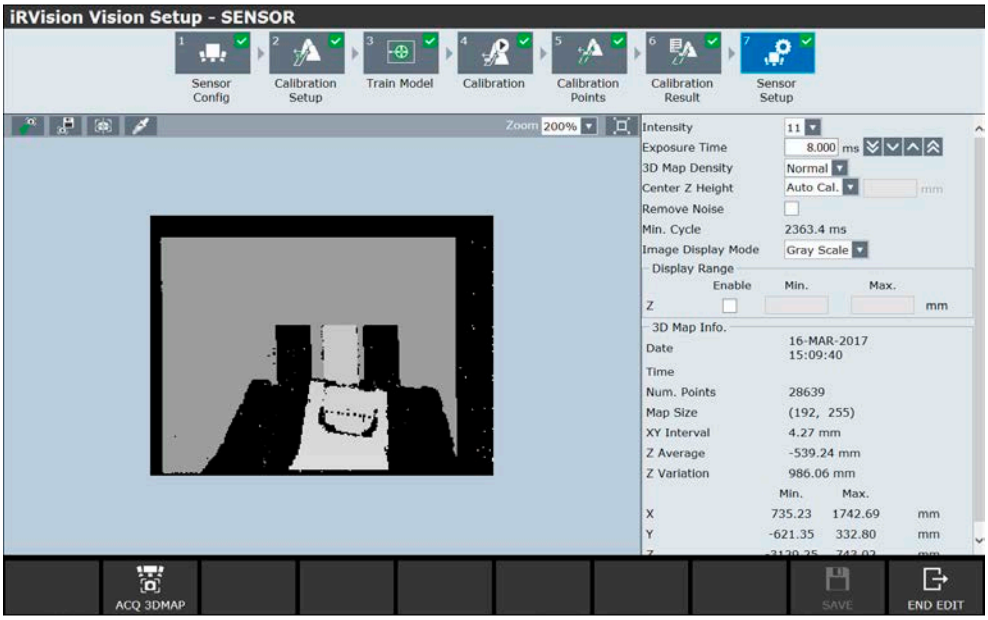
Performing automatic re-calibration requires that a robot program for automatic re-calibration be taught in advance.

> ⚠ **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.

2.2.6 3D Area Sensor Setup

Set and adjust the 3D map acquisition conditions for the 3D area sensor data after the calibration is completed. For details of the setup procedures for 3D area sensor, refer to "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL".

If you select [Sensor Setup] in the navigation area of the 3D area sensor data edit screen, the following screen appears in the setting items area.



The setting items area has the following parameters.

[Intensity]

Select the intensity of the projector light that is used when a 3D map is acquired. By default, [11] is selected. The higher the number is, the brighter the projected pattern is, but the larger the Min. Cycle (mentioned later) is.

[Exposure Time]

Specify the camera exposure time for 3D map acquisition. This value is shared with two camera units. The default value is 8ms. The longer the exposure time is, the longer the Min. Cycle is.

> **MEMO**
> When the ambient light is a fluorescent light or a mercury lamp, the brightness of the ambient light changes periodically. In such a case, set the exposure time to a multiple of the blinking period of the ambient light. This will make the 3D map acquisition stable.

[3D Map Density]

Select the density mode of 3D map. Only available modes with the selected projector unit are displayed as options.

[Normal]

It measures 239 x 192 3D points in the FOV of the 3D Area Sensor.

[Coarse]

It measures 119 x 96 3D points in the FOV of the 3D Area Sensor. Acquisition time is faster than that of the Normal mode.

[Fine]

It measures 479 x 384 3D points in the FOV of the 3D Area Sensor. Acquisition time is slower than that of the Normal mode.

[Center Z Height]

Set the middle height of the container in the application frame.

[Auto Cal.]

Normally, select [Auto Cal.].

[Override]

Enter the height of the center of the container on the application frame into the text box.

[Remove Noise]

Check this checkbox when you want to remove 3D points with a large error.

> **MEMO**
> Time to acquire a 3D map increases about 200~300 ms when this check box is checked.

[Min. Cycle]

The minimum interval time between successive 3D map acquisitions is displayed. The Min. Cycle depends on the selected exposure time and the selected projector intensity. The higher the projector intensity is or the longer the exposure time is, the longer the Min. Cycle is.

> ⚠ **CAUTION**
> When you try to acquire a next 3D map before the minimum interval time has passed after the last 3D map acquisition, 3D Area Sensor will automatically waits until the minimum interval time has passed and then start to acquire a 3D map.

[Image Display Mode]

Select the display mode of 3D map.

[Gray Scale]

The acquired 3D map is displayed as a grayscale image. Image pixel brightness indicates the Z height. The higher the Z height is, the brighter the pixel is. Where 3D points could not be measured is displayed in black.

[Color]

The acquired 3D map is displayed as a color image. Image pixel color indicates the Z height. 3D points with larger Z height are displayed in red, and 3D points with smaller Z height are displayed in blue. Where the 3D point could not be measured is displayed in black.

[Display Range]

Set the 3D map depth display range displayed in the image view area. Once the value is set, 3D map is displayed in the value corresponding to the range.

[Enable]

If checked, display range setup is enabled and allow [Min.] and [Max.] value input.

[Min]

Enter the minimum value of the depth displayed in the 3D map in the text box.

[Max]

Enter the maximum value of the depth displayed in the 3D map in the text box.

[3D Map Info.]

Information about the last 3D map is displayed.

[Date]
Date when the last 3D map is acquired

[Time]
Time to acquire the last 3D map

[Num. Points]
Number of 3D points included in the last 3D map

[Map Size]
Grid size of the 3D map

[XY Interval]
Average interval between adjacent 3D points in XY direction

[Z Average]
Average Z height of 3D points included in the last 3D map

[Z Variation]
Z height variation of 3D points included in the last 3D map

[Min],[Max]
Minimum and maximum value of X, Y and Z value of 3D points included in the last 3D map

[Function Keys]

If you select [Sensor Setup] in the navigation area of the 3D area sensor data edit screen, the following function key appears.

Icons	NAME	Function
	ACQ 3DMAP	Check if 3D map can be acquired.

2.2.7 Setup Procedures

3D Area Sensor is setup in the following procedures.

- Preparation before Setup
- User Frame Setup
- Creating a 3D Area Sensor Data
- Camera Calibration
- Setup Conditions of 3D Map Acquisition

2.2.7.1 Preparation before setup

1. Determine the projector standoff so that the projector FOV covers the upper opening of the container and the projected patterns are in focus from the top to the bottom of the container.
2. Determine the camera standoff and the distance between cameras based on the length of a longer side of the container and the required Z accuracy.
3. Prepare a solid pedestal based on the determined projector standoff, camera standoff and the distance between cameras.

2

MEMO
For details of layout adjustment and focus adjustment, refer to the description of 3D area sensor in "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL".

2.2.7.2 User frame setup

1. Setup the user frame to represent 3D points.
   Measured 3D points in a 3D map are represented in respective to the application frame. Z axis of the application frame needs to be perpendicular to the floor of the container, and its +Z direction needs to be toward the sensor.
2. Set the user frame that has been set as [Application Frame] in [Calibration Setup] of 3D area sensor data.

MEMO
For details of the setup procedures for user frame, refer to the description of frame setting in "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL".

2.2.7.3 Creating a 3D area sensor data

1. On the vision data list screen, click [CREATE] to create 3D area sensor data.
2. On the vision data list screen, after selecting the created 3D area sensor → click [EDIT] to display the 3D area sensor data edit screen.
3. Click [Sensor Config] in the navigation area to set the following parameters.
   - Select [1] for [Projector ID].
   - Select cameras connected to the robot controller for [Camera 1] and [Camera 2].
   - Select the type of camera calibration in [Calibration]. Here, select [Robot-Generated Grid Cal.].
4. Click [SNAP] to check if the image appears.

2.2.7.4 Camera calibration

Take an example of when [Robot-Generated Grid Cal.] is selected in [Calibration] on the 3D area sensor data edit screen.

1. 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.
2. Click [Calibration Setup] in the navigation area of the 3D area sensor data edit screen to set the following parameters.
   - 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.
   - Enter the spacing between calibration planes 1 and 2 in [Plane spacing].
3. After jogging the robot with the target attached so that the target can be snapped in the center of the camera field of view, click the [Record] button in [Initial position] to set the current position of the robot as the start position.
4. Click [Train Model] in the navigation area of the 3D area sensor data edit screen to teach the shape of the target as a model.
5. Click [Calibration] in the navigation area of the 3D area sensor edit screen, and select [SAVE] → click [END EDIT].
6. Perform calibration in the *i*RVision utility menu of the teach pendant.
   Execute the following operation in the *i*RVision utility menu.

- Setting Target
- Generating Calibration Program
- Executing Calibration Program

7 Click [Calibration Points] in the navigation area of the 3D area sensor data edit screen to check the calibration points. If there are any found points that have been found by mistake, delete the irrelevant found points.

8 Click [Calibration Result] in the navigation area of the 3D area sensor data edit screen to check the following calibration results.

- If [Focal Distance] is correct
- If [Pos. of Fixed Camera Relative to App. UFrame] is correct

2.2.7.5 Setup conditions of 3D map acquisition

1 Click [Sensor Setup] in the navigation area of the 3D area sensor data edit screen to set the following parameters.

- Adjust [Intensity] and [Exposure Time].
- Select [Auto Cal.] in [Center Z Height].
- Set the X and Y range accordingly.

2 Click F3 ACQ_3DMAP and confirm that a 3D map can be acquired properly.

3 Set [Image Display Mode] to [Color], and confirm that lower 3D points are displayed in blue.

4 Check the [Remove Noise] checkbox when the acquired 3D map is noisy.

2.2.8 Supplementary Explanation

Supplementary explanation about 3D Area Sensor shows below.

[Exchange of Camera Unit]

When you exchange a camera unit, you need to recalibrate the camera unit. After the camera calibration, confirm accuracy of measured 3D map.

[Exchange of Projector Unit]

When you exchange the projector unit, you may need to adjust the projector intensity. You don’t have to recalibrate the camera units.

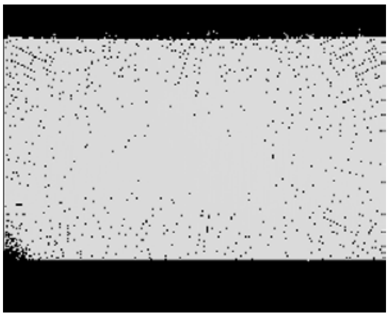
[Affect of Shadow]

3D map can be acquired even when a robot, a solid pedestal or equipment casts a shadow on the container, as long as the patterns are projected over workpieces in the container. However if the robot moves and the shadow of the robot moves during a 3D map acquisition, 3D points cannot be obtained in the area where the shadow of the robot has swept. So when you want to move the robot during a 3D map acquisition, be careful about the shadow of the robot. Blocking ambient lightings that make the shadow is also effective.

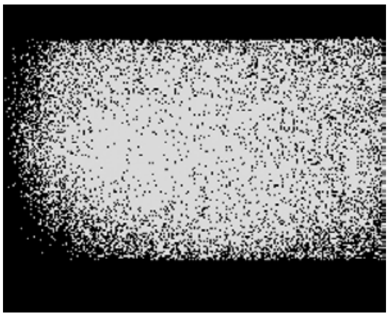
[Projector Intensity]

You can check whether the projector intensity is proper or not by acquiring a 3D map with placing a flat plane in the FOV of 3D Area Sensor.

When the projector intensity is proper, you will be able to get a 3D map as shown below. The density of 3D points is generally uniform. FYI: The black points are where 3D point could not be measured.

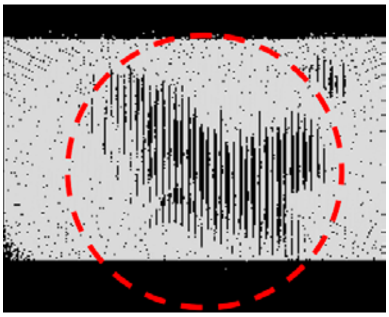


When the projector intensity is too low, 3D points in a 3D map is something like dotted, because the cameras cannot detect patterns. The following is an example of 3D map acquired with low projector intensity. As you can see, the surround area of the 3D map is like pepper and salt.



When the above 3D map is acquired, try to set the projector intensity higher.

When the projector intensity is too high, 3D points of a 3D map are linearly defective, because the snapped images are fogged by halation. The following is an example of 3D map acquired with high projector intensity. As you can see, 3D points are linearly lost at the center of the 3D map.



When the above 3D map is acquired, try to set the projector intensity lower.

3 VISION PROCESSES

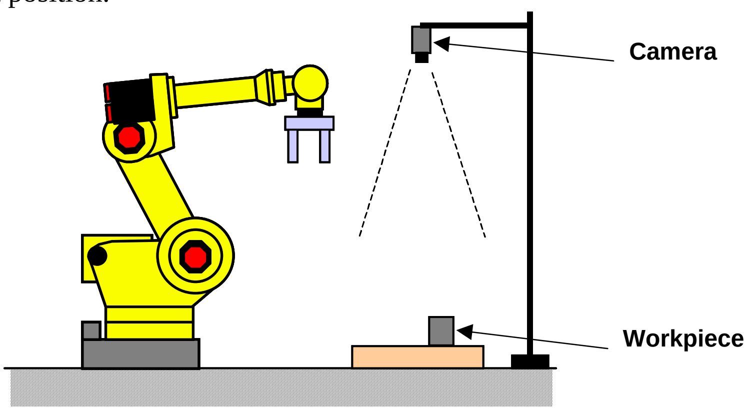
This chapter explains how to set up vision processes.

This chapter explains how to create, to train, to perform a test (find), and to set reference position of the following vision process.

- 2-D Single-View Vision Process
- 2-D Multi-View Vision Process
- Depalletizing Vision Process
- Gaze Line Offset Vision Process
- 2D Calibration-free Vision Process
- 3-D Tri-View Vision Process
- Floating Frame Vision Process
- Single View Inspection Vision Process
- Single-View Visual Tracking
- Reader Vision Process
- 3D Area Sensor Vision Process

3.1 2D SINGLE VIEW VISION PROCESS

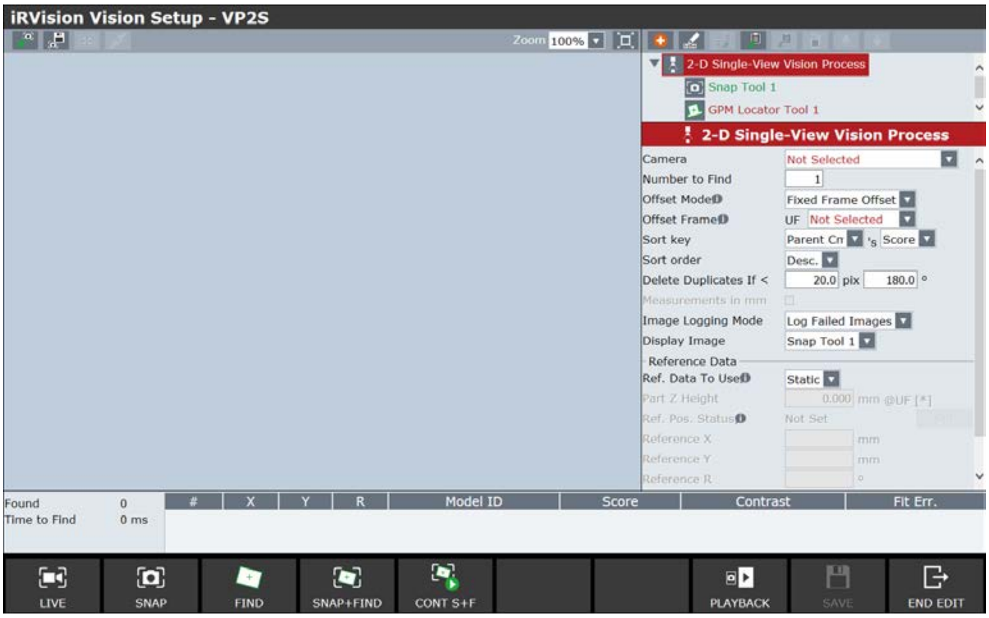
This is a vision process that detects the two-dimensional position of the workpiece with a single camera, and offsets the robot position.



2-D Single-View Vision Process

3.1.1 Setting up a Vision Process

If you select the vision process [2-D Single-View Vision Process] on the vision data list screen and click [EDIT], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Number to Find]

Enter the maximum number of workpieces to find per measurement in the text box. The specifiable range is 1 to 100.

[Offset Mode]

Select the robot position offset mode from the drop-down box.

[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.

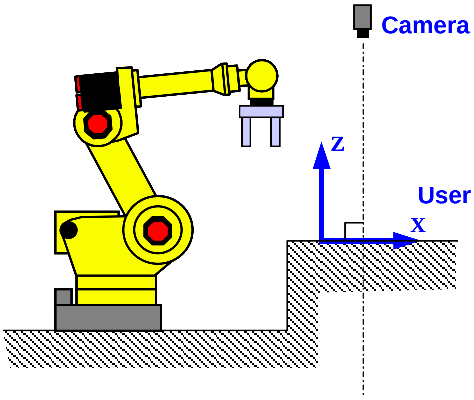
[Robot Holding Part]

This is displayed when [Tool Offset] is selected for [Offset Mode]. Select the controller name and the motion group number of the robot holding the workpiece from the drop-down box.

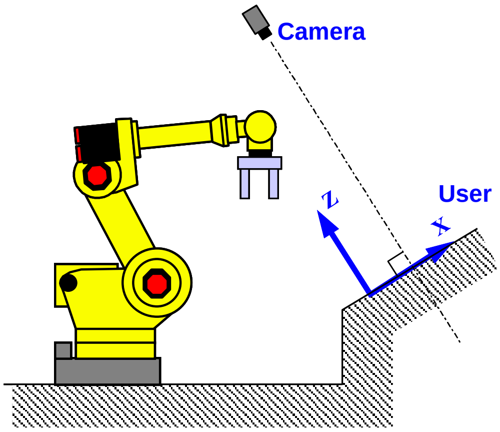
[Offset Frame]

A 2D vision process measures displacement of a workpiece on a plane. Select a frame to determine the plane from the drop-down box. The plane is defined as a plane parallel to the XY plane of 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.



2D offset on a horizontal plane



2D offset on an inclined plane

[Sort key]

Found results will be sorted when multiple workpieces are found. On this item, select a parameter to use as the sort key from the drop-down box.

[Sort order]

Found results will be sorted with the selected sort key. On this item, select the sort order used in the sorting from the drop-down box.

For details of [Sort key] and [Sort order], refer to "Setup: 1.8.14 Sorting".

[Delete Duplicates If <]

As a type of false detection, the same workpiece may be detected more than once. In such cases, the duplicated found results can be deleted, leaving only the one with the highest score. Specify the threshold with distance and angle on the image and the vision process consider found results are duplicated if they are closer than it.
Enter the thresholds for the distance and the angle difference between found results in the text boxes. If there are multiple found results within the thresholds, the results are assumed to be the same workpiece and only the one with the highest score remains.

[Measurements in mm]

If this is checked, child 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.

The following measurement values will be converted to millimeters:

BLOB LOCATOR TOOL
    Area, perimeter, semi-minor, semi-major
EDGE PAIR LOCATOR TOOL
    Length
POSITION CALCULATION TOOL
    Length such as distance
STATISTICS CALCULATION TOOL
    Interval

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process is executed. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**
>
> 1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
>
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

[Reference Data]

The reference data is used to calculate offset data from the found result.

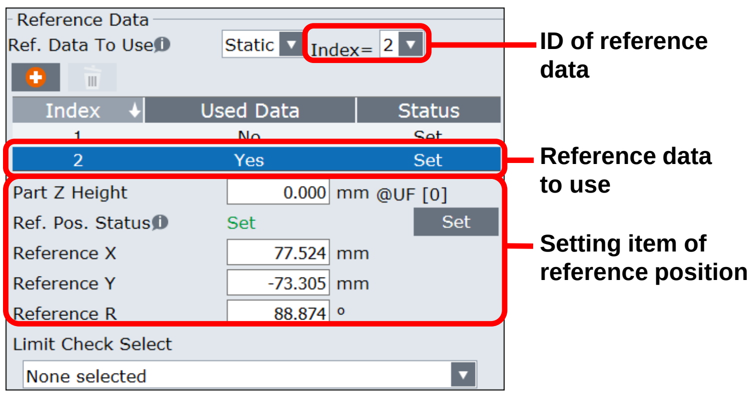
A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used. However, for example, if there are two types of workpiece, each having a different height, the vision process uses two sets of reference data because it needs to set a different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

[Ref. Data To Use]

Select how to determine the reference data to use from the drop-down box.

[Static]

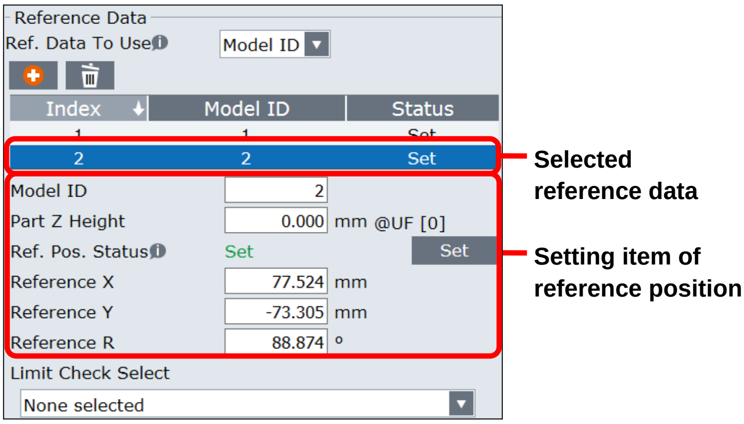
The same reference data is used to calculate the offset data.
When the vision process has multiple reference data, the following table is displayed. Select [Index] of the reference data to use from the drop-down box.



MEMO
When [Static] is selected and the vision process has only a single reference data, the reference data table is not displayed.

[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. Selecting a row in the reference data table shows the values set in the selected reference data.



Adding and setting reference data

The procedure to add and set reference data is as follows.

1 Click the button.
Reference data is added to the table and new Index is assigned.
2 Set the reference position. For details, refer to "Setup: 3.1.3 Setting the Reference Position".
When [Static] is selected, the reference position of the reference data selected in [Index] is to be set.
When [Model ID] is selected, the reference position of the reference data selected in the table is to be set.
3 If reference position setting is performed, [Status] of the reference data table will change to [Set].

Deleting reference data

The procedure to delete reference data is as follows.

1 Select the reference data to delete in the reference data table.
2 Click the button.
A deletion confirmation message will be displayed.
3 If the [OK] button is clicked, the reference data selected in step 1 is deleted.
If the [Cancel] button is clicked, delete is canceled.

MEMO
The reference data in use cannot be deleted when [Static] is selected.

[Model ID]

This is displayed when [Model ID] is selected for [Ref. Data To Use]. Model ID is the number assigned to the workpiece found.

[Part Z Height]

Enter the height of the workpiece to be detected in this text box, with respect to the frame specified in [Offset Frame].

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

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.

[Reference X], [Reference Y], [Reference R]

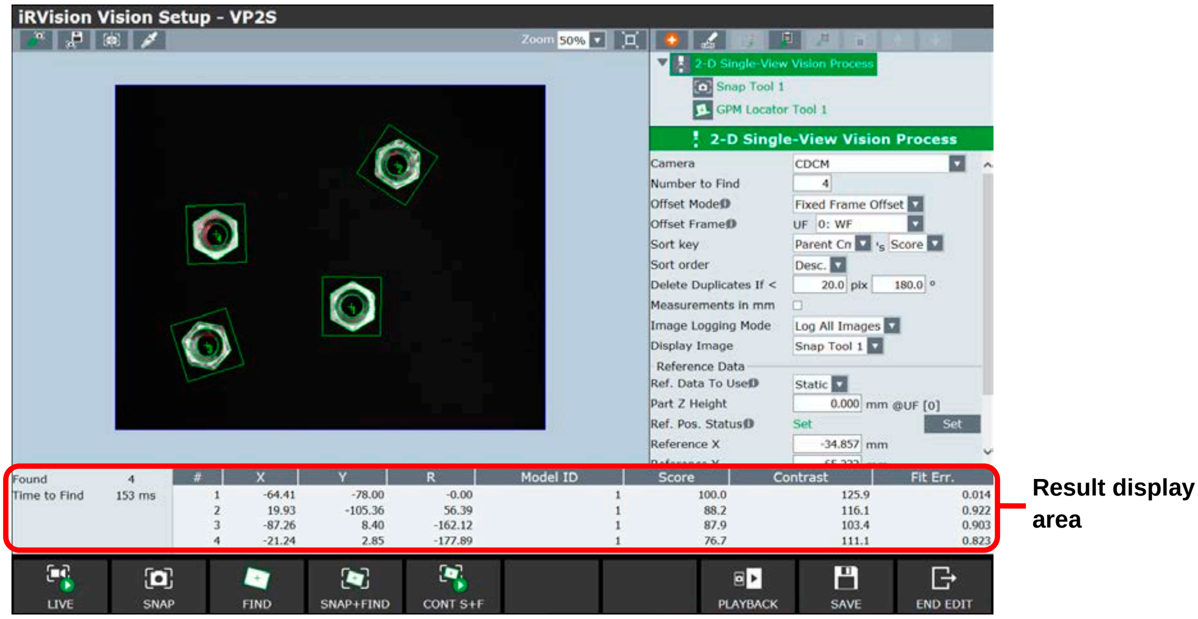
The coordinate values of the set reference position are displayed.
The values are in respect to the specified [Offset Frame].

[Limit Check Select]

From the drop-down box, select 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, refer to "Setup: 5.2 OFFSET LIMIT".

3.1.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the vision process took is displayed in milliseconds.

The following values are displayed in the result display area list view.

[X], [Y]
The coordinate values of the model origin of the found workpiece are with respect to [Offset Frame]. The units are millimeters.

[R]
The rotation angle of the found workpiece around the Z axis. The unit is degree.

[Model ID]
Model ID of the found workpiece.

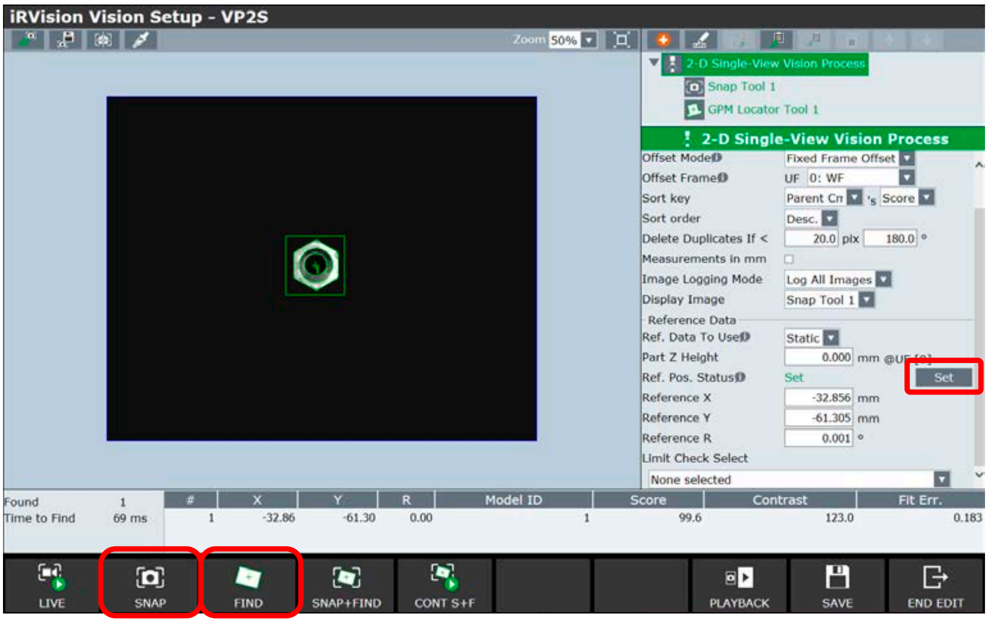
[Score]
Score of the found workpiece.

[Contrast]
Contrast of the found workpiece.

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

3.1.3 Setting the Reference Position

Set the reference position.
The offset data is calculated based on the reference position you set here and the actual position found at runtime.
Teaching the robot position is performed when the workpiece is located at the reference position.

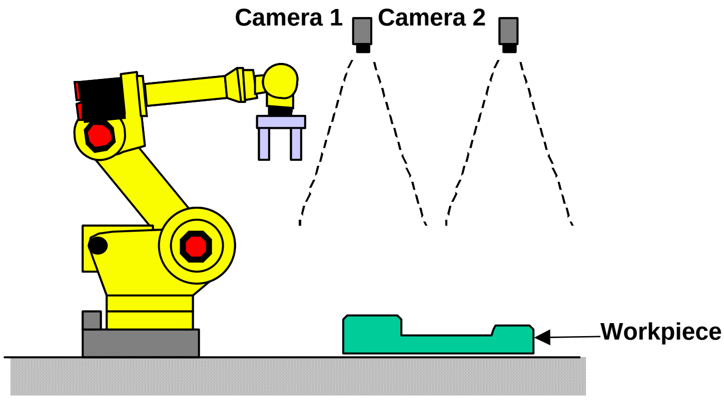


Set reference position using the following procedure.

1 Place a workpiece in the camera field of view and click [SNAP].
2 Click [FIND] and find the workpiece.
3 Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].
4 Check that values are set for all the reference position items.
5 Teach the position to the robot without moving the workpiece.

3.2 2D MULTI-VIEW VISION PROCESS

This is a vision process that finds multiple features on different parts of the workpiece, and then offsets the robot motion.
It is used when the workpiece is too large for a camera to capture its entire image.

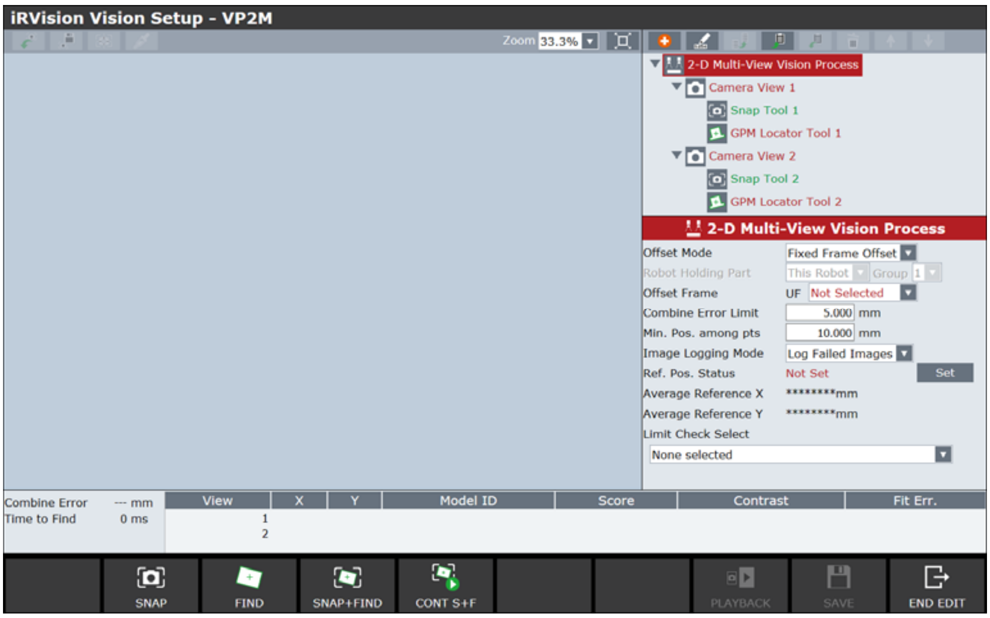


2-D Multi-View Vision Process

In 2D Multi-View Vision 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.

3.2.1 Setting up a Vision Process

If you select the vision process [2-D Multi-View Vision Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Offset Mode]

Select the robot position offset mode from the drop-down box.

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

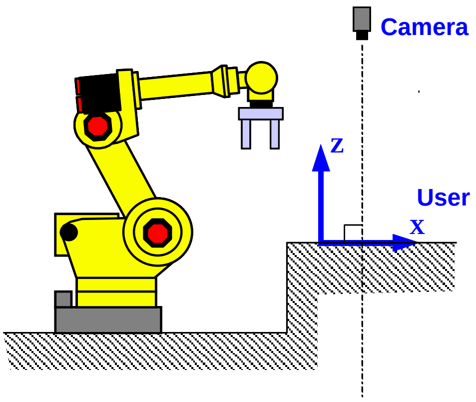
[Tool Offset]
The tool offset data will be calculated.

[Robot Holding Part]

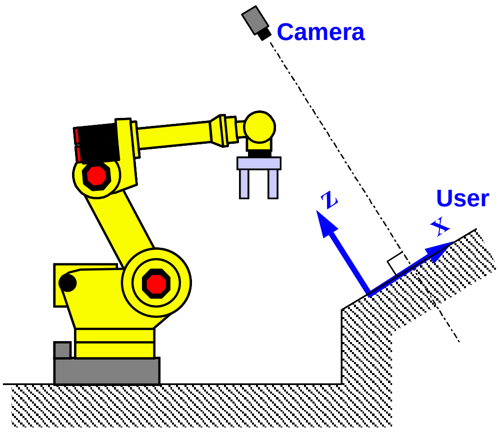
This is displayed when [Tool Offset] is selected for [Offset Mode]. Select the controller name and the motion group number of the robot holding the workpiece from the drop-down box.

[Offset Frame]

A 2D vision process measures displacement of a workpiece on a plane. Select a frame to determine the plane from the drop-down box. The plane is defined as a plane parallel to the XY plane of 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.



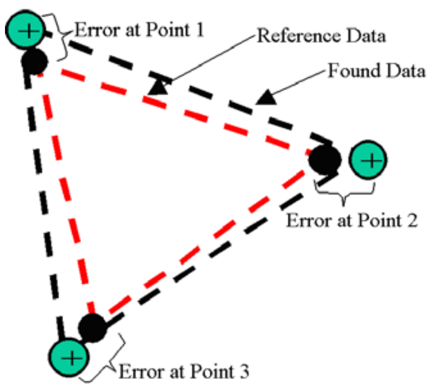
2D offset on a horizontal plane



2D offset on an inclined plane

[Combine Error Limit]

Enter Combine Error Limit in the text box. The units are millimeters.
When there is a variation in the distances between measurement points on the workpiece, for example due to individual difference, then the combine error will be produced between the reference positions and the actual positions even if the workpiece is not displaced.
The vision process computes the offset data so that the combine error becomes minimal, but if the calculated combine error is larger than the limit, the workpiece will not be found.



Combine errors for reference positions and found positions

[Min. Pos. among pts]

Enter the minimum distance limit between measurement points in the text box. The units are millimeters.
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]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**

1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

[Average ReferenceX]、[Average ReferenceY]

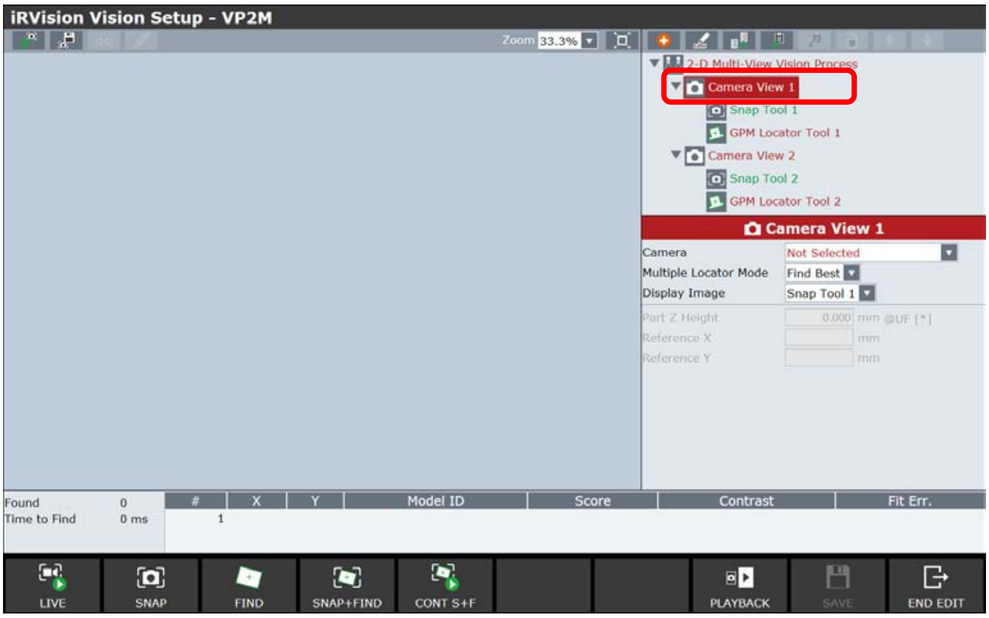
The average reference position, which is calculated from the reference positions of camera views, is displayed.
In 2D Multi-View Vision Process, the offset limit check is performed using the average position, instead of the individual found position of camera views.

[Limit Check Select]

From the drop-down box, select condition for checking whether a calculated offset 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, refer to "Setup: 5.2 OFFSET LIMIT".

3.2.2 Setting up a Camera View

If you click [Camera view 1] in the tree view on the editing screen for the vision process, the setting items for the camera view will be displayed in the setting items area.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, "Setup: 4.1 SNAP TOOL".

[Multiple Locator Mode]

If you have created more than one locator tool, select how to execute those tools from the drop-down box.

[Find Best]

All the locator tools are executed and the found result with the highest score is output. This is used when you give priority to location reliability over 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.
When it is necessary to execute all the locator tools such as sorting the workpiece, select [Find Best].

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

[Part Z Height]

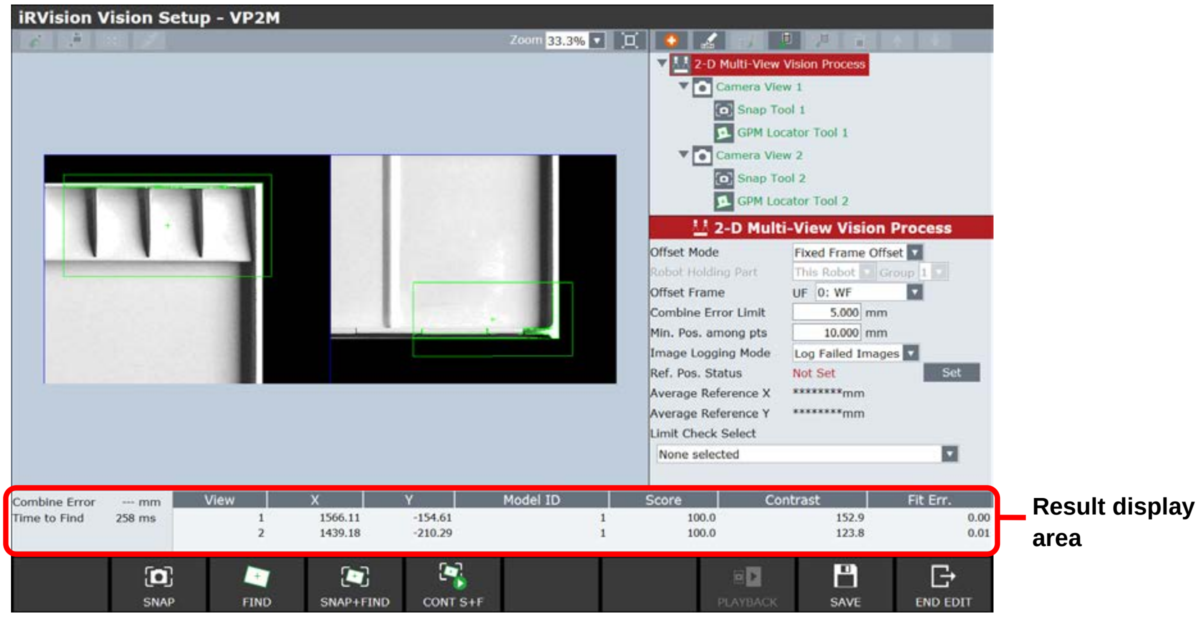
Enter the height of the upper surface of the workpiece in the text box for [Offset Frame].

[Reference X], [Reference Y]

The coordinate values of the reference position are displayed.
The values are in respect to the specified [Offset Frame].

3.2.3 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



Perform test runs using the following procedure.

1 Select [Camera View1] in the tree view and click [SNAP].
2 Select [Camera View2] in the tree view and click [SNAP].
At that time, if workpiece is outside the field of the view of camera view 2 in cases of robot-mounted camera or tool offset, move the robot so that the workpiece is within the field of view of the camera.
Repeat the same operation if there is [Camera View 3] or later.
3 Select [2-D Multi-View Vision Process] from the tree view, and click [FIND].
4 Check that the found results are displayed in the result display area.

If you can perform finding in all camera views without moving the robot, you can perform finding for all camera views at once by selecting [2-D Multi-View Vision Process] in the tree view and clicking [SNAP+FIND].

After you run a test, the result display area shows the following results:

[Combine Error]

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.

The following values are displayed in the list view of the result display area.

[X], [Y]

The position of the model origin of the found feature. The coordinate values are with respect to [Offset Frame]. The units are millimeters.

[Model ID]

Model ID of the found workpiece.

[Score]

Score of the found workpiece.

[Contrast]

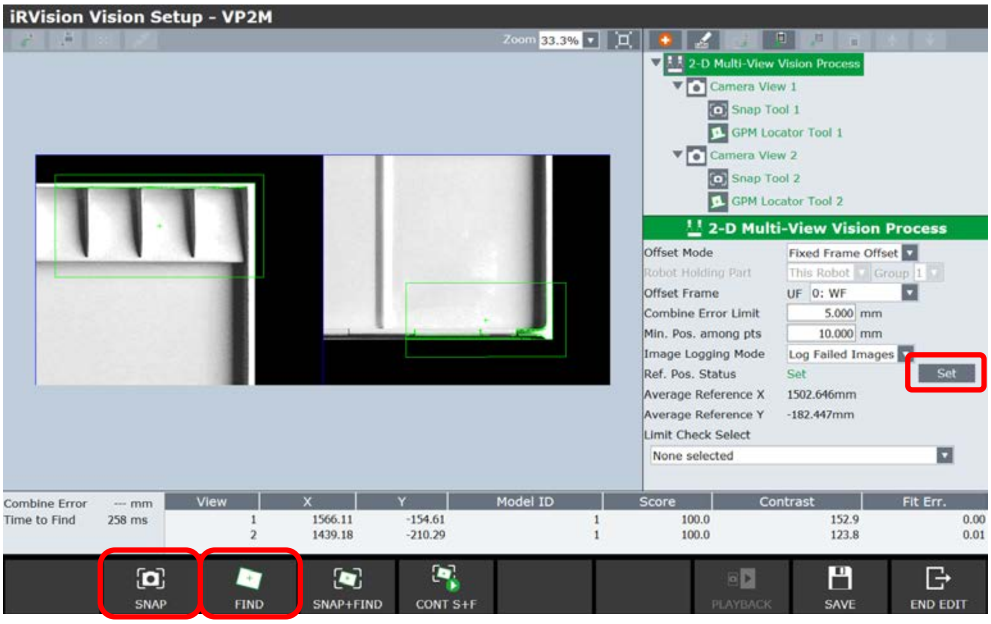
Contrast of the found workpiece.

[Fit Err]

Elasticity of the found workpiece (units: pixels).

3.2.4 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.
Position training for the robot is performed using the workpiece when the reference position was set.



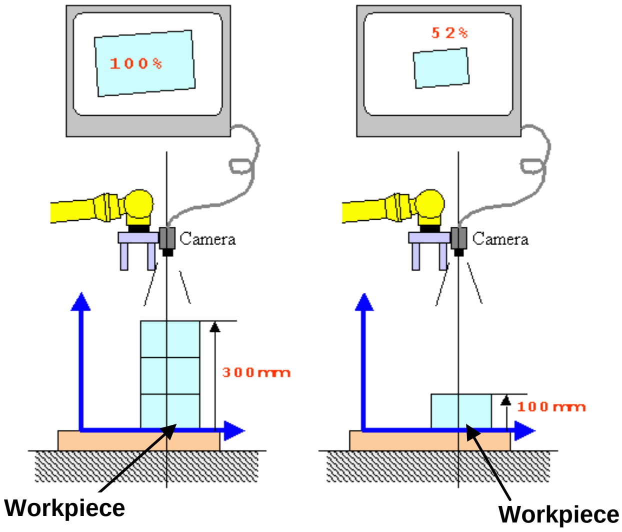
Set reference position using the following procedure.

1. Select [Camera View 1] from the tree view, locate 1 workpiece within the camera field of camera view 1, and click [SNAP].
2. Select [Camera View 2] from the tree view and click [SNAP].
   At that time, if workpiece is outside the field of camera view 2 in cases of robot-mounted or tool offset, move the robot so that the workpiece is within the field of view of the camera.
   Repeat the same operation if there is [Camera View 3] or later.
3. Select [2-D Multi-View Vision Process] from the tree view, and click [FIND].
4. Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].
5. Check that values are set for all the reference position items.
6. Teach the position to the robot without moving the workpiece.

If you can perform finding in all camera views without moving the robot, you can perform finding for all camera views at once by selecting [2-D Multi-View Vision Process] in the tree view and clicking [SNAP+FIND].

3.3 DEPALLETIZING VISION PROCESS

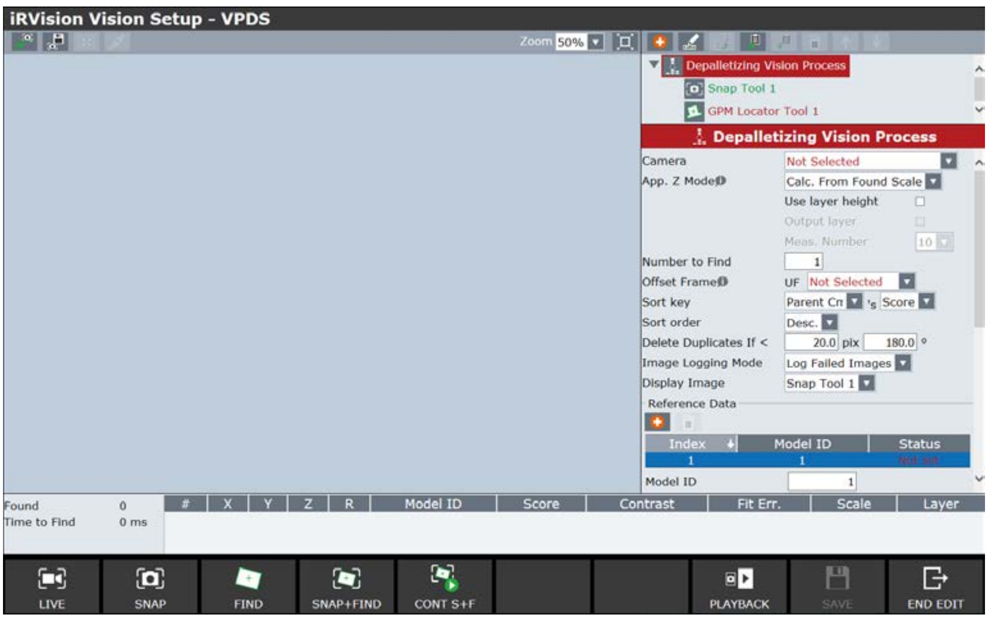
The Depalletizing Vision Process is a vision process that performs vertical-direction position offset in addition to the regular two-dimensional position offset.
The height of the workpiece is measured based on the apparent size of the workpiece captured by the camera.



Depalletizing Vision Process

3.3.1 Setting up a Vision Process

If you select the vision process of [Depalletizing Vision Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[App. Z Mode]

Select how to calculate the height of the workpiece from the drop-down box.

[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 [Meas. Number].

[Use Register Value]

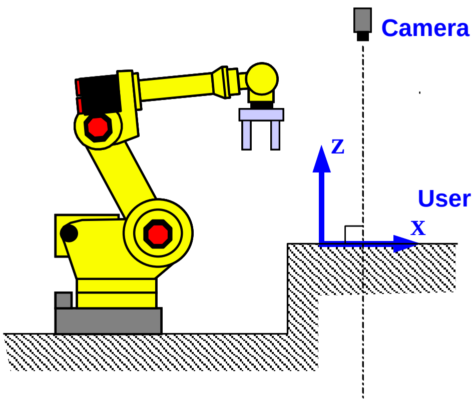
The value stored in the specified register of the robot controller will be used as the Z-direction height.

[Number to Find]

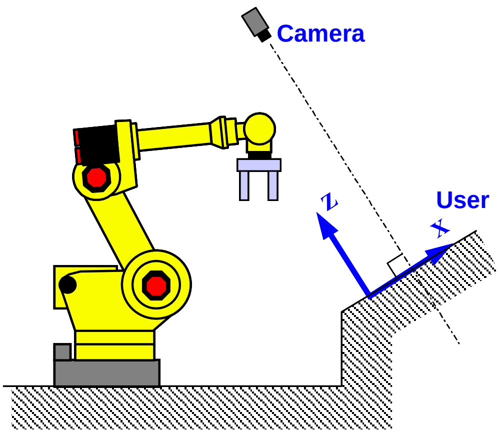
Enter the maximum number of workpieces to be found per measurement. The specifiable range is 1 to 100.

[Offset Frame]

A 2D vision process measures displacement of a workpiece on a plane. Select a frame to determine the plane from the drop-down box. The plane is defined as a plane parallel to the XY plane of the offset frame.
The following are examples of the offset frame in the case of Fixed Frame Offset.



2D offset on a horizontal plane



2D offset on an inclined plane

[Sort key]

Found results will be sorted when multiple workpieces are found. On this item, select a parameter to use as the sort key from the drop-down box.

[Sort order]

Found results will be sorted with the selected sort key. On this item, select the sort order used in the sorting from the drop-down box.

For details of [Sort key] and [Sort order], refer to "Setup: 1.8.14 Sorting".

[Delete Duplicates If <]

As a type of false detection, the same workpiece may be detected more than once. In such cases, the duplicated found results can be deleted, leaving only the one with the highest score. Specify the threshold with distance and angle on the image and the vision process consider found results are duplicated if they are closer than it.
Enter the thresholds for the distance and the angle difference between found results in the text boxes. If there are multiple found results within the thresholds, the results are assumed to be the same workpiece and only the one with the highest score remains.

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**
> 1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

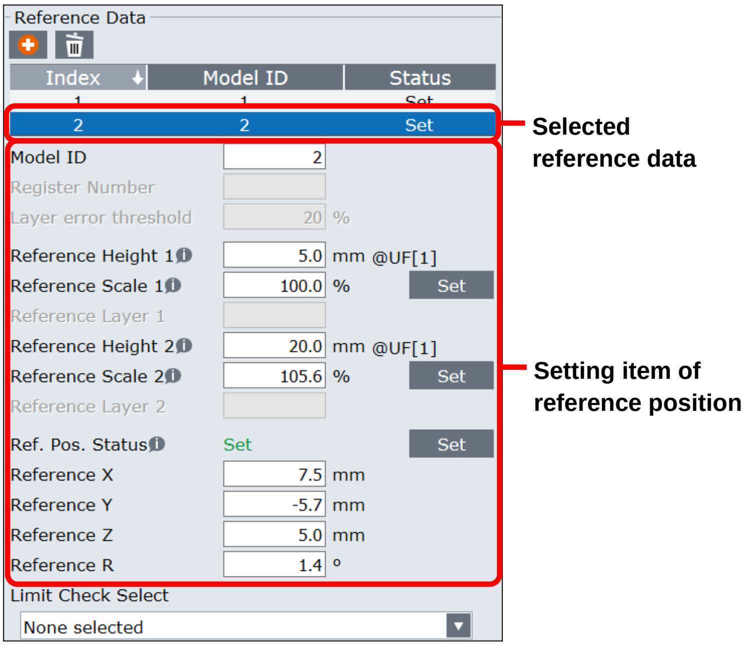
If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

[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.

If the row of ID to use in the reference data table, values are displayed in the reference position setting items.



Adding and setting reference data

The procedure to add and set reference data is as follows.

1 Click the button.
Reference data is added to the table and new Index is assigned.
2 Set the reference position. For details, refer to "Setup: 3.3.3 Setting the Reference Position".
3 If reference position setting is performed, [Status] of the reference data table will change to [Set].

Deleting reference data

The procedure to delete reference data is as follows.

1 Select the reference data to delete in the reference data table.
2 Click the button.
A deletion confirmation message will be displayed.
3 If the [OK] button is clicked, the reference position selected in procedure 1 is deleted.
If the [Cancel] button is clicked, delete is canceled.

[Model ID]

Model ID is the number assigned to the workpiece found.

[Register Number]

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

[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. Enter layer error threshold in text box with value between 1% and 50% as permissible calculation error.
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.

Set [Reference Height] and [Reference Scale]

Use this when [Calc. From Found Scale] is selected 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 using the following procedure.

1. Place one workpiece, and touch up the workpiece surface using touch-up pins. Enter this height data in [Reference Height 1].
2. Click [SNAP] and click [FIND].
   Check that detection of workpiece has succeeded.
3. Click [Set] in [Reference Scale1] on the vision process edit screen and set Reference Scale1.
4. Place n workpieces, and touch up the workpiece surface using touch-up pins. Enter this height data in [Reference Height 2].
5. Click [SNAP] and click [FIND].
   Check that detection of workpiece has succeeded.
6. Click the [Set] button in [Reference Scale2] on the vision process edit screen and set Reference Scale2.

[Reference Layer]

Use this when [Use layer height] is checked in [App. Z Mode].
Enter the maximum number of layers of the workpiece set in [Reference Height] and [Reference Scale] in the text box.

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

[Reference X], [Reference Y], [Reference Z], [Reference R]

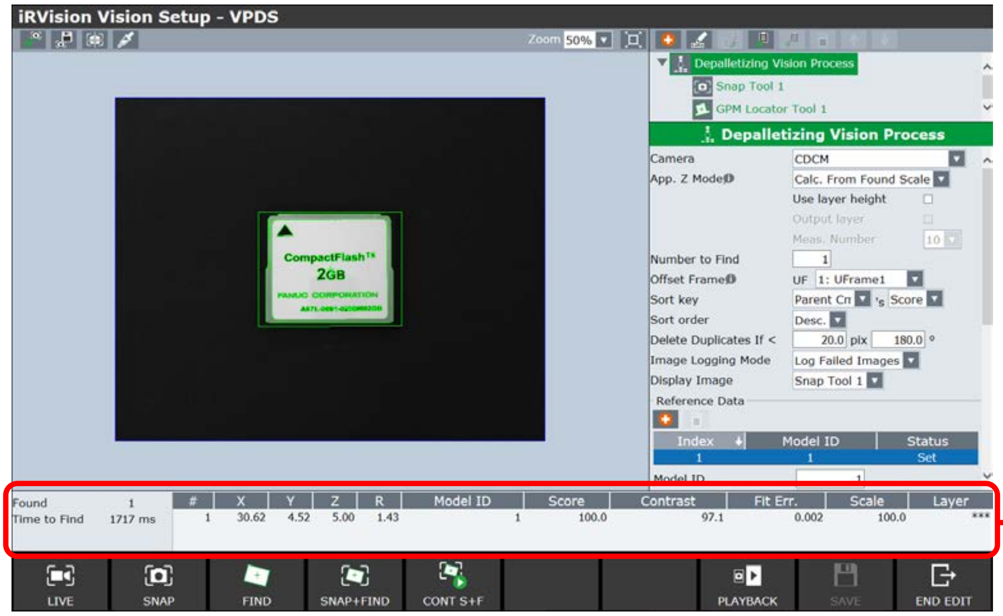
The coordinate values of the set reference position are displayed.
The values are in respect to the specified [Offset Frame].

[Limit Check Select]

From the drop-down box, select condition for checking whether a calculated offset 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, refer to "Setup: 5.2 OFFSET LIMIT".

3.3.2 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the vision process took is displayed in milliseconds.

The following values are displayed in the list view of the result display area.

[X], [Y], [Z]

The coordinate values of the model origin of the found workpiece are with respect to [Offset Frame]. The units are millimeters.

[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).

[Scale]
Size of the found workpiece.

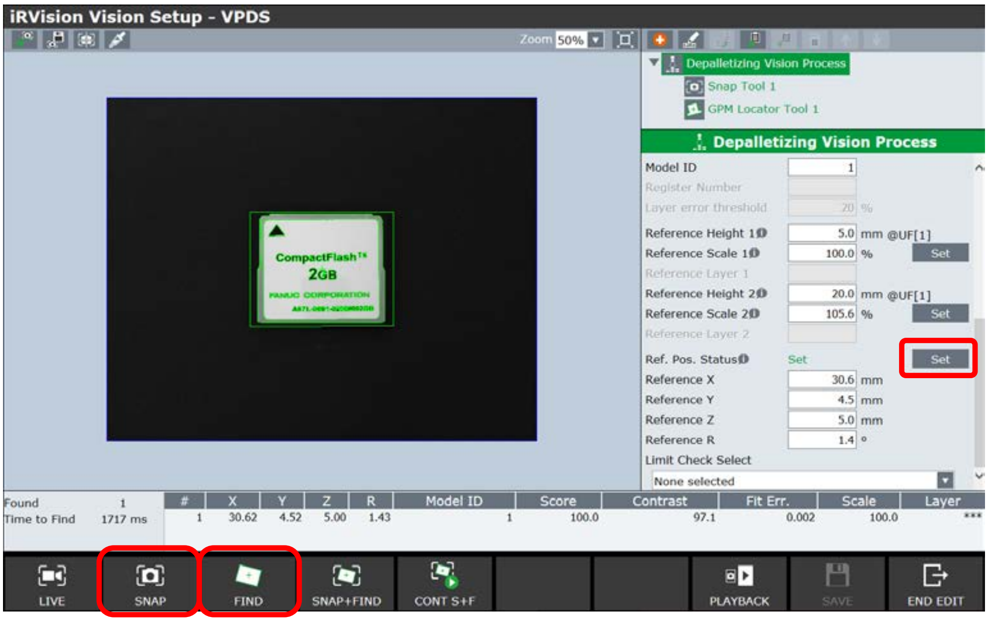
[Layer]
Number of the layer containing the workpiece that is calculated from the found size.

3

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

3.3.3 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.
Teaching the robot position is performed when the workpiece is located at the reference position.

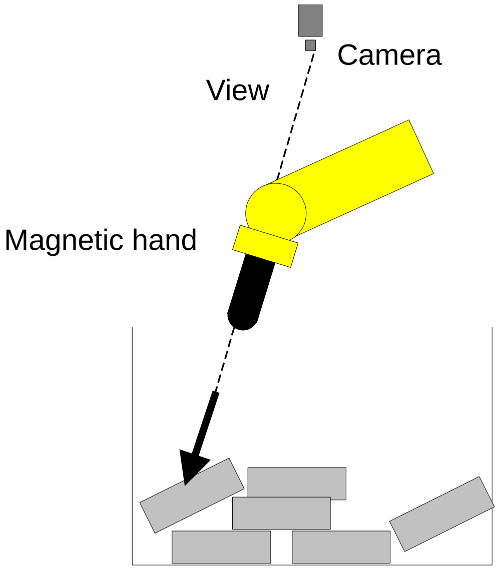


Set reference position using the following procedure.

1 Place a workpiece in the camera field of view and click [SNAP].
2 Click [FIND] and find the workpiece.
3 Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].
4 Check that values are set for all the reference position items.
5 Leave the workpiece as it is and teach the robot position.

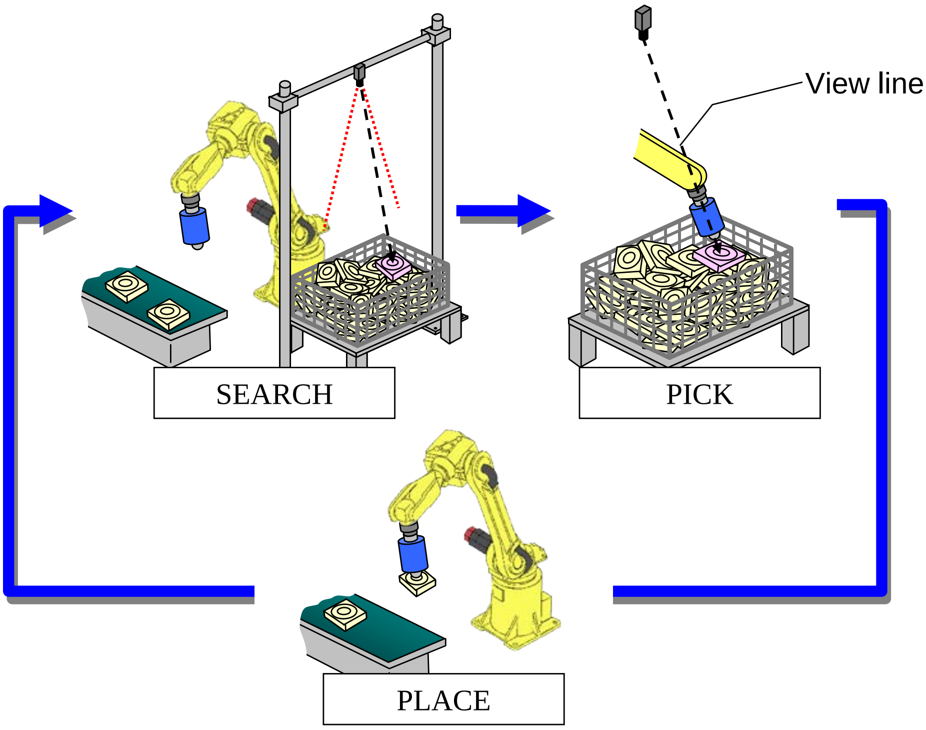
3.4 GAZE LINE OFFSET VISION PROCESS

GAZE LINE OFFSET VISION PROCESS is a vision process that offsets the robot motion based on the gaze line from camera to workpiece and the height of the workpiece estimated from the apparent size of the workpiece in the camera image in addition to normal 2-D View Vision Process. This allows to build a simple bin picking system (Bin Picking System with 2D Camera) with a magnetic gripper, etc.



Offset Direction

Workpieces are detected with a fixed camera mounted on a camera stand (SEARCH). The robot approaches the workpiece along the gaze line from the camera to the found workpiece and picks up the workpiece.

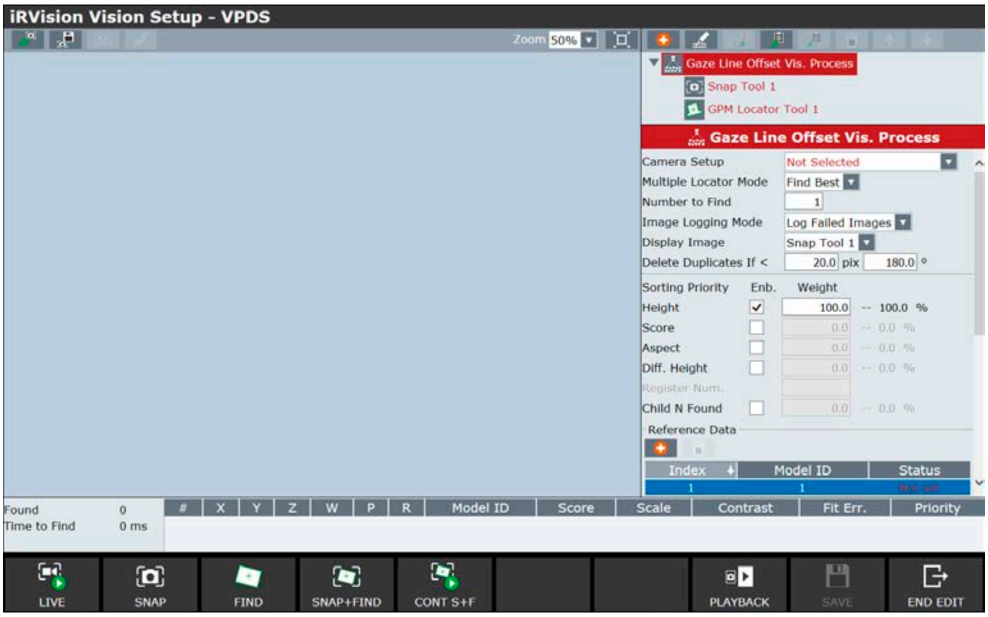


Flow of the system

For details of Bin Picking System with 2D Camera, refer to "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL".

3.4.1 Setting up a Vision Process

If you select the vision process of [Gaze Line Offset Vis. Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera Setup]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Multiple Locator Mode]

If you have created more than one locator tool, select how to execute those tools from the drop-down box.

[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 reliability before processing time.

[Find First]

The locator tools will be executed sequentially from the top until the specified number of workpieces has been found.
This is used when you give priority to location tool in the upper part of the tree view. When the number of found results reaches the specified number, locator tools will not be executed subsequently so the processing time becomes shorter than using [Find Best].
For your information, the processing of [Delete Duplicates If <] described later is performed every time one locator tool is executed. Here, check the number of found results excluding the duplicates and in cases when it exceeds the specified number, determine whether to run next location tool.

[Number to Find]

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

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**
>
> 1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
>
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

[Delete Duplicates If <]

As a type of false detection, the same workpiece may be detected more than once. In such cases, the duplicated found results can be deleted, leaving only the one with the highest score. Specify the threshold with distance and angle on the image and the vision process consider found results are duplicated if they are closer than it.
Enter the thresholds for the distance and the angle difference between found results in the text boxes. If there are multiple found results within the thresholds, the results are assumed to be the same workpiece and only the one with the highest score remains.

[Sorting Priority]

Specify the priority to determine the pick-up order to be applied when more than one workpiece has been found.
Gaze Line Offset Vision Process calculates the priority using the results of the following five items excluding [Register Num.] and sorts the results unlike the sorting of other vision processes.
You can specify which items are used for priority calculation and how much these items reflect the calculation by checking [Enb.] for each required item and setting weight for them.

MEMO
Priorities calculated with 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]
Check this [Enb.] when priority is given to the height.

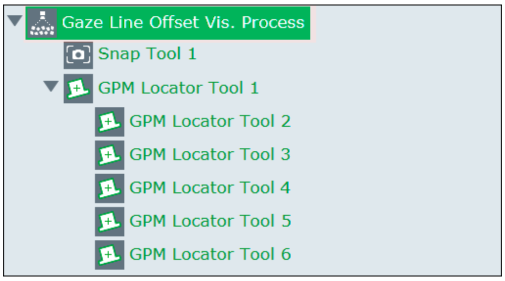
[Score]
Check this [Enb.] when priority is given to a workpiece with a high score.

[Aspect]
Check this [Enb.] when priority is given to a workpiece with a small inclination (a high ellipticity).

[Diff. Height]
Check this [Enb.] when priority is given to a workpiece with the height (Z value of the user frame) closest to that of the workpiece last picked out.

[Register Num.]
Modify your TP program so that it set a register to the Z value of the workpiece last picked out, and set the textbox of the [Register Num.] to the number of the register.
This will appear when the [Diff. Height] was checked and a value greater than 0 is set for [Weight].

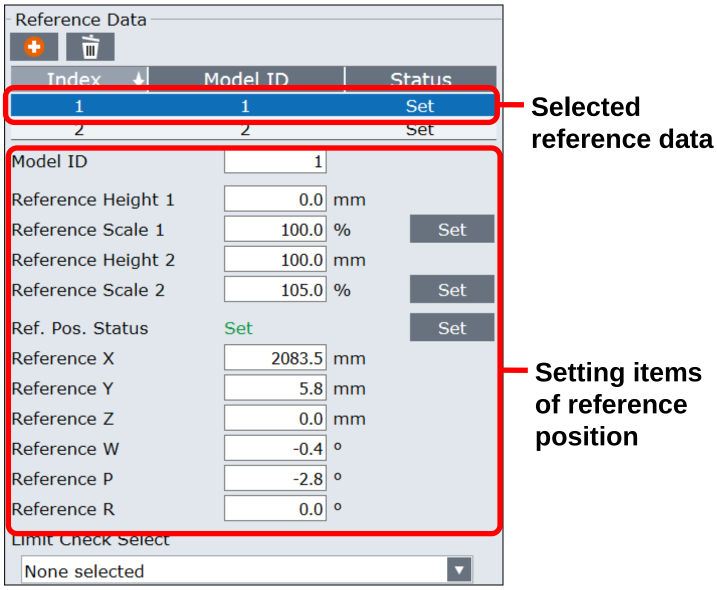
[Child N Found]
Check this [Enb.] when priority is given to a workpiece having many detected results of child tools. As a pattern match model, the entire workpiece is taught to the parent pattern match tool. Then, as a child tool of the parent pattern match, part of the workpiece is taught. Use this 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.

The values of the reference data selected on the reference data list are displayed in the reference position setting items.



Adding and setting reference data

The procedure to add and set reference data is as follows.

1 Click the button.
Reference data is added to the table and new Index is assigned.
2 Set the reference position. For details, refer to "Setup: 3.4.3 Setting the Reference Position".
3 If reference position setting is performed, [Status] of the reference data table will change to [Set].

Deleting reference data

The procedure to delete reference data is as follows.

1 Select the reference data to delete in the reference data table.
2 Click the button.
A deletion confirmation message will be displayed.
3 If the [OK] button is clicked, the reference position selected in procedure 1 is deleted.
If the [Cancel] button is clicked, delete is canceled.

[Model ID]

Model ID is the number assigned to the workpiece found.

Set [Reference Height] and [Reference Scale]

Set the relationship between the actual Z-direction height of the workpiece and the apparent size of the workpiece captured by the camera using the following procedure.

1 Place one workpiece and touch up the workpiece surface using touch-up pins. Enter this height information in [Reference Height1].
2 Click [SNAP] and click [FIND].
Check that detection of workpiece is successful.
3 Click the [Set] button in [Reference Scale1] on the vision process edit screen and set Reference Scale1.
4 Place n workpiece, and touch up the workpiece surface using TCP. Enter this height information in [Reference Height2].
5 Click [SNAP] and click [FIND].
Check that detection of workpiece is successful.
6 Click the [Set] button in [Reference Scale2] on the vision process edit screen and set Reference Scale2.

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

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

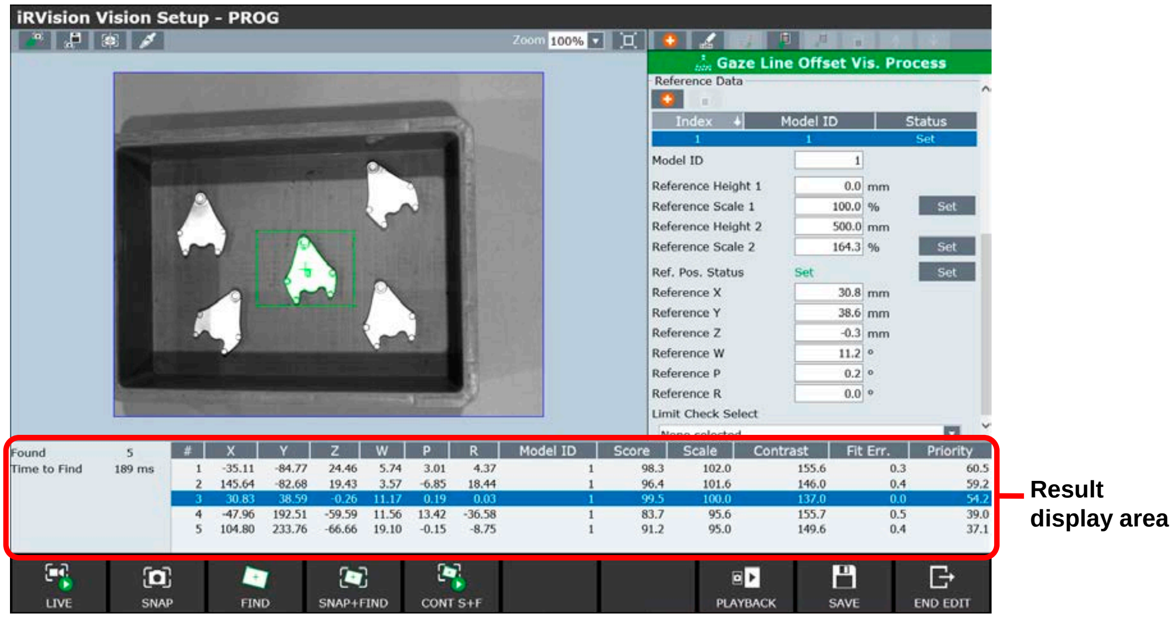
The coordinate values of the reference data selected on the reference data list are displayed in the reference position setting items.

[Limit Check Select]

From the drop-down box, select condition for checking whether a calculated offset 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, refer to "Setup: 5.2 OFFSET LIMIT".

3.4.2 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the vision process took is displayed in milliseconds.

The following values are displayed in the list view of the result display area.

[X], [Y], [Z]

Coordinates of the model origin of the found workpiece (units: mm).
The position on the [Application Frame] selected in [Calibration Setup] in camera data is output.

[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.

[Scale]
Size of the found workpiece.

[Contrast]
Contrast of the found workpiece.

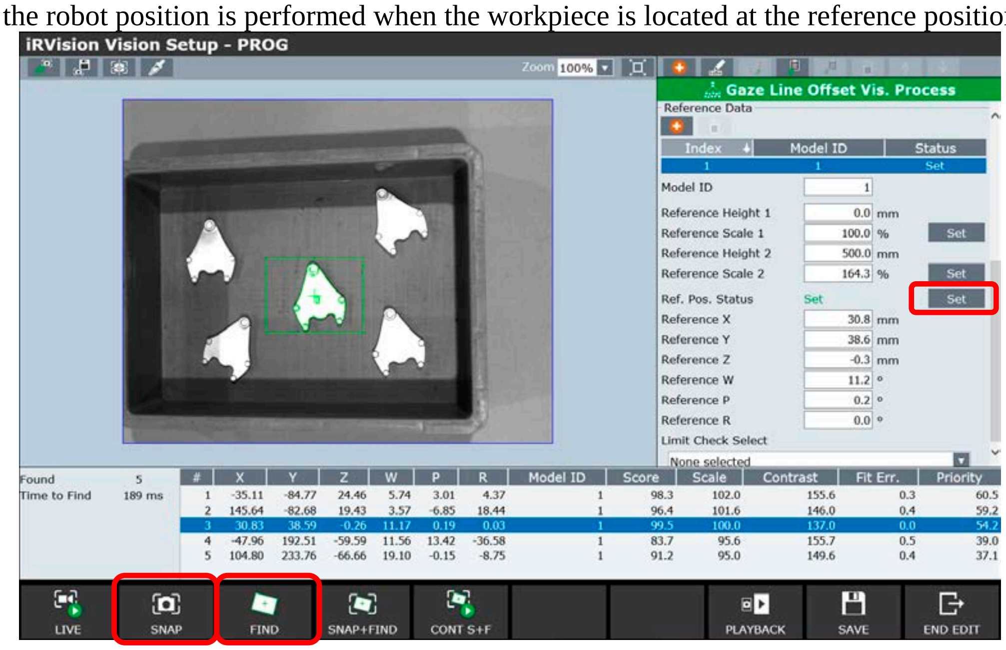
[Fit Err]
Elasticity of the found workpiece (units: pixels).

[Priority]
Pick-up priority given to the found workpiece.

> **MEMO**
> 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.

3.4.3 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.
Teaching the robot position is performed when the workpiece is located at the reference position.

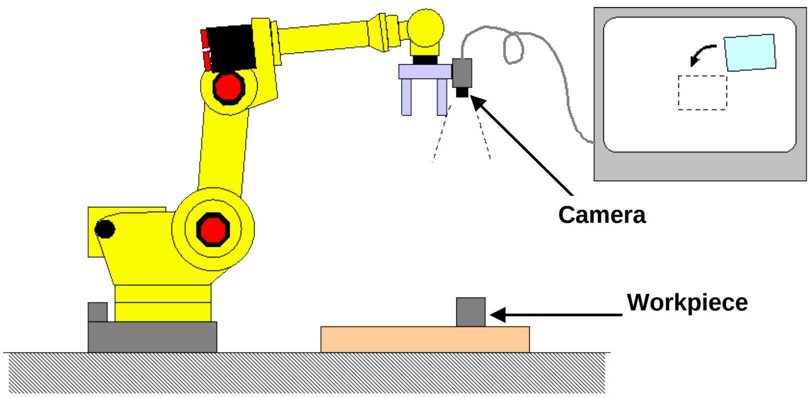


Set reference position using the following procedure.

1. Place a workpiece on center of the camera view to setup the reference position and click [SNAP]. By placing a workpiece on center of the camera view, teaching of the robot position training becomes easy.
2. Click [FIND] and find the workpiece.
3. Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].
4. Check that values are set for all the reference position items.
5. Leave the workpiece as it is and teach the robot position.

3.5 2D CALIBRATION-FREE VISION PROCESS

This is a vision process that does not require a camera calibration.
In addition, user frames and the other related setups are also not required. Thus, in comparison to a conventional 2D Single-view vision process, the ease of installing a vision application has improved.



2D CALIBRATION-FREE VISION PROCESS by the robot

In 2D Calibration-Free Vision Process, the KAREL program IRVHOMING is used instead of VISION RUN_FIND. For details, refer to "Setup: 6.2.6 IRVHOMING". When IRVHOMING is executed, the robot moves automatically so that the found pose of the workpiece in the camera image matches the destination pose trained at setup, and then offset data is calculated.

2D Calibration-free Vision Process supports the following types of applications.

- Fixed-frame Offset with a robot-mounted camera.
- Tool Offset with a fixed-mounted camera.

Because every 2D Calibration-free Vision Process detection is accompanied by a robot motion, the detection tends to take a little longer than a conventional 2D Single-view Vision Process.

3.5.1 Setting up a Vision Process

If you select the vision process of [2-D Calibration-free VisProc] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.

The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.
In 2D Calibration-free Vision Process, the offset type is determined by how the camera is mounted.

Settings related to snap, such as snap window and exposure mode, are carried out with the snap tool. For details, refer to "Setup: 4.1 SNAP TOOL".

[Offset Mode]

Offset mode will be automatically displayed according to the selected camera data.

[Prioritize]

Select the priority order for when multiple workpieces are found in a single detection from the drop-down box. The default is [High Score].

[From Image Left]
The robot will work starting from the target found closest to the left side of the image.

[From Image Right]
The robot will work starting from the target found closest to the right side of the image.

[From Image Top]
The robot will work starting from the target found closest to the top of the image.

[From Image Bottom]
The robot will work starting from the target found closest to the bottom of the image.

[High Score]
The robot will work starting from the target found with the highest score.

[Largest]
The robot will work starting from the largest target found.

[Position Accuracy]

In program execution, enter in the text box distance threshold for judging that the destination pose has been reached. The default is 0.1mm.

[Angle Accuracy]

In program execution, enter in the text box angle threshold for judging that the target angle has been reached. The default is 0.1 degrees.

[Height Compensation]

When the item is enabled, the robot will offset also in Z direction, making it act similar to a Depalletizing Vision Process. However, the detection will take a bit longer.
The checkbox is initially not checked.

> ⚠ **CAUTION**
> When enabling [Height Compensation], make sure to enable [Scale] of [DOF] in the GPM Locator Tool setup page.
> If [Height Compensation] is enabled without enabling [Scale], the offset height may not be calculated correctly and the end of arm tooling may collide with workpieces.

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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.

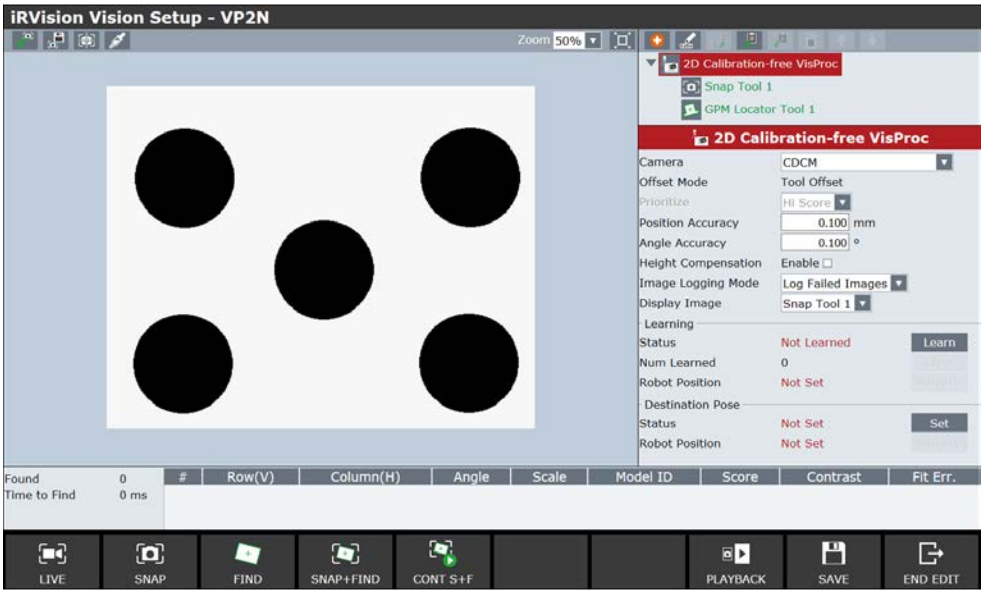
> ⚠ **CAUTION**
> 1 The execution of the next vision process cannot start until the image logging operation for the preceding vision process execution is completed. The time required to log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

3.5.2 Learning

When a 2D Calibration-free Vision Process is created, iRVision does not know how to move the robot in order to match the found pose of a workpiece on the image with the destination pose. Therefore, the learning process is required to make iRVision learn how to move the robot.



The learning process is done by measuring markers placed on the plane where the workpieces are placed. Even when [Height Compensation] is enabled for depalletizing application, the markers should be placed at the same height.

The markers for learning do not have to be created specially; generic circular stickers or circles printed on a sheet of paper will suffice. However, the markers must be the same size and thickness if multiple markers are prepared.

Displayed Items

The display status of learning is as follows.

[Status]

The status of the learning process is displayed.

- When the learning process is completed, [Complete] is displayed in green.
- While the learning process has started, [In Process] is displayed in black.
- When the learning process has not been started, [Not Learned] is displayed in red.

[Num Learned]

The number of marker locations used for the learning process is displayed. The status becomes [Learned] when 5 or more marker locations are learned.
Two markers placed at the same location will only count as one location.

[Robot Position]

When the learning process is started, the robot position where the learning started is recorded.

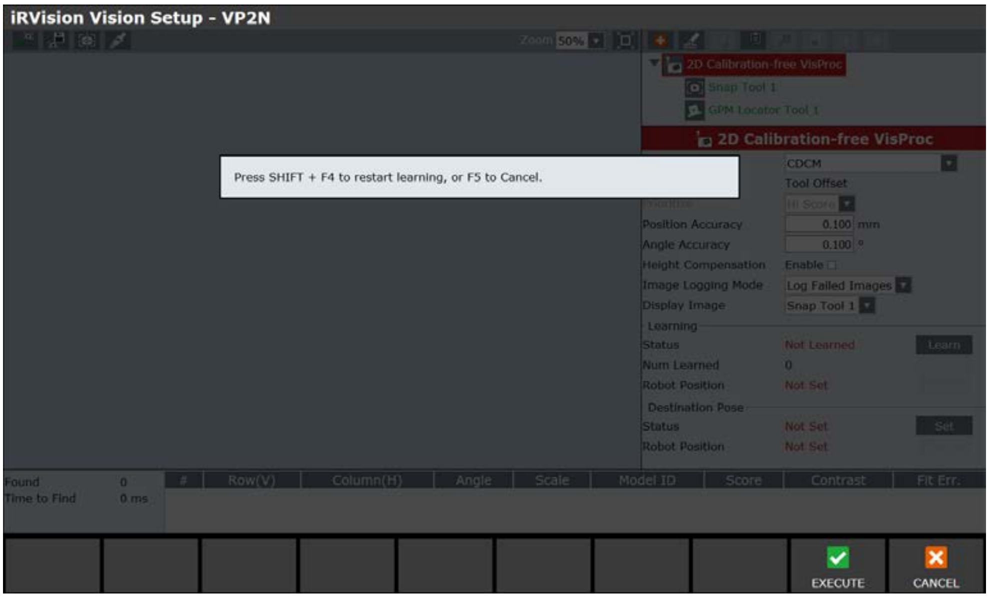
When it is recorded, [Set] is displayed in green.
When it is not recorded, [Not set] is displayed in red.

MEMO
Learning is carried out by moving the robot with teach pendant.

Execute learning

Learning is executed with the following procedure.

1 When the [Learn] button for [Status] is clicked, the following popup message is displayed.



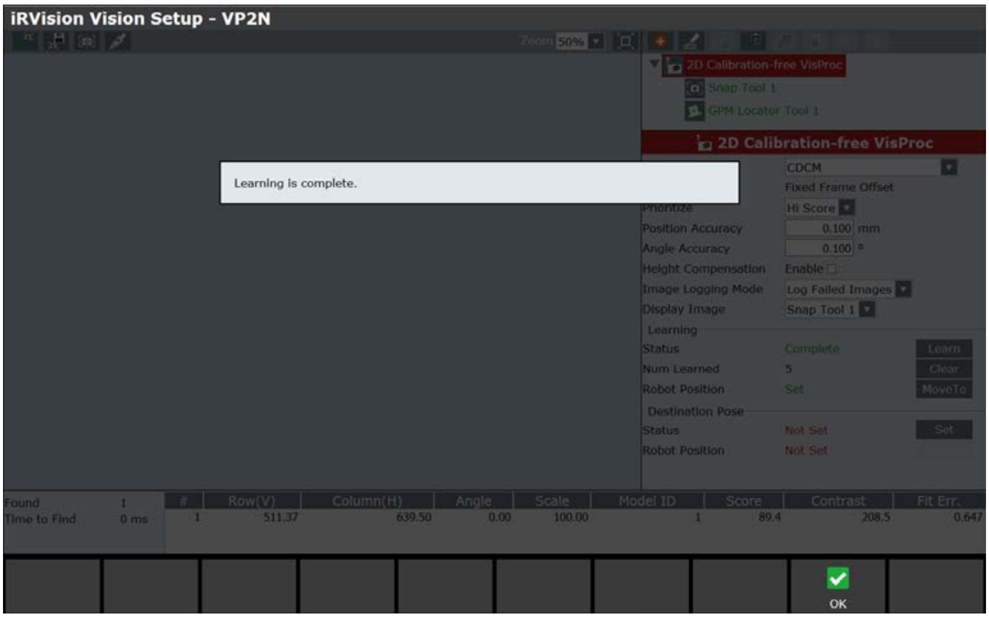
2 If F4 [EXECUTE] is pressed while holding down the [SHIFT] key on the teach pendant, the robot will start the learning process. The detection results are displayed on the image of the teach pendant display screen.

3 Keep the [SHIFT] key held down throughout the learning process.

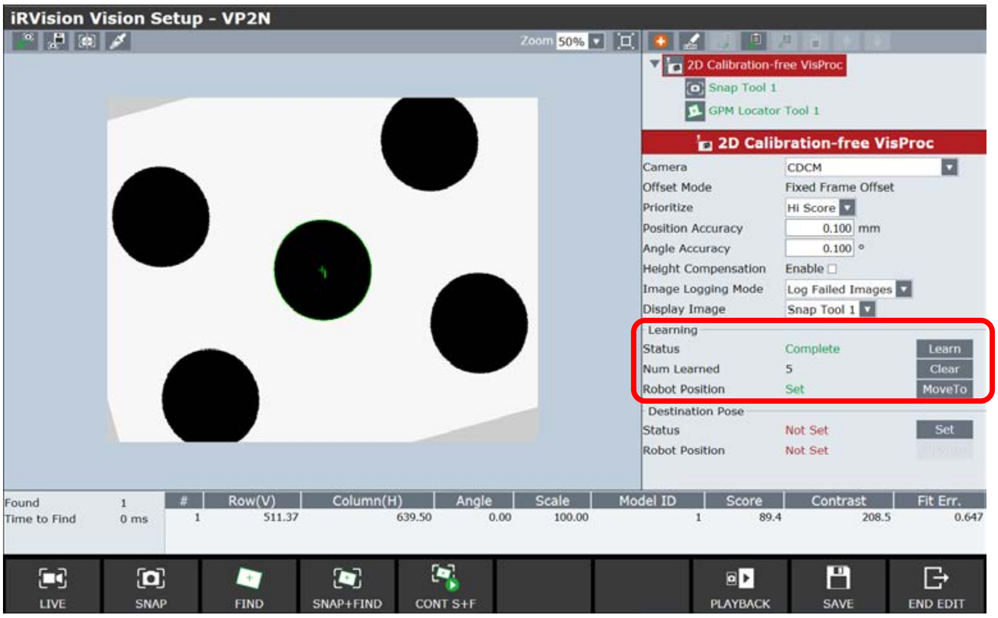
If the [SHIFT] key is released while the learning process, the robot will stop learning and a message "Learning is terminated." will be displayed.

To resume the learning process from where it was interrupted, click the [Learning] button in the vision process edit screen again and press F3 [RESUME] while holding down the [SHIFT] key.

A popup message "Learning is complete." is displayed when the learning process is completed.



4 Click [OK] to go back to the vision process edit screen.
The [MoveTo] button is enabled, when [Robot Position] for [Learning] is set.

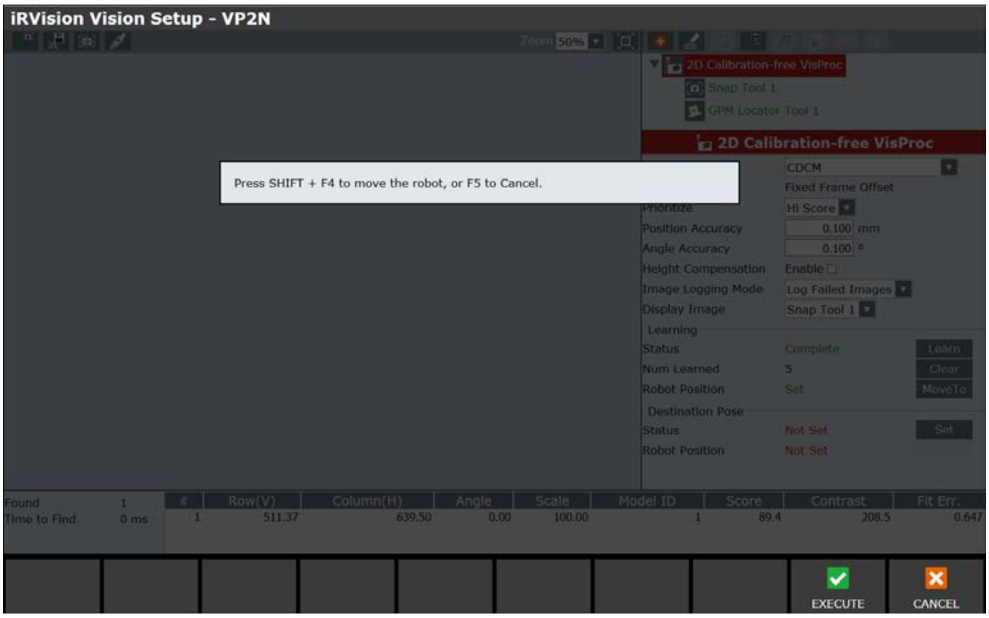


MEMO
To clear the number of learned data, click the [Clear] button of [Num Learned].

Moving to Robot Position

You can move the robot to the recorded position to start learning with the following procedures:

1 Click the [MoveTo] button in [Learning]. The following popup message is displayed.



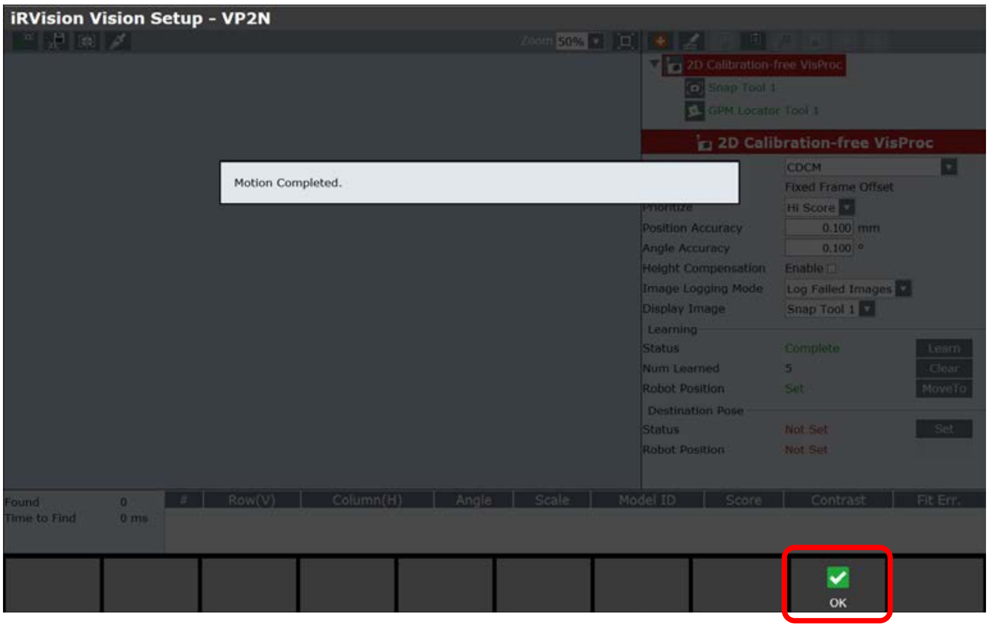
2 Press F4 [EXECUTE] while holding down the [SHIFT] key on the teach pendant.
The robot will start moving to the recorded position.

3 Keep the [SHIFT] key held down during movement.

If the [SHIFT] key is released while moving, the robot will stop moving and the message "Motion Terminated." will be displayed.

To resume the moving from where it was interrupted, click the [MoveTo] button in the vision process edit screen again and press F3 [RESUME] while holding down the [SHIFT] key on the teach pendant.

A message, "Motion Completed." is displayed when the moving process is completed.



4 Click [OK] to go back to the vision process edit screen.

3.5.3 Destination Pose

The destination pose to move the found pose is trained.
When the vision process is executed, the robot moves to a position such that the workpiece is found with the same pose as the destination pose.

Displayed Items

Status display of destination pose is as follows.

[Status]

The status of the destination pose is displayed.

- When the destination pose is set, [Set] is displayed in green.
- When the destination pose is not set, [Not set] is displayed in red.

[Robot Position]

The status of the robot position when the destination pose is set is displayed.

- When the robot position is recorded, [Set] is displayed in green.
- When the robot position is not recorded, [Not set] is displayed in red.

Set Destination Pose

Set the destination pose using the following procedure.

1 Place a workpiece which you want to set the destination pose for, in the camera's field of view.
2 Click [SNAP] and then click [FIND] to find the workpiece.
3 Click the [Set] button next to [Status] on the vision process edit screen.
4 Confirm that [Status] and [Robot Position] is changed to [Set].

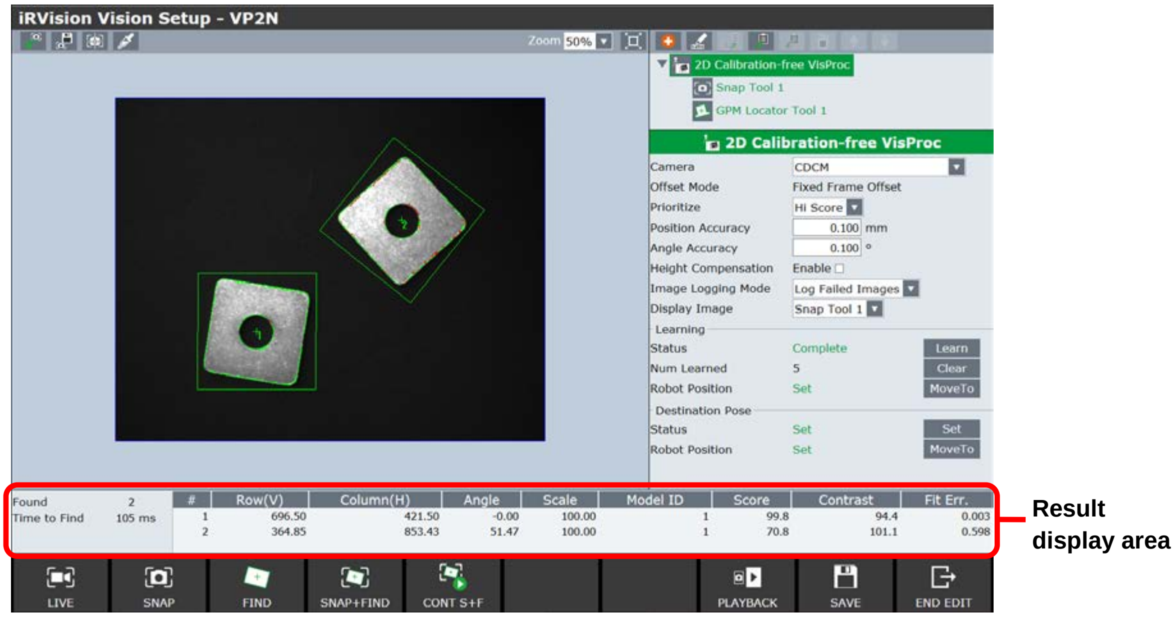
Moving to Robot Position

You can move the robot to the recorded position with the following procedures:

1 When the [MoveTo] button for [Robot Position] in the setup page of the vision process is clicked, a popup message will be displayed.
For details of moving procedure, refer to the moving procedure of "Setup: 3.5.2 Learning".

3.5.4 Running a Test

Click [Find] to perform a test, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

[Found]
The number of found workpieces is displayed.

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

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]
Coordinate values of the model origin of the found target (units: pixels).

[Angle]
Rotation angle of the found target (unit: degrees).

[Scale]
Size of the found workpiece (unit: %).

[Model ID]
Model ID of the found target.

[Score]
Score of the found workpiece.

[Contrast]
Contrast of the found workpiece.

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

3.5.5 Setup Guidelines

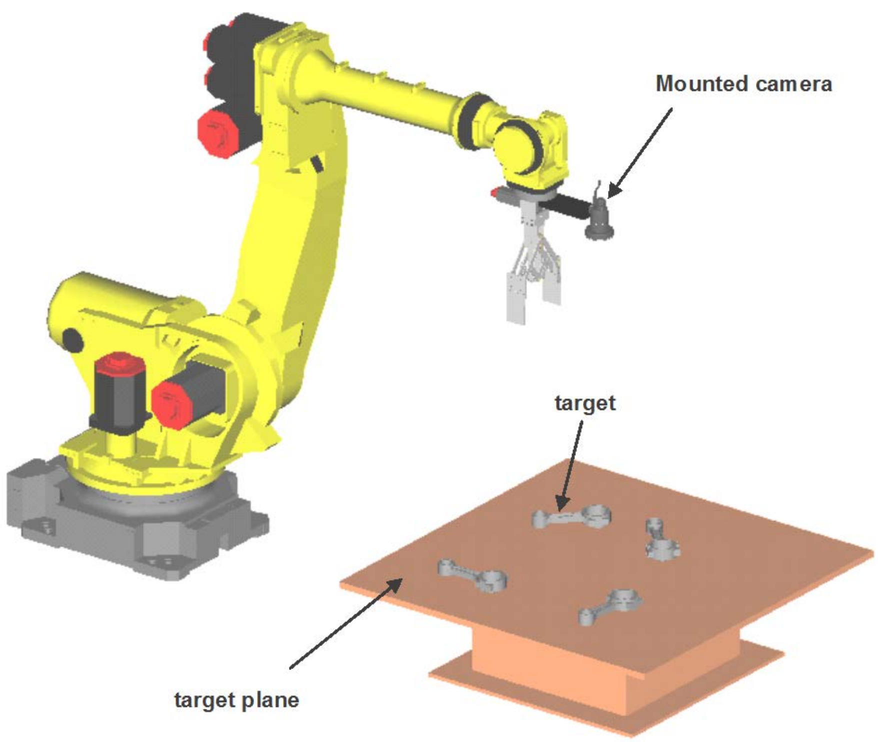
In this section, a basic training procedure for 2D Calibration-free Vision Process is described. The procedures are common to both fixed-frame offset and tool offset.

The basic training procedure of 2D Calibration-free Vision Process is as follows.

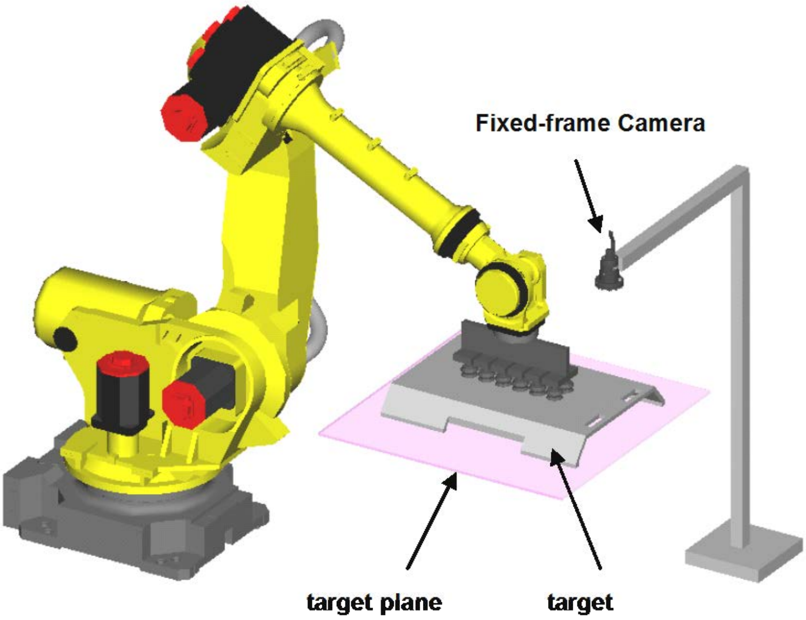
Move to Detection Position
↓
Learning
↓
Train Model
↓
Set Destination Pose
↓
Teach Robot Program

Moving the robot to the detection position

Determine the robot position to run vision detection. Set the camera to a live mode, and move the robot such that the camera optical axis is more or less perpendicular to the target plane (such as the table where the targets are placed in the case of fixed-frame offset, and the plane where the gripping error occurs in the case of tool offset), and the measurement area fits within the camera field of view. Once the detection position is determined, adjust the lens focus and aperture.



Detection position (In cases of tool offset)



Detection position (In cases of fixed frame offset)

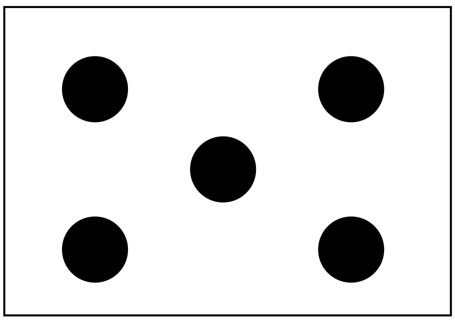
In the case of fixed-frame offset using a robot-mounted camera, if the measurement field is larger than the camera field of view, detection will be made at multiple robot positions. In that case, the following status shall be the same at all the detection positions.

- Robot posture
- Height from the workpiece moving plane to the camera

Learning

Learning is started from the vision process setup page. Below are some pointers when starting the learning process.

- Learning data is acquired by observing markers placed at five or more locations.
- For fixed-frame offset, place the markers on the plane where the targets are placed.
- For tool offset, place the markers on the same plane of a target or a plate held by a robot.
- The markers can be placed all at the same time, or can be placed one at a time in five different locations.
- The locations of the placement can be arbitrary, but the markers should not form a line.
- The learning is done more accurately by spreading the markers widely on the measurement field.
- The diagram below shows an example of the placement seen in the measurement field. The learning process can proceed smoothly by placing the markers to resemble a five on dice.

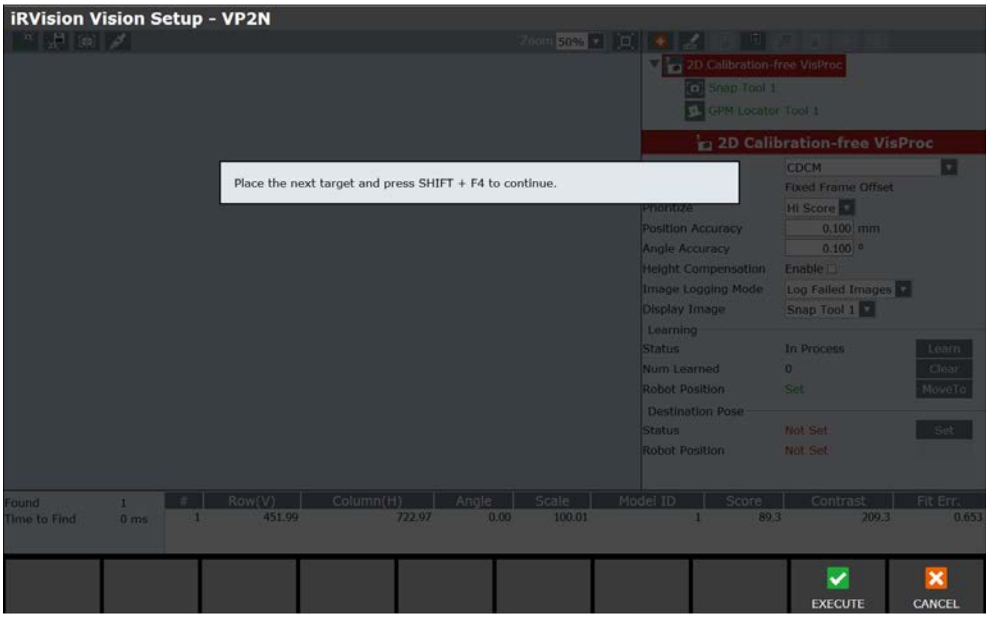


Marker placement pattern

Learning is executed with the following procedures.

1 Move the robot to a position to start learning. Usually, this is the same as the detection position. When starting the learning process from a different position, choose the position such that the robot posture is identical to the posture at the detection position.
2 Enable the teach pendant.
3 If another program is running or paused, end the program.
4 Reset the alarm.
5 Click the [Learn] button in [Learning] on the vision process edit screen.
6 Press F4 [EXECUTE] while holding down the [SHIFT] key on the teach pendant.

If the learning process does not complete with the markers detected within the field of view, the following popup message is displayed and the learning will pause.



After moving the markers, press F4 [EXECUTE] while holding down the [SHIFT] key to continue learning.

MEMO

- Markers placed at the same location will not advance the learning process, so give a generous displacement to each marker before proceeding. When the number of detected markers reaches the required amount, the learning process will end.
- In the case of fixed-frame offset using a robot-mounted camera, if the measurement field is larger than the camera field of view, spread the markers throughout the measurement field and proceed with learning in sections with various starting positions. In such a case, the robot posture for each position must coincide with the initial posture of the position where the learning was started.

MEMO

- If the image of the marker or the background is saturated, a detection size variance may occur which would result in an inaccurate learning data. In order to obtain an accurate learning data, the marker material and the lighting source should be carefully considered so that the markers detected from the same height would be found with the same size.
  For fixed-frame offset using a robot-mounted camera, the use of a ring-light at the camera mount is recommended.

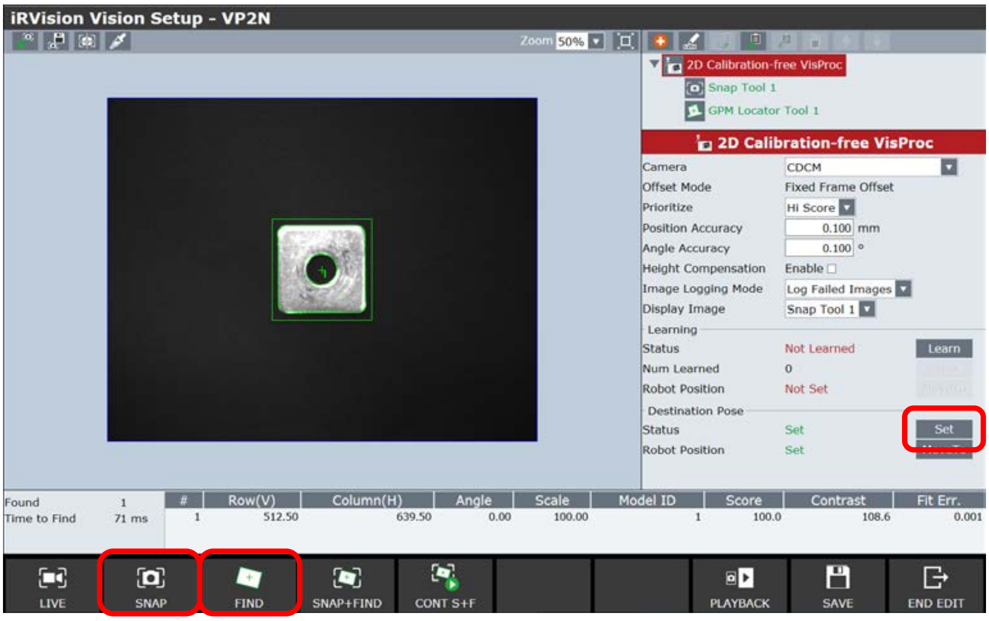
Train Model

With the robot positioned at the detection position, place a target more or less in the middle of the camera field of view and train the GPM locator tool model.

Set Destination Pose

With the robot positioned at the detection position, set the destination position in the vision process setup page.

Setting is executed with the following procedure.



1 Place a workpiece which you want to set the destination pose for, in the camera field of view.
2 Click [SNAP] and then click [FIND] to find the workpiece.
3 Click the [Set] button in [Destination Pose].
4 Confirm that [Status] and [Robot Position] is changed to [Set].

Teach Robot Program

While keeping the target at the position where the destination pose was set, teach the robot program (such as handling paths).

Shown below is an example for executing a calibration-free vision process, and offsetting the robot motion.

```
1:J P[1] 100% FINE
2:   CALL IRVHOMING('NOCAL', 1000)
3:   VISION GET_OFFSET 'NOCAL' VR[1] JMP LBL[10]
4:L P[2] 500mm/sec FINE VOFFSET, VR[1]
```

- Train the detection position at P[1].
- Select the vision program to run in the first argument of IRVHOMING.
- Specify the motion speed (mm/sec) in the second argument of IRVHOMING.

3.5.6 Advanced Mode

In the 2D Calibration-free Vision Process setup page, seldom used items are hidden in order to improve the ease of use for beginners. To display all the items, set the system variable $VP2N_CFG.ADVANCED to TRUE and reopen the vision process. The setup page in this state is called to be in advanced mode.

If an item only shown in advanced mode is changed, the setup page for that particular vision process will be displayed in advanced mode even after reverting the system variable $VP2N_CFG.ADVANCED to FALSE.

The items shown in advanced mode are described below.

[Robot Holding Part]

This is displayed when [Tool Offset] is selected for [Offset Mode]. Select the controller name and the motion group number of the robot holding the workpiece from the drop-down box.

[Sort key]

Found results will be sorted when multiple workpieces are found. On this item, select a parameter to use as the sort key from the drop-down box.

[Sort order]

Found results will be sorted with the selected sort key. On this item, select the sort order used in the sorting from the drop-down box.

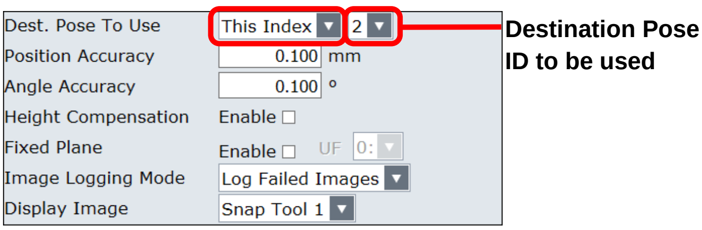
For details of [Sort key] and [Sort order], refer to "Setup: 1.8.14 Sorting".

[Dest. Pose To Use]

Select how to determine the destination pose to use from the drop-down box.

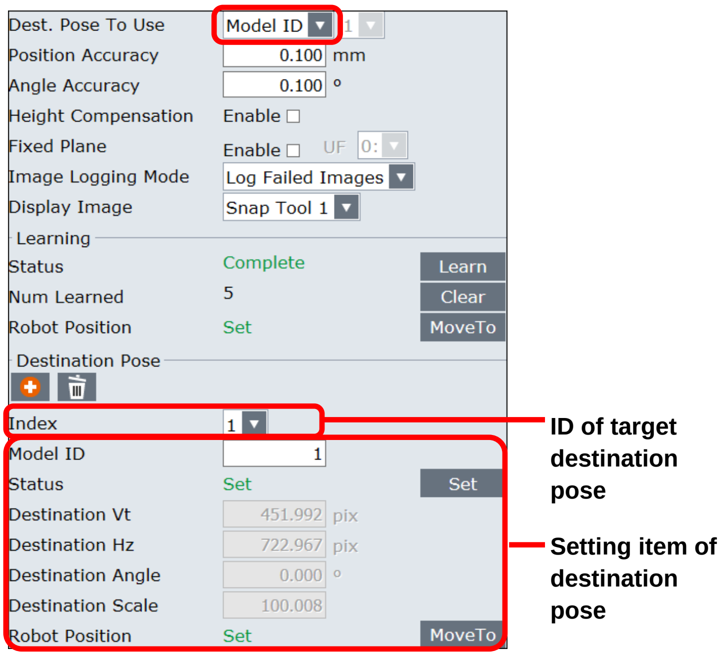
[This Index]

The same destination pose is used. Select [Index] of the destination pose to use from the drop-down box.



[Model ID]

A different destination pose is used depending on the model ID of the found workpiece.



[Fixed Plane]

A plane on which the robot is moved to compensate the found work displacement is called an offset plane. In general, the offset plane is automatically determined with the learning process, but if [Enable] of this item is checked, the offset plane can be fixed to the XY plane of a specific user frame.
If a robot with 5 or less axes is used, this checkbox is checked automatically.

[UF]

When [Fixed Plane] is enabled, select the user frame number to use as the offset plane from the drop-down box.

[Destination Pose]

Information of a destination pose set for each Model ID. Multiple destination poses can be created.

Add a destination pose

The procedure to add a new destination pose is as follows.

1 Click the button.
A new destination pose is added. New Index can be selected from the drop-down box.

Deleting a Destination Pose

The procedure to delete a destination pose is as follows.

1 Select [Index] of the destination pose to delete from the drop-down box.
2 Click the button.
A deletion confirmation message will be displayed.
3 If [OK] is clicked, the selected destination pose is deleted.
If [Cancel] is clicked, the deletion is canceled.

[Index]

Select [Index] of the destination pose to display from the drop-down box.
The setting items of the selected destination pose will be displayed.

[Model ID]

Specify the model ID of the found result to set the destination pose for.

[Destination Vt], [Destination Hz]

The image coordinate values of the set destination pose are displayed.

[Destination Angle]

The destination angle is displayed.

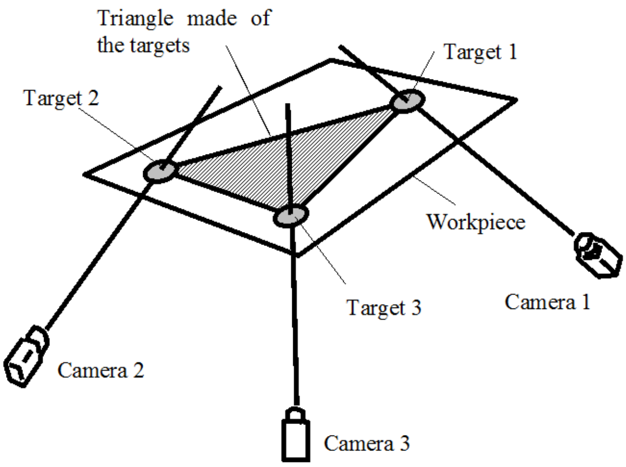
[Destination Scale]

The destination scale is displayed.

3.6 3D TRI-VIEW VISION PROCESS

This vision process detects three parts of a large workpiece, such as a vehicle, by using three cameras, and offsets the robot operation 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.



Gaze from the three cameras to the detection target

In 3-D Tri-View Vision Process, a tool called "Camera View" is positioned under the vision process. One camera view handles one measurement point. The number of camera views is three and cannot be changed.

3.6.1 Application Consideration

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

3.6.1.1 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.

3.6.1.2 Camera position

Camera configuration is carried out in the order "Decide the field of view," "decide the camera positions," and then "decide the lens focal distance."

Determining the camera view

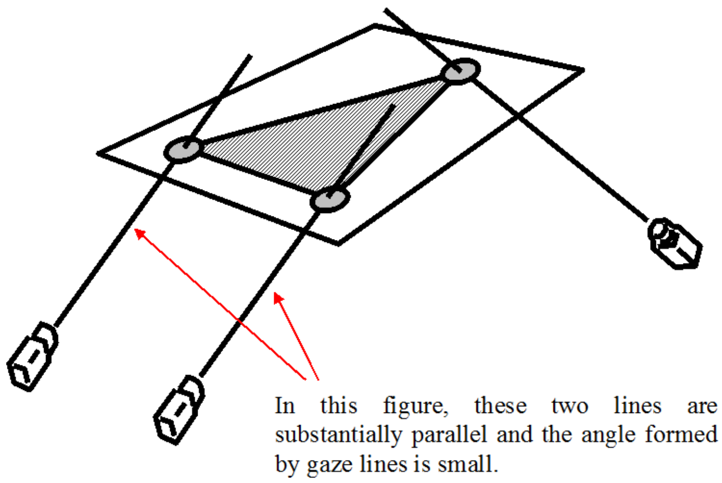
Determine the size of the camera view so that the detection targets stay in the view even if they maximally deviate.

Making the camera view extremely large may make it impossible to ensure the required offset accuracy.

Determining the camera position

With three cameras, the targets are found and three gazes are measured. When you configure the cameras, be careful of the following points.

- Configure the gazes in such a way that no two gazes are close to being parallel.
- We recommend that the angles between the gazes be 60 degrees or more.
  Measurement is possible even if the angle is less than 60 degrees, but the measurement accuracy is better with a larger angle.



Three camera positions

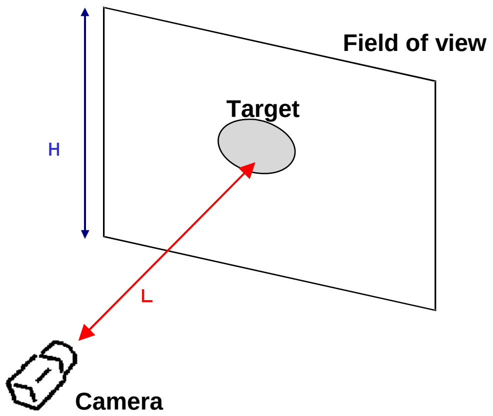
Determining the lens focal distance

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 where the camera is [SC130E2] and the [Binning Level] of Snap Tool is set to "1", the focal distance is calculated by the following equation:

f = 5.43 x L / H

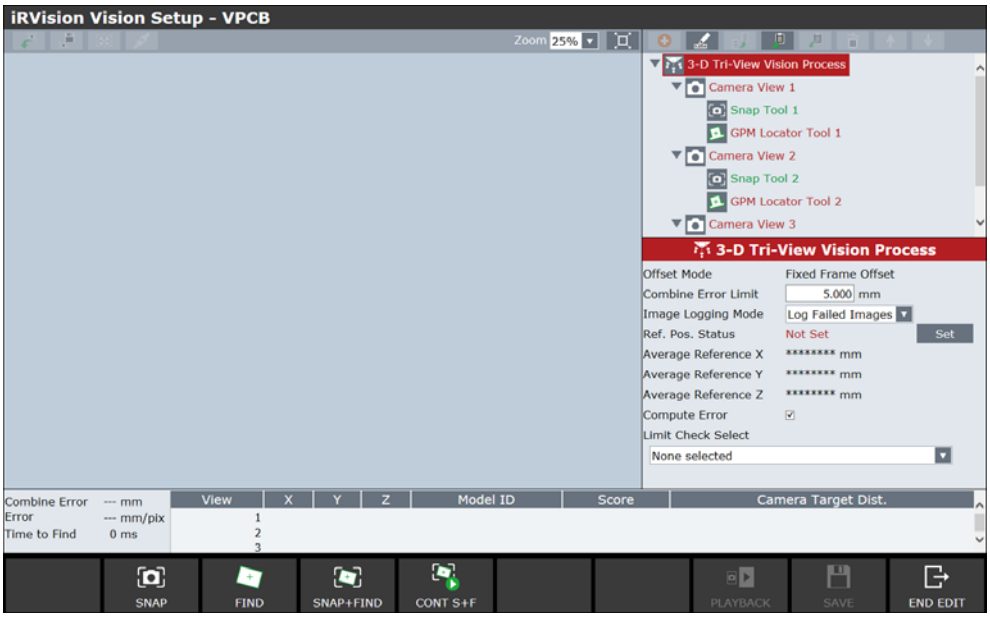
f: Focal distance
L: Distance between the camera and detection target (mm)
H: Size of the camera view (mm)



Lens focal distance

3.6.2 Setting up a Vision Process

If you select the vision process [3-D Tri-View Vision Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

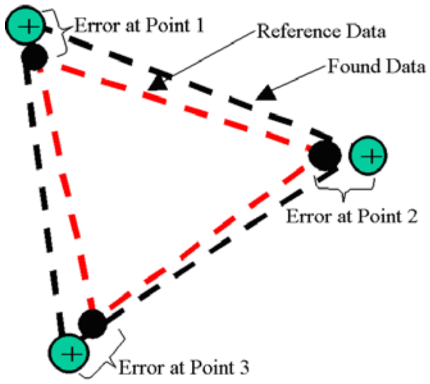
[Offset Mode]

The method of robot position offset operation will be displayed. Only location offset can be made in the 3-D Tri-View Vision Process.
Offset data for the fixed frame offset is calculated.

[Combine Error Limit]

When there is a variation in the distances between measurement points on the workpiece, for example due to individual difference, then the combine error will be produced between the reference positions and the actual positions even if the workpiece is not displaced.

The vision process offsets them so that the fit errors become minimal, but if the calculated combine error is larger than the value specified here, it will be [Not Found].



Combine error between reference data and found data

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**

1. 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
2. You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

[Average ReferenceX], [Average ReferenceY], [Average ReferenceZ]

The average reference calculated from the reference data of each camera view. In 3DS Tri-View Vision Process, offset data is checked using average reference, not the find position of each camera view.

[Compute Error]

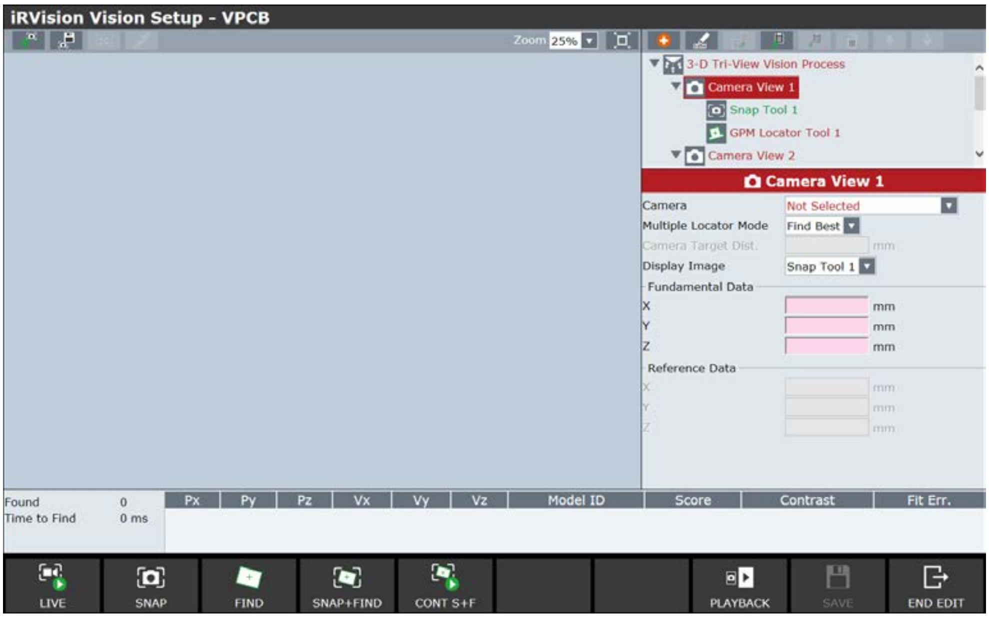
If this checkbox is checked and the detection of the vision process became successful, the detection error in the locator tool on the image is calculated.

[Limit Check Select]

From the drop-down box, select the condition for checking whether a calculated offset 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, refer to "Setup: 5.2 OFFSET LIMIT".

3.6.3 Setting up a Camera View

If you click [Camera view 1] in the tree view on the editing screen for the vision process, the setting items for the camera view will be displayed in the setting items area.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Multiple Locator Mode]

If you have created more than one locator tool, select how to execute those tools from the drop-down box.

[Find Best]

All the locator tools are executed and the found result with the highest score is output. This is used when you give priority to location reliability over 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.
When it is necessary to execute all the locator tools such as sorting the workpiece, select [Find Best].

[Camera Target Dist.]

Enter an approximate distance between the camera and the target to find in text box.
Default is the distance between the camera and the origin of dot pattern jig at the time of calibration.
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.

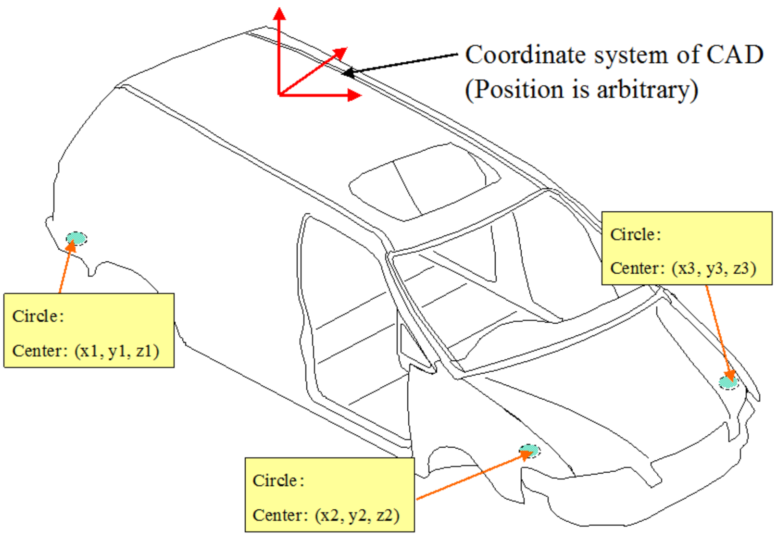
[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

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.



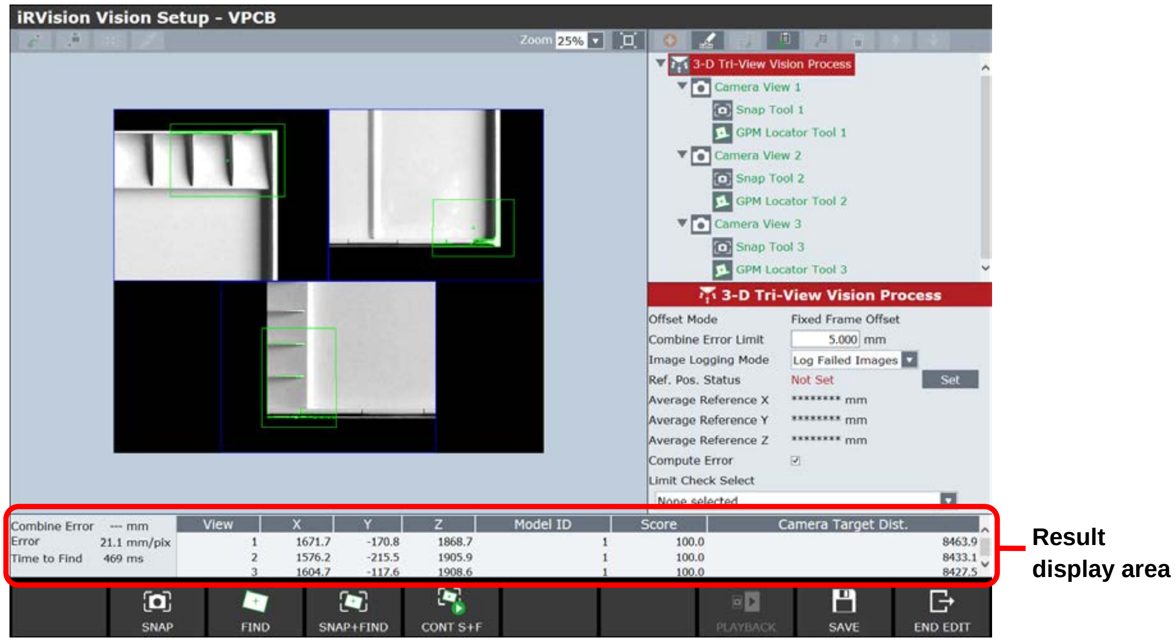
Coordinate value of figure data

Reference Position[X], [Y], [Z]

The coordinate values of the set reference position are displayed.
Coordinates of the model origin of the found target.

3.6.4 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



Perform test runs using the following procedure.

1 Select [Camera View1] in the tree view and click [SNAP].
2 Select [Camera View2] in the tree view and click [SNAP].
At that time, if workpiece is outside the field of the view of camera view 2 in cases of robot-mounted camera or tool offset, move the robot so that the workpiece is within the field of view of the camera.
Repeat the same operation for [Camera View 3].
3 Select [3-D Tri-View Vision Process] from the tree view, and click [FIND].
4 Check that the found results are displayed in the result display area.

If you can find in all camera views without moving the robot, you can find all camera views at the same time by selecting [3-D Tri-View Vision Process] in the tree view and clicking [SNAP+FIND].

After you run a test, the result display area shows the following results:

[Combine Error]

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 x 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.

Also, in the result display area list view, the following values are displayed.

[X], [Y], [Z]

The coordinates of the set reference position are displayed. Coordinates of the model origin of the found target (units: mm).

[Model ID]

Model ID of the found target.

[Score]

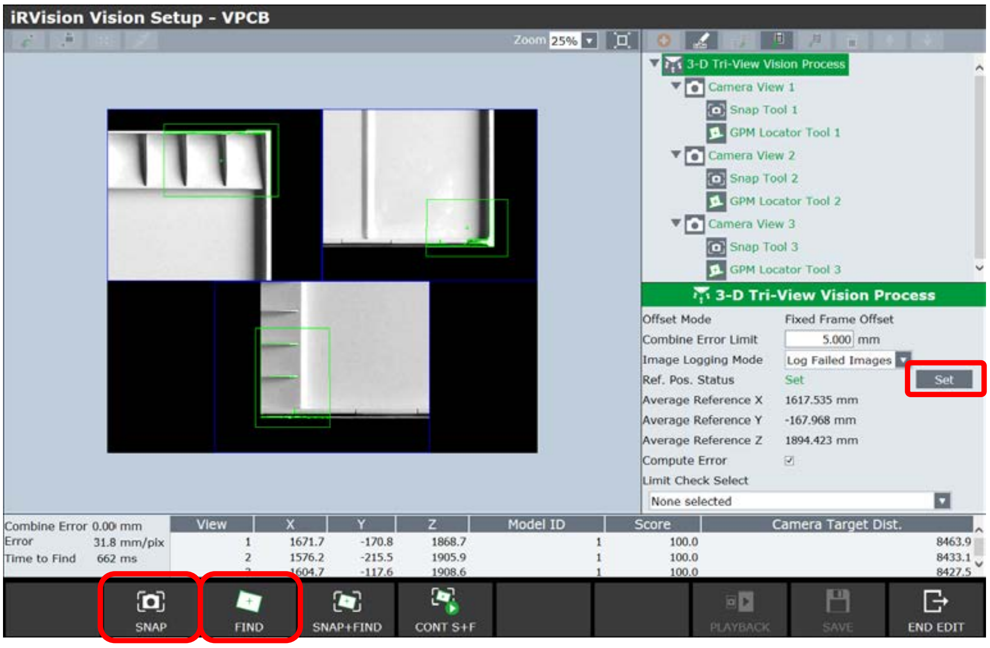
Score of the found workpiece.

[Camera Target Dist.]

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

3.6.5 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.
Position training for the robot is performed using the workpiece when the reference position was set.



Set reference position using the following procedure.

1. Select [Camera View 1] from the tree view, locate 1 workpiece within the camera field of camera view 1, and click [SNAP].
2. Select [Camera View 2] from the tree view and click [SNAP].
   At that time, if workpiece is outside the field of camera view 2 in cases of robot-mounted camera or tool offset, move the robot so that the workpiece is within the field of view of the camera.
   Repeat the same operation for [Camera View 3].
3. Select [3-D Tri-View Vision Process] from the tree view, and click [FIND].
4. Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].

5 Check that values are set for all the reference position items.
6 Leave the workpiece as it is and teach the robot position.

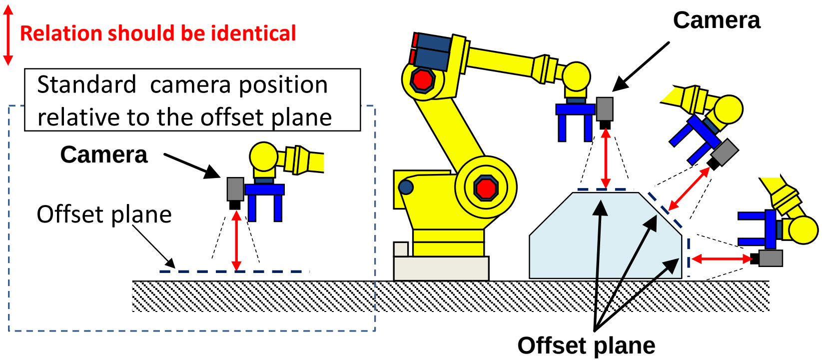
If you can find in all camera views without moving the robot, you can find all camera views at the same time by selecting [3-D Tri-View Vision Process] in the tree view and clicking [SNAP+FIND].

3.7 FLOATING FRAME VISION PROCESS

The Floating Frame Vision Process finds targets with the robot-mounted camera and offsets the robot. By setting the relationship between the offset plane and the camera in advance and carefully keeping it while in measurement, it allows measuring the targets with various robot postures.
This vision process should only be used for special cases as shown in examples below.

Example 1

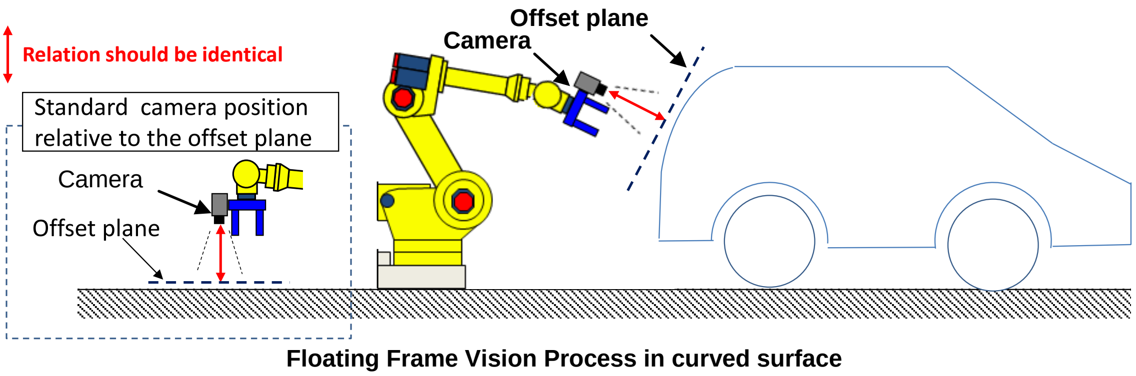
When the same target needs to be measured on multiple planes facing various directions.



Floating Frame Vision Process in different planes

Example 2

When the target is on a curved surface, for example part of a car body, and setting the user frame on it is difficult.



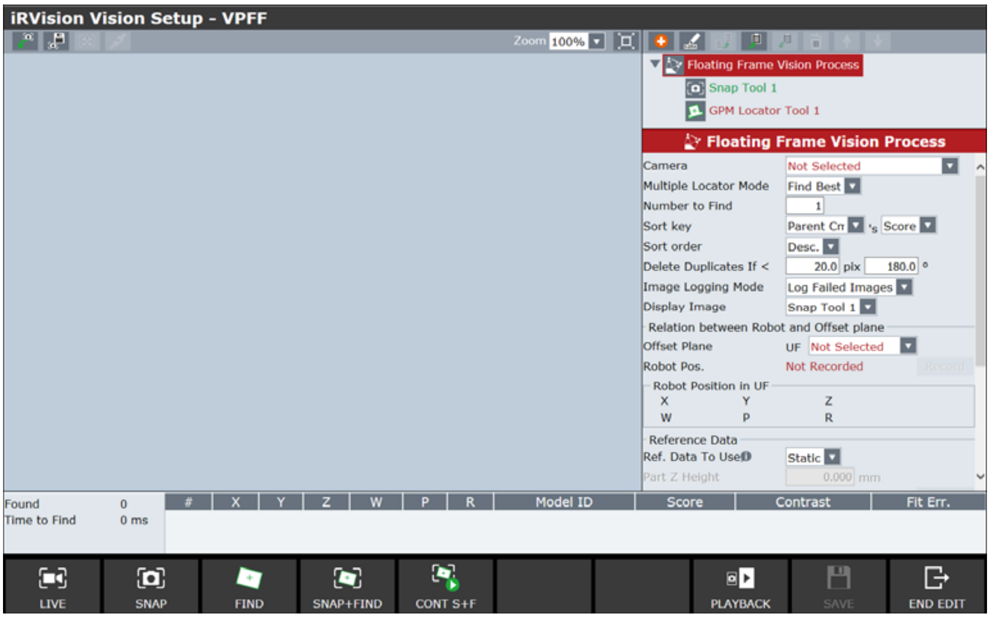
Floating Frame Vision Process in curved surface

⚠ CAUTION

1. For two-dimensional vision application with a robot-mounted camera, usually the 2D Single-view Vision Process described in "Setup: 3.1 2D SINGLE VIEW VISION PROCESS" should be used, because it can offset a robot more accurately and easily than the Floating Frame Vision Process. The Floating Frame Vision Process should be used only for special cases as shown in the examples above.
2. Once the relationship between the offset plane and the camera is set in advance, this vision process assumes that the offset plane moves along together the camera mounted on the robot with keeping the relationship when the robot moves. Therefore, when you teach the robot position for measurement, you should be careful so that the relationship between the actual offset plane, on which the target is, and the camera is exactly identical to the one set in advance. If the relationship is not identical, the robot will not be offset correctly.

3.7.1 Setting up a Vision Process

If you select the vision process of [Floating Frame Vision Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Multiple Locator Mode]

If you have created more than one locator tool, select how to execute those tools from the drop-down box.

[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 reliability before processing time.

[Find First]

The locator tools will be executed sequentially from the top until the specified number of workpieces has been found.
This is used when you give priority to location tool in the upper part of the tree view. When the number of found results reaches the specified number, locator tools will not be executed subsequently so the processing time becomes shorter than using [Find Best].
For your information, the processing of [Delete Duplicates If <] described later is performed every time one locator tool is executed. Here, check the number of found results excluding the duplicates and in cases when it exceeds the specified number, determine whether to run next location tool.

[Number to Find]

Enter the maximum number of workpieces to find per measurement in the text box. The specifiable range is 1 to 100.

[Sort key]

Found results will be sorted when multiple workpieces are found. On this item, select a parameter to use as the sort key from the drop-down box.

[Sort order]

Found results will be sorted with the selected sort key. On this item, select the sort order used in the sorting from the drop-down box.

For details of [Sort key] and [Sort order], refer to "Setup: 1.8.14 Sorting".

[Delete Duplicates If <]

As a type of false detection, the same workpiece may be detected more than once. In such cases, the duplicated found results can be deleted, leaving only the one with the highest score. Specify the threshold with distance and angle on the image and the vision process consider found results are duplicated if they are closer than it.
Enter the thresholds for the distance and the angle difference between found results in the text boxes. If there are multiple found results within the thresholds, the results are assumed to be the same workpiece and only the one with the highest score remains.

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**
> 1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

[Relation between Robot and Offset plane]

Record the relationship between the offset plane and the camera (more specifically, the position of the robot holding the camera). The actual measurement needs to be performed while keeping the relationship recorded in this process.

[Offset Plane]

Select the user frame number from the drop-down box. Select the user frame whose XY plane indicates the offset plane.

[Robot Pos.]

Move the robot so that the camera is in the expected relationship with respect to the XY plane of the user frame selected in [Offset Plane], and record the robot position.

- When the robot position is recorded, [Recorded] is displayed in green.
- When the robot position is not recorded, [Not Recorded] is displayed in red.

[Robot Position in UF]

This is the relationship between the offset plane and the camera.
The position of the robot mechanical interface frame (the robot wrist flange) relative to the user frame selected as the offset plane is displayed.

[Reference Data]

The reference data is used to calculate offset data from the found result.

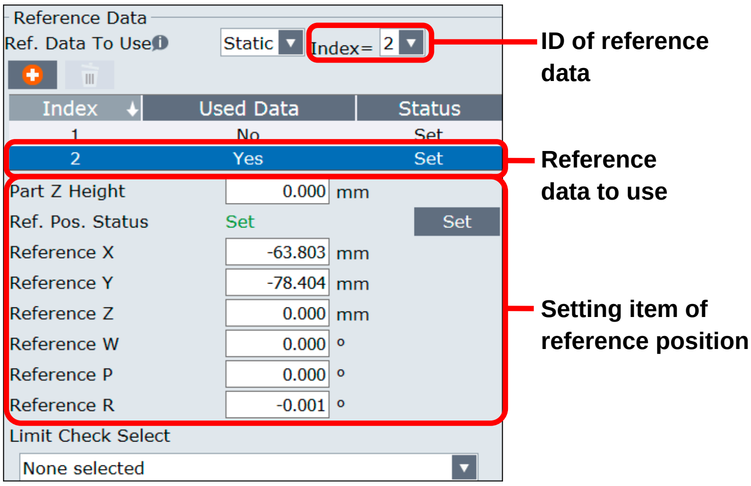
A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used.
However, for example, if there are two types of target, each having a different height, the vision process uses two sets of reference data because it needs to set a different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

[Ref. Data To Use]

Select how to determine the reference data to use from the drop-down box.

[Static]

The same reference data is used to calculate the offset data.
When the vision process has multiple reference data, the following table is displayed. Select [Index] of the reference data to use from the drop-down box.

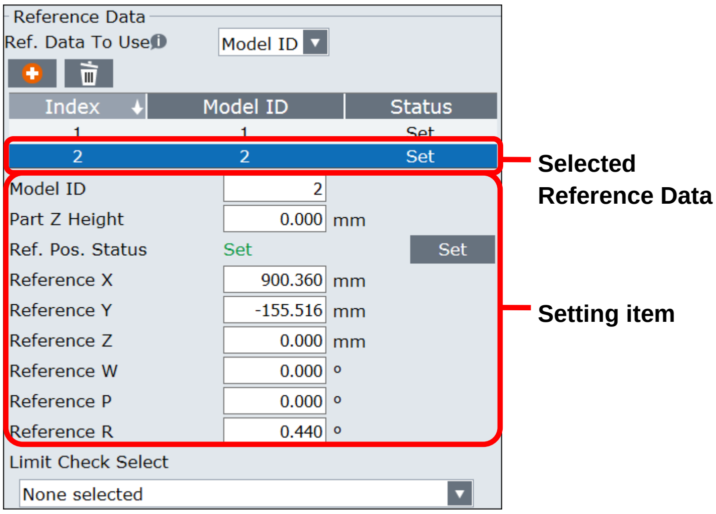


MEMO

When [Static] is selected and the vision process has only a single reference data, the reference data table is not displayed.

[Model ID]

Different reference data is used depending on the model ID of the found target. Choose this in such cases as when there are two or more types of target having different heights.
If the row of Index to use in the reference data table is selected, values are displayed in the reference position setting items.



Adding and setting reference data

The procedure to add and set reference data is as follows.

1 Click the button.
Reference data is added to the table and new Index is assigned.

2 Set the reference position. For details, refer to "Setup: 3.7.3 Setting the Reference Position".
When [Static] is selected, the reference position of the reference data selected in [Index] is to be set.
When [Model ID] is selected, the reference position of the reference data selected in the table is to be set.

3 If reference position setting is performed, [Status] of the reference data table will change to [Set].

Deleting reference data

The procedure to delete reference data is as follows.

1 Select the reference data to delete in the reference data table.
2 Click the button.
A deletion confirmation message will be displayed.
3 Click [OK].
The reference data selected in procedure 1 is deleted.
If the [Cancel] button is clicked, delete is canceled.

MEMO
The reference data in use cannot be deleted when [Static] is selected.

[Model ID]

This is displayed when [Model ID] is selected for [Ref. Data To Use]. Model ID is the number assigned to the workpiece found.

[Part Z Height]

Enter the height of the target to be detected with respect to the offset plane.

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

The reference position is the position of the workpiece when robot positions are trained. The offset data is the difference between the actual position found at runtime and the reference position.

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

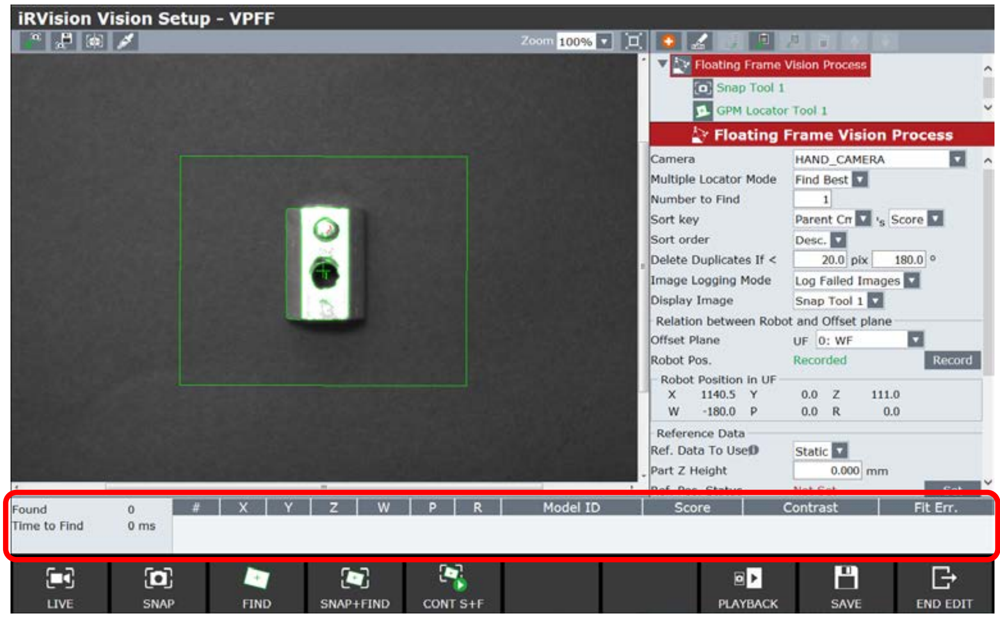
The coordinate values of the set reference position are displayed.
Frame values on the user frame specified in [Offset Plane].

[Limit Check Select]

From the drop-down box, select the condition used to check whether the calculated offset value is within the specified range.
By default, [None selected] is selected and the offset limit check is not performed.
For information about the offset limit check conditions, refer to "Setup: 5.2 OFFSET LIMIT".

3.7.2 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



Result display area

After you run a test, the result display area shows the following results:

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the vision process took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[X], [Y], [Z]

The frame values of the model origin of the found workpiece (Frame values on the user frame specified in Offset plane). The units are millimeters.

[W], [P], [R]

Rotation angle of the found target around the X, Y and Z axis of the user frame selected as the offset plane (units: degrees).

[Model ID]

Model ID of the found target.

[Score]

Score of the found workpiece.

[Contrast]

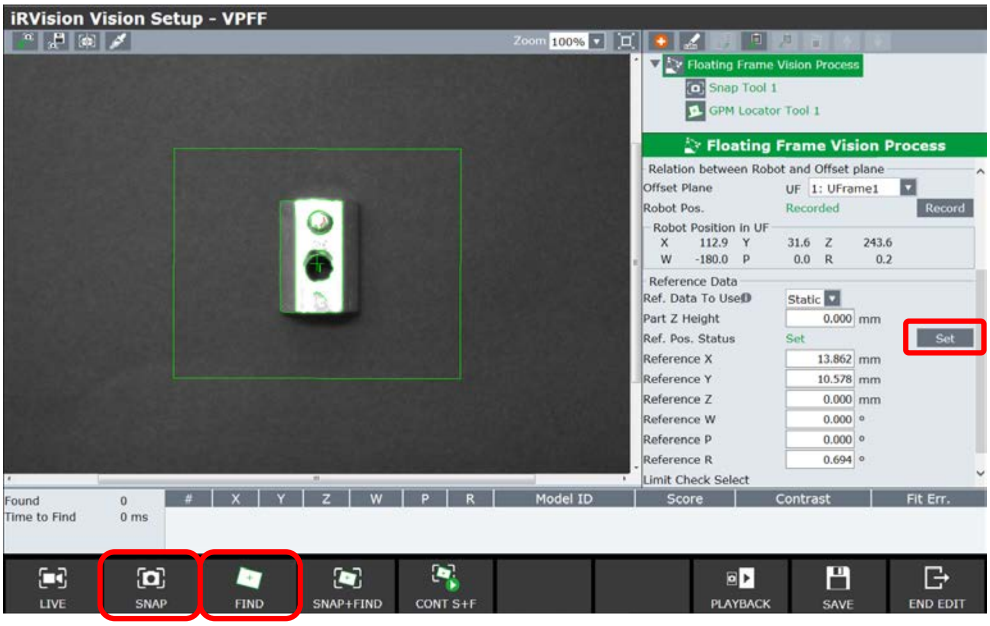
Contrast of the found workpiece.

[Fit Err]

Elasticity of the found workpiece (units: pixels).

3.7.3 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.
Teaching the robot position is performed when the workpiece is located at the reference position.



Set reference position using the following procedure.

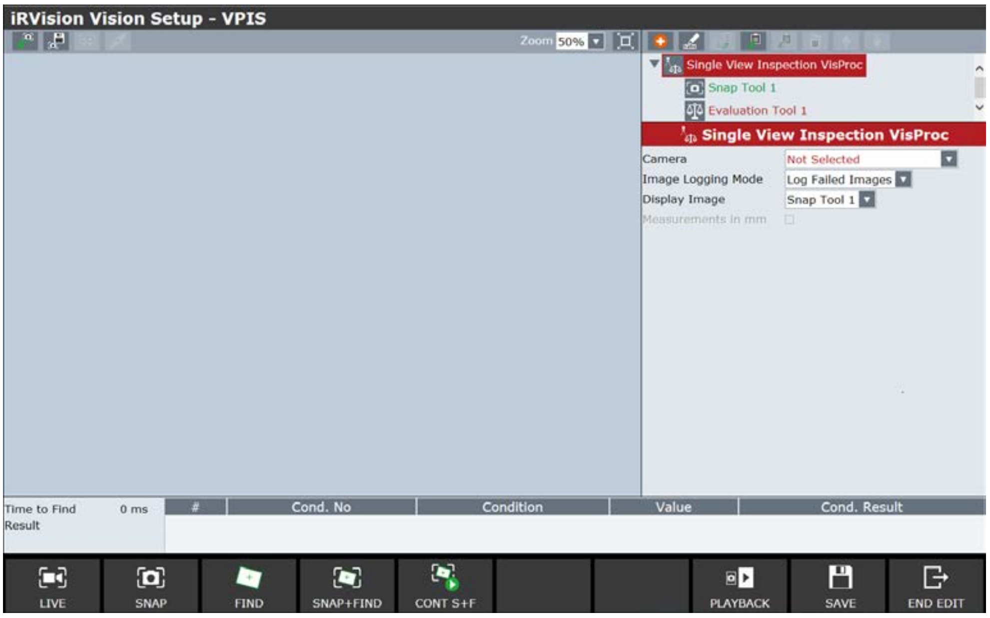
1 Place a workpiece in the camera field of view and click [SNAP].
2 Click [FIND] and find the workpiece.
3 Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].
4 Check that values are set for all the reference position items.
5 Leave the workpiece as it is and teach the robot position.

3.8 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.

3.8.1 Setting up a Vision Process

If you select the vision process of [Single View Inspection VisProc] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[Do Not Log]
Do not save any images to the vision log.

[Log Failed Images]
Save logged images when the result is [fail] or [Undetermined].

[Log All Images]
Save all images.

> ⚠ **CAUTION**
> 1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".
For measurement plane information, refer to "Setup: 3.8.2 Setting a Measurement Plane".

3.8.2 Setting a Measurement Plane

In a single view inspection vision process, evaluation is carried out in pixels by default but it can be carried out in millimeters if the measurement plane is set.

To convert length into millimeters, mount the calibration grid at the same height as and parallel to the measurement plane, snap the calibration grid with the camera, and set the measurement plane information.

[Grid Spacing]

Enter in the text box the spacing between grid points on the calibration grid used. The units are millimeters.

[Override Focal Dist.]

Select [Yes] and input in the text box the nominal focal distance of the lens. The units are 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.

[Scale Conversion]

It indicates the conversion factor between one pixel on the image and the length in millimeters on the measurement plane. The units are millimeters/pixels.

The procedure to snap an image of the calibration grid and train the measurement plane is as follows.

1. Click [SNAP].
2. Click the [Train] button of [Scale Conversion].
   The reddish purple rectangle window (measurement area) is displayed.
3. Adjust the 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 reddish purple rectangle is set to the full screen mode.
4. Click [OK].
   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].

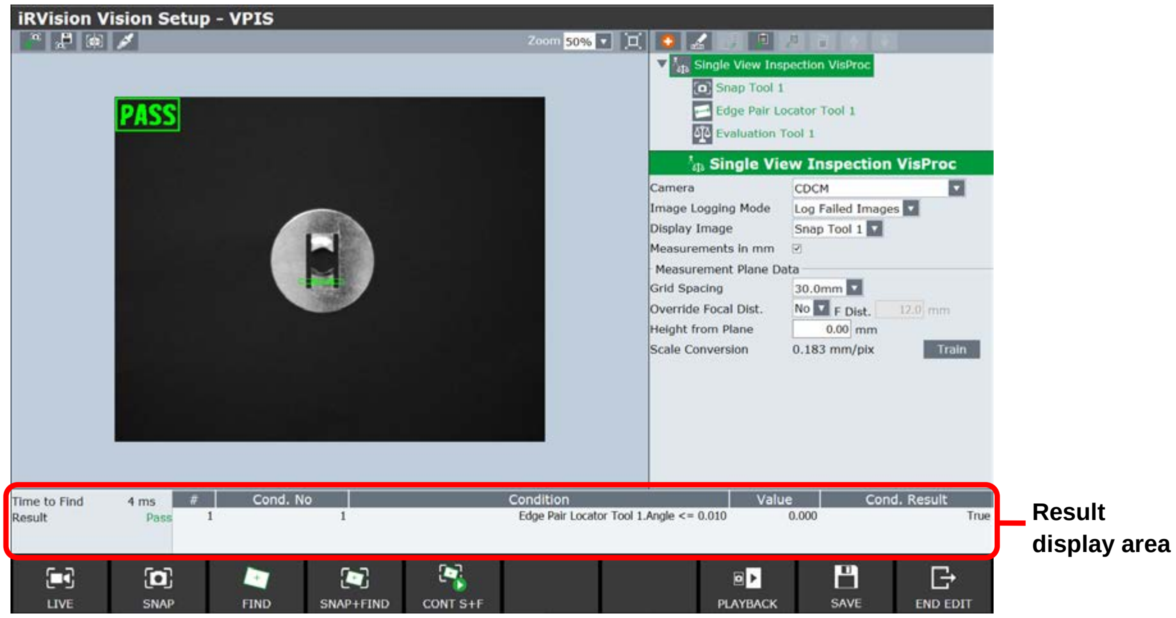
MEMO
When there is lens distortion or the camera optical axis is not perpendicular to the measurement plane, the scale is not even in the image. So the shown scale is the "average value."

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-trained, these command tools may need to be trained again as necessary.

CAUTION
When the measurement plane is trained after command tools had been trained, we recommend to re-train those command tools that have measurement values subjected to millimeter conversion.

3.8.3 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

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

[Result]
The result of the single view inspection is displayed.

Also, in the result display area list view, the following values are displayed.

[Cond. No]
Number of the conditional expression.

[Condition]
Conditional expression that is set.

[Value]

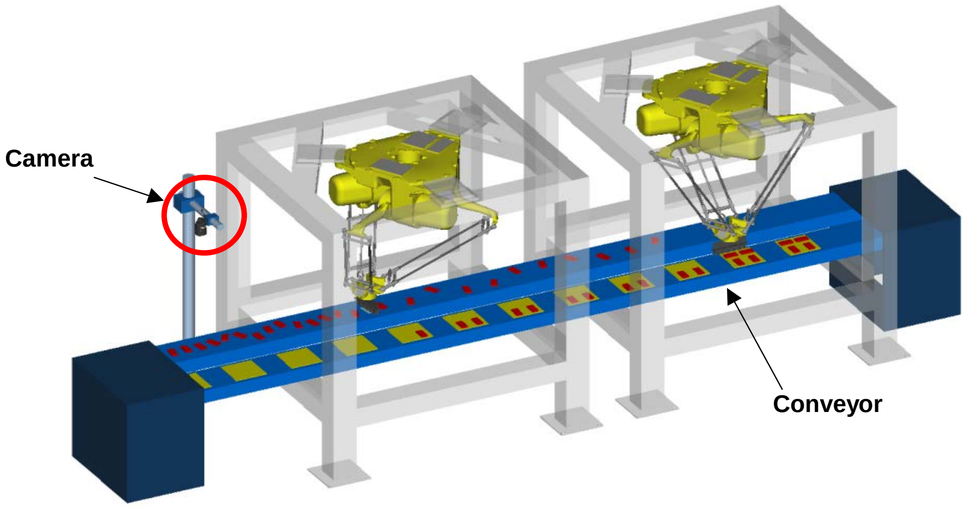
Evaluation target value evaluated with the conditional expression.

[Cond. Result]

Evaluation result of the conditional expression.

3.9 SINGLE VIEW VISUAL TRACKING

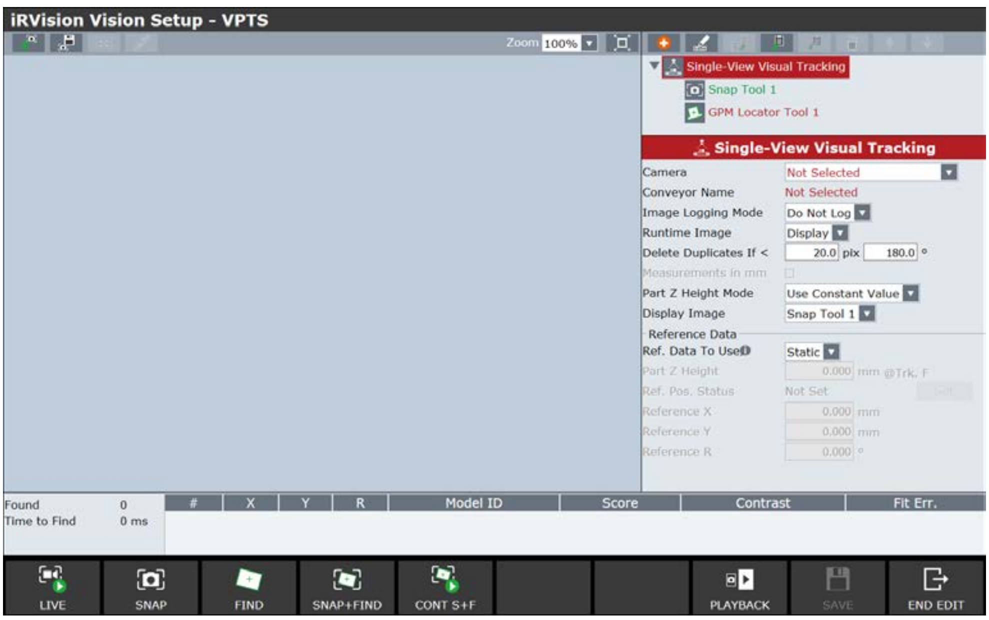
This is a vision process to perform robot position offset operation that finds a workpiece being carried on a conveyor with a single camera and detects the two dimensional position of the workpiece without stopping the conveyor.



2D position compensation of workpiece on the conveyor

3.9.1 Setting up a Vision Process

If you select the vision process of [Single-View Visual Tracking] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Conveyor Name]

The name of the Conveyor set in the selected camera data is displayed.
For the Conveyor, refer to "R-30*i*B Plus CONTROLLER *i*RPickTool OPERATOR'S MANUAL".

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

MEMO

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

1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Runtime Image]

Select a display method for the runtime display in the drop-down box.
Since displaying an image on the runtime monitor takes time, choose an option as appropriate for the system's tracking time requirement.

[Display]

The image will be displayed on the runtime monitor.

[Don't Display]

No image will be displayed on the runtime monitor. Runtime for the vision process become fastest.

[Delete Duplicates If <]

As a type of false detection, the same workpiece may be detected more than once. In such cases, the duplicated found results can be deleted, leaving only the one with the highest score. Specify the threshold with distance and angle on the image and the vision process consider found results are duplicated if they are closer than it.
Enter the thresholds for the distance and the angle difference between found results in the text boxes. If there are multiple found results within the thresholds, the results are assumed to be the same workpiece and only the one with the highest score remains.

[Measurements in mm]

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

The following measurement values will be converted to millimeters:

BLOB LOCATOR TOOL

Area, perimeter, semi-minor, semi-major

[Part Z Height Mode]

Select specification method of [Part Z Height] to specify in reference data from the drop-down box.

[Use Constant Value]

Enter the height (value) of the target to be detected in [Part Z Height].

[Use Register Value]

Specify the register number for the [Part Z Height].

[Reference Data]

The reference data is used to calculate offset data from the found result.

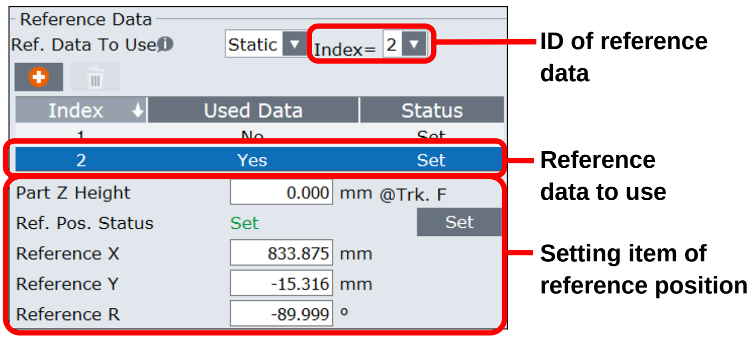
A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used.
However, for example, if there are two types of workpieces being carried on the conveyor, each having a different height, the vision process uses two sets of reference data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

[Ref. Data To Use]

Select how to determine the reference data to use from the drop-down box.

[Static]

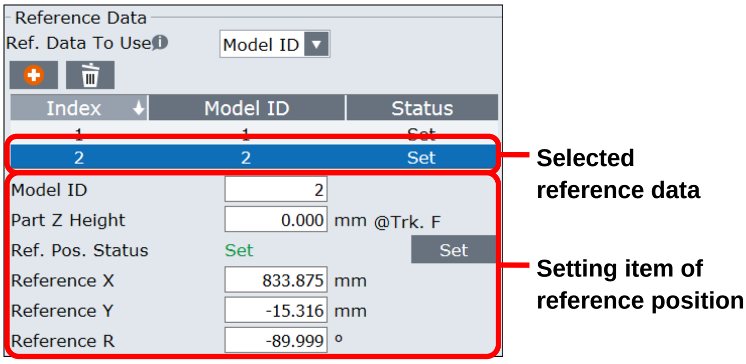
The same reference data is used to calculate the offset data.
When the vision process has multiple reference data, the following table is displayed. Select [Index] of the reference data to use from the drop-down box.



> **MEMO**
> When [Static] is selected and the vision process has only a single reference data, the reference data table is not displayed.

[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. The values of the reference data selected on the reference data list are displayed in the reference position setting items.



Adding and setting reference data

The procedure to add and set reference data is as follows.

1 Click the button.
Reference data is added to the table and new Index is assigned.
2 Set the reference position. For details, refer to "Setup: 3.9.3 Setting the Reference Position".
When [Static] is selected, the reference position of the reference data selected in [Index] is to be set.
When [Model ID] is selected, the reference position of the reference data selected in the table is to be set.
3 If reference position setting is performed, [Status] of the reference data table will change to [Set].

Deleting reference data

The procedure to delete reference data is as follows.

1 Select the reference data to delete in the reference data table.
2 Click the button.
A deletion confirmation message will be displayed.
3 If the [OK] button is clicked, the reference data selected in procedure 1 is deleted.
If the [Cancel] button is clicked, delete is canceled.

> **MEMO**
> ID in use cannot be deleted, if [Static] is selected for [Ref. Data To Use].

[Model ID]

This is displayed when [Model ID] is selected for [Ref. Data To Use]. Model ID is the number assigned to the workpiece found.

[Part Z Height]

Enter the height of the target to be detected in the text box
When selecting [Use Constant Value] in [Part Z Height Mode], enter the height of the target.
When selecting [Use Register Value] in [Part Z Height Mode], enter an R number.

> ⚠ **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]

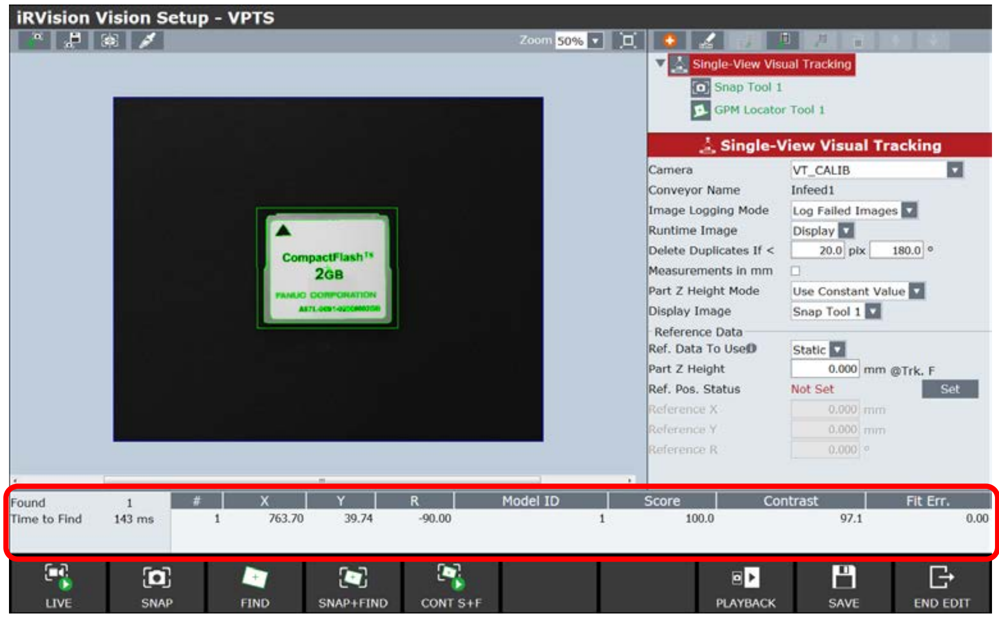
Displays the setting statuses of the reference position.
When the reference position is set, [Set] is displayed in green.
When the reference position is not set, [Not set] is displayed in red.

[Reference X], [Reference Y], [Reference R]

The coordinate values of the set reference position are displayed.

3.9.2 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



Result display area

After you run a test, the result display area shows the following results:

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the vision process took is displayed in milliseconds.

Also, in the result display area list view, 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 target.

[Score]

Score of the found workpiece.

[Contrast]

Contrast of the found workpiece.

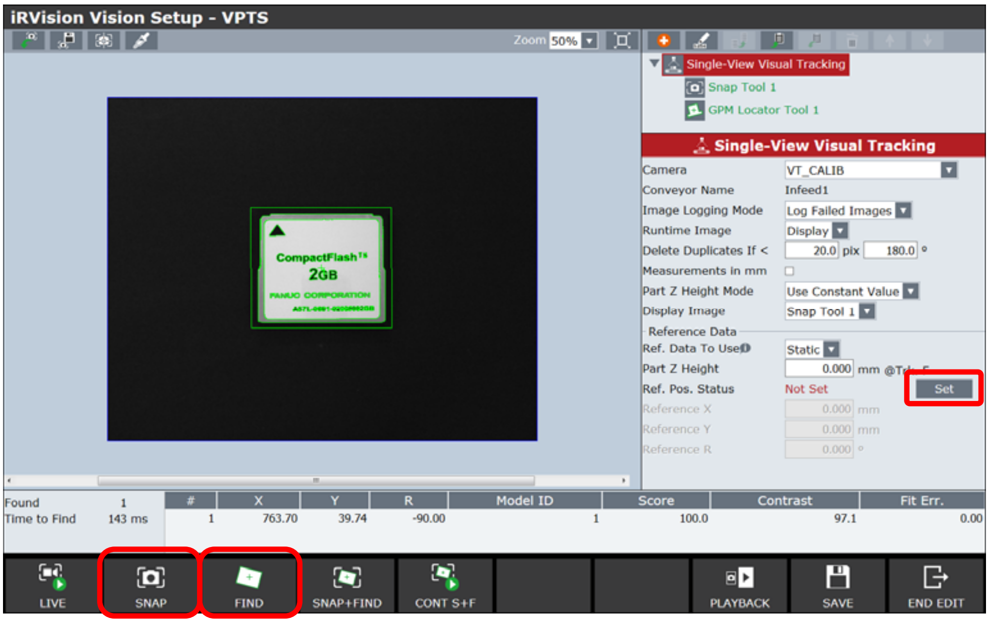
[Fit Err]

Elasticity of the found workpiece (units: pixels).

3.9.3 Setting the Reference Position

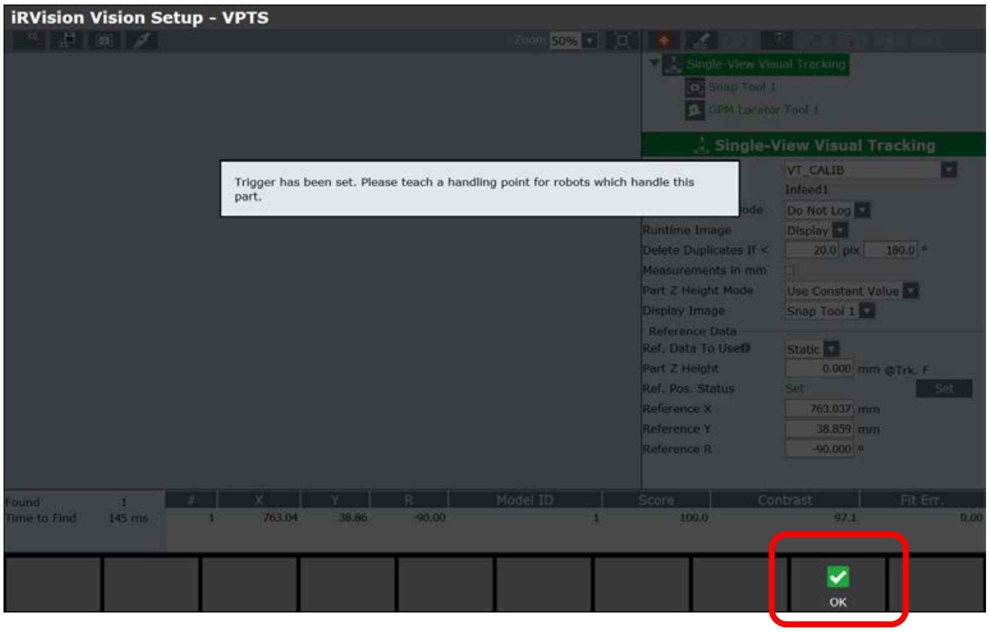
Set the reference position.
The offset value is calculated based on the relationship between the reference position you set here and the found position.
The encoder value of the conveyor at the time of the reference position setting is set as the trigger value (count) of the tracking for each robot on the conveyor.

> **MEMO**
> If you use *i*RPickTool, you can configure the reference position by using the Reference Position Guide. In this case, you need not to configure the reference position with the vision program.



Set up a reference position using the following procedure.

1. Place a workpiece within the camera's field of view and click [SNAP].
2. Click [FIND] and find the workpiece.
3. Click the [Set] button in the [Ref. Pos. Status].
   When the reference position is set, the following message appears.



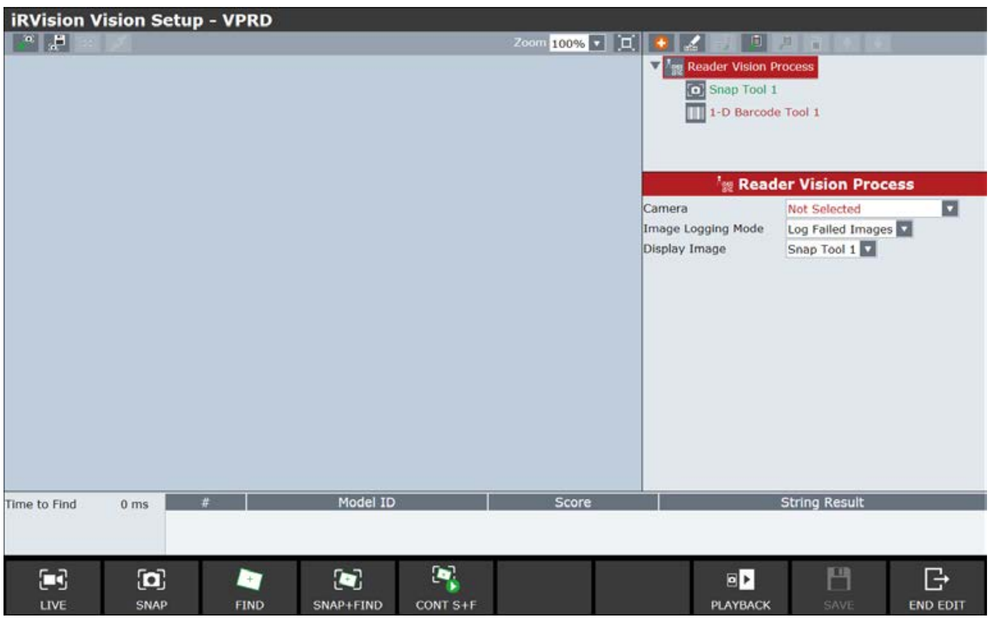
4 Check the message, and click [OK].
5 Confirm that [Ref. Pos. Status] is changed to [Set].
6 Run the conveyor without touching the workpiece on it until the workpiece comes in front of a robot, and perform teaching of the robot position. If there are multiple robots on the conveyor, teach the position from the first robot on the conveyor.

3.10 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.

3.10.1 Setting up a Vision Process

If you select the vision process of [Reader Vision Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Camera]

Select a camera data to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Image Logging Mode]

From the drop-down box, select whether you will store logged images during the process in execution. Note that when the vision log is disabled on the Vision Config page, images are not saved.

[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**

1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.

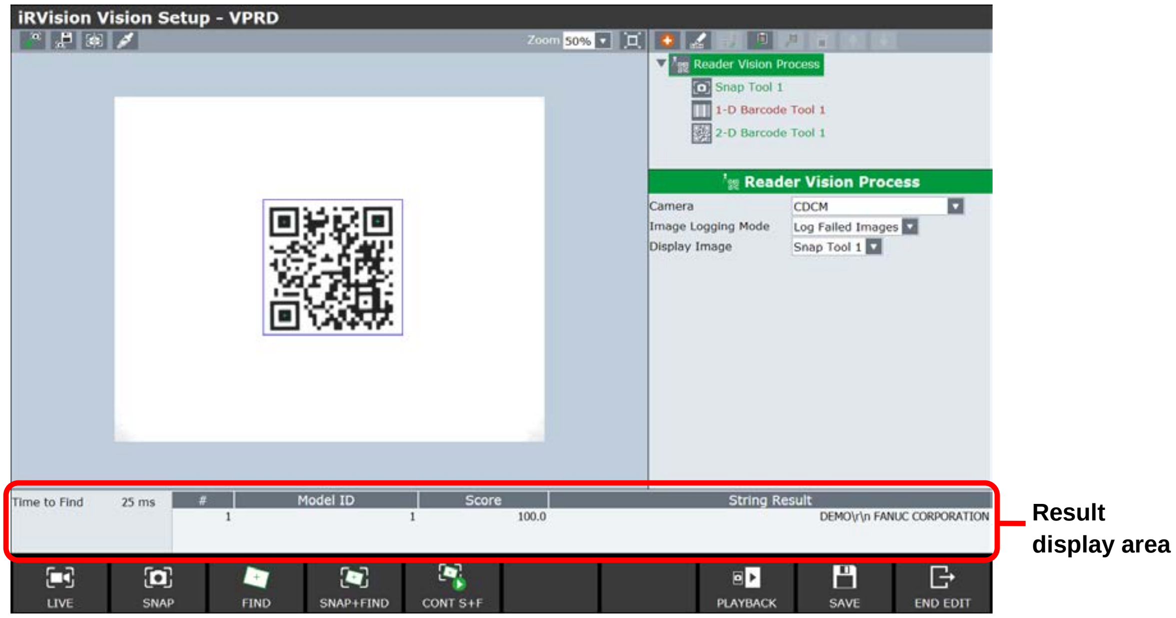
2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.
For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

3.10.2 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

[Time to Find]

The time the vision process took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[Model ID]

Model ID of the found barcode.

[Score]

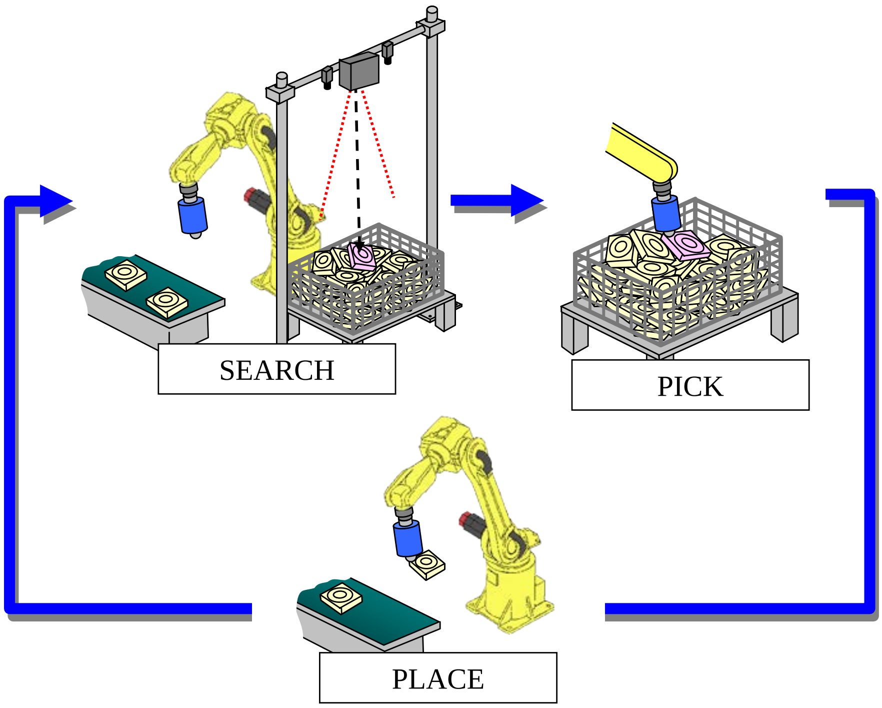
Score of the found barcode.

[String Result]

String of the found barcode.

3.11 3D AREA SENSOR VISION PROCESS

This is a vision program that detects the three-dimensional position of the workpiece with a single 3D Area Sensor, and offset the robot motion.
Workpieces are detected with the 3D Area Sensor mounted on a camera stand (SEARCH) and are picked up by the robot.

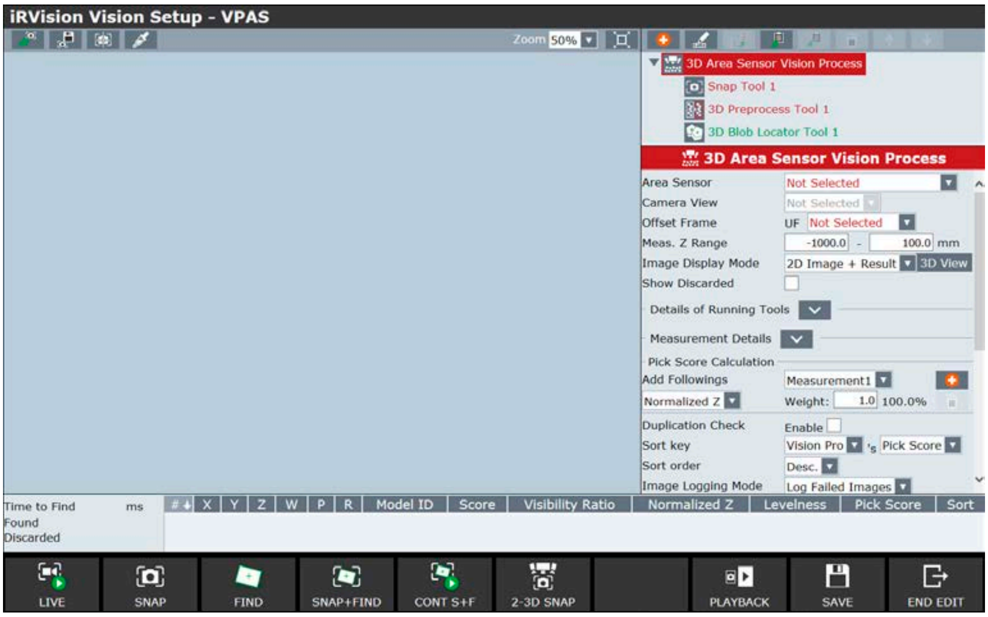


Process flow

For details of Bin Picking System with 3D Area Sensor, refer to "R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL".

3.11.1 Setting up a Vision Process

If you select the vision process of [3D Area Sensor Vision Process] on the vision data list screen and click [Edit], the following edit screen for the vision process will be displayed.



The setting items area has the following parameters.

[Area Sensor]

Select a 3D Area Sensor to use from the drop-down box.

Settings related to image acquisition, such as the snap window and the exposure mode, will be set in the snap tool setup page. For details, refer to "Setup: 4.1 SNAP TOOL".

[Camera View]

Select a camera view to use from the drop-down box. Specify either camera view that corresponds to each of 2 cameras that compose a 3D Area Sensor. Snap an image by the camera with the specified view number.

[Offset Frame]

Specify a user frame number. A 3D area sensor vision process measures the offset data with respect to this specified user frame.

[Meas. Z Range]

Specify the range of Z-direction to acquire a 3D map. Enter the upper and lower limits of the range of Z-direction in the text-box. The units are millimeters. Set the value in the frame specified at [Offset Frame].
When changing [Meas. Z Range], [Image Display Mode] described later shifts to [3DMap]. We recommend that a value is adjusted as checking the 3D map.

[Image Display Mode]

Select the image display mode for the Setup Page.

[2D Image + Points]

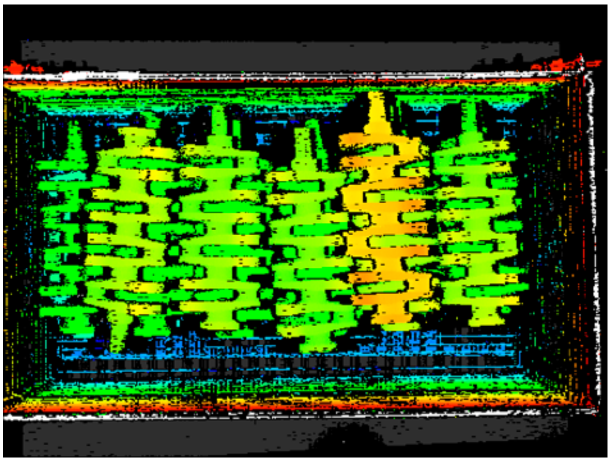
Display the acquired 3D points on the image snapped by the camera.

[2D Image + Result]

Display the found results on the image snapped by the camera.

[3DMap]

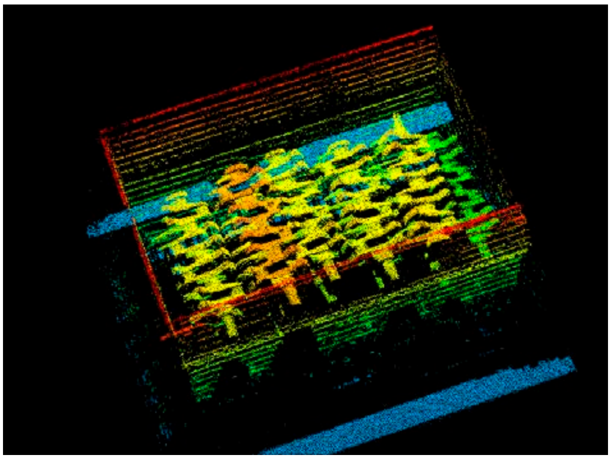
Display the acquired range image of the 3D map as follows.



In [Meas. Z Range], 3D points with higher Z are displayed in redder and 3D points with lower Z are displayed in bluer.
3D points with higher Z than the upper limit of [Meas. Z Range] are displayed in white and 3D points with lower Z than the lower limit of [Meas. Z Range] are displayed in gray.
3D points that have not been acquired are displayed in black.

[3D View] button

The acquired 3D map is displayed as 3D graphics in other window as follows.



MEMO
The acquired 3D map is displayed as 3D graphics in cases of the Internet Explorer 11 only.

[Show Discarded]

A 3D Area Sensor Vision Process selects results to be output from the found results of the command tools.
When this checkbox is checked, discarded results are displayed in image display. Results of command tools can be discarded by duplication or visibility threshold.

[Details of Running Tools]

Clicking the [∨] button shows the detail setting items related to the running tools. Clicking the [∧] button hides the detail setting items related to the running tools.

The following items will appear as the detail setting items related to the running tools.

[Multiple 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 reliability before processing time.

[Find First]

The locator tools will be executed sequentially from the top until the specified number of workpieces has been found.
This is used when you give priority to location tool in the upper part of the tree view. When the number of found results reaches the specified number, locator tools will not be executed subsequently so the processing time becomes shorter than using [Find Best].
For your information, the processing of [Duplication Check] described later is performed every time one locator tool is executed. Here, check the number of found results excluding the duplicates and if it exceeds the specified number, determine whether to run next location tool.

[Number to Find]

Enter the maximum number of workpieces to find per measurement in the text box. The specifiable range is 1 to 100.

[Interval]

Specify an interval for judging for spatial duplication check and visibility calculation.
[Auto] is checked by default. Setting does not need to be changed except the cases where a fine adjustment is required.

The setting item becomes enabled in one of the following cases:

- There are the 3D One-Sight-Model Locator Tool, 3D Cylinder Locator Tool and 3D Box Locator Tool as child tools of the Vision Process.
- There is the 3D Plane Measurement Tool as the child tool of the GPM locator Tool.

However, when selecting [Find First] in [Multiple Locator Mode], this setting becomes disabled because duplication ratio and visibility ratio are not calculated.

When [Auto] is checked, an interval is automatically calculated from a 3D map. When setting manually, uncheck [Auto] and enter the interval in the text box displayed on the right. The units are millimeters.
A smaller value can get finer check result but take much longer time. If this value is smaller than an interval between the points in a 3D map, the check result becomes inaccurate.

[Combination Optimization]

Set whether to perform combination optimization for found results. For combination optimization, this vision process selects found results to make the duplication smaller and matching area larger.
[Calc.] is checked by default.

The setting item becomes enabled in the following cases:

- There are the 3D One-Sight-Model Locator Tool, 3D Cylinder Locator Tool and 3D Box Locator Tool as child tools of the Vision Process.
- There is the 3D Plane Measurement Tool as the child tool of the GPM Locator Tool.

[Max. Dup. Ratio]

This will appear when [Calc.] is checked in [Combination Optimization].
This vision process selects results of detections to make the duplication smaller and matching area larger. The matching area means area where 3D model matches to 3D points. The ratio of duplication to matching area is calculated as duplication ratio. If the duplication ratio exceeds this threshold the result is discarded.

[Measurement Details]

Clicking the [ ] button shows the detail setting items of the measurement calculated by a 3D Area Sensor Vision Process. Clicking the [ ] button hides the detailed setting items of the measurement.

The following items will appear as the detail setting items related to the measurements.

[Visibility Ratio]

A visibility ratio is a ratio of the area where other objects do not exist above the found workpiece using their 3D models and the 3D Data. They are expressed using values of 0 to 100. The probability of succeeding in picking is generally higher when a visibility ratio is higher.
Check [Threshold], enter the threshold in the text box, and a found result with a smaller visibility ratio than the specified threshold is discarded. When [Measurement] is selected from the drop-down box of the [Output], a visibility ratio is output to selected measurement.
A visibility ratio can be calculated only by the following tools having workpiece model.

- 3D Cylinder Locator Tool
- 3D Box Locator Tool
- 3D One-Sight-Model Locator Tool
- 3D Plane Measurement Tool

For tools other than tools written above such as a 3D Blob Locator Tool, a visibility ratio is always output as 100.0.

[Normalized Z]

Normalized Z is the relative Z height of the found results against the Z range specified in the [Meas. Z Range]. They are expressed using values of 0 to 100.
Check [Threshold], enter the threshold in the text box, and a found result with a smaller threshold than the normalized Z is discarded. When [Measurement] is selected from the drop-down box of the [Output], a normalized Z is output to selected measurement.

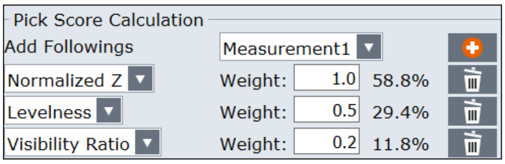
[Levelness]

Levelness is ratio of inclination of found results. When a found result is horizontal to offset frame, "100.0" is output. When it inclines at 90.0 degrees, "0.0" is output. The probability of succeeding in picking is generally higher when levelness is bigger.
Check [Threshold], enter the threshold in the text box, and a found result with a smaller threshold than the levelness is discarded. When [Measurement] is selected from the drop-down box of the [Output], levelness is output to selected measurement.
There are tools in the command tools such as the 3D Peak Locator Tool that do not calculate inclination. For such tools, levelness of found results is always output as 100.0.

[Pick Score Calculation]

Using weighted sum of up to 5 measurement values, set a pick score so that the found result that is most easily picked up has the highest score.

Select the type of measurement to use for calculation of a pick score from the drop-down box and enter [Weight] into the text box.
In cases of increasing measurement for operation, click the button. In cases of deleting unnecessary measurement, click the button.
When measurement is increased, a screen example is as follows.



A normalized Z is set at weight 1 by default, and there is often no problem with such setting basically. We recommend that the measurements for pick score are added in accordance with the following policy when the system is actually running.

- When you want to give priority to found results with higher scores calculated by the command tools, add [Score].
- When you want to give priority to found results that the other objects do not exist above the found results, add [Visibility Ratio].
- When you want to give priority to found results that are inclines as less as possible, add [Levelness].

[Add Followings]

Select measurement for outputting operation results of a pick score from the drop-down box.

[Duplication Check]

In cases where positions and angles of two found results are closer than that of specified threshold, the duplicate check discards one of the found results. As one type of find failure, same workpiece may be detected more than once. In such cases, use of the duplicate check prevents from outputting multiple found results for one workpiece.

When checking [Enable], the duplicate check becomes enabled and setting items of the duplicate check will appear.

[Delete Duplicates If <]

The position and angle of each found result on the camera image 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 most reliable result is output.

[Dup. Check Key]

Select the key for the duplication check. If there are multiple found results with in the specified pixels and angle, the result of that the selected key value is the highest or lowest in these found results is output.

- Pick Score
- Score
- Normalized Z
- Visibility Ratio
- Levelness
- Measurement1 - Measurement10

This will appear when [Enable] is checked in [Duplication Check].

[Dup. Check Order]

Specify the order of the duplication check. If you select the [Score] in the [Dup. Check Key], the Remove Low Result] is automatically specified.

[Remove Low Result]

The result of that the selected key value is the highest in the found results with in the specified pixels and angle is output.

[Remove High Result]

The result of that the selected key value is the lowest in the found results with in the specified pixels and angle is output.

This will appear when [Enable] is checked in [Duplication Check].

[Sort key]

Found results will be sorted with the selected sort key.
By default, [Pick Score] of [Vision Process Level] has been selected. Basically, any setting change is not necessary.

[Sort order]

Sort the found results using the parameter selected with [Sort key]. On this item, select the sort order used in the sorting from the drop-down box.

For details of [Sort key] and [Sort order], refer to "Setup: 1.8.14 Sorting".

[Image Logging Mode]

Specify whether to save 2D image and 3D map to the vision log when running the vision process from the drop-down box.
Note that when the vision log is disabled on the Vision Config page, images are not saved.

[Do Not Log]

Do not save any images to the vision log.

[Log Failed Images]

Save image and 3D map only when the vision operation fails.

[Log All Images]

Save all images and 3D maps.

> ⚠ **CAUTION**
>
> 1 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 log images depends on the type of storage device in use. Use this function after checking whether the delay of logging images is acceptable for your application.
>
> 2 You cannot start the next vision process until storing of the logged images for the last vision process is completed. We recommend to use [Log All Images] only in cases where it is necessary such as for troubleshooting, and [Do Not Log] or [Log Failed Images] under normal circumstances.

[Display Image]

If there are multiple snap tools in the vision process, select an image to show on the image view from the drop-down box.

For details of snap tool, refer to "Setup: 4.1 SNAP TOOL".

[Reference Data]

The reference data is used to calculate offset data from the found result.

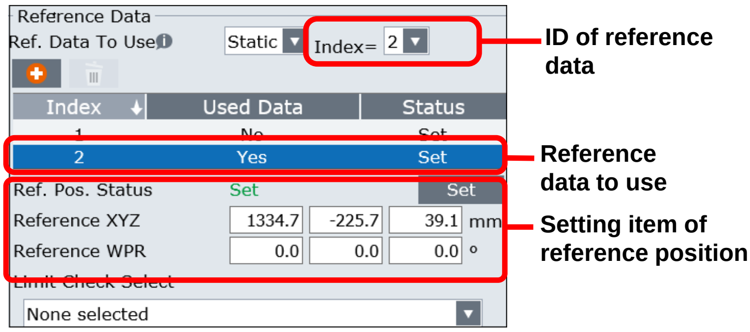
A vision process might have more than one set of reference data. Under normal conditions, only one set of reference data is used.
However, in cases where multiple command tools are used and each command tool has different way how to pick up workpiece, it is necessary to set up multiple reference data.

[Ref. Data To Use]

Select how to determine the reference data to use from the drop-down box.

[Static]

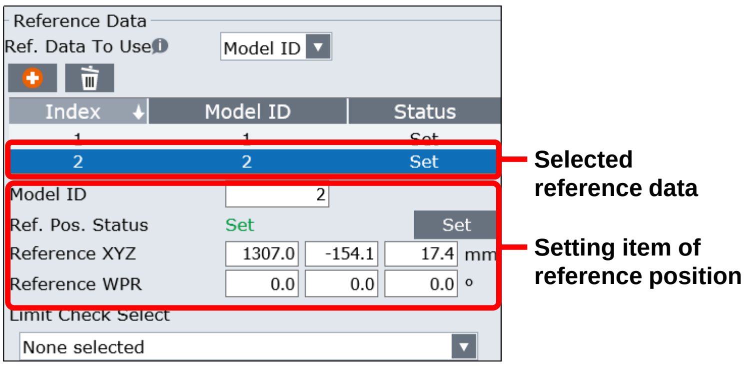
The same reference data is used to calculate the offset data.
When the vision process has multiple reference data, the following table is displayed. Select [Index] of the reference data to use from the drop-down box.



MEMO
If [Static] has been selected and reference data is only one, reference data table is not displayed.

[Model ID]

Reference data to use is switched depending on the model ID of the found workpiece. Choose this in such cases as when there are multiple types of workpiece.
The values of the reference data selected on the reference data list are displayed in the reference position setting items.



Adding and setting reference data

The procedure to add and set reference data is as follows.

1 Click the button.
Reference data is added to the table and new Index is assigned.
2 Set the reference position. For details, refer to "Setup: 3.11.3 Setting the Reference Position".
When [Static] is selected, the reference position of the reference data selected in [Index] is to be set.
When [Model ID] is selected, the reference position of the reference data selected in the table is to be set.
3 If reference position setting is performed, [Status] of the reference data table will change to [Set].

Deleting reference data

The procedure to delete reference data is as follows.

1 Select the reference data to delete in the reference data table.
2 Click the button.
A deletion confirmation message will be displayed.
3 If the [OK] button is clicked, the reference data selected in procedure 1 is deleted.
If the [Cancel] button is clicked, delete is canceled.

> **MEMO**
> The reference data in use cannot be deleted when [Static] is selected.

[Ref. Pos. Status]

Displays the setting statuses of the reference position.

- When the reference position is set, [Set] is displayed in green.
- When the reference position is not set, [Not set] is displayed in red.

[ReferenceXYZ]

The frame values X, Y and Z of the reference position recorded in the reference data are displayed. The units are millimeters.

[ReferenceWPR]

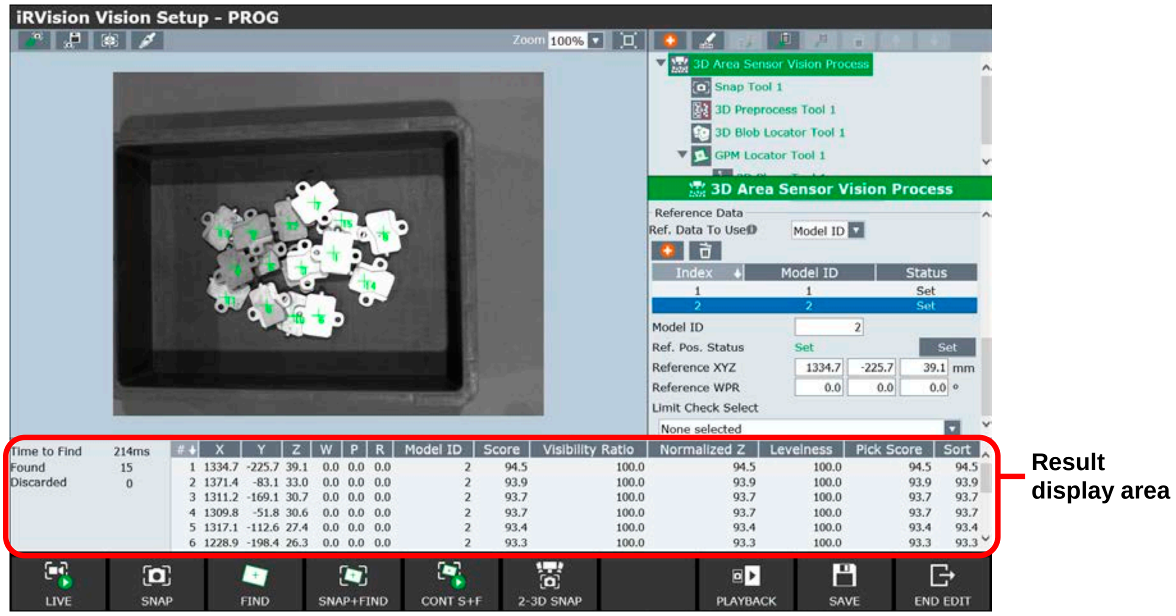
The angles (rotation angle around X, Y, and Z) of the frame values W, P and R of the reference position recorded in the reference data are displayed. The units are degrees (°).

[Limit Check Select]

Specify the condition used to check whether the calculated offset values is within the specified range. By default, [Not Selected] is set, in which case the offset limit check is not made. For information about the offset limit check conditions, refer to "Setup: 5.2 OFFSET LIMIT".

3.11.2 Running a Test

Click [Find] to execute a test, and check whether it operates as expected.



After you run a test, the result display area shows the following results:

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

[Found]
The number of found workpieces is displayed.

[Discarded]
The number of found results discarded by limitation on number to find, a threshold of measurement, combination optimization, etc. is displayed.

Also, in the result display area list view, 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).

[Model ID]
Model ID of the found target.

[Score]
Score of the found workpiece.

[Visibility Ratio]
Visibility ratio of the found workpiece.

[Normalized Z]

Normalized Z of the found workpiece.

[Levelness]

Levelness of the found workpiece.

[Pick Score]

Pick score of the found workpiece.

[Dup.Chk.]

This item is displayed when [Enable] is checked in [Duplication Check].

[Sort]

The value of the selected sort key is displayed.

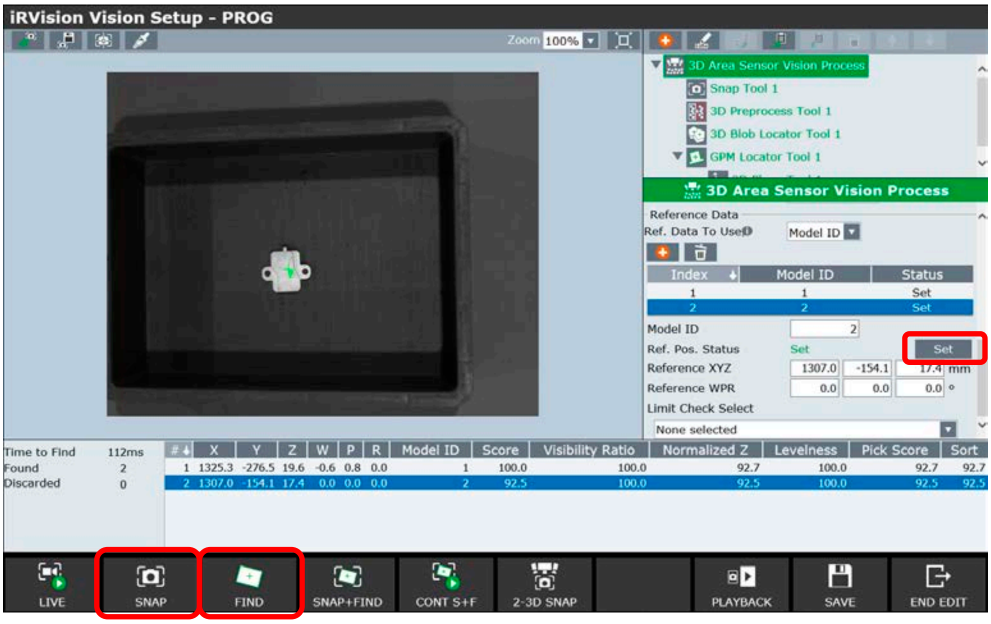
> **MEMO**
> When [Show Discarded] has been checked in program teaching, found results that the Vision Process discarded in [3D Area Sensor Vision Process] are displayed.

Checking the found results displayed on the result view area enables to confirm reasons to be discarded.

- The columns of the visibility ratio, normalized Z, levelness, pick score and duplication check key are all blank for discarded results in [Combination Optimization].
- The columns of the pick score is blank for the results discarded by the threshold of the visibility ratio, normalized Z or levelness. Please check the displayed values and set thresholds to see which measurement they were discarded by.
- All columns are displayed for the found results that were discarded by the duplicate check or limitation on number to find.

3.11.3 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.
Teaching the robot position is performed when the workpiece is located at the reference position.



Set reference position using the following procedure.

1 Place a workpiece in the camera field of view and click [2-3D SNAP].
2 Click [FIND] and find the workpiece.
3 Click the [Set] button of [Ref. Pos. Status], and check that [Ref. Pos. Status] changes to [Set].
4 Check that values are set for all the reference position items.
5 Leave the workpiece as it is and teach the robot position.

4 COMMAND TOOLS

This chapter explains how to set the command tools.

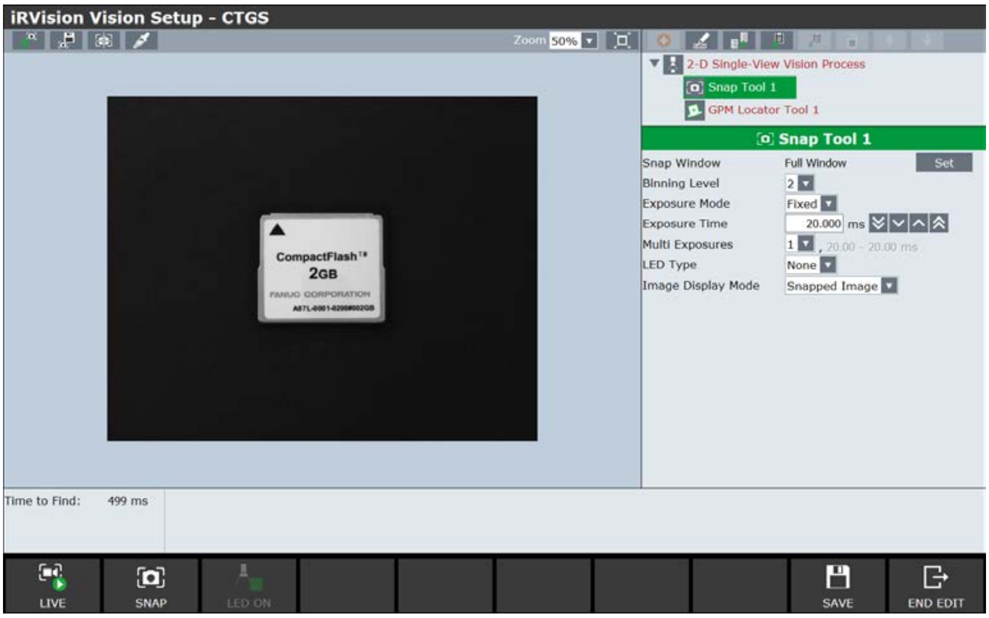
Operation of command tools

If you add or edit command tools in the vision process, perform the operation in the tree view. For the details of tree view, refer to "Setup 1.8.2: Tree View".

4.1 SNAP TOOL

The Snap Tool is a tool that snaps images. You can set snap conditions such as the snap window and exposure time.
Place at least one snap tool right under the vision process or camera view. For the visual tracking and calibration-free vision process, only one snap tool can be set to the process. For other vision processes, you can locate multiple snap tools, change snap conditions and snap multiple images.

When you select [Snap Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.1.1 Setup Items

The Snap Tool has the following parameters.

> **MEMO**
> The setting items depend on the type of the vision process or selected items.

[Snap Window]

Instead of a whole 2D image, if you want to snap an image partially, set a snap window. This parameter is set to full screen by default.
Click the [SET] button to change the snap window. When a rectangular window appears on the image, adjust the snap window. For the operation method for the window, refer to " Setup: 1.8.8 Window Setup".

[Binning Level]

When snapping, you can shrink an image and reduce the resolution. Select the degree of shrinking from the drop-down box. Select from 1 to 4. If you select 1, the image will not be shrunk. If you select 2 or higher, the image will be shrunk to 1/n of its size lengthwise and breadthwise and then snapped. The range of value that can be set depends on the types of cameras. If 2 or more can be set, 2 is selected by default.

[Exposure mode]

Select the exposure mode from the drop-down box.
If the vision process is 'Single-View Visual Tracking' or '2D CALIBRATION-FREE VISPROC,' it does not appear.

[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.
The unit is mm. Input numeric value or change the value using buttons. The larger the value is, the brighter the images that will be snapped.
When [Fixed] is specified in [Exposure Mode], this item can be modified with this parameter.
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. This is a parameter that appears when [Auto] is selected in [Exposure mode].
The image displayed when the photometric area is set is used as the reference image for automatic exposure.

1. Select [Fixed] from the [Exposure mode] drop-down box.
2. Adjust the exposure time to obtain appropriate brightness for the image.
3. Select [Auto] from the [Exposure mode] drop-down box.
   Click [OK] on the displayed pop-up that asks for the auto exposure area to be taught.
4. Set the auto exposure area.
   - If [Auto Exposure Area] is [Not trained], the window opens to set the photometric area.
   - In the case of [Trained], click the [Train] button to set the photometric area.

   For the operation method for the window, refer to " Setup: 1.8.8 Window Setup".
5. If there is any area to be ignored in the photometric area, click the [Mask] button to mask the area to be ignored.
   For the setting method for the mask, refer to " Setup: 1.8.13 Editing Masks".

MEMO

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. This is a parameter that appears when [Auto] is selected in [Exposure mode].

[Multi Exposures]

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.

If the vision process is 'Single-View Visual Tracking' or '2D CALIBRATION-FREE VISPROC,' it does not appear.

[Multi Exposure Area]

It does not appear when [1] is selected in [Multi Exposures]. If the photometric area used for multi-exposure is specified, image synthesis is performed based on the brightness in the photometric area. As the default, the photometric area is set full screen. Usually, it is not necessary to change.

Only when necessary to set the photometric area, click the [Train] button to set a window. For the operation method for the window, refer to " Setup: 1.8.8 Window Setup".

When the photometric area includes an area of which brightness is to be ignored, click the [Mask] button to mask the area to be ignored. For the setting method for the mask, refer to " Setup: 1.8.13 Editing Masks".

[Multi Exposure Mode]

Select a method for image synthesis in multi-exposure from the drop-down box. It does not appear when [1] is selected in [Multi Exposures].

[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.

[LED Type]

Select a LED type for snapping a 2D image from the [LED Type] drop-down box.

[None]
Use no LED ligh.

[Integrated]
Use the camera package's integral LED light.

[External]
Use external LED light.

> ⚠ **CAUTION**
> When selecting [External] for [LED Type], an LED light, power of an LED light, signal cable, etc. should be arranged by a customer.

[LED Intensity]

Set the intensity of LED. One of 1~16 is specified. The default value is 8. Adjust the intensity. The larger the value is, the brighter the images that will be snapped. This is a parameter that appears when [Integrated] is selected in [LED Type].

[LED Signal]

Select the type of LED signal and the on/off relationship between LED signals and LED lightning from the drop-down box. If [DO] or [RO] is selected, a signal number needs to be entered. Enter a signal number in the displayed text box. This is a parameter that appears when [External] is selected in [LED Type].

[MUX]
Use signals from the MUX.

[DO]
Use DO signals of the robot controller.

[RO]
Use RO signals of the robot controller.

[Normal]
Turn on LED light when turning on LED signals.

[Reverse]
Turn on LED light when turning off LED signals.

Select [Normal] to turn on when LED signals are on and [Reverse] to turn off when signals are on.

[Use Strobe]

Check this check box when a stroboscopic light is used for the LED lightning. When checking it, the LED light flashes synchronizing with image snapped by the camera. This is a parameter that appears when [External] is selected in [LED Type] and [MUX] is selected in [LED Signal].

[LED delay]

Set the time from when the LED signal is output until when intensity of the LED lightning becomes stable. The units are milliseconds. Under normal conditions, set 0. It varies depending on a LED type used and a LED power supply. *i*RVision waits for the time period specified here and then starts exposure of the camera. This is a parameter that appears when [External] is selected in [LED Type].

[White Balance]

Adjust the proportion of RGB gains to capture a white object as white pixels on an image. The default values for [R], [G] and [B] are 1.00 respectively. 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. This is a parameter when a camera that is used for this vision process is a color camera.

[Image Display Mode]

Select the image to be displayed for the Setup Page from the drop-down box.

[Snapped Image]

The actual snapped image will be displayed.

[Full Image]

The whole 2D image, with an area set in [Snap Window] with blue line, will be displayed.

4.1.2 Vision Override

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to “Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Exposure Time]

Specify a number in milliseconds.
If [Exposure Mode] 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 Exposures]

Number of Exposure. Specify a number between 1 and 6.

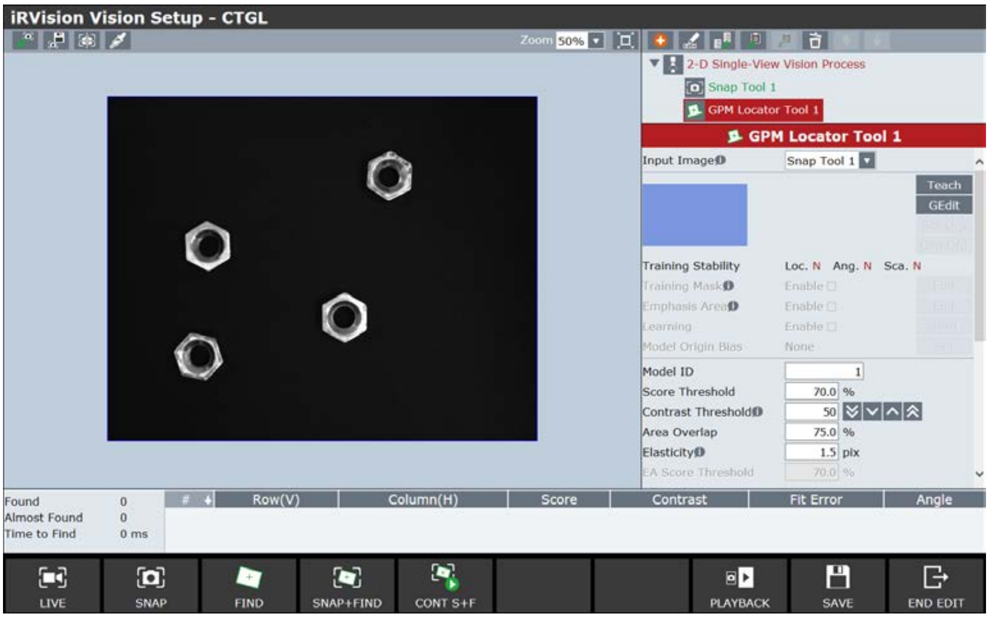
[LED Intensity]

The intensity of LED Type. Specify a number between 1 and 16. This can only be specified if [Integrated] is selected in [LED Type].

4.2 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.

When you select [GPM Locator Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.2.1 Setup Items

The GMP locator tool has the following parameters.

[Input Image]

Select an image to use in teaching and finding of model patterns from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Teach] button

Teach the model pattern of the workpiece you want to find. For details, refer to "Setup: 4.2.2 Teaching the Model".

[GEdit] button

Add a graphical shape (segmented-line, rectangle, or circle) to the model pattern or edit it. For details, refer to 'Adding or editing graphical shapes' in "Setup: 4.2.2.1 Teaching the Model Pattern".

[Set Org] button

Move the position of the model origin manually. For details, refer to "Setup: 4.2.2.4 Model Origin".

[Cen Org] button

Set the model origin at the rotation center. For details, refer to "Setup: 4.2.2.4 Model Origin".

[Training Stability]

The evaluation results for items [Location], [Orientation], and [Scale] of the taught model pattern are displayed. For details, refer to "Setup: 4.2.2.2 Training Stability".

[Training Mask]

If the taught model pattern has unnecessary features or blemishes in the background or on the workpiece, you can mask them with the red-colored areas on the pattern. For details, refer to "Setup: 1.8.13 Editing Masks".
When [Enable] is unchecked, the mask is ignored.

[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, click the [Edit] button on [Emphasis Area]. 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.
Filling operation is similar to mask editing. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".
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.
When [Enable] is unchecked, an emphasis area is ignored.

[Learning]

Model learning uses a user defined set of images to optimize the trained model pattern. To use the model learning function, click the model learning [Start] button. For details, refer to "Setup: 4.2.4 Learning GPM Locator Tool".
When [Enable] is unchecked, the optimization of the model pattern through model learning will be disabled.

[Model Origin Bias]

This function corrects found results so that the tool outputs the same found position data as another GPM Locator Tool that has already been taught. For details, refer to "Setup: 4.2.2.5 Model Origin Bias".

[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.

[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. The units are %. 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 threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. Input the value or change the value using buttons. The default value is 50. If a small value is set, objects that cannot be seen clearly can be detected, but

processes will take time. The minimum value is 1.
If something with low contrast, such as dust, is mistakenly detected, increase this value. Those image features whose contrast is lower than the threshold are ignored. Selecting [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. The default value is 1.5 pixels.
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 pattern, 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. This is a parameter that appears when you check [Enable] in [Emphasis Area].

[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. This is a parameter that appears when you check [Enable] in [Emphasis Area].

[Ignore Polarity]

This can be specified to perform detection ignoring dark/light polarity of a trained model pattern. Refer to "Setup: 4.2.6 Setup Guidelines" for polarity ".

[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, click the [SET] button. When a rectangle appears on the image, adjust its geometry, as when teaching a model pattern. For detailed information about the operation method, refer to "Setup: 1.8.8 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.
To change the run-time mask, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks ".

[DOF]

Specify the range to be searched.

[Orientation]

Specify the range of orientation subject to be searched. The tool searches for a model pattern rotated in the range specified by [Min.] and [Max.], with the orientation of the taught model pattern being 0 degrees. The specifiable value range is from –360 to +360 degrees for both [Min.] and [Max.]. 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 [Enable] this box, the orientation is ignored and the tool searches only for a model pattern having the orientation specified in [Nom.].
By default, the orientation search is enabled and the range is from −180 to +180 degrees. When it is a child tool of another locator tool, specify the range relatively in respect to a parent tool's found result.

[Scale]

Specify the range of scale to be searched. With the size of the taught model pattern being 100%, the tool searches for a model pattern expanded or reduced by the ratio specified in [Min.] and [Max.]. The specifiable value range is from 25% to 400% for both [Min.] and [Max.]. The narrower the size range is, the faster the search process ends.
If you uncheck [Enable] this box, the scale is ignored and the tool searches only for a model pattern having the scale specified in [Nom.].
By default, the scale search is disabled.
When it is a child tool of another locator tool, specify the range relatively in respect to a parent tool's found result.

[Aspect]

Specify the range of aspect ratios to be searched. With the ratio of the taught model pattern being 100%, the tool searches for a model pattern flattened by the ratio specified in [Min.] and [Max.]. The specifiable value range is from 50% to 100% for both [Min.] and [Max.]. The narrower the aspect ratio range is, the faster the search process ends.
If you uncheck [Enable] this box, the aspect ratio is ignored and the tool searches only for a model pattern having the aspect ratio specified in [Nom.].
By default, the aspect ratio search is disabled. When it is a child tool of another locator tool, specify the range relatively in respect to a parent tool's found result.

[Time-Out]

If the location process takes longer than the time specified here, the tool ends the process without finding all of the workpieces.

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run from the drop-down box.

[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 Origin Only]
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 from the drop-down box.

[Image]
The image selected in [Input Image] will appear.

[Image + Results]
The image selected in [Input Image] and the results of FIND will appear.

[Image + Edges]
The image selected in [Input Image] and features in the image will appear.

[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.

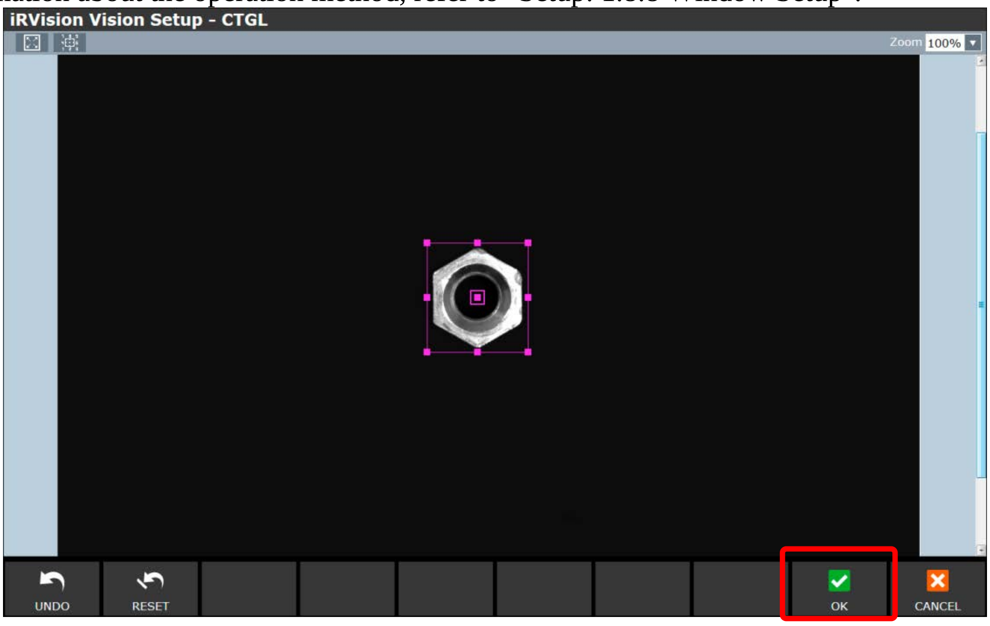
4.2.2 Teaching the Model

Teach the model pattern of the workpiece you want to find.

4.2.2.1 Teaching the model pattern

Teach the model pattern as follows.

1 Click [LIVE] in the GPM locator tool edit screen.
It will be switched to live image display.
2 Place the workpiece near the center of the camera view.
3 Click [STOP] and then click [SNAP] to snap the image of the workpiece.
4 Click [Teach].
A window that has control points (reddish purple rectangle) will appear.
5 Enclose the workpiece within the red rectangle that appears, and click [OK]. For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".

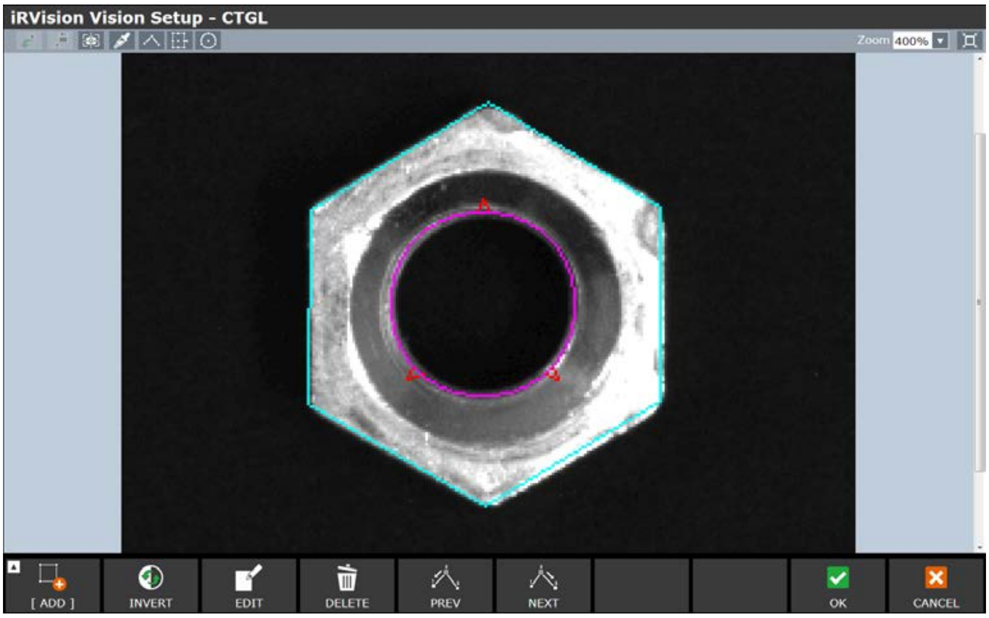


When the model pattern teaching process is completed, [Training Stability] is displayed. For details, refer to "Setup: 4.2.2.2 Training Stability".

Adding or editing graphical shapes

If needed, you can add graphical shapes such as segmented-lines, rectangles or circles to the model pattern, and edit the added graphical shapes. You can create model patterns that only include graphical shapes.

1 Click the [GEdit] button in the GPM locator tool edit screen.
Graphical shape edit screen will appear.



2 Click [ADD] then a graphical shape to be added.
The display will be in a status to edit a graphical shape.
You can also add graphical shapes if you click the buttons on the left of the menu bar (: segmented-line, : rectangular, and : circle).
In order to edit graphical shapes, click [PREV] or [NEXT] to select a graphical shape you want to edit, and click [EDIT].
3 Move a control point of a graphical shape in the image, adjust the position and size, and determine the graphical shape.
Click the [RESET] button to return the position and size of the graphical shape back to the original status.
Click [UNDO] to cancel the previous operation.
4 Click [OK].
Graphical shape editing is ended.
Clicking [CANCEL] will cancel setup.

If the model pattern is not trained, the magenta rectangle is displayed on the image display before the above the screen. Specify the image area you want to set as the background of the model pattern, in a similar manner to "Setup: 4.2.2.1 Teaching the Model Pattern".

On this screen, the selected graphical shape is plotted in magenta, the other graphical shapes are plotted in cyan, and features from the image are plotted in green over the model image. Red triangles indicate the dark/light polarity of the selected graphical shape as shown in the above figure. The peak of the red triangles points toward the light side. Check that the red triangle direction is dark → bright, if the bright/dark is reversed, you have to click [INVERT] to reverse the direction of the triangle. For detailed information about the light/dark polarity, refer to "Setup: 4.2.6 Setup Guidelines".

For details about how to edit graphical shapes, refer to "Setup: 1.8.8 Window Setup", "Setup: 1.8.11 Segmented-Line Setup" "Setup: 1.8.12 Circle Setup".

Function Key

The following function keys will appear on the graphical shape edit screen.

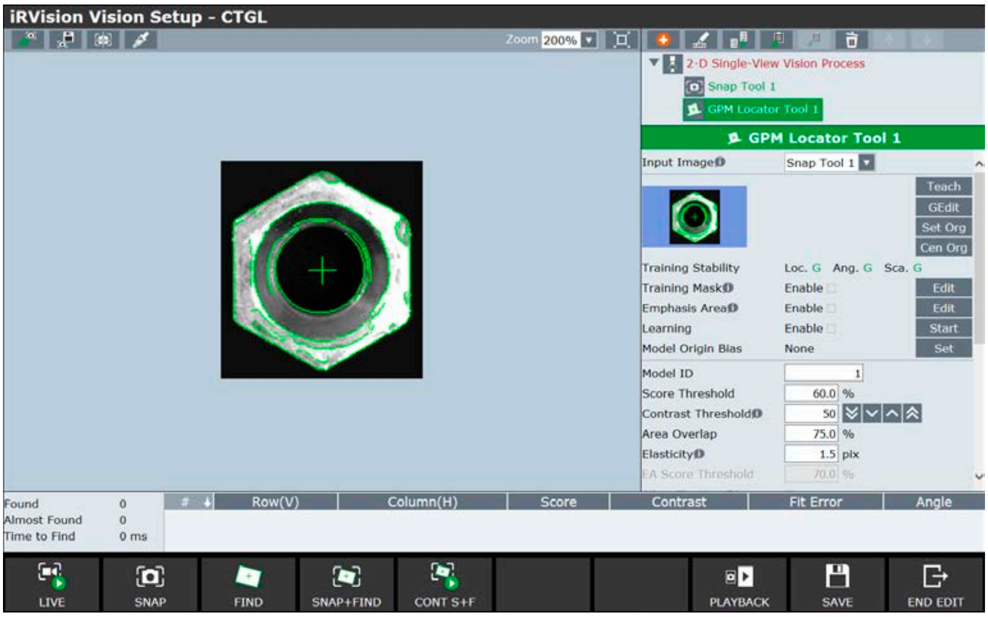
Icons	Name	Function
	INVERT	Invert the dark/light polarity of the selected graphical shape.
	DELETE	Delete the selected graphical shape. If there are not graphical shapes, this function key is disabled.
	ADD	Add a graphical shape to the model pattern.
	PREV	Select the previous graphical shape.
	NEXT	Select the next graphical shape.

4

4.2.2.2 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 found stably.
Poor: Cannot be found very stably.
None: Cannot be found.



If each item is poor or none, change the taught model pattern as shown below.

[Loc.]
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 pattern.

[Ang.]

Poor: Use the emphasis area or change the part to be taught as a model pattern.
None: Uncheck [Enable] in [Orientation] of [DOF].

[Sca.]

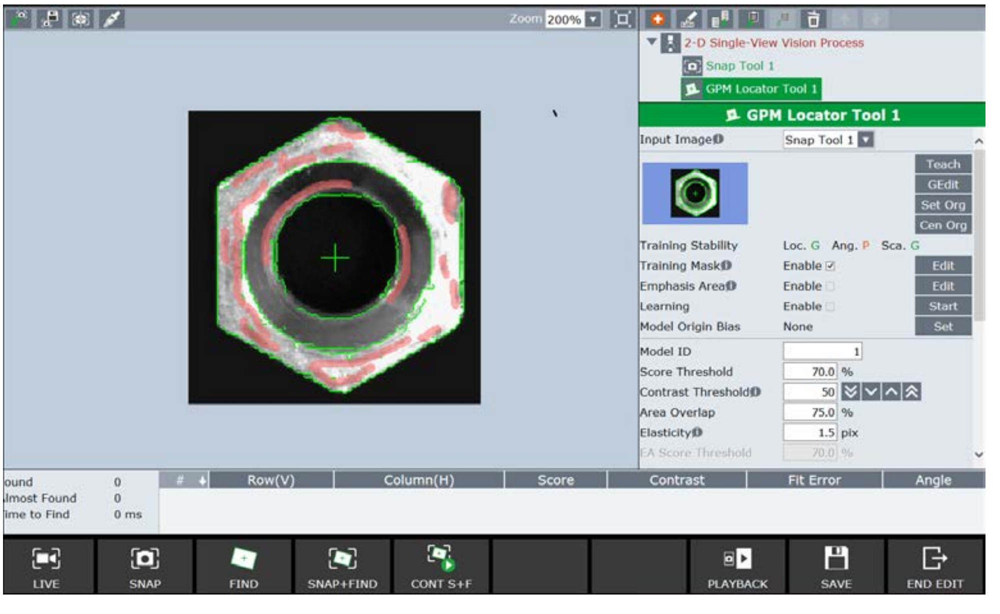
Poor: Use the emphasis area or change the part to be taught as a model pattern.
None: Uncheck [Enable] in [Scale] of [DOF].

MEMO
For details of model patterns that can be found stably, refer to "Setup: 4.2.6.2 Model Pattern".

4.2.2.3 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. Unnecessary features include background on which a workpiece is placed, and features and blemishes that are not necessarily on all workpieces.

1 Click the [Edit] button of [Training Mask] in the GPM locator tool edit screen.
The display will be in a status to edit a mask.
2 Fill the section you do not want to include in the model pattern with the color of red.
Filling operation is similar to mask editing. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".
3 Click [OK].
Editing a mask is complete.



4.2.2.4 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. It appears as '+' (green) on the screen.

[Set Org]

Move the position of the model origin manually using the following procedure.

1. Click the [Set Org] button in the GPM locator tool edit screen.
   The display will be in a status to edit the point. At the current position of the model origin, will appear.
2. Move .
   The position of the model origins moves.
   For the operation method for the point, refer to "Setup: 1.8.7 Point Setup".
3. Click [OK].
   Editing a model origin is complete.

[Cen Org]

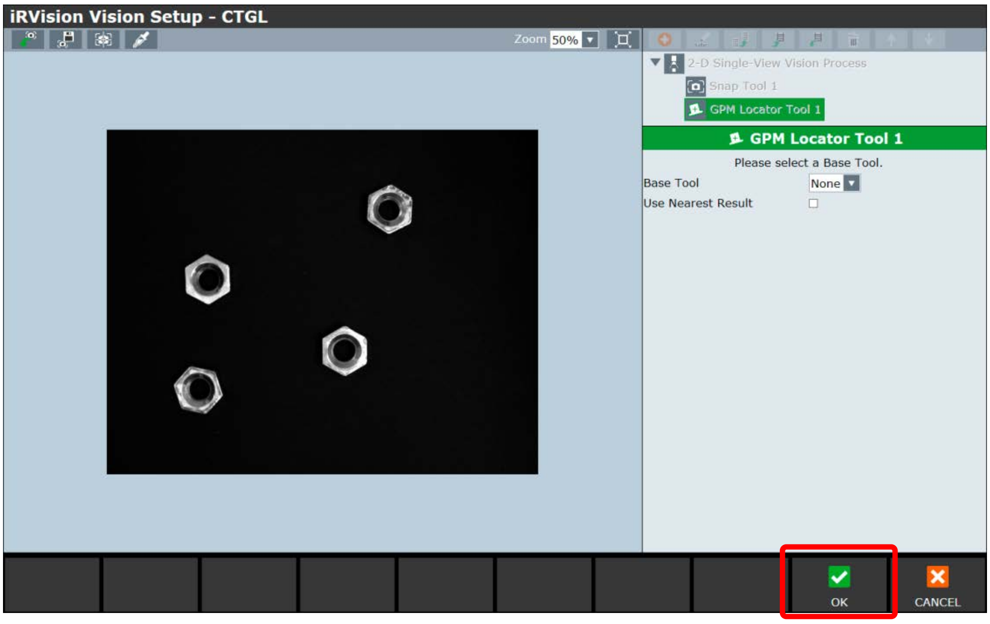
If the taught model pattern is rotatable, you can calculate the rotation center and set the model origin there. For example, when the taught model pattern is a circular hole, the model origin can be set at the center of the circle. To set the model origin at the rotation center, click the [Cen Org] button. 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.

4.2.2.5 Model origin 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. Click the [Set] button of [Model Origin Bias] in the GPM locator tool edit screen.
   The display will be in a status to edit the model origin bias settings.
2. Select the GPM locator tool which is already trained as the [Base Tool].



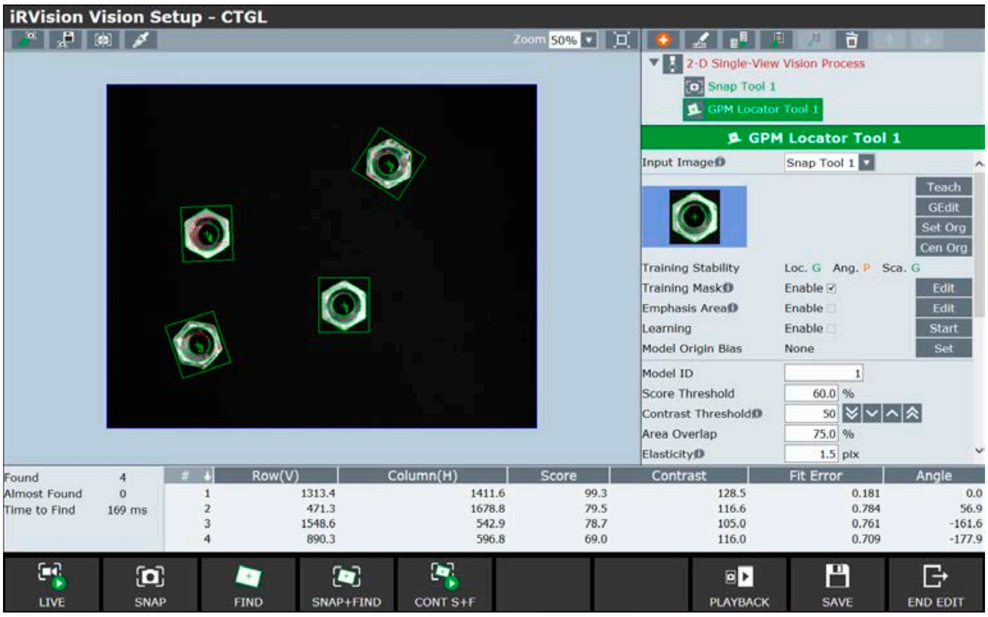
3. Click [OK]. The tool attempts to find the workpiece using the model image of the reference tool. When the tool finds the workpiece successfully, the bias is set. When the bias is set properly, the model origin is changed so that the tool outputs the same found position as the reference tool.

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.

4.2.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[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 [Almost Found] check box is not checked.

[Time to Find]
The time the location process took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]
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. It will appear when you check [Enable] in [Emphasis Area].

[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). It will appear when you check [Enable] in [Angle] of [DOF].

[Scale]
Scale of the found pattern (units: %). It will appear when you check [Enable] in [Scale] of [DOF].

[Aspect]
Aspect ratio of the found pattern (units: %). It will appear when you check [Enable] in [Aspect] of [DOF].

[Skew]
Skew angle of the found pattern (units: degrees). It will appear when you check [Enable] in [Aspect] of [DOF].

4.2.4 Learning GPM Locator Tool

Learning GPM locator tool is a function the finds the trained model pattern in multiple different images and performs learning based on the detection results. The learning function changes the trained model pattern based on the detection results. By performing model learning, the model pattern will be optimized in the points below.

- Removing any needless/unreliable features of the model pattern.
- Averaging the shape of the model pattern against variations in the shapes of the workpieces detected.

The optimized model pattern will improve the scores of the found targets, which will allow the score threshold to be increased. Increasing the score threshold will reduce the possibility of false detection and shorten the time to find.

MEMO

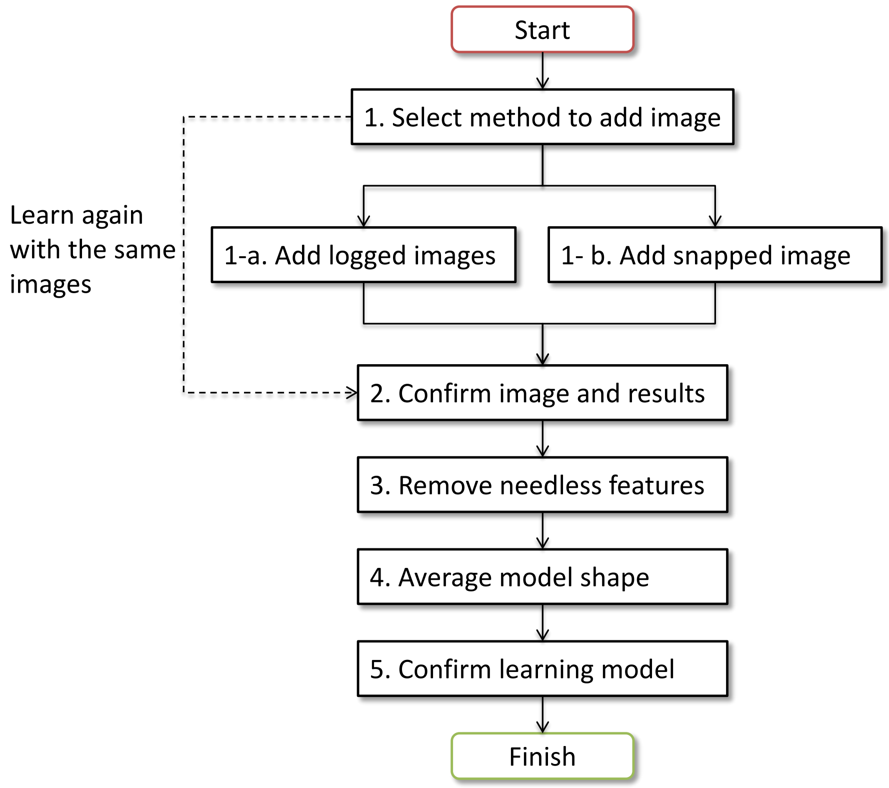
1 Learning GPM locator tool uses images containing the target. Images that can be used are:
   - Images saved to the vision log
   - Images newly snapped on the Learning GPM locator tool screen
     To use images saved in the vision log, you must create the vision log before starting Learning GPM locator tool. The vision log can be created by running a TP program with the vision instructions or by clicking Snap and Find on the vision setup page. To log images, Enable Logging must be checked on the Vision Config screen and Log All Images must be selected on the vision process. For information about the vision log, refer to "Setup: 1.6 VISION LOG".
     To use images newly snapped on the Learning GPM locator tool screen, place workpieces in the camera view and snap images in the process of Learning GPM locator tool.

MEMO

2 In Learning GPM locator tool, information necessary for model learning is saved to the same device as the folder specified for the [Log Path] on the Vision Config screen. Before starting Learning GPM locator tool, insert the memory device specified in the [Log Path]. During Learning GPM locator tool, "Enable Logging" on the Vision Config screen does not need to be checked.

4.2.4.1 Overview of learning GPM locator tool wizard

Learning GPM locator tool is setup using the Learning GPM locator tool Wizard. Follow the steps of the Learning GPM locator tool Wizard to complete the model learning. The steps of the Learning GPM locator tool Wizard are shown below in the flowchart. The areas enclosed in rectangles represent the steps of the wizard.



Each screen of the Learning GPM locator tool wizard is shown below.

A Tool bar of the wizard. Displayed on the left side is the title of the present step. Displayed on the right side are tools such as the drop-down box for changing the zoom magnification of the image displayed in area B and the text box for switching pages.

B Area displaying information about the steps of the wizard. Displayed in the upper part is the flow of the wizard. Displayed in the middle is an explanation of the task to carry out in the present step. Displayed in the lower part are the number of images used in the last learning and the number of detection results, as well as the number of images added in the present learning and the number of detection results.

C Area in which to carry out the task in the present step. You mainly use this area to perform operations and confirmations in each step.

D Function Key Area. The function keys to use with the learning GPM locator tool wizard differ from step to step.

Function Key

The function keys to use with the learning GPM locator tool differ from step to step, but the function keys listed below are the common ones that are used throughout the learning GPM locator tool.

Icons	Name	Function
	< BACK	Go back to the last step.
	NEXT >	Go to the next step.
	CANCEL	Cancel Learning GPM locator tool and return to the GPM Locator tool setting screen. Any added images and detection results are discarded.

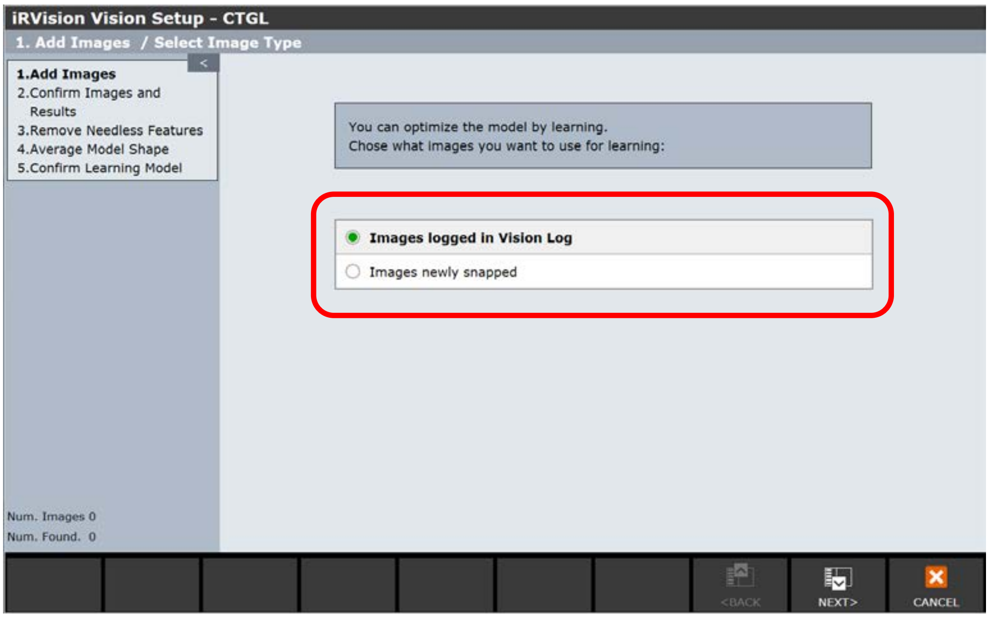
4.2.4.2 Select method to add images

On this step, the method to add the images is selected. The displayed screen is different when the learning is executed for the first time or when the model pattern that is previously learned is learned again in this GPM locator tool.

When the learning is executed for the first time in this GPM locator tool

1 Click the [Start] button of [Learning] in the GPM locator tool edit screen.
The wizard of learning GPM locator tool starts.

2 The method to add the images to use is selected.



[Images logged in Vision Log]
Perform learning by using the images already logged in the vision log.

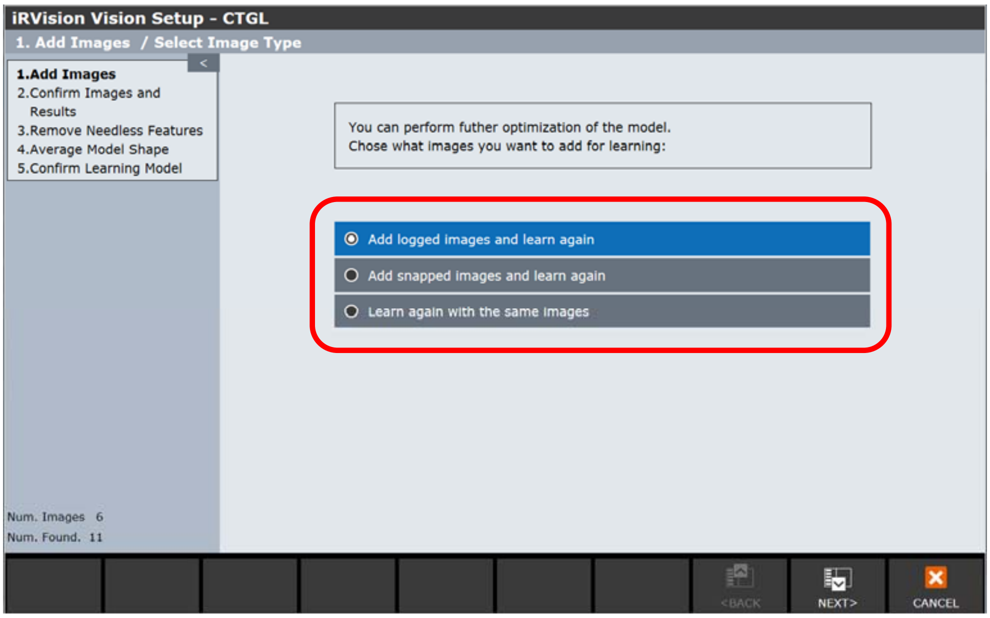
[Images newly snapped]
Snap images in the next step, and perform learning by using the snapped images.

3 Click [NEXT>].
Proceeds to the next step.
- [Images logged in Vision Log] → "Setup: 4.2.4.3 Add Logged Images"
- [Images newly snapped] → "Setup: 4.2.4.4 Add Snapped Images"

When the model pattern in this GPM locator tool is learned again

1 Click the [Start] button of [Learning] in the GPM locator tool edit screen.
The wizard of learning GPM locator tool starts.

2 The method to add the images to use is selected.



[Add logged images and learn again]

In addition to the images last used, use the logged images selected in the next step in learning.

[Add snapped images and learn again]

In addition to the images last used, use the newly snapped images in the next step in learning.

[Learn again with the same images]

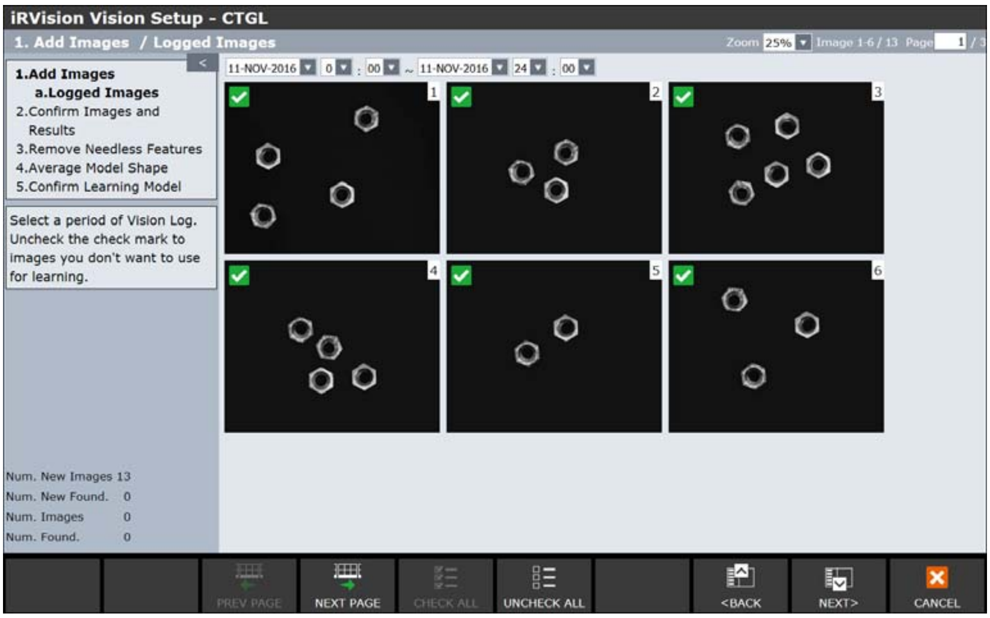
Do not add new images, but learn again with the images last used.

3 [Next>] to go to the next step.

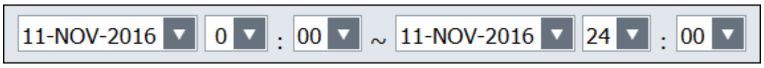
- [Add logged images and learn again]→"Setup: 4.2.4.3 Add Logged Images"
- [Add snapped images and learn again]→"Setup: 4.2.4.4 Add Snapped Images"
- [Learn again with the same images]→"Setup: 4.2.4.5 Confirm Images and Results"

4.2.4.3 Add logged images

In this step, select the logged images to use in Learning GPM locator tool.



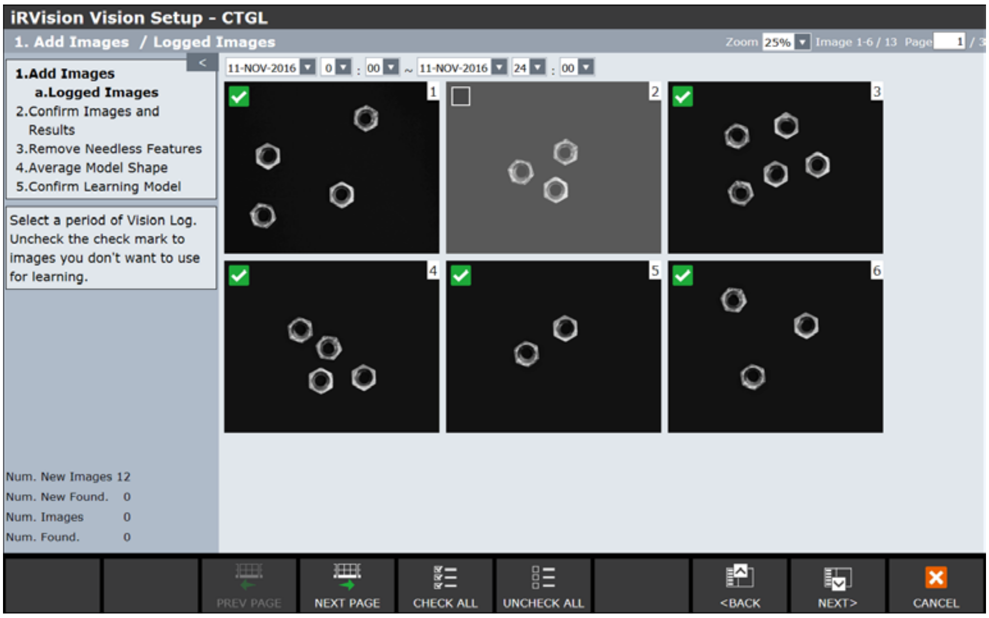
1 Specify the date and time at the drop-down box in the following figure. The logged images that are saved in the period that is specified here appear on the screen.



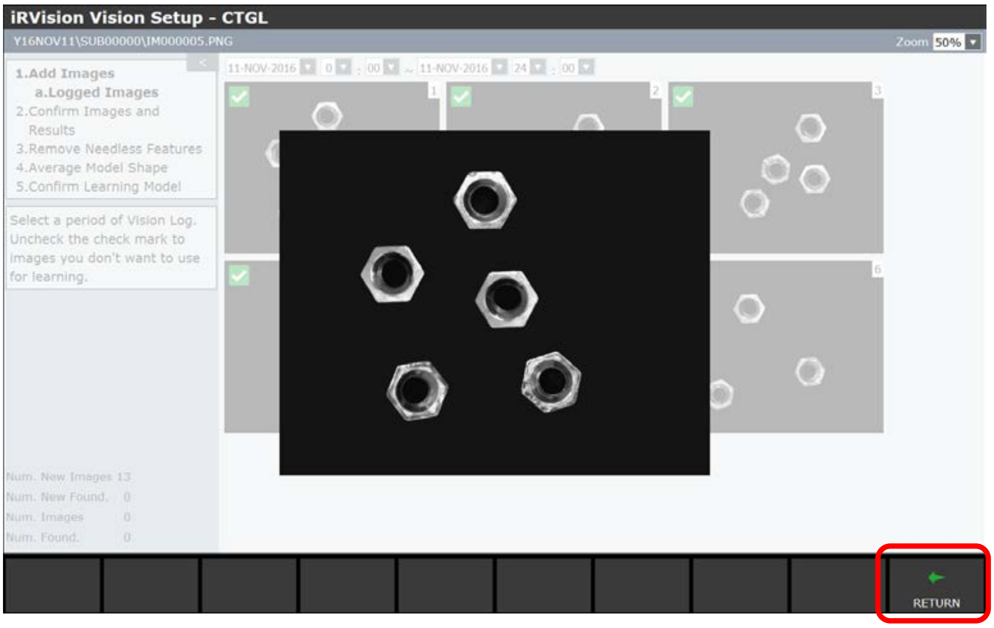
MEMO

If the logged images in the selected period cannot be displayed on a single page, they are displayed on more than one page. To change pages, either click [PREV PAGE] and [NEXT PAGE] as appropriate or enter a value directly in the text box displaying the page number, [Page], in the tool bar.

2 Select logged images to use.
Images with will be the targets for use. In the initial state, all logged images are selected.
Click a icon deselects the logged image, and the ion changes to .
Click a icon selects the logged image, and the icon changes to .
Click a [CHECK ALL] Select all logged images.
Click a [UNCHECK ALL] Deselect all logged images.

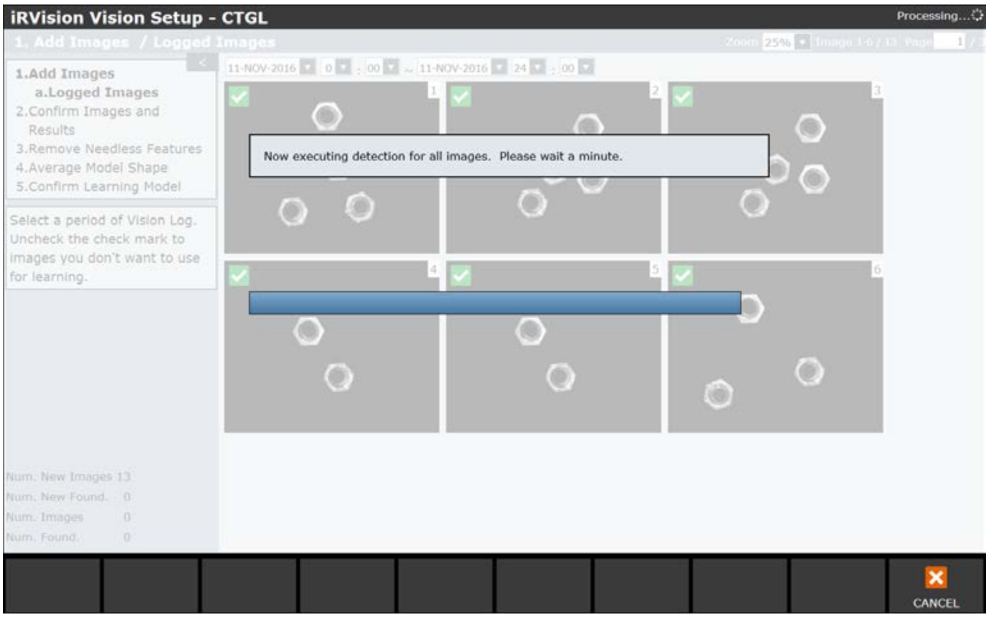


Clicking a logged image enlarges the logged image.



Clicking [RETURN] or click the screen returns you to the original thumbnail screen.

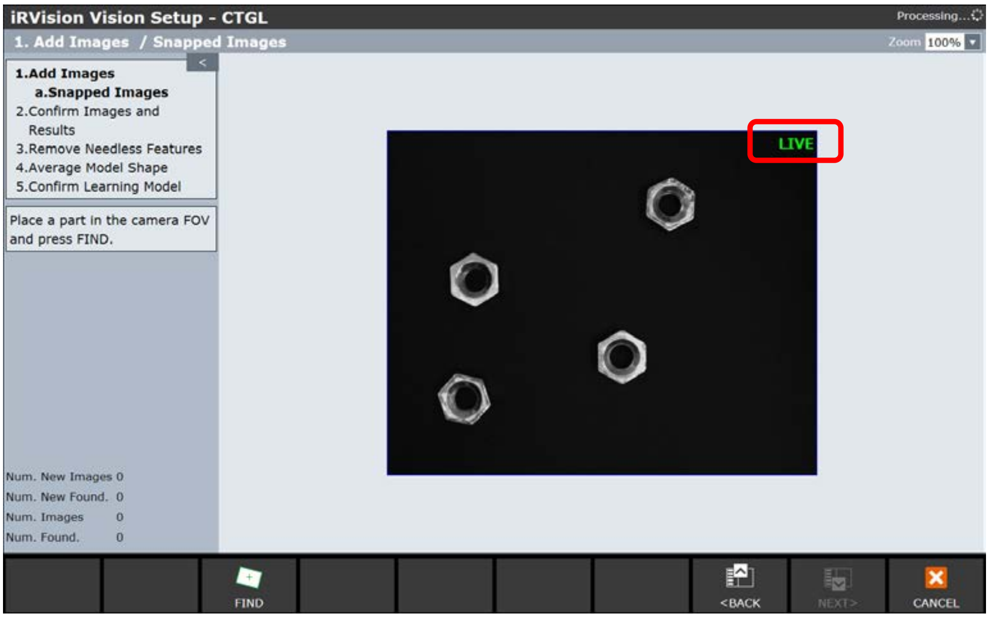
3 Clicking [Next>].
Detection is performed for the selected logged images.



Upon the completion of detection, you automatically go to the next step ("Setup: 4.2.4.5 Confirm Images and Results").

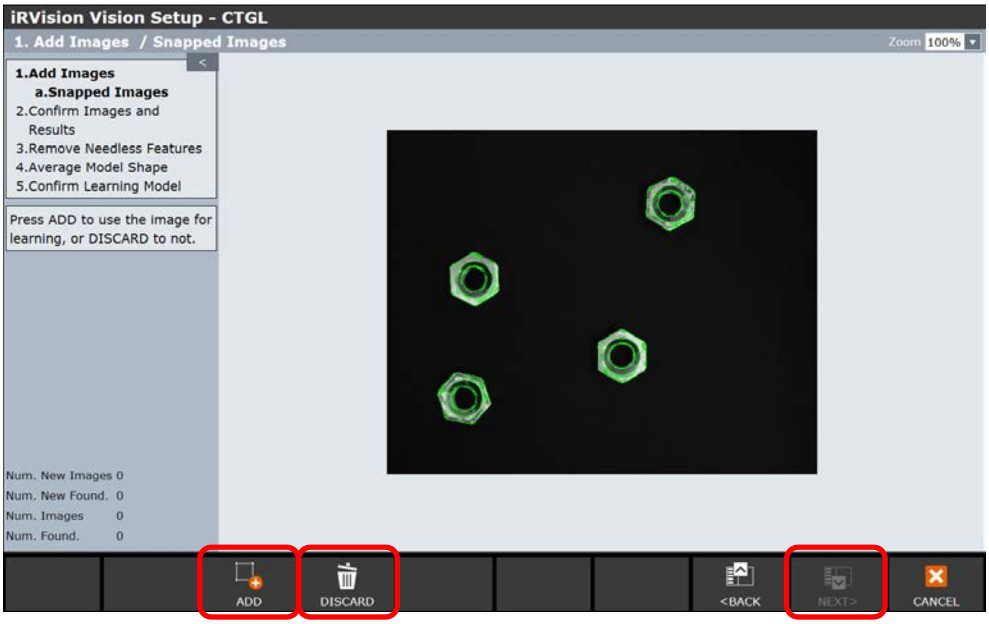
4.2.4.4 Add snapped images

In this step, snap the images are used in Learning GPM locator tool.
A live image from the camera is displayed, shown in the figure below.



Add snapped images with the procedure below.

1 Place target objects in the camera view. Use the live image to confirm the target objects are properly within the field of view.
2 [FIND] to snap the images and perform detection.
Upon the completion of detection, detection results are plotted on the images shown in the figure below.



3 If the target objects are detected correctly, click [ADD] to add these images as part of the images to use in Learning GPM locator tool. If there are multiple detection results and they include incorrect ones, they can be removed in a later step, so you may add them.

If there are no objects detected correctly, click [DISCARD] to discard the images and the detection results.

No matter which of [ADD] and [DISCARD] you select, the live image display starts again, so you can perform detection again.

> **MEMO**
> If you have not added or discarded any images, you cannot click [Next>]. [ADD] or [DISCARD] images and return to the live image display before clicking [Next>].

4 Change the scene by moving the object or objects within the field of view and repeat steps 1 to 3 to add a sufficient number of images and detection results. The more the images and detection results, the more accurate the learning results. It is desirable that the target objects be dispersed into the same positions as those when the production operation is performed. For a target object that has individual differences, it is preferable to snap images of multiple instances.

5 Click [Next>] to go to the next step.

4.2.4.5 Confirm images and results

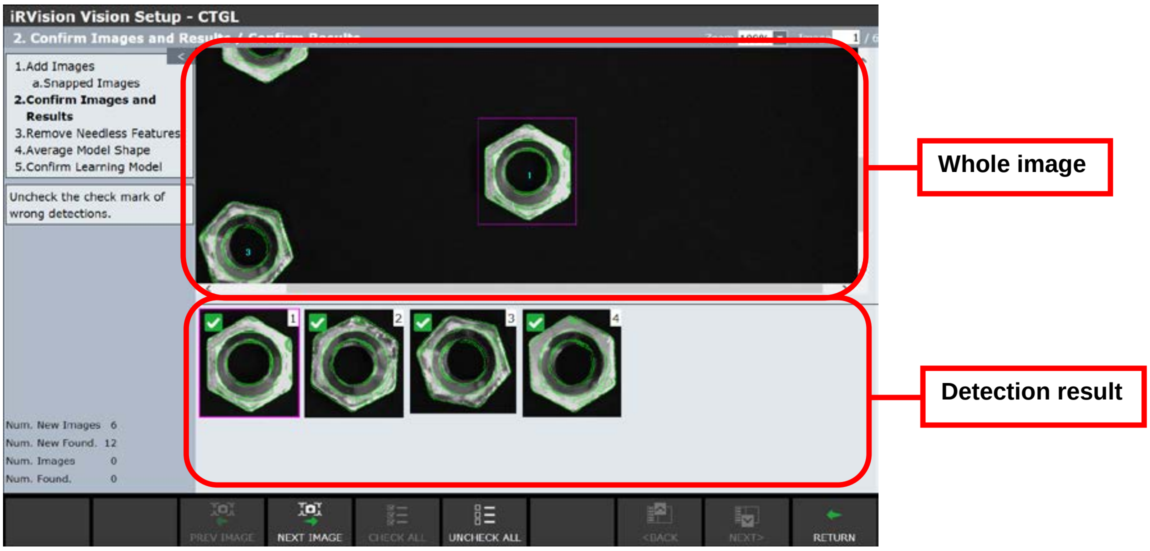
The steps confirm the images and detection results to use in Learning GPM locator tool are shown below.

> **MEMO**
> The screen in this step consists of two screens, a list of images and a list of detection results. By moving between these two screens, confirm the images and the detection results and remove any incorrect detection results you may find.

In the image list screen, the images to use in learning are displayed as thumbnails shown in the figure below.

For each image, detection results are plotted.

1 Click the image where you want to check the found results.
The list screen for found results will appear.

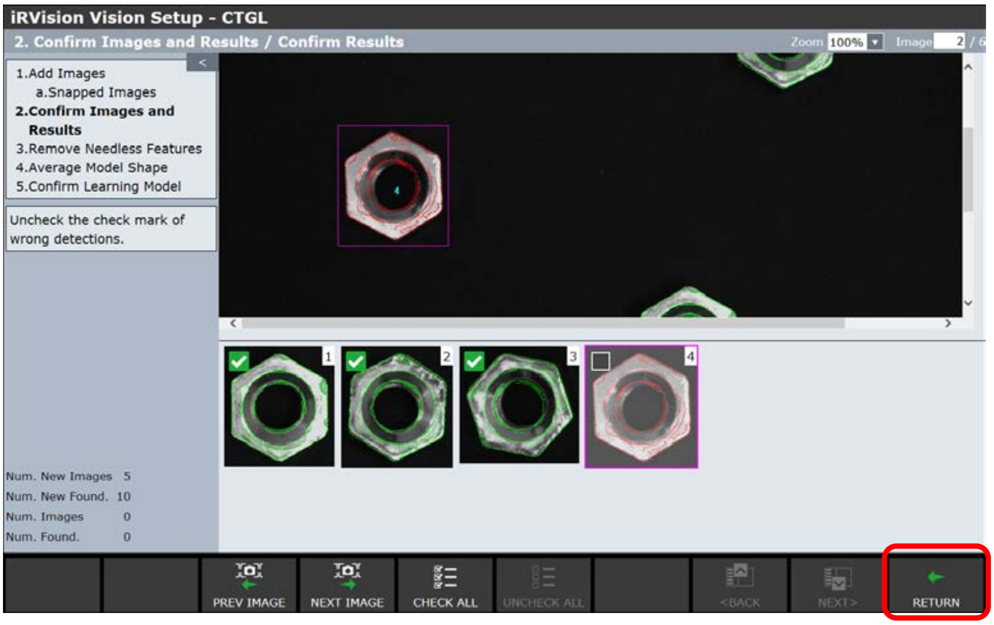


In the upper half of this screen, the selected entire image is displayed, and in the lower half, all results found from the image are displayed.

You can change the display size of the entire image displayed in the upper half with [Zoom] in the tool bar.

2 Check the found results and select the found results that are used in learning.
Click [CHECK ALL] to select all the found results.
Click [UNCHECK ALL] to deselect all the found results. If you uncheck all found results, all images that are used for learning will be unchecked when you go back to the image list screen.

If you click the thumbnail of a detection result, the detection result is highlighted in both the entire image and the thumbnail of the detection result.
If you find any incorrect detection result, click the icon of the detection result to remove the detection result.

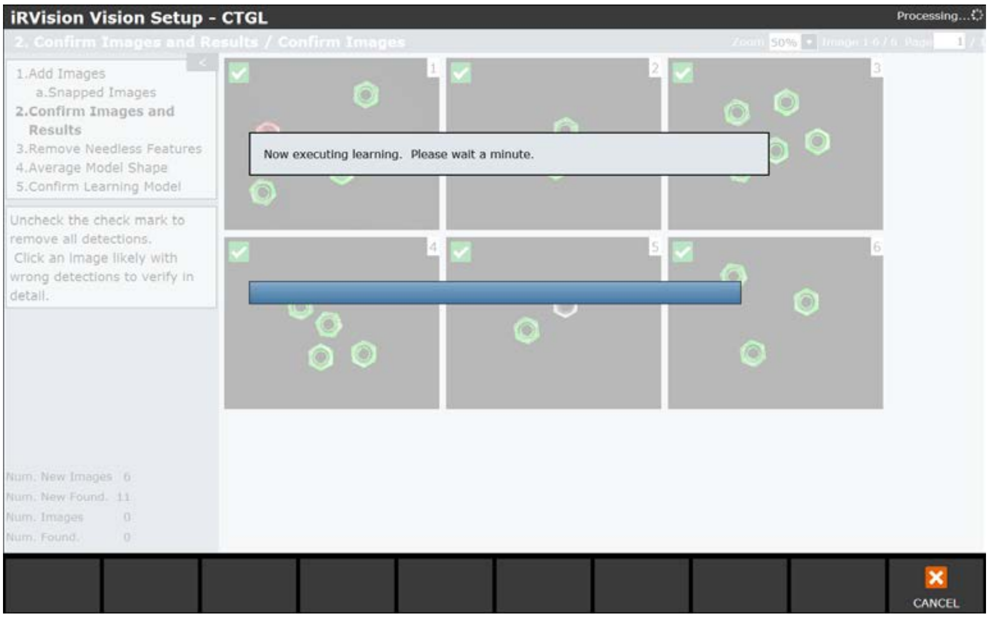


[FIND] appears only when [Learn again with the same images] is selected. You can discard the existing found results of this image and find the target objects again.

3 Click [RETURN].
Return to the logged image list screen. From this screen, you cannot move directly to the next or previous step of the wizard. You must click this [RETURN] to return to the logged image list screen first.

4 Repeat the operation in steps 1 to 3 and check images and found results.

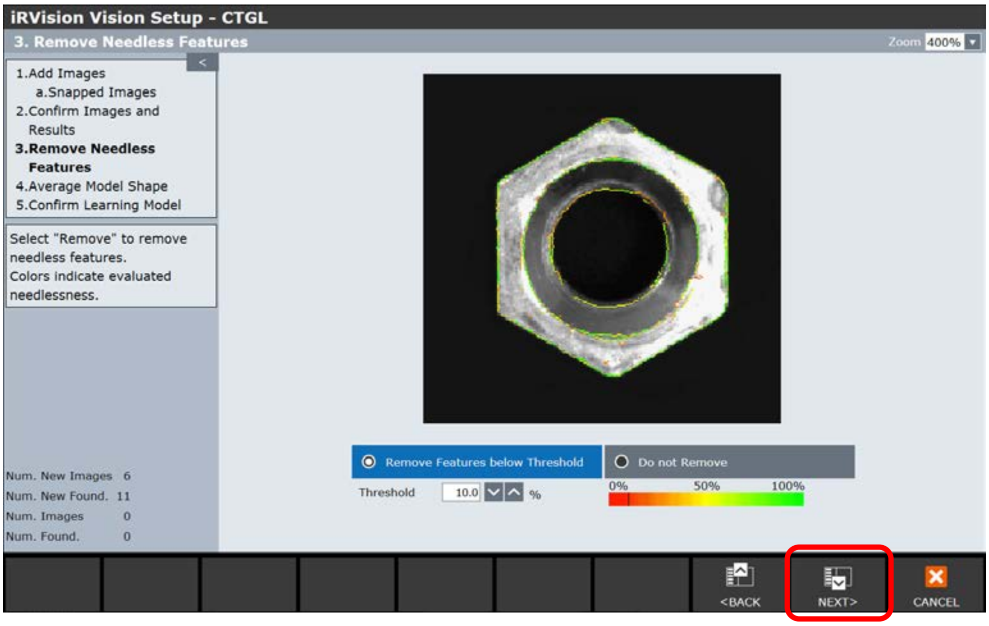
5 After confirming all the images and detection results, click [Next>].
Then, model learning is started, using the added images and detection results.



Upon the completion of model learning, you automatically go to the next step.

4.2.4.6 Remove needless features

The step to remove any features that are judged potentially needless through learning is shown below. The model pattern as a result of learning is displayed on the screen shown in the figure below.



On the image, each feature of the model pattern is displayed in a color. A feature whose need in detection is considered high is displayed in green, while a feature whose need is considered low (that is highly likely not necessary) is displayed in red. Any features whose need is less than the [Threshold] value are not displayed.

1. Click [Remove Features below Threshold].
2. Adjust the [Threshold] value in such a way that the features you want to remove are not displayed. The higher the value, the more features will be removed. If the needed features are no longer displayed, reduce the [Threshold] value.
3. Click [Next>] to go to the next step.

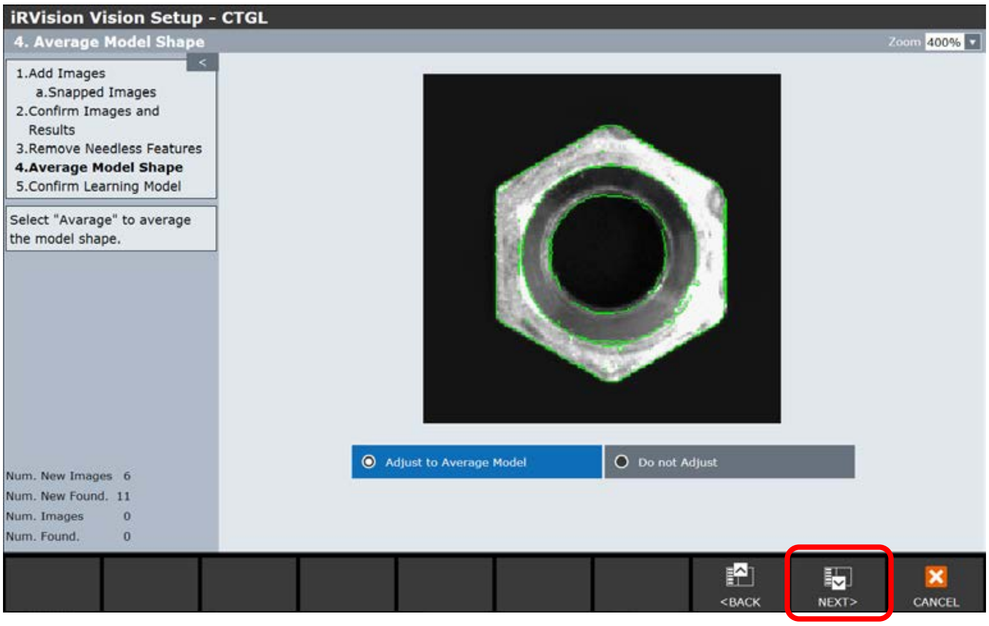
If you do not want to remove the needless features, select [Do not Remove].

MEMO

After learning, you can mask any needless features on the model pattern manually later. It is recommended that you leave features unremoved except those that are clearly needless.

4.2.4.7 Average model shape

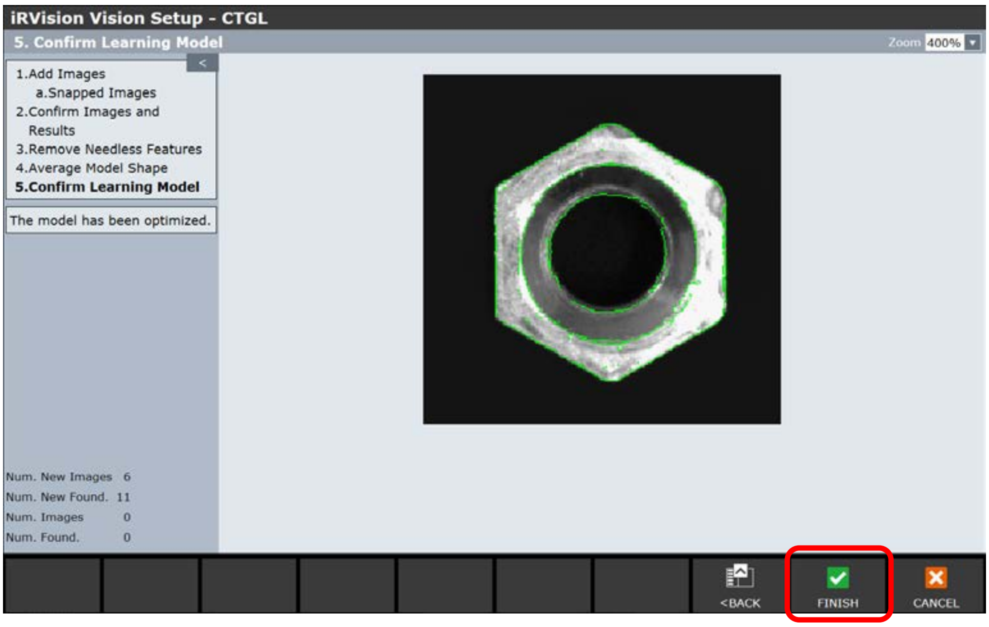
The step to average the shape of the model pattern is shown below.
The model pattern as a result of learning is displayed on the screen, shown in the figure below.



1 Click [Adjust to Average Model].
If you do not want to average the model shape, select [Do not Adjust].
2 Click [Next>] to go to the next step.

4.2.4.8 Confirm learning model

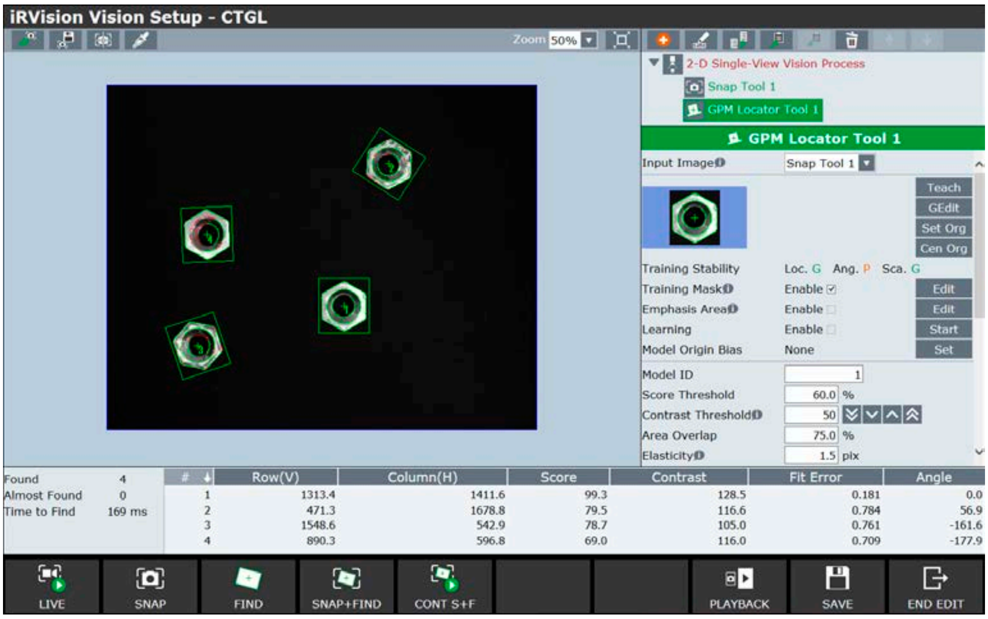
The step to confirm that the model pattern has been optimized through learning is shown below.



1 [FINISH] to adopt the learning model pattern and return to the GPM Locator tool setting screen.
[CANCEL] to discard the learning model pattern and return to the GPM Locator tool setting screen.

The optimization of the model pattern through model learning is now completed.

Click [FIND] in the GPM locator tool edit screen. Optimize the model pattern and execute a test. For details, refer to "Setup: 4.2.3 Running a Test".



MEMO

1 When vision data is saved, information about the images and detection results used in Learning GPM locator tool is saved to the same device as that used for the vision log. Thus, this information will not be lost even after the controller is turned off.

2 If you find any problems with the learning model pattern, you can return the model pattern to the state before learning by unchecking [Enable] of [Learning].

4.2.5 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to “Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 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.

[Orientation]

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.

[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.

[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.

4.2.6 Setup Guidelines

Read these guidelines for a deeper understanding of how the GPM Locator tool works.

4.2.6.1 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.

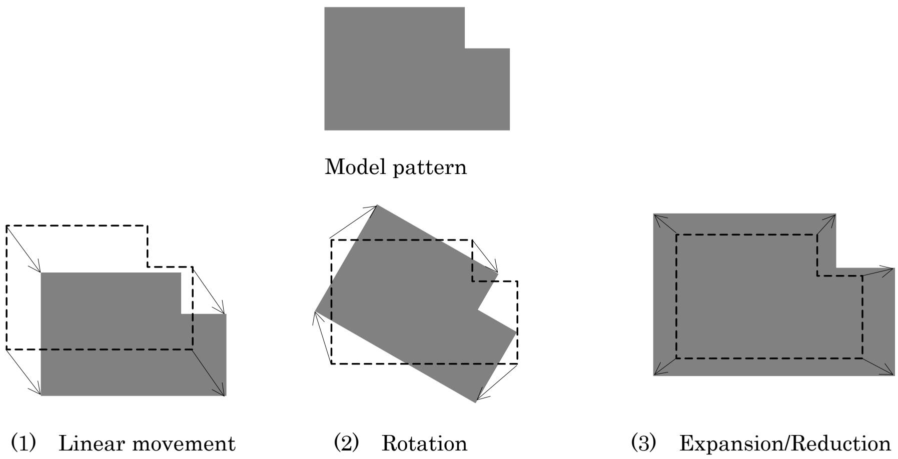


Fig 4.2.6.1 (a) Pattern movement

What is the same 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

I will discuss about a “figure having the same geometry”.
For example, suppose that you look at circular cylinders via a camera, as in Fig. 4.2.6.1(b). While the figures in Fig. 4.2.6.1(b) (i) and Fig. 4.2.6.1(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. 4.2.6.1(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. 4.2.6.1(b) (i) and Fig.4.2.6.1(b) (ii). Therefore, the tool considers the figure in the image in Fig. 4.2.6.1(b) (iii) to have a “different geometry” from those in Fig. 4.2.6.1(b) (i) and Fig. 4.2.6.1(b) (ii).

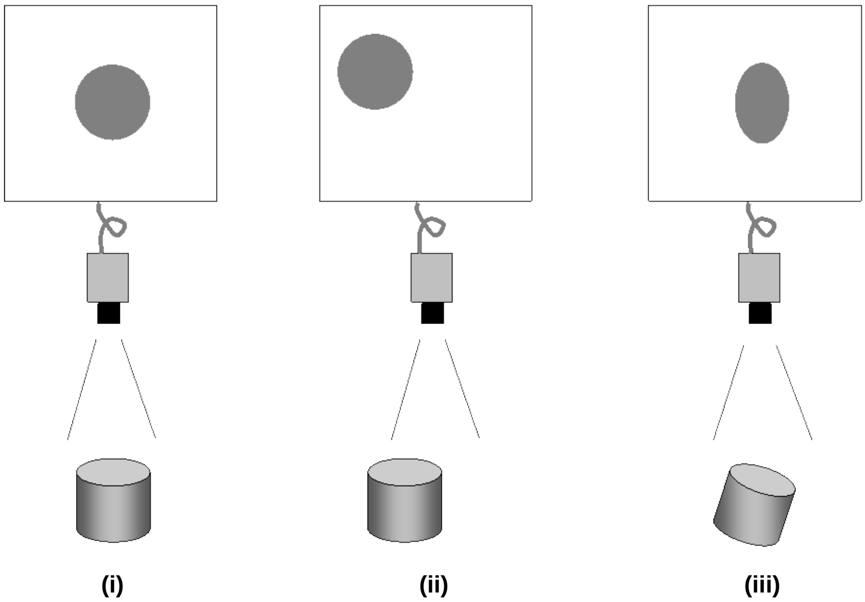


Fig 4.2.6.1 (b) When seen from the

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 model patterns are distorted differently.

The GPM Locator Tool is designed to allow a “certain degree of geometric deviation” between two patterns. Fig. 4.2.6.1(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.

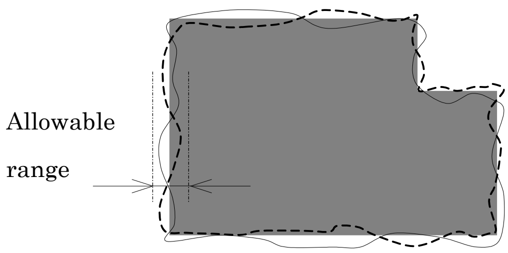


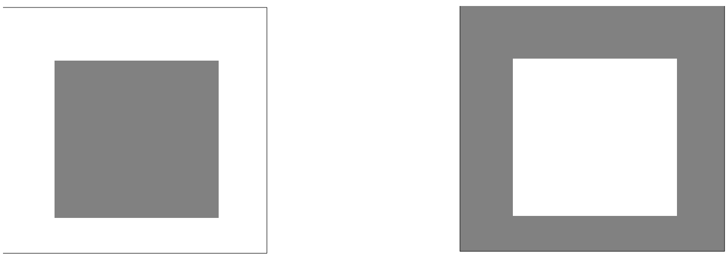
Fig4.2.6.1 (c) Geometric deviation

Also, the cause of a circular cylinder being presented as an ellipse, as in Fig. 4.2.6.1(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

I will discuss about a “figure having the same dark/light polarity”.
Suppose you have two images as shown in Fig. 4.2.6.1(d) (i) and Fig.4.2.6.1(d) (ii). The figures in Fig. 4.2.6.1(d) (i) and Fig. 4.2.6.1(d) (ii) have the same geometry because both are squares of the same size. However, Fig. 4.2.6.1(d) (i) has a dark square on a light background, while Fig. 4.2.6.1(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. 4.2.6.1(d) (i), the tool cannot find a pattern like the one in Fig. 4.2.6.1(d) (ii).

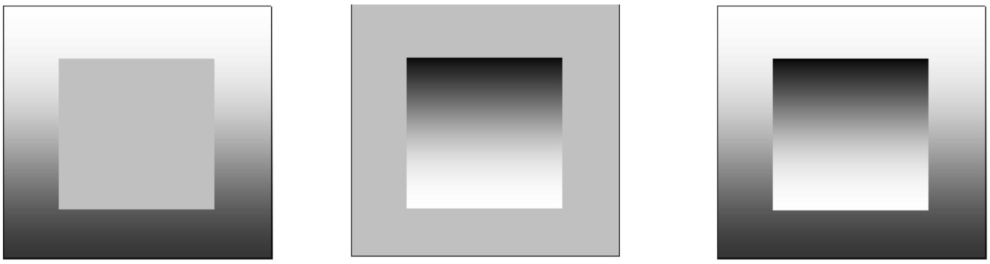


(i) **(ii)**

Fig 4.2.6.1 (d) Dark/light polarity

Next, suppose that you teach the pattern in Fig. 4.2.6.1(d) (i) as the model pattern and then obtain images with the patterns shown in Fig. 4.2.6.1(e). The image in Fig. 4.2.6.1(e) (i) has uneven brightness in the background, and the image in Fig. 4.2.6.1(e) (ii) has uneven brightness in the workpiece (square). The image in Fig. 4.2.6.1(e) (iii) has uneven brightness in both the background and the workpiece.

These three patterns all have the same dark/light polarity as Fig. 4.2.6.1(d) (i) in the upper half of the square and as Fig. 4.2.6.1(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 4.2.6.1 (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. 4.2.6.1(d) and Fig. 4.2.6.1(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. 4.2.6.1(f) (i) as the model pattern and then have an image captured by the camera with the pattern shown in Fig. 4.2.6.1(f) (ii). The pattern in Fig. 4.2.6.1(f) (b) does not contain a white circle, which is found in the model pattern in Fig. 4.2.6.1(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. 4.2.6.1(f) (ii) is considered to be different from the model pattern in Fig. 4.2.6.1(f) (i) in that “it is missing the white circle”.

What happens if you teach the pattern in Fig. 4.2.6.1(f) (ii) as the model pattern and then have an image captured by the camera with the pattern shown in Fig. 4.2.6.1(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. 4.2.6.1(f) (i) is considered to have the “same geometry” as the model pattern in Fig. 4.2.6.1(f) (ii).

(i) (ii)

Fig 4.2.6.1 (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”.

4.2.6.2 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.

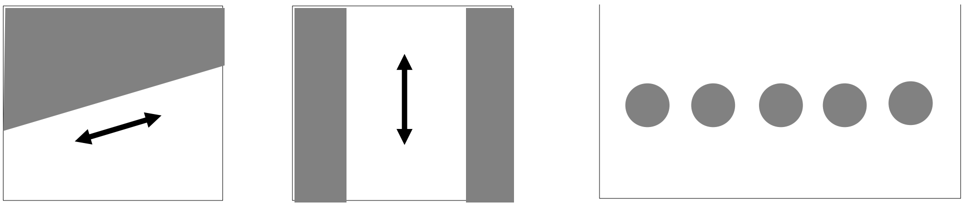
Geometries whose position cannot be determined

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. 4.2.6.2(a) (i) and Fig. 4.2.6.2(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**

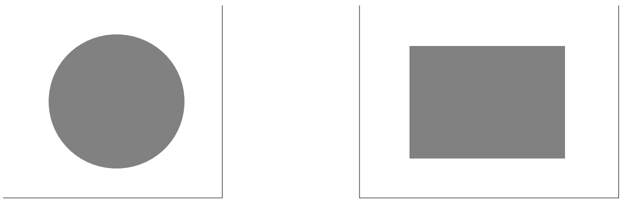
Fig 4.2.6.2 (a) Geometries whose position cannot be

Care must be exercised as well when identical features are equally spaced, as shown in Fig. 4.2.6.2(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 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. 4.2.6.2(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. 4.2.6.2(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 4.2.6.2 (b) Geometry whose orientation cannot be determined

<3> Geometries whose scale cannot be determined

As for a corner like the one shown in Fig. 4.2.6.2(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 4.2.6.2 (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.

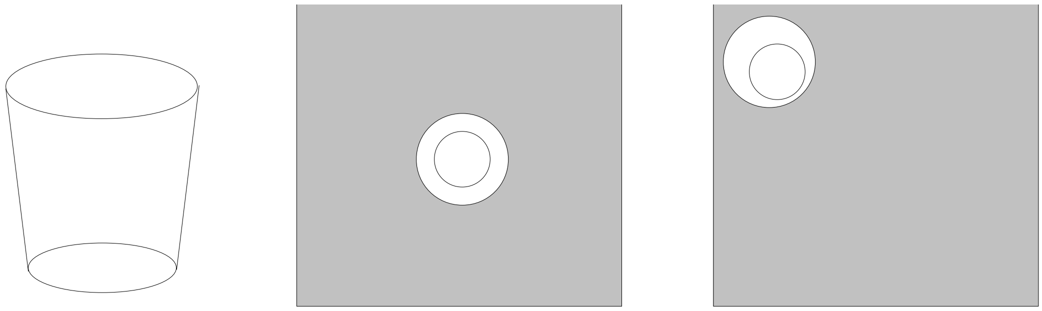
The GPM Locator Tool allows you to mask a specific part of the image and to remove that part from the model pattern after the model pattern teaching operation. This process is called “masking the model pattern”. If the image taught as a model pattern includes any of the parts described below, mask those 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. 4.2.6.2(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. 4.2.6.2(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. 4.2.6.2(d) (iii). Since the patterns in Fig. 4.2.6.2(d) (ii) and Fig. 4.2.6.2(d) (iii) differ in geometry, the pattern in Fig. 4.2.6.2(d) (iii) cannot be found even if the pattern in Fig. 4.2.6.2(d) (ii) is taught as the model pattern.



(i) (ii) (iii)

Fig 4.2.6.2 (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

<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”.

4.2.6.3 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" in "Setup: 4.2.6.2 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:

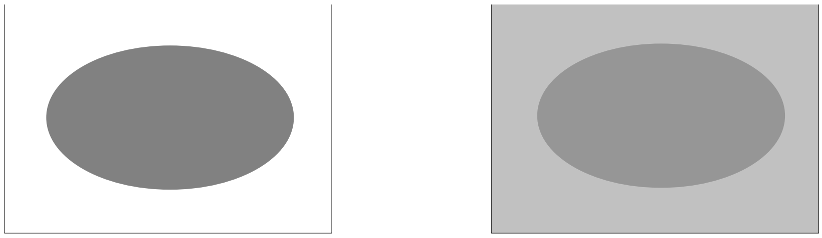
- Whether the lens is in focus
- Whether the lens diaphragm is properly adjusted
- Whether the type of lighting is adequate
- Whether the brightness of lighting is properly adjusted

- Whether the points described in "Masking the model pattern" in "Setup: 4.2.6.2 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. 4.2.6.3 (i) and Fig. 4.2.6.3 (ii). Since the ellipse in (i) is seen clearly, it has a higher contrast value than the one in (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. (ii) is invisible because of low contrast, the pattern's score is reduced as much.



(i) High contrast **(ii) Low contrast**

Fig 4.2.6.3 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

4.2.6.4 Location parameters

This section provides the guidelines on adjusting the parameters of the GPM Locator Tool.

[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" in "Setup: 4.2.6.2 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 threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. 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. Contrast depends on whether ambient light is present. Test whether ambient light is present.

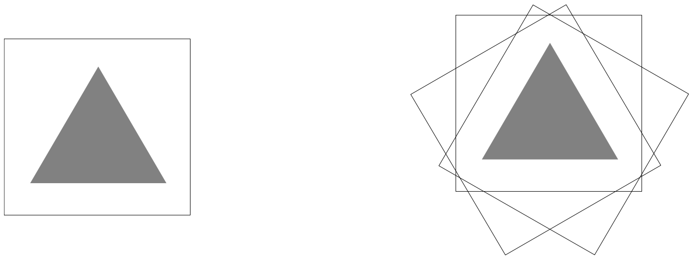
A higher contrast threshold leads to a shorter location process.
If you set the contrast threshold to lower than 20 for the find test, check the following.

- 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" in "Setup: 4.2.6.2 Model Pattern" are followed

[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. 4.2.6.4(a) (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. 4.2.6.4(e) (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 4.2.6.4(a) Overlap restriction

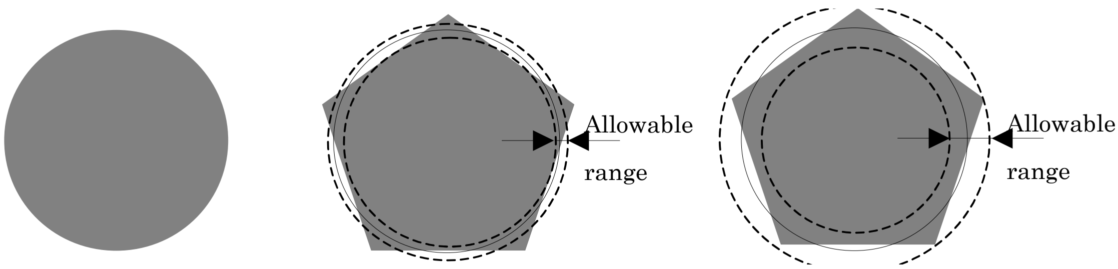
Whether two patterns overlap is determined by whether the area where the patterns' rectangular frames overlap is larger than the ratio specified for overlap restriction. If the ratio of the overlapping area is larger than the specified value, the patterns are judged to overlap. If you specify 100% for overlap restriction, the tool will not delete overlapping patterns unless they fully overlap one another (i.e. they have completely the same geometry). The default value is 75%.

[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. 4.2.6.4(b) (i), as the model pattern, and you have a pentagon in the image, as shown in Fig. 4.2.6.4(b) (ii). When a small value is set for the allowable elasticity, the pattern in Fig. 4.2.6.4(b) (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. 4.2.6.4(b) (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 4.2.6.4(b) 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. 4.2.6.4(b) (iii). Keep in mind that setting a large value for the allowable elasticity can generally result in frequent incorrect locations.

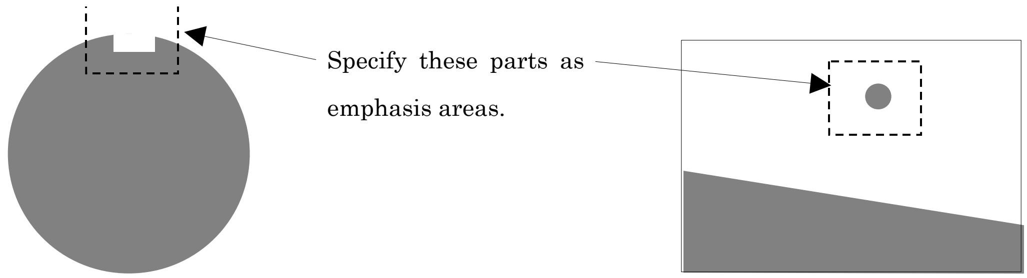
Using an emphasis area

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. 4.2.6.4(c) 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 4.2.6.4(c) 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. 4.2.6.4(d) (i) and (ii) mixed in the mage and want the tool to find only the pattern of Fig. 4.2.6.4(d) (ii). You teach the pattern of Fig. 4.2.6.4(d) (ii) as the model pattern. However, the pattern of Fig. 4.2.6.4(d) (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. 4.2.6.4(d) (ii). In such a case, specify the white circle, which is contained only in the pattern of Fig. 4.2.6.4(d) (ii), as an emphasis area. Doing so allows the tool to find only the pattern of Fig. 4.2.6.4(d) (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.

If you want only the pattern of Fig. 4.2.6.4(d) (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 4.2.6.4(d) Emphasis area

[EA Score 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.

[Allow Floating EA]

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. 4.2.6.4(e) (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 4.2.6.4(e) 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. 4.2.6.4(e) (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.

[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] of [DOF]

Set an orientation search.

<1> Ignore orientation in the search
<2> Do an orientation search within the range specified by the upper and lower limits

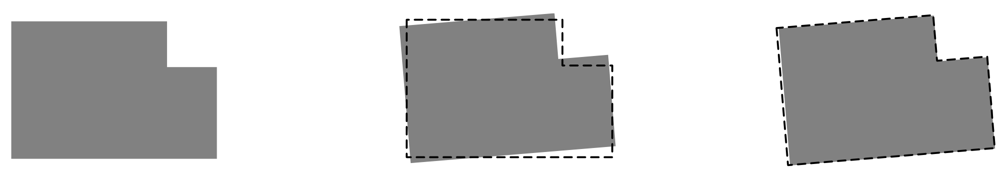
For example, suppose that you teach the geometry shown in Fig. 4.2.6.4(f) (i) and that the image captured by the camera shows the workpiece having the same geometry but rotated at 5 degrees.

If you specify <1>, orientation is ignored in the search. The tool pays attention only to the orientation specified by the [Nom.] and finds those patterns that are not rotated like the one shown in Fig. 4.2.6.4(f) (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 [Min.] and [Max.] limits. Therefore, a pattern like the one shown in Fig. 4.2.6.4(f) (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 4.2.6.4(f) Orientation range

[Scale] of [DOF]

Set a scale search.

<1> Ignore scale in the search
<2> Do a scale search within the range specified by the upper and lower limits

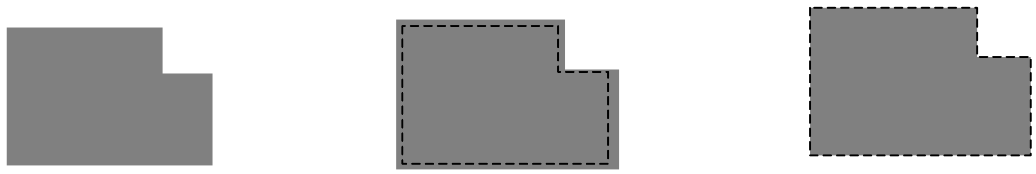
For example, suppose that you teach the geometry shown in Fig. 4.2.6.4(g) (i) and that the image captured by the camera shows the workpiece having the same geometry but expanded by 3%.

If you specify <1>, scale is ignored in the search. The tool pays attention only to the scale specified by the [Nom.] and finds those patterns that are not expanded like the one shown in Fig. 4.2.6.4(g) (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 [Min.] and [Max.] limits. Therefore, a pattern like the one shown in Fig. 4.2.6.4(g) (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 [Min.] and [Max.] 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 4.2.6.4(g) Scale range

[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.

[Show 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

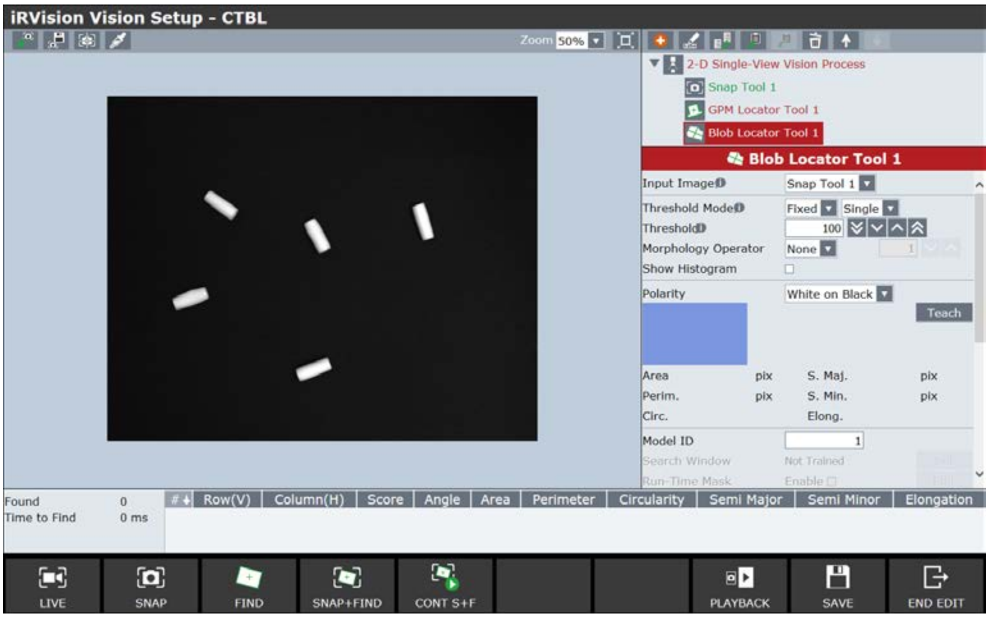
- Pattern whose contrast is slightly lower than the threshold
- Pattern whose emphasis area is slightly lower than the threshold
- Pattern whose orientation is slightly outside the range
- Pattern whose scale is slightly outside the range

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.

4.3 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.



4.3.1 Setup Items

The blob locator tool has the following parameters.

[Input Image]

Select an image to use in teaching and finding of blobs from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Threshold Mode]

For the left dropdown box, select one of the followings:

[Fixed]

Binarize the image using the specified threshold set in [Threshold] as it is.

[Auto]

Calculate the threshold automatically for an individual image as brightness changes based on the threshold value specified for the image used for training.

For the right dropdown box, select one of the followings:

[Single]

Binarize the image using a single threshold value. Pixels darker than the threshold become black, and pixels brighter than the threshold become white.

[Dual]

Binarize the image using two (lower and upper) threshold values. Pixels darker than the lower threshold and pixels brighter than the upper threshold become black, and pixels which are brighter than the lower threshold and darker than the upper threshold become white.

[Threshold value]

This item is the threshold value for the Single mode. Set the threshold using an integer in the range of 0 to 255. Enter a new value in the field, or change the existing value using button, so that there is a clear black-and-white distinction between the object and the background. This is a parameter that appears when [Single] is selected in [Threshold value].

[Lower Threshold]

This item is the lower threshold value for the Dual mode. Set the threshold for binarization using an integer in the range of 0 to [Upper Threshold]. Enter a new value in the field, or change the existing value using button, so that there is a clear black-and-white distinction between the object and the background. This is a parameter that appears when [Dual] is selected in [Threshold Mode].

[Upper Threshold]

This item is the upper threshold value for the Dual mode. Set the threshold for binarization using an integer in the range of [Lower Threshold] to 255. Enter a new value in the field, or change the existing value using button, so that there is a clear black-and-white distinction between the object and the background. This is a parameter that appears when [Dual] is selected in [Threshold Mode].

[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.

[Show Histogram]

Set whether histogram display is enabled or disabled.

[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.

[Both]

Find both.

[Teach] button

Teach the workpiece to be found as the model blob. For details, refer to "Setup: 4.3.2 Teaching a Model".

[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.

[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, click 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, refer to "Setup: 1.8.8 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.

To change the run-time mask, click the [Edit] button. The operation method for editing the run-time mask is the same as the mask. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

[Calculate 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. Specify it when you checked [Calculate Angle].

[Axes 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]

Specify the range to be searched.

[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 [Min.] and [Max.], the location succeeds. If [Enable] is uncheck the box, the area will not be checked.

[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 [Min.] and [Max.], the location succeeds. If [Enable] is uncheck the box, the perimeter will not be checked.

[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 [Min.] and [Max.], the location succeeds. If [Enable] is uncheck the box, the degree of circularity will not be checked.

[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 [Min.] and [Max.], the location succeeds. If [Enable] is uncheck the box, the semi-major axis length will not be checked. When the minimum rectangle is selected in the Angle Calc Method, the semi-major axis length means the radius of the minimum rectangle.
Specify it when you checked [Calculate Angle].

[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 [Min.] and [Max.], the location succeeds. If [Enable] is uncheck the box, the semi-minor axis length will not be checked. When the minimum rectangle is selected in the Angle Calc Method, the semi-minor axis length means the radius of the minimum rectangle.
Specify it when you checked [Calculate Angle].

[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 [Min.] and [Max.], the location succeeds. If [Enable] is uncheck the box, the elongation will not be checked.
Specify it when you checked [Calculate Angle].

[Plot 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 from the drop-down box.

[Gray scale image]
The image selected in [Input Image] will appear.

[Gray Scale Im.+ Results]
The image selected in [Input Image] and the results of FIND will appear.

[Gray Scale + Threshold]
The image selected in [Input Image] and masks will appear. The white areas of binarized image are displayed as green masks.

[Binary Image]
The binary image of the image selected in [Input Image] will appear.

[Binary Image + Results]
The binary image of the image selected in [Input Image] and the results of FIND will appear.

[Model Image]
The taught model image will appear.

4.3.2 Teaching the Model

Teach the workpiece to be found as the model.

4.3.2.1 Setting the Image binarization

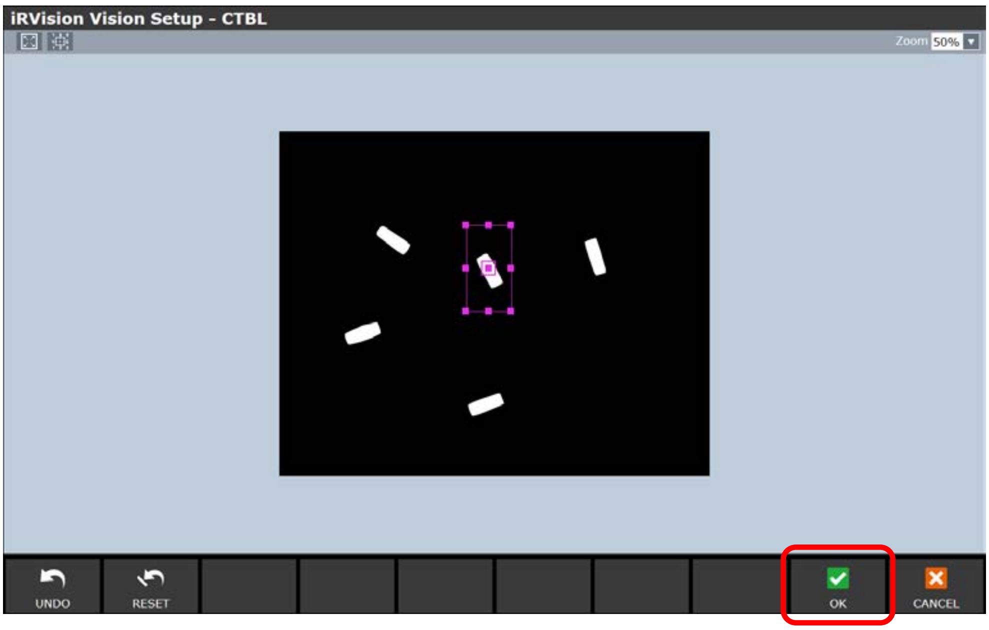
The blob locator tool converts an input gray-scale image into a binarized black-and-white image before performing image processing. First, set the conditions for the binarization of an image.

1 Put the workpiece in the field of camera view.
2 In the drop-down box on the left of [Threshold Mode], select [Fixed] or [Auto].
3 In the drop-down box on the right of [Threshold Mode], select [Single] or [Dual].
4 Specify the threshold value in [Threshold value].
This parameter is not displayed if you selected [Dual] for [Threshold Mode].
5 If you want to filter the binarized image, specify a filter type and the size in [Morphology Operator].

4.3.2.2 Train model

Teach the model as follows.

1 Click [LIVE] in the blob locator tool edit screen.
It will be switched to live image display.
2 Place the workpiece near the center of the camera view.
3 Click [STOP] and then click [SNAP] to snap the image of the workpiece.
4 Select the color of the blob to be found in [Polarity].
A full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
5 Enclose the workpiece within the displayed rectangle, and click [OK].
The workpiece is trained as the model.
For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".



Trained model info.

When the model is trained, the thumbnail image inside the window that was set when training the model and the feature information of the trained blob is displayed.

[Area]

Area of the trained blob. By default, it is in pixels.

[Perimeter]

Perimeter of the trained blob . By default, it is in pixels.

[Circularity]

Degree of circularity of the trained blob.

[Semi Major]

Long axis length of the trained blob. By default, it is in pixels.

[Semi Minor]

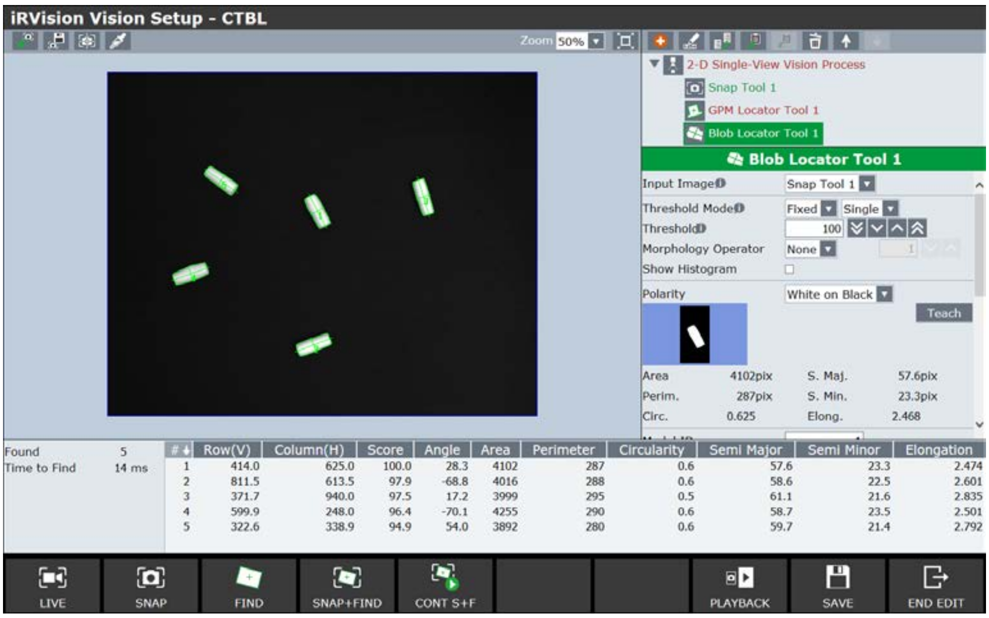
Short axis length of the trained blob. By default, it is in pixels.

[Elongation]

Elongation of the trained blob.

4.3.3 Running a Test

[FIND] to run a test and see if the tool can find blobs properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found blobs is displayed.

[Time to Find]

The time the location process took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed

[Row(V)], [Column(H)]
Coordinate values of the center of mass of the found blob. By default, it is in pixels.

[Score]
Score of the found blob.

[Angle]
Orientation of the found blob. This is displayed only when the [Calculate Angle] check box is checked.

[Area]
Area of the found blob. By default, it is in pixels. When [Measurements in mm] is enabled in the parent vision process, it is converted to millimeters.

[Perimeter]
Perimeter of the found blob. By default, it is in pixels. When [Measurements in mm] is enabled in the parent vision process, it is converted to millimeters.

[Circularity]
Degree of circularity of the found blob.

[Semi Major]
Long axis length of the found blob. It will appear when [Calculate Angle] is checked.
By default, it is in pixels. When [Measurements in mm] is enabled in the parent vision process, it is converted to millimeters.

[Semi Minor]
Short axis length of the found blob. By default, it is in pixels. It will appear when [Calculate Angle] is checked.
When [Measurements in mm] is enabled in the parent vision process, it is converted to millimeters.

[Elongation]
Elongation of the found blob. It will appear when [Calculate Angle] is checked.

✐MEMO

1 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.

2 When [Measurements in mm] is enabled in the parent vision process, Area, Perimeter, Semi-major and Semi-minor are converted to millimeters.
Semi-major and Semi-minor can be converted accurately. Area and Perimeter are approximate values calculated by using the average scale.

3 When you enable/disable [Measurements in mm] after teaching the model blob, you need to reteach the model blob.

4.3.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE".

[Area]

Specify 1 to enable the checking, or 0 to disable it.
Also, the minimum and maximum DOF can be specified.
Specify a number equal to or larger than 0 for minimum and maximum area.

[Perimeter]

Specify 1 to enable the checking, or 0 to disable it.
Also, the minimum and maximum DOF can be specified.
Specify a number equal to or larger than 0 for minimum and maximum perimeter.

[Circularity]

Specify 1 to enable the checking, or 0 to disable it.
Also, the minimum and maximum DOF can be specified.
Specify a number between 0 and 1 for minimum and maximum circularity.

[Semimajor]

Specify 1 to enable the checking, or 0 to disable it.
Also, the minimum and maximum DOF can be specified.
Specify a number equal to or larger than 0 for minimum and maximum semi-major axis length.

[Semiminor]

Specify 1 to enable the checking, or 0 to disable it.
Also, the minimum and maximum DOF can be specified.
Specify a number equal to or larger than 0 for minimum and maximum semi-minor axis length.

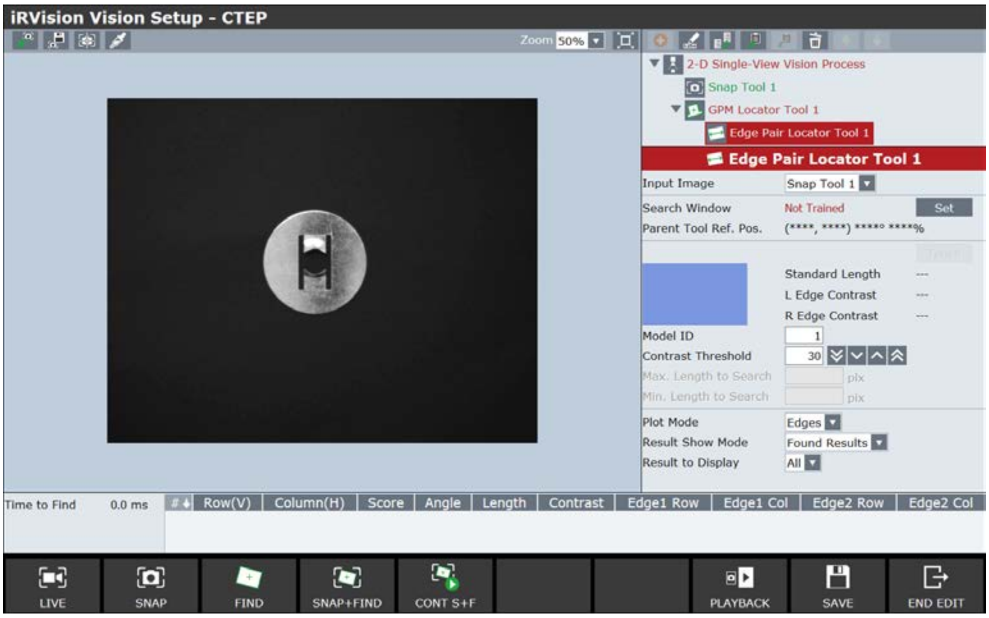
[Elongation]

Specify 1 to enable the checking, or 0 to disable it.
Also, the minimum and maximum DOF can be specified.
Specify a number equal to or larger than 0 for minimum and maximum elongation.

4.4 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.



4.4.1 Setup Items

The edge pair locator tool has the following parameters.

[Input Image]

Select an image to use in teaching and finding of models from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[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. For detailed information about the operation method, refer to "Setup: 4.4.2 Setting the Search Window".

[Parent Tool Ref. Pos.]

It will appear when the edge pair locator tool is used as a child tool. The found position of the parent tool that is used to set [Search Window] appears.

[Teach] button

Teach the edge pair to be found as the model. For details, refer to "Setup: 4.4.3 Teaching a Model". It should be performed after setting [Search Window].

[Model ID]

When you want to have taught two or more 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 threshold for how much contrast (difference between light and dark) is required in the image to identify something as an edge. Input the value or change the value using buttons. 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.

[Max. 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.

[Min. 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.

[Plot Mode]

Select the image display mode for the Setup Page.

[Edges]

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.

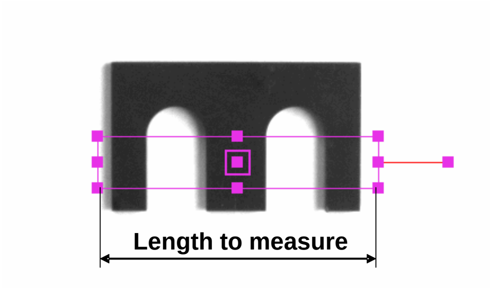
[Result to Display]

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.

4.4.2 Setting the Search Window

Set the area to be searched for an edge pair. The shorter the search window is in height, the more accurately the position of the edges is found. Set the search window as follows:

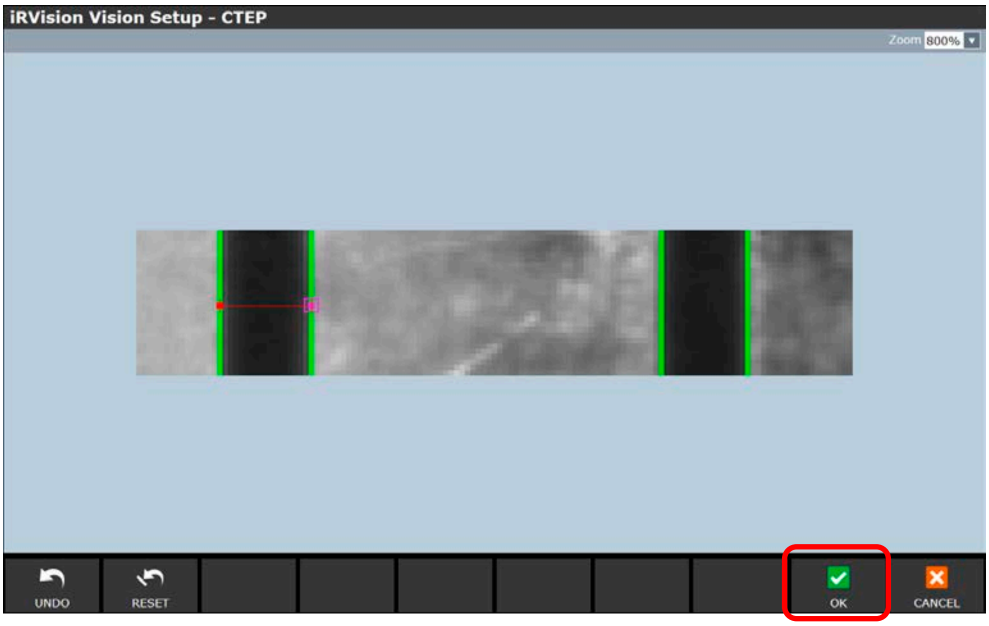
1 Click the [Set] button in [Search Window] in the edge pair locator tool edit screen.
  A window that has control points (reddish purple rectangle) will appear.
2 When a rectangle appears on the image, enclose the area containing the edge pair to find with the displayed rectangle, and click [OK].
  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.



In order to change the search window that has been already set, click the [Set] button in [Search Window] in the edge pair locator tool edit screen. When a window that has control points appears on the image, adjust as when teaching a model.
For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

4.4.3 Teaching the Model

Teach the edge pair to be found as the model. The procedure for teaching the model is as follows.



1 Click [LIVE] in the edge pair locator tool edit screen.
  It will be switched to live image display.
2 Place the workpiece near the center of the camera view.
3 Click [STOP] and then click [SNAP] to snap the image of the workpiece.
4 Click the [Teach] button.
  Edges found in the search window will appear on the screen.

5 Move the left tip of the red line to the left edge of the edge pair used as the model.
6 Move the right tip of the red line to the right edge of the edge pair used as the model.
7 Click [OK].
The selected edges are trained as the model edge pair.

Model Edge Pair

When the model is trained, the thumbnail image inside the window that was set when training the model is displayed. In the thumbnail image, the taught edge pair will appear as green straight lines. The distance between edges will appear as green arrows.
The polarity of the edges to be found (from white to black or black to white) can be seen.

[Standard Length]

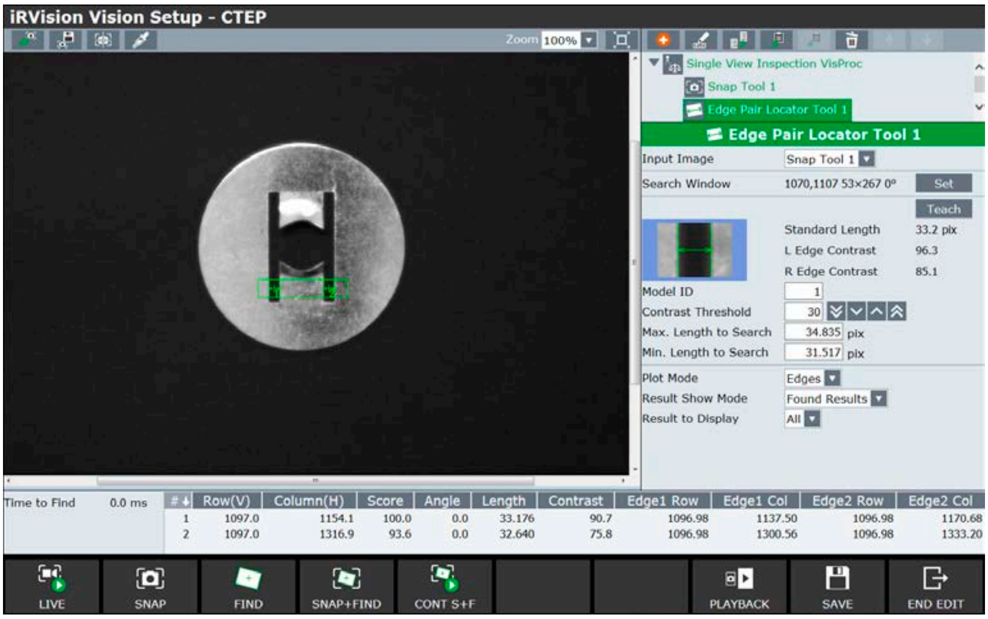
It is the distance between edges of the model edge pair. At runtime, if two or more edge pair candidates are found in the search window and they overlap each other, priority is given to the edge pair whose distance between edges is closest to the standard length.

[L Edge Contrast], [R 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.

4.4.4 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[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.

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

Coordinates of the center of mass of the found edge pair. By default, it is in pixels.
It will appear when [Found Results] is selected in [Result Show Mode].

[Score]

Score of the found edge pair.
It will appear when [Found Results] is selected in [Result Show Mode].

[Angle]

The angle of the search window when FIND is executed. This shows how much it has rotated after the search window was set. The units are degrees.
It will appear when [Found Results] is selected in [Result Show Mode].

[Length]

Inter-edge distance of the found edge pair. By default, it is in pixels. If [Measurements in mm] is checked in the parent vision process, the units are mm.

[Contrast]

Average contract of the found edge pair.
It will appear when [Found Results] is selected in [Result Show Mode].

[Edge1 Row]

Vertical-direction coordinate of the left edge of the found edge pair (unit: pixel).
It will appear when [Found Results] is selected in [Result Show Mode].

[Edge1 Col]

Horizontal-direction coordinate of the left edge of the found edge pair (unit: pixel).
It will appear when [Found Results] is selected in [Result Show Mode].

[Edge2 Row]

Vertical-direction coordinate of the right edge of the found edge pair (unit: pixel).
It will appear when [Found Results] is selected in [Result Show Mode].

[Edge2 Col]

Horizontal-direction coordinate of the right edge of the found edge pair (unit: pixel).
It will appear when [Found Results] is selected in [Result Show Mode].

[Length]

Distance between found edge pairs (unit: pixel).
It will appear when [All Edge Pairs] is selected in [Result Show Mode].
If [Measurements in mm] is checked in the parent vision process, the units are mm.

[Contrast 1]

Average contrast of the left edge of the found edge pair.
It will appear when [All Edge Pairs] is selected in [Result Show Mode].

[Contrast 2]

Average contrast of the right edge of the found edge pair.
It will appear when [All Edge Pairs] is selected in [Result Show Mode].

4.4.5 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

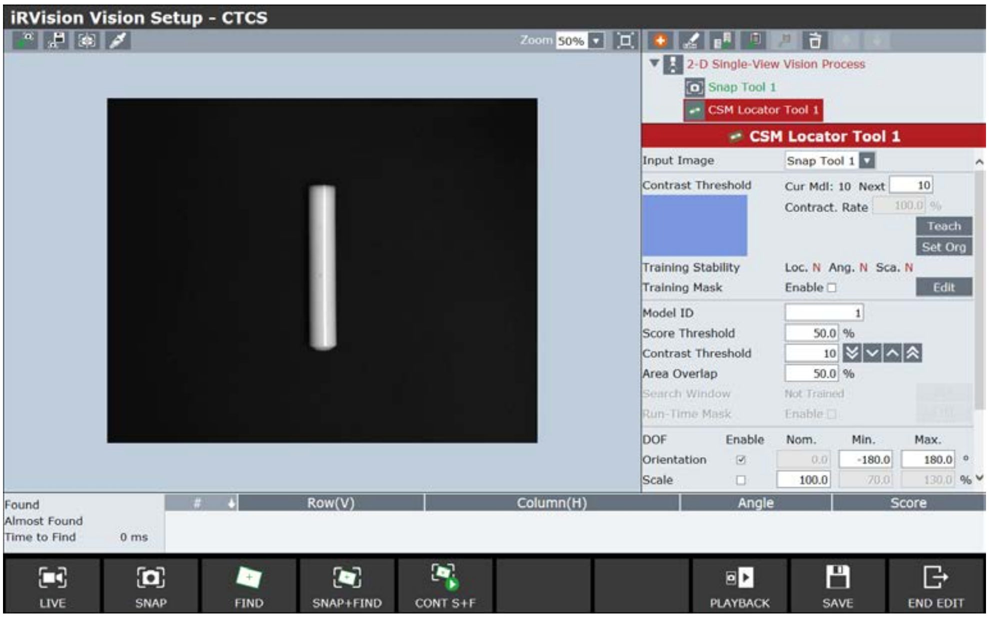
[Contrast Threshold]

Specify a number between 1 and 250.

4.5 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 [CSM Locator Tool] in the tree view of the setup page for the vision process, a screen like the one shown below appears.



4.5.1 Setup Items

The curved surface locator tool has the following parameters.

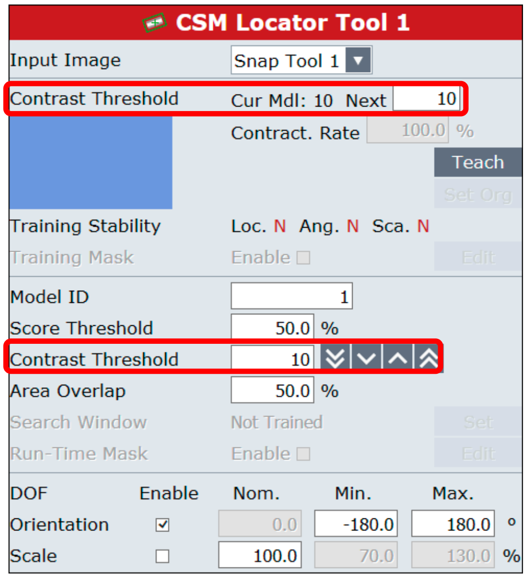
[Input Image]

Select an image to use in teaching and finding of models from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Contrast Threshold]

Specify the threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. Input the value or change the value using buttons.

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.
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 + Gradations] in [Image Display Mode] lets you check the image features extracted based on the current threshold.
In the curved surface locator tool, set contrast threshold at two locations in the setting items area.



[Contrast Threshold] that is located above the [Teach] button is used only when models are taught.
[Contrast Threshold] that is located below [Score Threshold] is used when RUN_FIND is executed.

[Contract. Rate]

The reduction rate when models are taught. In order to reduce the time to find, the curved surface locator tool teaches models which are reduced. Normally, you do not have to change the reduction rate because it is automatically calculated when models are taught. If you set larger value, more detailed features can be recognized but processing time will be longer.

[Teach] button

Teach the model pattern of the workpiece you want to find. For details, refer to "Setup: 4.5.2 Setting up a Model".

[Set Org] button

Move the position of the model origin manually. For details, refer to "Setup: 4.5.2.4 Model Origin".

[Training Stability]

The evaluation results for items [Location], [Orientation], and [Scale] of the taught model pattern are displayed. For details, refer to "Setup: 4.5.2.2 Training Stability".

[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.
For details, refer to "Setup: 4.5.2.3 Training Mask".

[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.

[Score Threshold]

Specify the score threshold for a pattern to be found. The units are %. 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.

[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, click 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, refer to "Setup: 1.8.8 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, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

[Parent Tool Ref. Pos.]

It will appear when the curved surface locator tool is used as a child tool. The found position of a parent tool that is used to set [Search Window] appears.

[DOF]

Specify the range to be searched.

[Orientation]

Specify the range of orientation subject to be searched. The tool searches for a model rotated in the range specified by [Min.] and [Max.], with the orientation of the taught model being 0 degrees.
The specifiable value range is from -360 to +360 degrees for both [Min.] and [Max.]. 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 [Enable] is uncheck the box, the orientation is ignored and the tool searches only for a model having the orientation specified in [Nom.].
By default, the orientation search is enabled and the range is from -180 to +180 degrees.

[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 [Min.] and [Max.]. The specifiable value range is from 30% to 160% for both [Min.] and [Max.]. The narrower the size

range is, the faster the search process ends.
If [Enable] is uncheck the box, the scale is ignored and the tool searches only for a model having the scale specified in [Nom.].
By default, the scale search is disabled.
When it is a child tool of another locator tool, specify the range relatively in respect to a parent tool's found result.

[Time-out]

If the location process takes longer than the time specified here, the tool ends the process without finding all of the workpieces.

[Plot 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 Features]
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 Origin Only]
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]
The image selected in [Input Image] will appear.

[Image + Results]
The image selected in [Input Image] and the results of FIND will appear.

[Image + Gradations]
The image selected in [Input Image] and features in the image will appear.

[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.

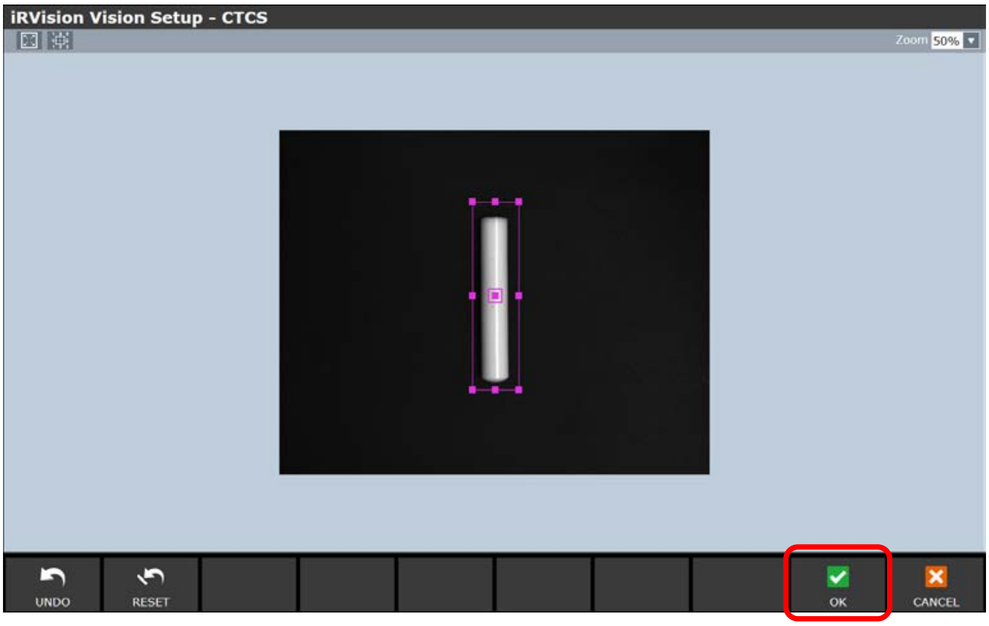
4.5.2 Setting up a Model

Teach the model pattern of the workpiece you want to find.

4.5.2.1 Teaching the model pattern

Teach the model pattern as follows.

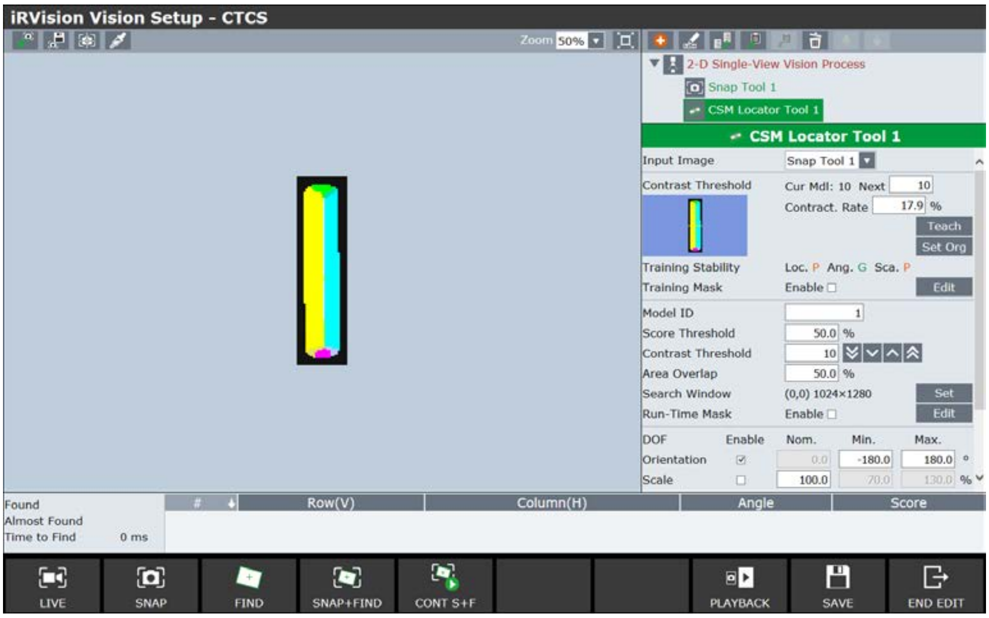
1. Click [LIVE] in the curved surface locator tool edit screen.
   It will be switched to live image display.
2. Place the workpiece near the center of the camera view.
3. Click [STOP] and then click [SNAP] to snap the image of the workpiece.
4. Select [Image + Gradations] in [Image Display Mode], and 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 teaching] for [Contrast Threshold] for model teaching (above the [Model Train] button), and reset [Contrast Threshold] for execution (below [Teach]) to its original value.
6. Click [Teach].
   A full-screen image will appear, and a window that has control points (reddish purple rectangle) will appear.
7. Enclose the workpiece within the red rectangle that appears, and click [OK].
   The model pattern will be taught.
   For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".



4.5.2.2 Training stability

When the model is trained, the evaluation results for items [Location], [Orientation], and [Scale] of the taught model in [Training Stability] are displayed as one of the following three levels.

Good: Can be found stably.
Poor: Cannot be found very stably.
None: Cannot be found.

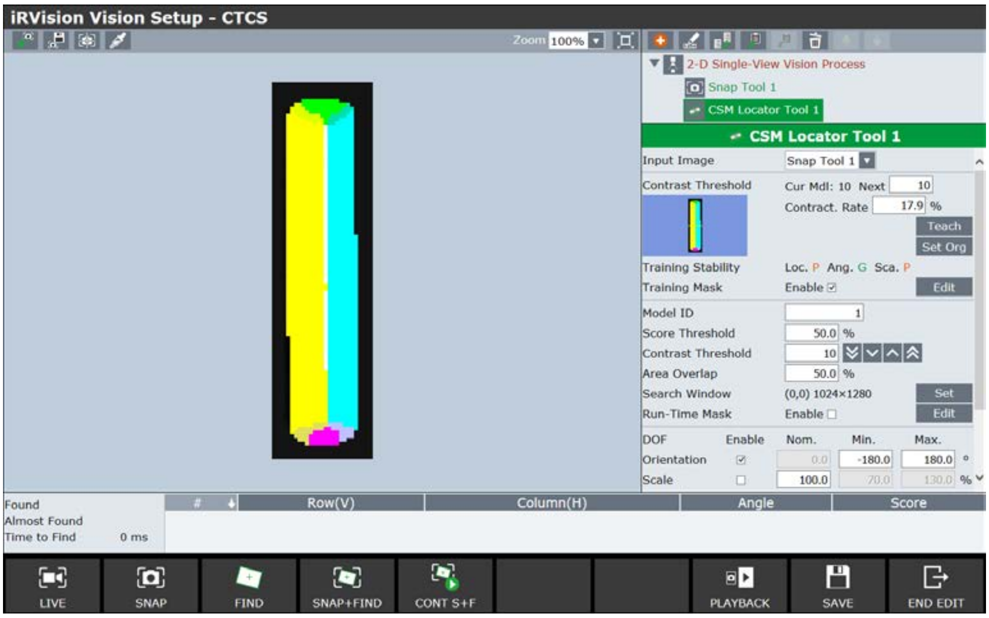


> ⚠ **CAUTION**
> When [×] appears in the evaluation results, reteach the model.

4.5.2.3 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.

1 Click the [Edit] button of [Training Mask] in the curved surface locator tool edit screen.
The display will be in a status to edit a mask.
2 Fill the section that is not necessary in the model pattern with the color of red.
Filling operation is similar to mask editing. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".
3 Click [OK].
Editing a mask is complete.



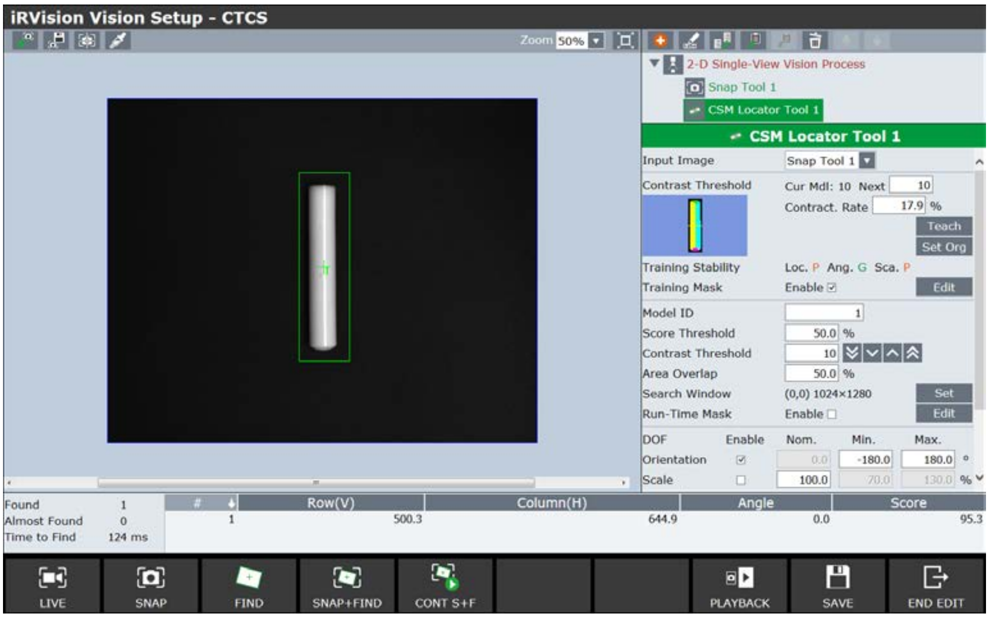
4.5.2.4 Moving model origin

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.

1 Click the [Set Org] button in the curved surface locator tool edit screen.
The display will be in a status to edit the point. At the current position of the model origin, will appear.
2 Move .
The positions of model origins move.
For the operation method for the point, refer to "Setup: 1.8.7 Point Setup".
3 Click [OK].
Editing a model origin is complete.

4.5.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[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.

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

Coordinates of the model origin of the found pattern. By default, it is in pixels.

[Orientation]

Orientation of the found pattern (units: %). It will appear when you check [Enable] in [Orientation] of [DOF].

[Scale]

Scale of the found pattern (units: %). It will appear when you check [Enable] in [Scale] of [DOF].

[Score]

Score of the found pattern.

4.5.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to “Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Score Threshold]

Specify a number between 10 and 100.

[Contrast Threshold]

Specify a number between 1 and 250.

[Orientation]

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.

[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 30 and 160 for the minimum, maximum and nominal scales.

4.5.5 Setup Guidelines

Read these guidelines for a deeper understanding of how the curved surface locator tool works.

4.5.5.1 Mechanism of curved surface locator tool

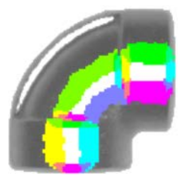
This subsection provides an overview of the curved surface locator tool, describing what you can do and how you see objects with this tool.

What you can do with the curved surface locator tool

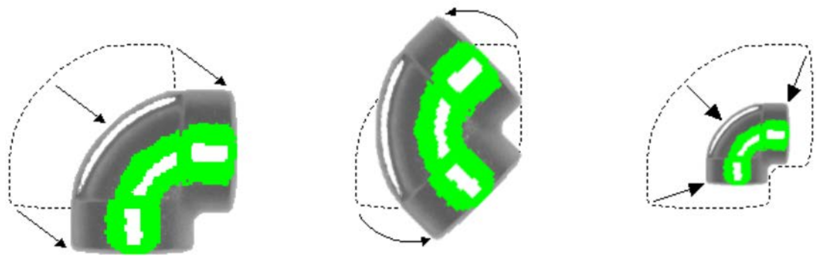
The curved surface locator tool offers image processing capabilities to process images captured by the camera, find the same pattern in an image as the pattern taught in advance, and output the position and orientation of the found pattern. The pattern taught in advance is called a model pattern, or 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:

- 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.



Model pattern



(1) **Linear movement** (2) **Rotation** (3) **Expansion/Reduction**

Patterns that can be found by the curved surface locator tool

What is the same pattern?

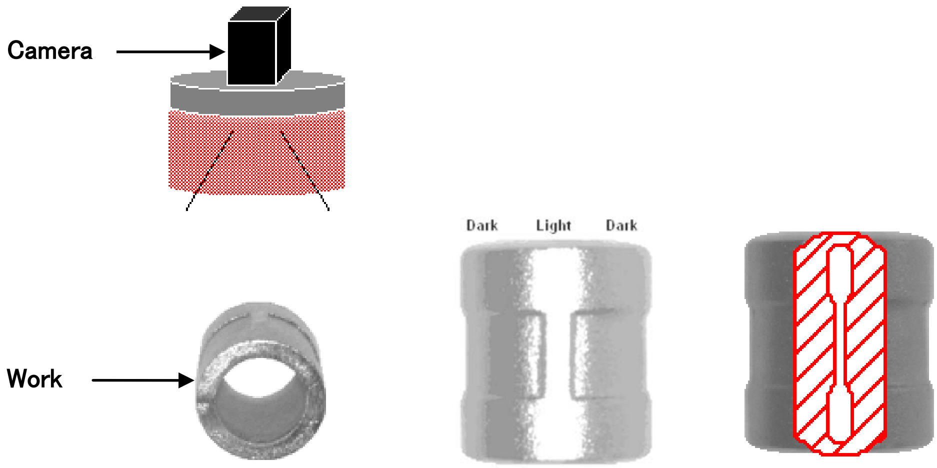
What does the curved surface locator tool consider the "same pattern" as the model pattern? The curved surface locator tool has the following two criteria to judge whether a pattern is the "same pattern" as the model pattern. When the pattern meets both of the criteria, the curved surface locator tool 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.

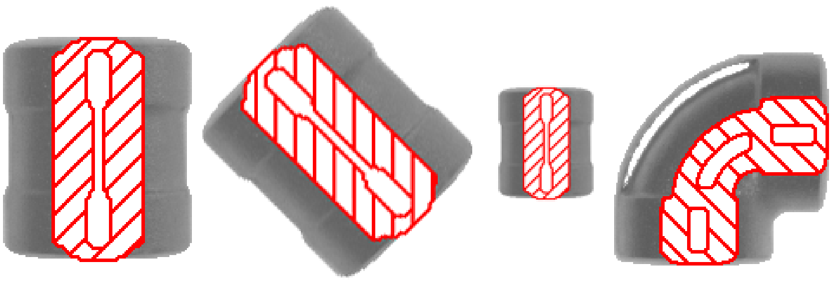
Figure having the same geometry of distribution of gradation

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.



When you look at a circular cylinder via a camera with coaxial lighting

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.

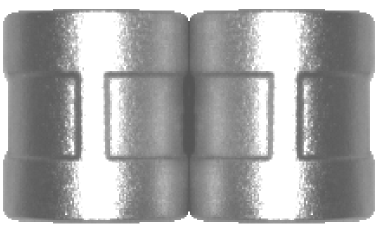


The figures that have the different geometries of distribution of gradation

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.

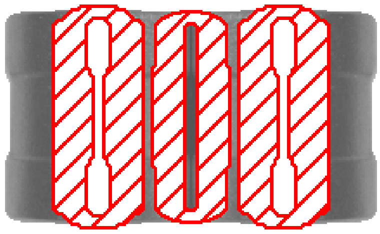
Figure having the same orientation of gradation

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.



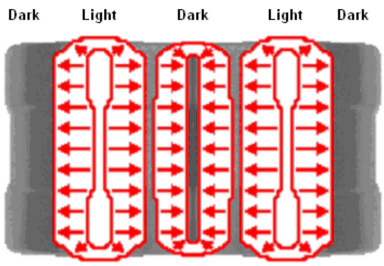
When you check an image where 2 cylinders are aligned in parallel

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.



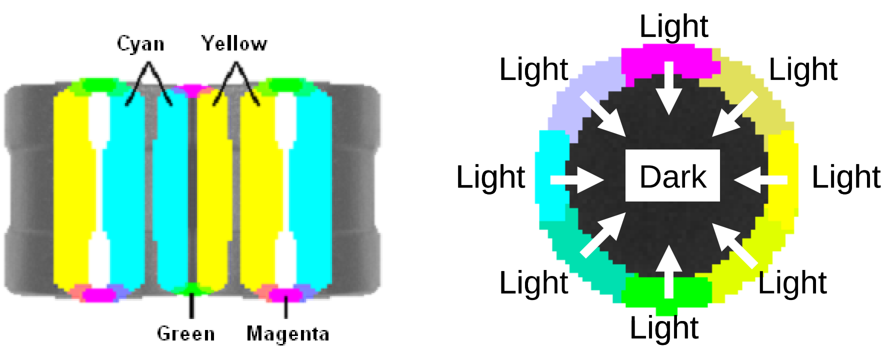
Distribution of gradation

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.



Orientation of gradation

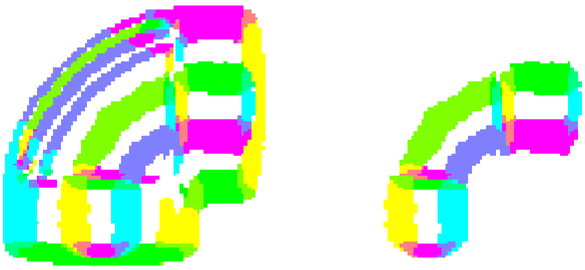
In the setup page of the curved surface locator tool, a total of eight colors, magenta, cyan, green, yellow, and colors between them, are used to make the orientation of gradation easy to check.



Classification by coloring of orientation of graduation

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.



Missing or extra gradation area

Pattern similarity

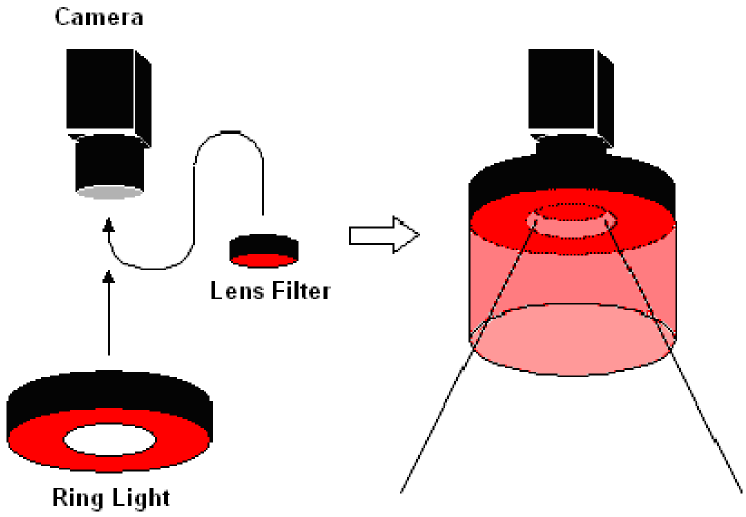
We have discussed the criteria concerning the geometry of distribution, orientation, and missing and extra areas in regard to gradation in patterns. However, not all these criteria need to be satisfied fully. It is virtually impossible to eliminate the difference between patterns. The curved surface 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”.

4.5.5.2 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.



Recommended lighting environment for the curved surface locator tool

4.5.5.3 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

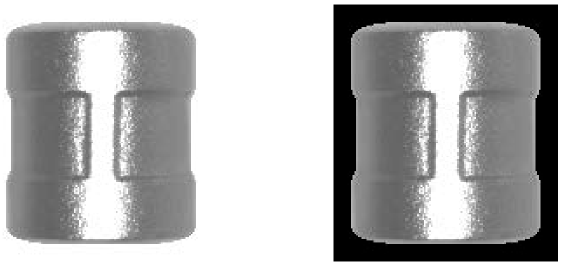
As described earlier in “Missing or extra gradation area”, if a gradation area found in the model pattern is missing from the pattern in the image, the curved surface locator tool judges that the pattern is different by as much as that missing gradation area. On the other hand, however, the tool ignores 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

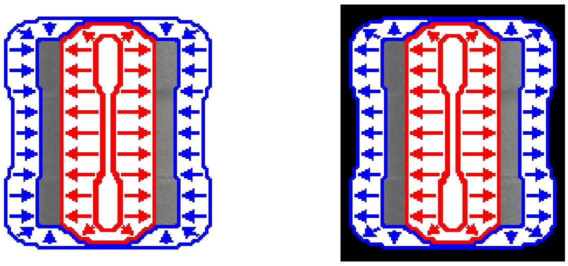
When the position, orientation, or background of an object is changed, the orientation of gradation in the figure in the image might change as well. As described earlier, the curved surface locator tool considers a pattern different if its orientation of gradation is different. Therefore, masking the 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.



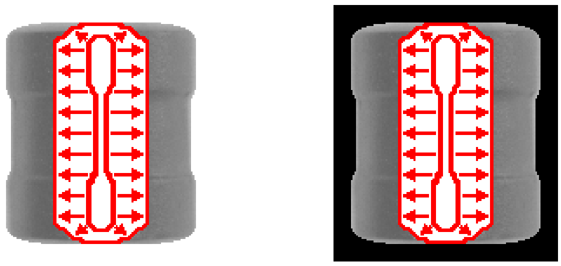
Background of an object

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.



Orientation of gradation in the periphery of the object

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.



Gradation that is independent of the background

<2> Part that looks differently for each workpiece

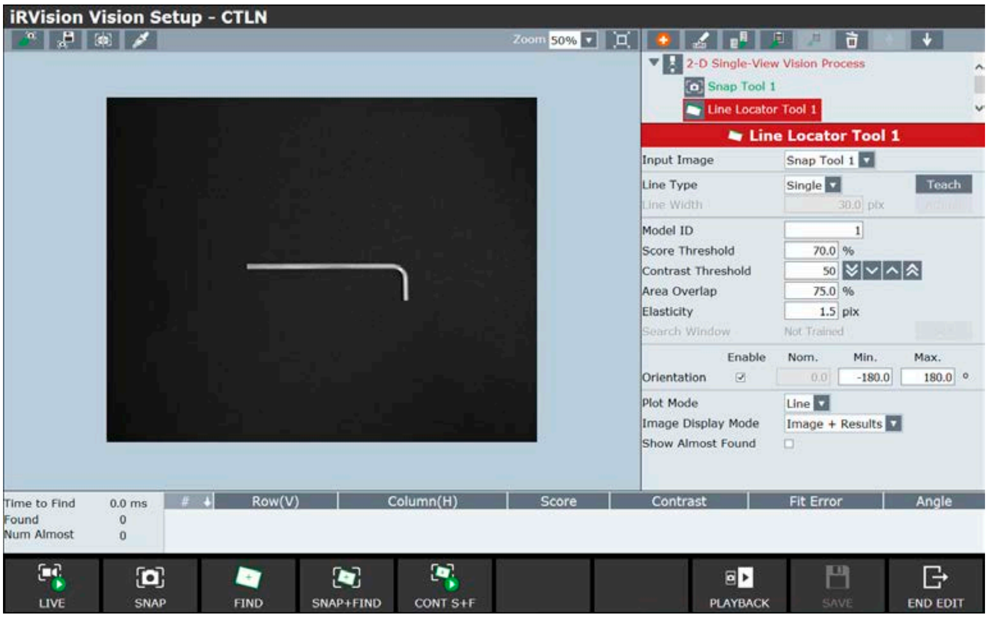
The image sometimes might contain a feature, such as a blemish, that looks different for each workpiece or each time the position of the workpiece is changed. The curved surface locator tool pays attention to such features as well when searching the image for a pattern identical to the taught model pattern. 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

4.6 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] tool in the tree view of the setup page for the vision process, a setup page like the one shown below appears.



4.6.1 Setup Items

The line locator tool has the following parameters.

[Input Image]

Select an image to use in teaching and finding of models from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Line Type]

Teach the type of the line to find. For details refer to "Setup: 4.6.2.1 Line Type".

[Teach] button

Teach the model line length. For details, refer to "Setup: 4.6.2 Setting up a Model".

[Line Width]

Specify the line width to find in pixels. Set a value between 1 and 50. This is a parameter that is set when any of double lines are selected in [Line Type].

[Adjust]

When one of the double line types is selected as the [Line Width], the line width is automatically adjusted to the found line width by clicking the [Adjust] button.

[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.

[Score Threshold]

Specify the score threshold for a pattern to be found. The units are %. Set a value between 10 and 100. The default value is 70%. 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. Setting a small value might lead to inaccurate location.

[Contrast Threshold]

Specify the threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. Input the value or change the value using buttons. 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 [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 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 pixels. 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 clicking the [Teach] 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, click 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, refer to "Setup: 1.8.8 Window Setup".

[Orientation]

Specify the range of orientation subject to be searched.
When [Enable] is checked, set [Min.] and [Max.] of the search range.
The tool searches for a model rotated in the range specified by [Min.] and [Max.], 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 [Min.] and [Max.]. 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 [Enable] is uncheck the box, the orientation is ignored and the tool searches only for a model having the orientation specified in [Nom.].

By default, the orientation search is enabled and the range is from –180 to +180 degrees.

[Plot 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]
The image selected in [Input Image] will appear.

[Image + Edges]
The image selected in [Input Image] and features in the search range will appear.
When the search window is not taught, the image that was selected in [Input Image] and the features in the image will be displayed.

[Image + Results]
The image selected in [Input Image] and the results of FIND will appear.

[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 multiple parent locator tools are found while running a test, select the found results that will appear in the image from the drop-down box. This is a parameter that appears when the line locator tool is a child tool of a different locator tool.

[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.

4.6.2 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.

4.6.2.1 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)]

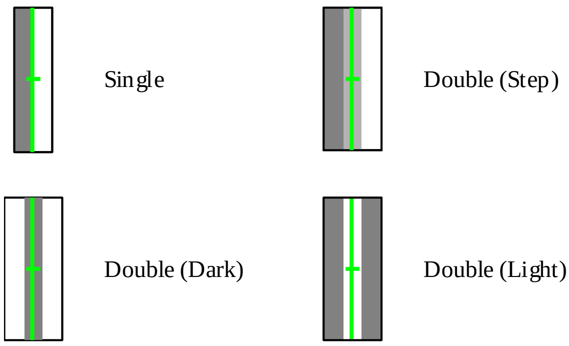
Two parallel lines are considered as a single thick line through the center of the two lines.
A 0-degree model is generated as a vertical straight line with the line having brightness between the brightness of the left and right regions, where the left region is darker and the right region is lighter 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.



Type of a line to find

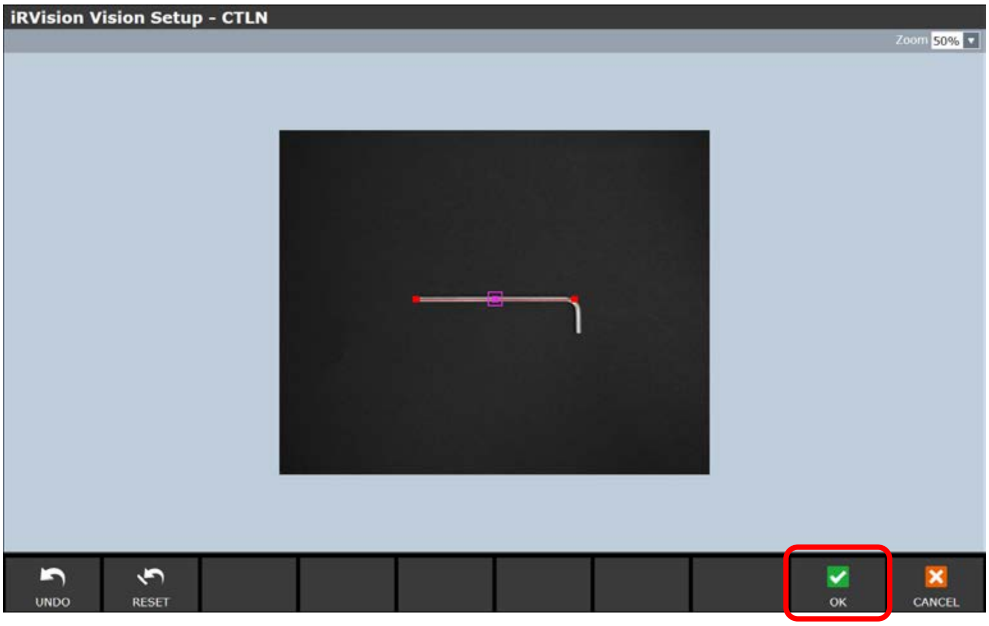
4.6.2.2 Teaching the model

Teach the model line length as follows.

1. Click [LIVE] in the line locator tool edit screen.
   It will be switched to live image display.
2. Place the workpiece near the center of the camera view.
3. Click [STOP] and then [SNAP] to snap the image of the workpiece.
4. Click the [Teach] button.
   A full-screen image will appear, and a single line or double line that has a control point (reddish purple single line or double line) will appear.

5 Set the displayed single line or double line on a workpiece, and click [OK].
The line is taught.
For details of line operation methods, refer to "Setup: 1.8.9 Single Line Setup" and "Setup: 1.8.10 Double Line Setup".

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.



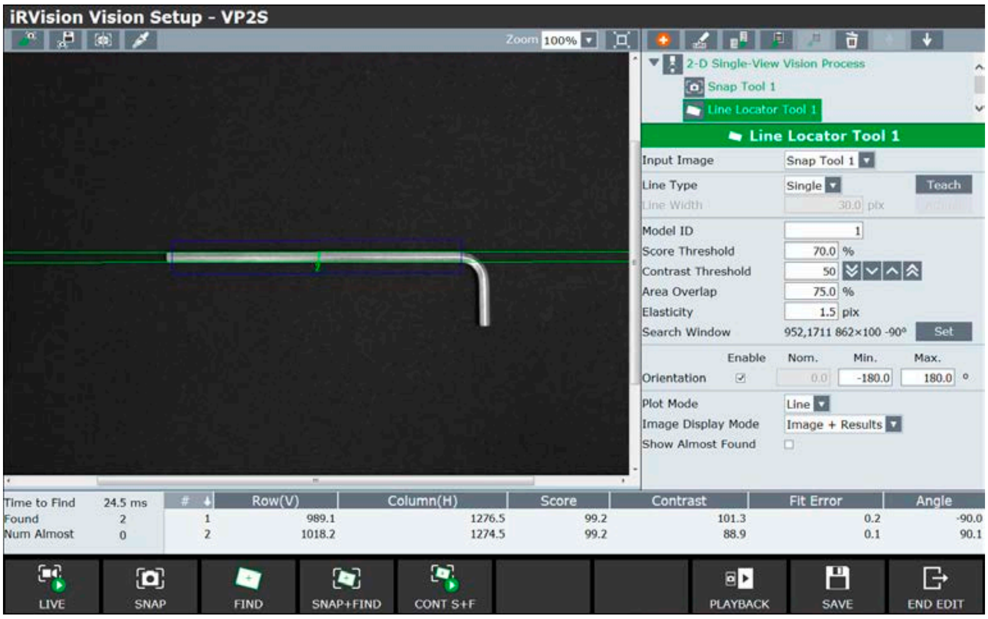
In the case of a double line, adjust the value of line width by entering value in [Line Width] or click the [Adjust] button.

MEMO

1. The line width is automatically adjusted by finding the line internally. Specify a width close to the actual width in [Line Width] before executing.
2. The model origin is automatically set at the center of the trained line segment, and it cannot be changed. The coordinate values (Row, Column) of the found result indicate the location of the model origin. When the found result is displayed on the image, a + mark(green) appears at the model origin.

4.6.3 Running a Test

Click [FIND] to run a test and see if the tool can find lines properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]
The time the location process took is displayed in milliseconds.

[Found]
The number of found lines is displayed.

[Num Almost]
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.

Also, in the result display area list view, 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).
It will appear when you check [Enable] in [Orientation].

4.6.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Score Threshold]

Specify a number between 10 and 100.

[Contrast Threshold]

Specify a number between 1 and 200.

[Elasticity]

Specify a number between 1 and 5.

[Orientation]

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.

4.6.5 Setup Guidelines

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.

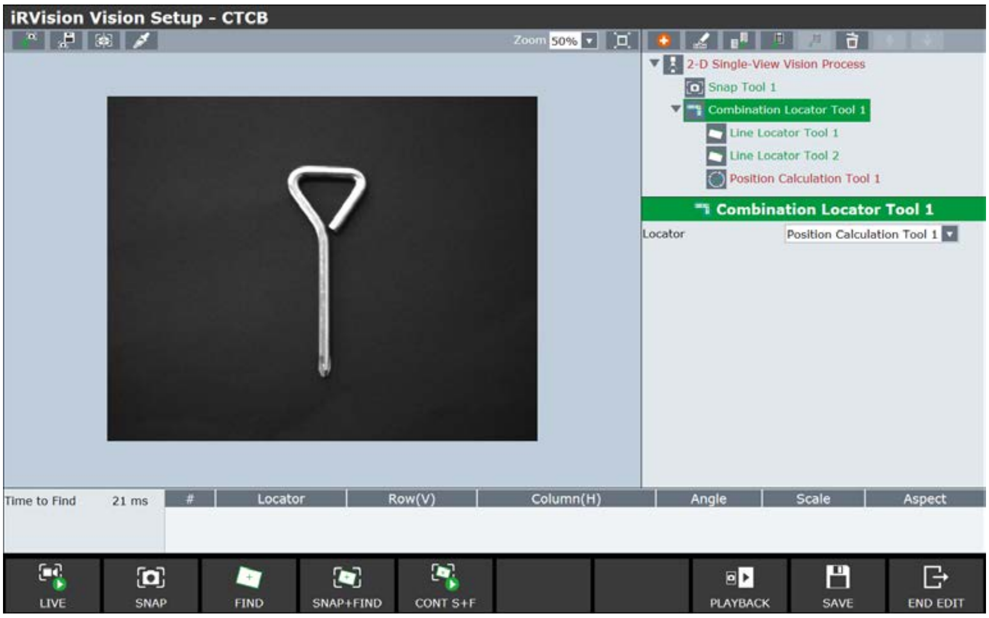
The position information output by a line locator tool has a different meaning from the position information output by GPM locator tools. Where as a GPM locator tool outputs the position as a “point” in the image, the line locator tool outputs the position as a “line,” and *i*RVision differentiates them 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.

4.7 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.



4.7.1 Setup Items

The combination locator tool has the following parameters.

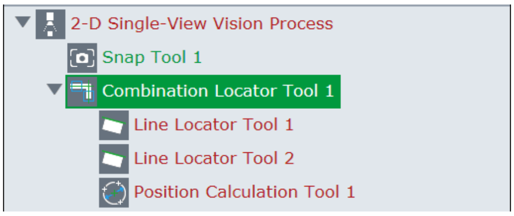
[Locator]

The position calculation tool is specified. The results of the position calculation tool that are specified in [Locator] will be output as the total results of all combination locator tools. Results of a child tool other than the selected position calculation tool will not be output. For details of the position calculation tool, refer to "Setup: 4.32 POSITION CALCULATION TOOL".

4.7.2 Teaching the Tools

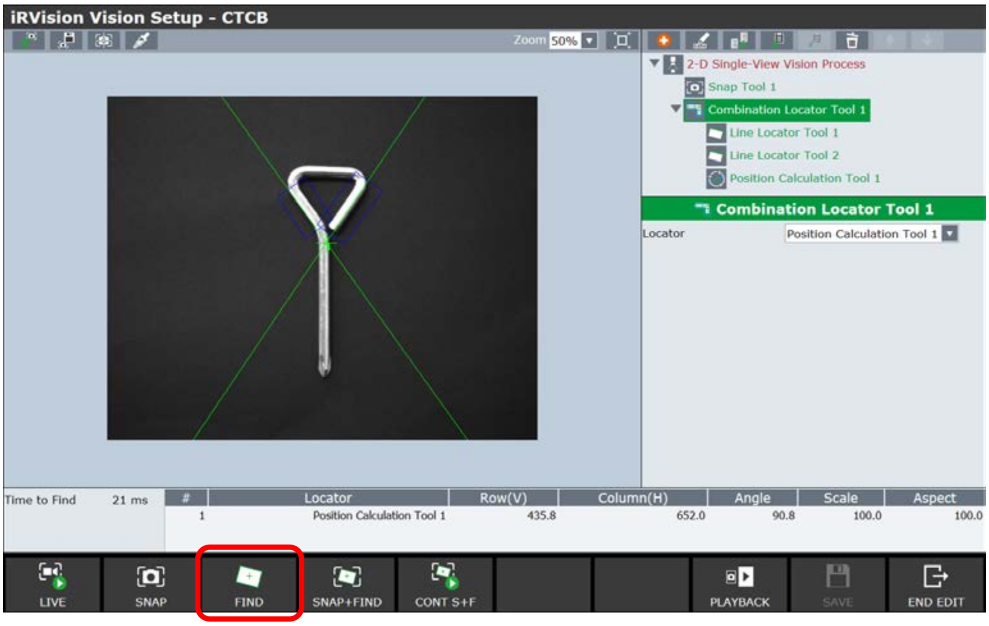
Setup the combination locator tool.
When a combination locator tool is created, two line locator tools and a position calculation tool are added by default as its child tools. The output results can be customized by changing the combinations of child tools.

The following tree view is used when the [Line Locator 1] and [Line Locator 2] detect lines and [Position Calculation Tool 1] calculates the intersection of the lines and [Combination Locator Tool 1] outputs the result of the calculation.



4.7.3 Running a Test

Click [FIND] to run a test and see if the tool can output the result of the selected position locator tool properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the location process took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[Locator]

Name of the locator tool that output the result.

[Row(V)], [Column(H)]

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]

Aspect ratio of the found pattern (units: %).
If the selected command tool result does not have the aspect ratio parameter, 100 is displayed.

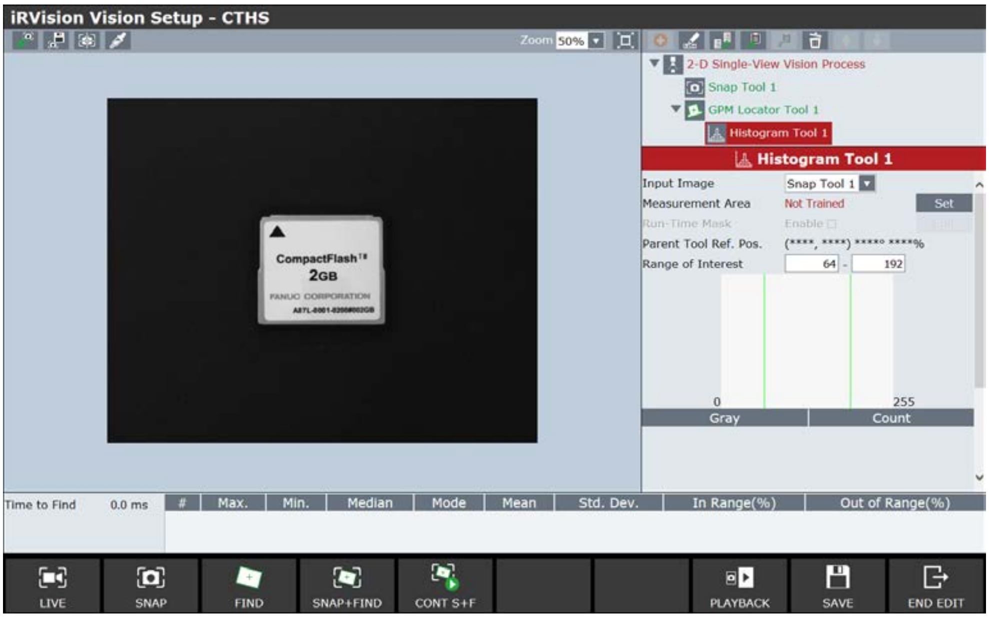
4.7.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.8 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.



4.8.1 Setup Items

The histogram tool has the following parameters.

[Input Image]

Select an image to use in teaching and finding of models from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Computed RT Mask]

When this check box is checked, a blob found by the parent tool is used as the measurement area and the runtime mask of this histogram tool. Normally, this check box is unchecked.
This is a parameter that appears when this histogram tool is a child tool of the blob locator tool.

[Measurement Area]

Set the measurement area. For details, refer to "Setup: 4.8.2 Setting the Measurement Area".

[Run-Time Mask]

Specify an area of the measurement window where images are not processed as an arbitrary geometry. This is used to specify search windows with an arbitrary shape, such as circular windows and donut windows.
Click the [Edit] button to change the Run-Time Mask. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

[Parent Tool Ref. Pos.]

It will appear when the histogram tool is used as a child tool. The found position of a parent tool that is used to set [Measurement Area] appears.

[Range of Interest]

Specify the brightness range of interest from 0 (dark) to 255 (bright). [Within range (%)] in the result display area indicates the percentage of pixels within the specified brightness range.

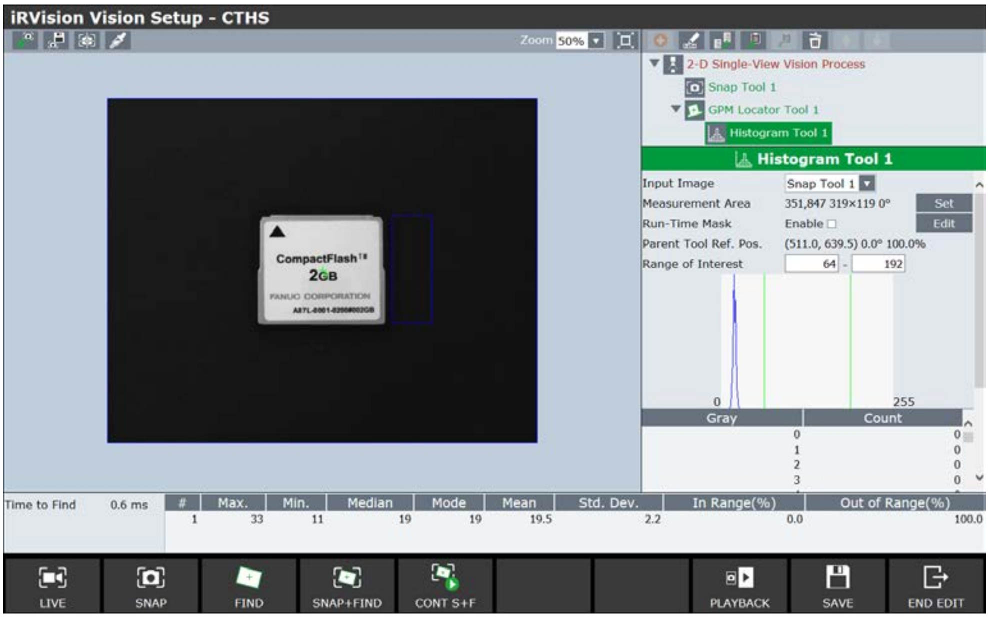
4.8.2 Setting the Measurement Area

Set the measurement area as follows.

1. Click [LIVE] in the histogram tool edit screen.
   It will be switched to live image display.
2. Place the workpiece near the center of the camera view.
3. Click [STOP] and then click [SNAP] to snap the image of the workpiece.
4. Click the [SET] button for [Measurement area].
   The parent locator tool will be executed. After locating is complete, a full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
   The found targets will display '＋' (green). If a target cannot be found by a parent tool, an alarm massage to that effect is displayed and the measurement area setting of the histogram tool is stopped.
5. Enclose the workpiece within the rectangle that appears, and click [OK].
   The measurement area is set. Return to the histogram tool edit screen.
   For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".

4.8.3 Running a Test

Click [FIND] to run a measurement test to see if the tool can find brightness properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the histogram measurement took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[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] to the total number of pixels in the area whose brightness has been measured (units: %).

[Out of Range(%)]
Ratio of the number of pixels outside the brightness range specified in [Range] to the total number of pixels in the area whose brightness has been measured (units: %).

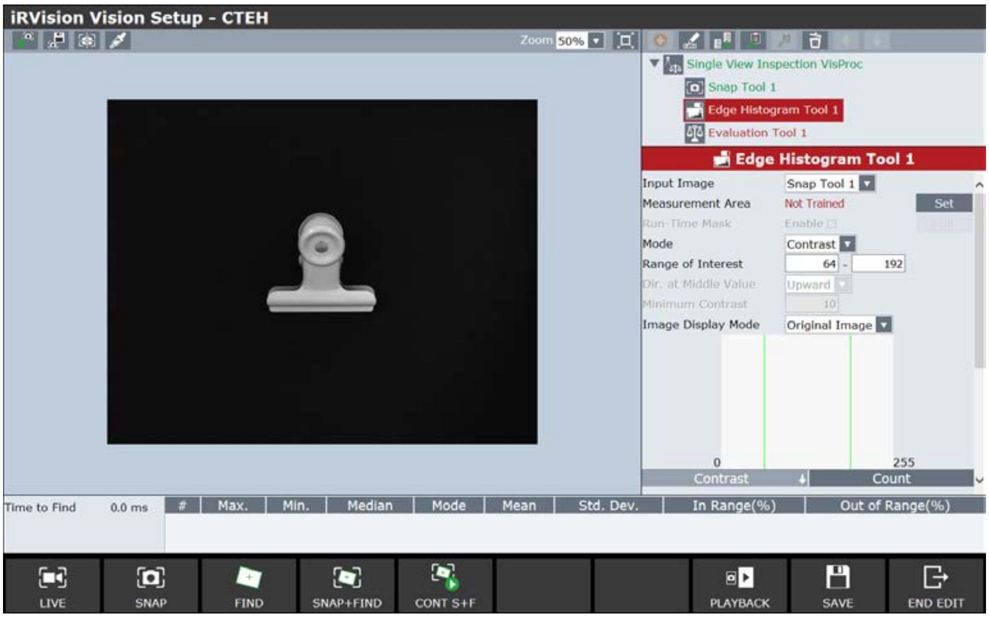
4.8.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.9 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.



4.9.1 Setup Items

The edge histogram tool has the following parameters.

[Input Image]

Select an image to use in teaching and finding of models from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Computed RT Mask]

When this check box is checked, a blob found by a parent tool is used as the measurement area and the runtime mask of this edge histogram tool. Normally, this check box is unchecked.
This item is available only when this edge histogram tool is a child tool of a blob locator tool.

[Measurement Area]

Set the measurement area. For details, refer to "Setup: 4.9.2 Setting the Measurement Area".

[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, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

[Parent Tool Ref. Pos.]

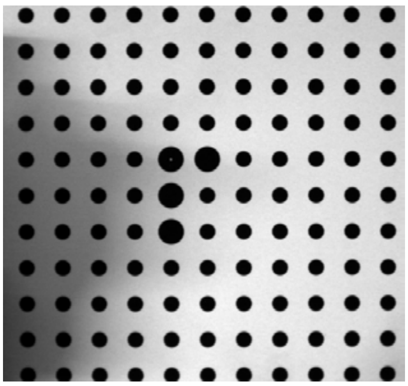
It will appear when the edge histogram tool is used as a child tool. The found position of a parent tool that is used to set [Measurement Area] appears.

[Mode]

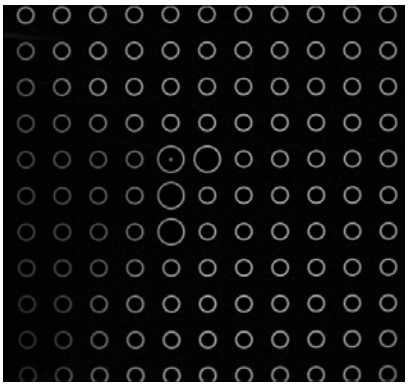
A gradient has two elements - contrast and direction. Of these, specify the element whose distribution is to be measured.

[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]

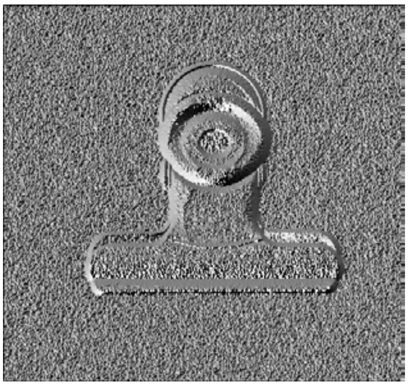


[Contrast Image]

Gradient Magnitude

[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 set in [Dir. at Middle Value].



[Original Image] **[Direction Image]**

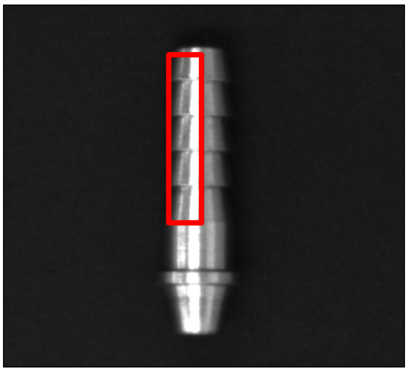
Gradient Direction

[Range of Interest]

Specify the contrast or direction range of interest in 256 steps from 0 to 255. [In Range(%)], described later, indicates the percentage of pixels within the specified brightness range.

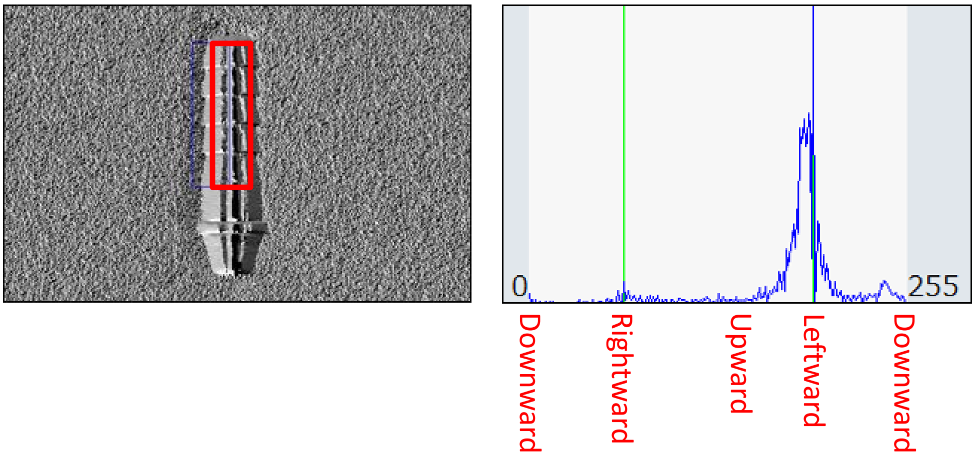
[Dir. at Middle Value]

This field is valid only when [Direction] is selected for [Mode]. In the direction image, directions of the gradient distribution are represented with grayscale values from 0 to 255. This item is used to specify which gradient direction is assigned to which grayscale value. For example, when [Upward] is specified, the gradient direction with waning brightness toward the top of the image is assigned to 128, which is the [Dir. at Middle Value], and plotted at the center of the histogram. Select the direction that best represents the characteristics of the range to be measured. For your reference, the result of the histogram chart when each option is selected is described for the image shown below. Since majority of the gradient direction in the area enclosed by the red rectangle is right-to-left (leftward), the peak is plotted at the center of the histogram chart when [Leftward] is selected.



[Upward]

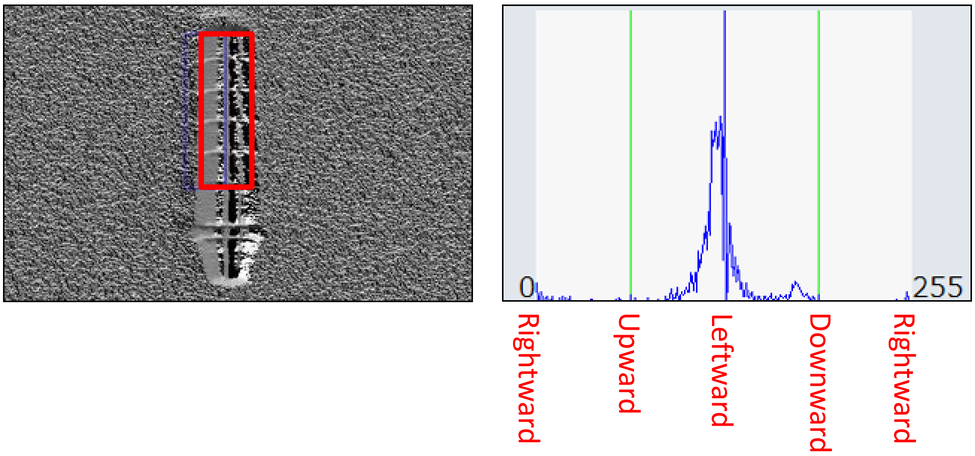
The gradient direction with waning brightness toward the top of the image (upward) is plotted at the grayscale value of 128. The grayscale value of 64 represents the rightward gradients, and the grayscale value of 192 represnets the leftward gradients. The grayscale values 0 and 255 represent downward gradients.



Example of a grayscale gradient image and histogram by the direction at middle value in the graph (upward)

[Leftward]

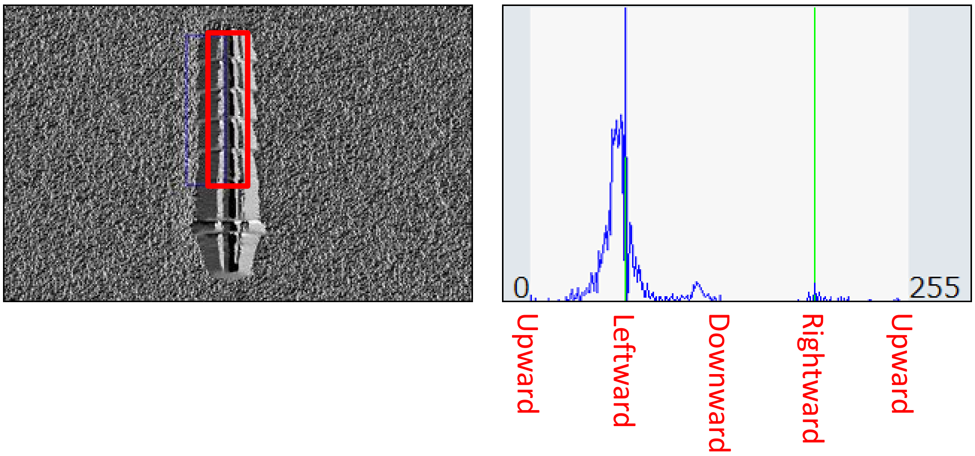
The gradient direction with waning brightness toward the left of the image (lefward) is plotted at the grayscale value of 128. The grayscale value of 64 represents the upward gradients, and the grayscale value of 192 represents the downward gradients. The grayscale values 0 and 255 represent rightward gradients.



Example of a grayscale gradient image and histogram by the direction at middle value (leftward)

[Downward]

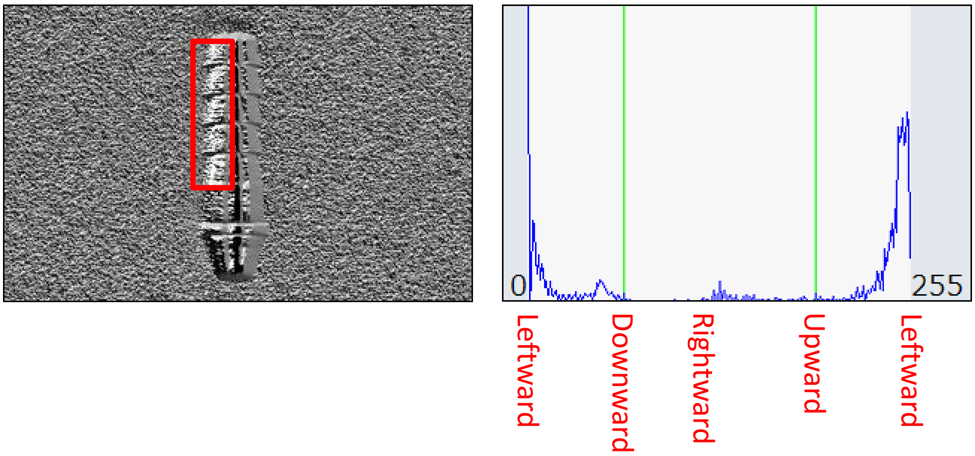
The gradient direction with waning brightness toward the down of the image (downward) is plotted at the grayscale value of 128. The grayscale value of 64 represents the leftward gradients, and the grayscale value of 192 represents the rightward gradients. The grayscale values 0 and 255 represent upward gradients.



Example of a grayscale gradient image and histogram by the direction at middle value (downward)

[Rightward]

The gradient direction with waning brightness toward the right of the image (rightward) is plotted at the grayscale value of 128. The grayscale value of 64 represents the downward gradients, and the grayscale value of 192 represents the upward gradients. The grayscale values 0 and 255 represent leftward gradients.



Example of a grayscale gradient image and histogram by the direction at middle value (rightward)

[Minimum contrast]

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. This is a parameter that appears when [Direction] is selected in [Mode].

[Image Display Mode]

Select the image to be displayed for operation from the drop-down box.

[Original image]

The image selected in [Input Image] will appear.

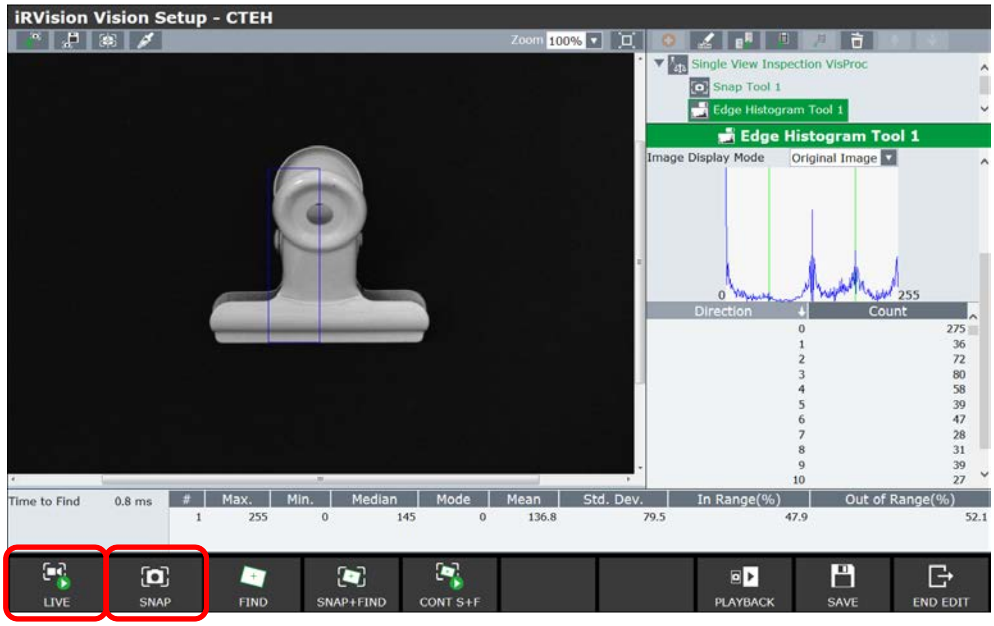
[Edge Image]

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.

4.9.2 Setting the Measurement Area

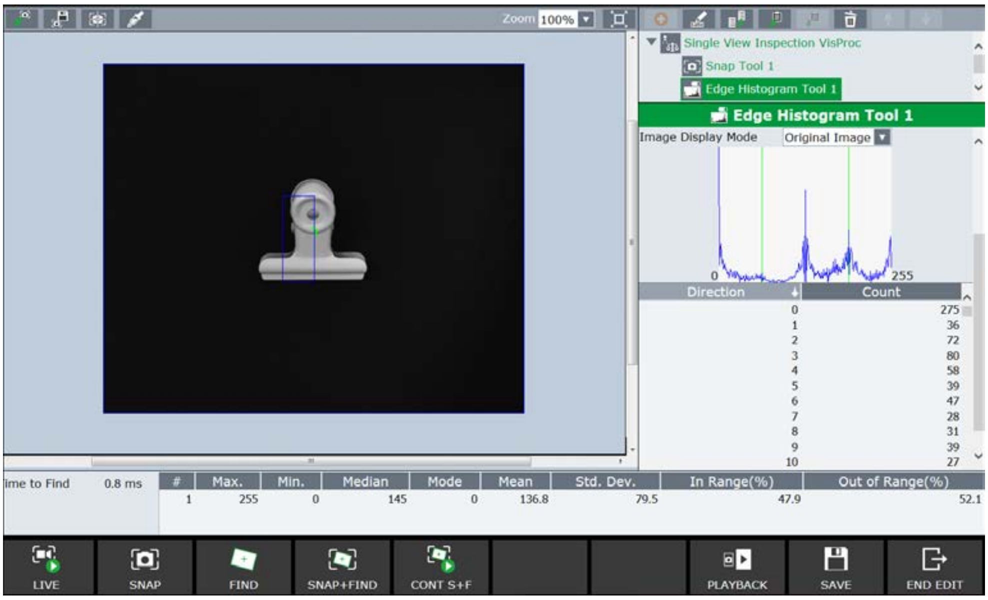
Set the area whose gradients are to be measured as follows.

1 Click [LIVE] in the edge histogram tool edit screen.
It will be switched to live image display.
2 Place the workpiece near the center of the camera view.
3 Click [STOP] and then click [SNAP] to snap the image of the workpiece.
4 Click the [SET] button for [Measurement Area].
The parent locator tool will be executed. After locating is complete, a full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
The found targets will display red '＋'. If a target cannot be found by a parent tool, an alarm massage to that effect is displayed and the measurement area setting of the edge histogram tool is stopped.
5 Select the area to measure, using the displayed red rectangle, and click [OK]. For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".



4.9.3 Running a Test

Click [FIND] to run a measurement test to see if the tool can find brightness properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the gradient distribution measurement took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[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.

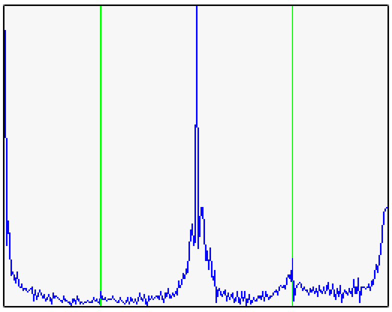
[In Range(%)]

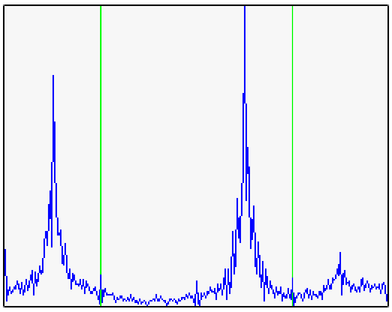
Ratio of the number of pixels within the range specified in [Range of Interest] to the total number of pixels in the gradient distribution measurement area (units: %).

[Out of Range(%)]

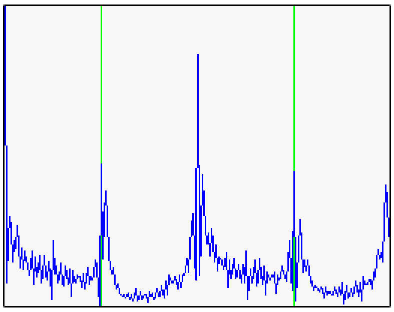
Ratio of the number of pixels outside the range specified in [Range of Interest] to the total number of pixels in the gradient distribution measurement area (units: %).

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.

4.9.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.10 COLOR SORTING TOOL

The Color Sorting Tool allows the users to sort found parts by their colors. The color of a found part is compared against the trained colors, and then the model ID of the found part is changed according to the matched trained color.

> **MEMO**
> White balance of the color camera is important for Color Sorting Tool to sort found colors. Be sure to set white balance of the color camera before teaching a color to Color Sorting Tool.

Color Representation

The Color Sorting Tool represents a color by its hue, saturation and intensity.

Hue

The hue is the attribute of a color which is discernible as red, blue, green, etc. The range of the hue is 0 to 360 degrees. The hue values of two similar colors are close to each other. For example, the hue value of red is close to that of brown, but far from that of blue.

Saturation

The saturation is the attribute that represents how vivid a color is. The range of the saturation is 0 to 100%. Primary colors and vivid colors have a large saturation value.

Intensity

The intensity is the attribute that represents the luminance of a color. The range of the intensity is 0 to 255. The intensity value of a color is equal to the pixel value in a grayscale image.

Term Definition

The following terms are used in the Color Sorting Tool.

Unsaturated Color

Unsaturated colors are colors that have a hue value, which are also called chromatic colors. Red, blue, and green are examples of unsaturated colors. The Color Sorting Tool uses unsaturated colors for sorting.

Saturated Color

Saturated color is colors that are saturated and do not have a hue value, which is also called achromatic color. White, black and gray are examples of saturated colors. A saturated color looks the same in either a color image or a grayscale image. The Color Sorting Tool mainly uses the hue for sorting, so it can’t distinguish saturated colors.

Measured Color

The measured color is the color of a found part that is measured in the measurement area. Generally colors in the measurement area are not even, so the measured color usually indicates the average color in the measurement area.

Trained Color

The trained color is the color that is trained on the setup page. As well as the measured color, colors in the training area are not always even, so the trained color indicates the average color in the training area.

Color judgment

The color sorting tool judges if the measured color and trained color are the same color, using hue only or hue and saturation.

Hue only

When the hue difference between the measured color and trained color is within the tolerance value, both colors are judged as the same color. Saturation and brightness are not compared. When there are multiple trained colors whose hue differences are within the tolerance value, the trained color with most small hue difference is judged as the same color.

Hue and saturation

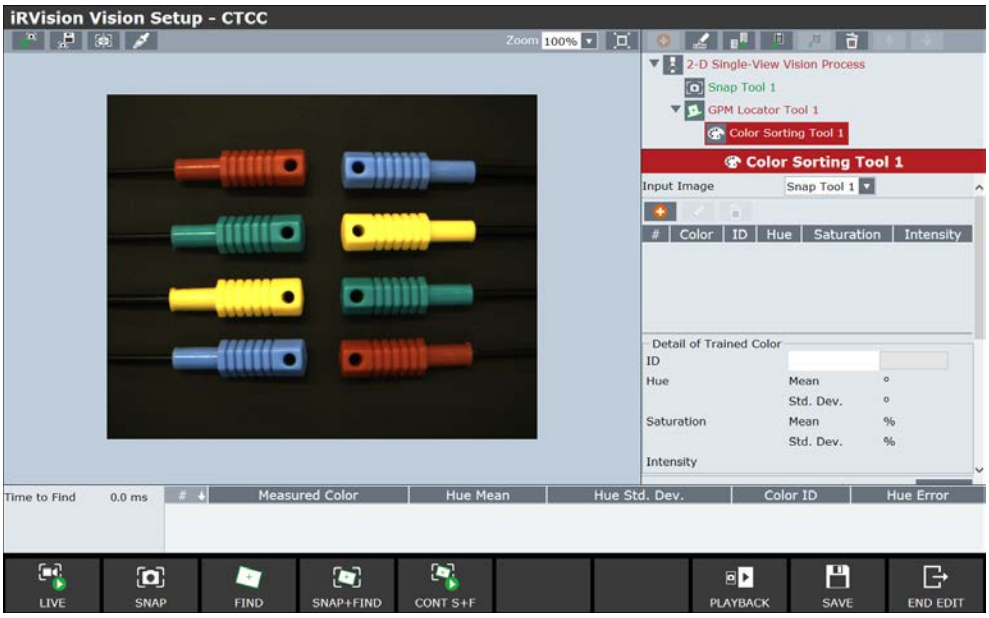
When both the hue difference and saturation difference between the measured color and trained color are within the tolerance values, both colors are judged as the same color. Brightness is not compared. When there are multiple trained colors whose hue differences and saturation differences are within the tolerance value, the trained color with most small total of hue difference and saturation difference is judged as the same color.

Good Measurement Condition

Even when the color of a part is constant, the color that appears on an image can be variable depending on the illumination. Make sure to use uniform illumination such as a diffused white LED light, and measure the same place of the part every time.

> **MEMO**
> When the illumination is too strong or too weak, the color of the part can look too light or to too dark to distinguish the color. Adjust the illumination so that all colors that you want to distinguish appear on the image clearly.

If you select [Color Sorting Tool] in the tree view of the setup page, a screen like the one shown below appears.



4.10.1 Setup Items

The color sorting tool has the following parameters.

[Input Image]

Select an image to use in color sorting from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

Color list view

The list shows trained colors that have been trained. The following values are displayed.

[Color]

The color of the trained color is displayed.

[ID]

The color ID is the number assigned to the trained color. The color ID can be changed with the steps described later. This number is added to the model ID of the found part.

[Hue]

The hue of the trained color

[Saturation]

The saturation of the trained color

[Intensity]

The intensity of the trained color

Training the Color

Train the color with the following steps.

1. Click the button.
   A full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
2. Enclose where you want to train a color with the displayed display, and then click [OK].
   If different or unwanted colors or shades are included in the training area, mask them to remove them from the trained color. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

MEMO
Because of characteristics of digital camera, false colors can appear in areas where the color changes sharply, such as outlines of a workpiece, and colors in such an area are unstable. Be sure not to include such an area when training a color, the measurement area and the run-time mask.

Retraining the Color

You can retrain a trained color with the following steps.

1 Select a trained color in the list of trained colors.
2 Click the button.
A full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
3 Enclose where you want to train a color with the displayed, and then click [OK].
If different or unwanted colors or shades are included in the training area, mask them. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

Delete the Trained Color

You can delete a trained color with the following steps.

1 Select a trained color in the list of the trained colors.
2 Click button.
It will be deleted from the list of trained colors.

[Detail of Trained Color]

The detailed information of the selected trained color is displayed. The color ID, the mean and the standard deviation of the hue, and the mean and the standard deviation of the saturation are displayed. You can change the color ID of the selected trained color here.

[Measurement Area]

Specify the search area where you want to measure the color. The smaller the area, the faster the measurement process executes. To change the measurement area, click the [Set] button. For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".

> ⚠ **CAUTION**
> The Color Sorting Tool measures the color in the measurement area on the assumption that only one color is included in the measurement area. Train the measurement area not to include multiple colors.

[Run-Time Mask]

Specify an area within the measurement area that you do not want to be processed. The filled area will be masked in the rectangle specified as the measurement area and will not be subject to the image processing. To change the run-time mask, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

[Parent Tool Ref. Pos.]

It will appear when the color sorting tool is used as a child tool. The found position of a parent tool that is used to set [Measurement Area] appears.

[Sort By]

Select the method to distinguish the color.

[Hue]

The hue is always used to distinguish the color. Set the right text box to the tolerance of the hue. When the difference between the hue of the measured color and that of the trained color is less than the tolerance of the hue, the measured color is judged to match the trained color.

[Saturation]

Check [Enable] the check box if you want to distinguish the color with not only the hue but also the saturation. Set the right text box to the tolerance of the saturation. When the difference between the saturation of the measured color and that of the trained color is less than the tolerance of the saturation, the measured color is judged to match the trained color.

[When appropriate color is found]

Select the action to be performed when the measured color matches one of the trained colors.

[No Action]

Do nothing.

[Invaidate this result]

Invalidate this result.

[Add color ID to model ID]

Add the color ID of the trained color to the model ID of found part.

[Otherwise]

Select the action to be performed when the measured color does not match any of the trained colors.

[No Action]

Do nothing.

[Invalidate this result]

Invalidate this result.

[Add the following value to model ID]

Add the specified value to the model ID of the found part.

[Image Display Mode]

Select the type of the image to be displayed in the image display frame from the followings:

[Original image]

The image selected in [Input Image] will appear.

[Chromatic Color]

Displays the image that was selected in [Input Image], in which the saturated color pixels filled by black.

[Extraction (Trained)]

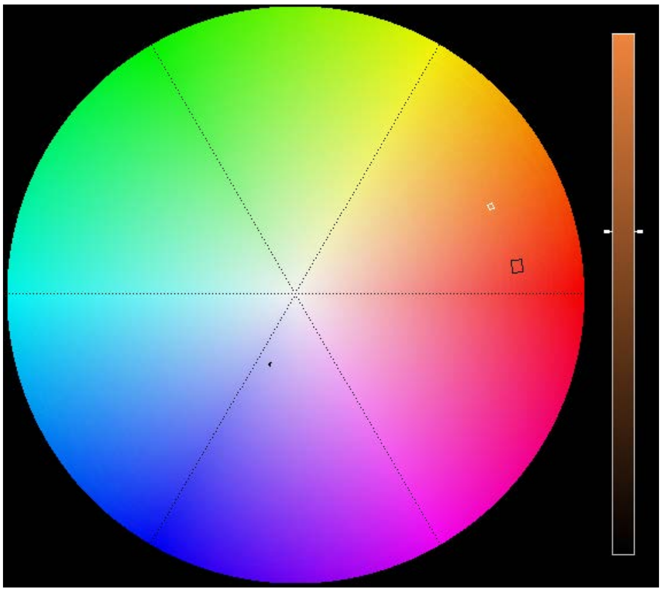
Displays the image that was selected in [Input Image] and is shown using a gray scale value in which the intensity of each pixel indicates the similarity to the trained color currently selected in the list of trained colors.

[Extraction (Measured)]

Displays the image that was selected in [Input Image] and is shown using a gray scale value in which the intensity of each pixel indicates the similarity to the measured color. When there are several measured results, the measured color of the measured result that is currently selected is used.

[Color Wheel (Trained)]

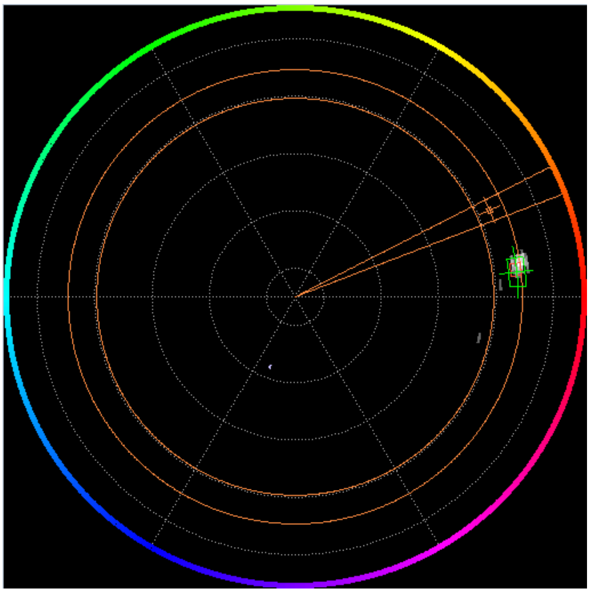
Displays the following figure. In the circle on the left, the direction from the center represents the hue and the distance from the center represents the saturation. Trained colors are shown as a fan shape. The selected color is white and the non-selected colors are black. The bar on the right shows the intensity of the color whose hue and saturation are the same as the selected trained color, the brightest at the top of the bar and darkest at the bottom. The white mark on both side of the bar represents the intensity of the selected trained color.



Color Wheel (Trained)

[Color Wheel (Measured)]

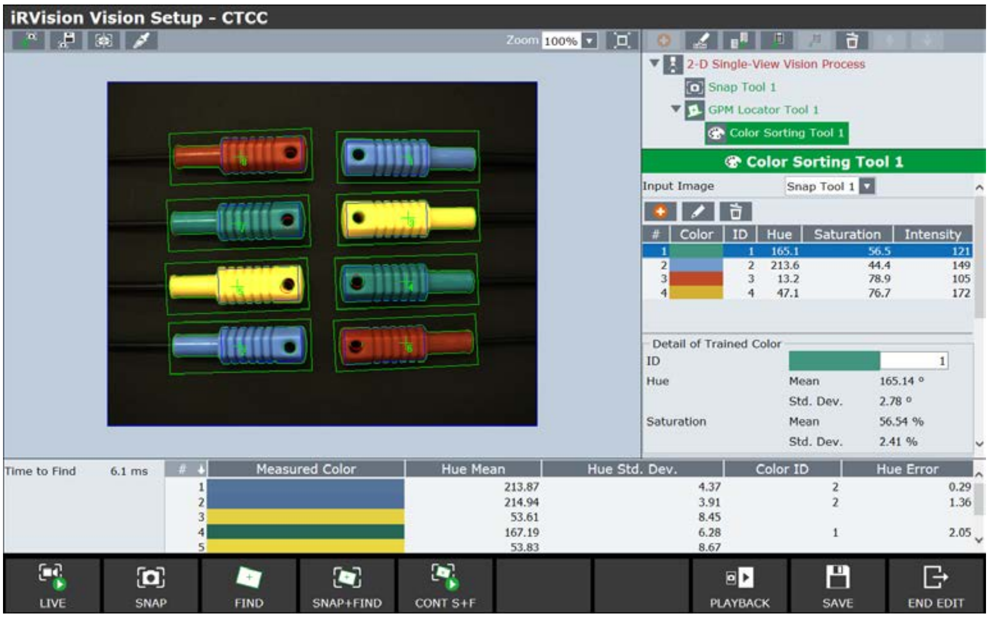
Displays the following figure. The direction from the center represents the hue and the distance from the center represents the saturation. Trained colors are shown as a fan shape. Around the selected trained color, auxiliary lines that represent tolerance of the hue and the saturation are shown. Measured colors are shown as green fans. The distribution of the selected measured color is displayed as a cloud.



Color Wheel (Measured)

4.10.2 Running a Test

Click [FIND] to run a measurement test to see if the tool can measure the color properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time to run the Color Sorting Tool took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[Measured color]

The measured color is displayed.

[Color ID]

The color ID of the trained color that matches the measured color is displayed.

[Hue error]

Absolute difference between the hue of the measured color and that of the trained color is displayed.
If there is no matched trained color, it will be 180°.

[Hue Mean]

The mean of the hue of colors in the measurement area is displayed.

[Hue Std. Dev.]

The standard deviation of the hue of colors in the measurement area is displayed.

[Saturation error]

Absolute difference between the saturation of the measured color and that of the trained color is displayed.
If there is no matched trained color, it will be 100%.

[Saturation Mean]

The mean of the saturation of colors in the measurement area is display.

[Saturation Std. Dev.]

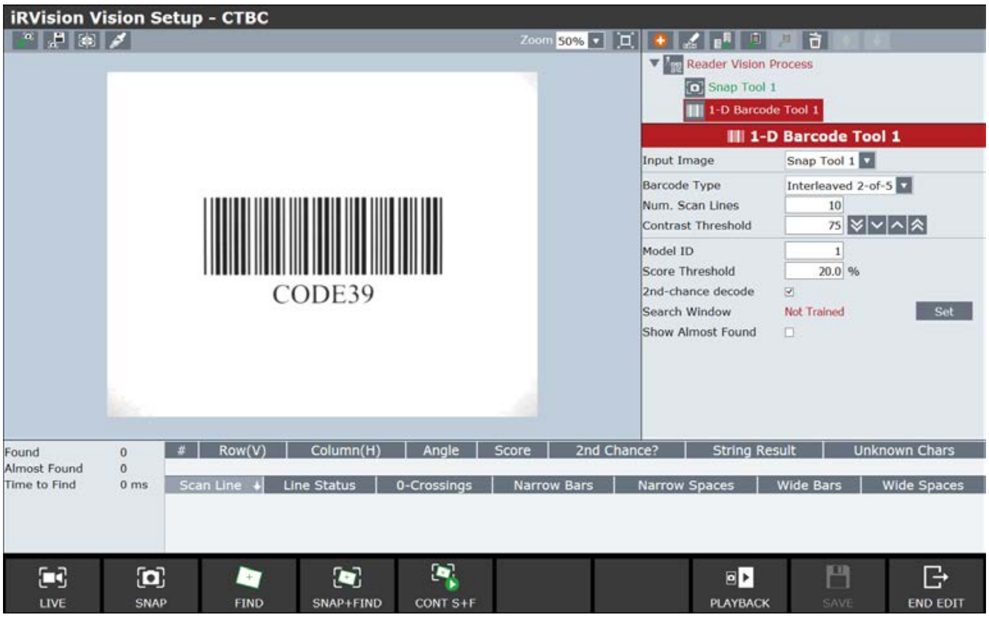
The standard deviation of the saturation of colors in measurement area is displayed.

4.10.3 Overridable Parameters

This command tool has no parameters that can be overridden with Vision Override.

4.11 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.

The following 1-D barcode are supported.

- Interleaved 2-of-5
- Code 39
- NW7 (Codabar)
- EAN (JAN)
- UPC

MEMO
1-D Barcode Tool requires that the narrowest bar appears at least 3 pixels in width in the image in order to be decoded reliably.

4.11.1 Setup Items

Set the barcode parameters.

[Input Image]

Select an image which is used for training search area and detection 1-D Barcode. When the vision process has an 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 "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Barcode Type]

The types of barcodes supported by the 1-D barcode tool. Select one of the followings:
Refer to "Setup: 4.11.4 Terminologies" for more information.

- Interleaved 2-of-5
- Code 39
- NW7 / Codabar
- EAN / UPC

[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]

Specify the threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. Input a value or change the value with the button. The default value is 75, 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.

[2nd-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]

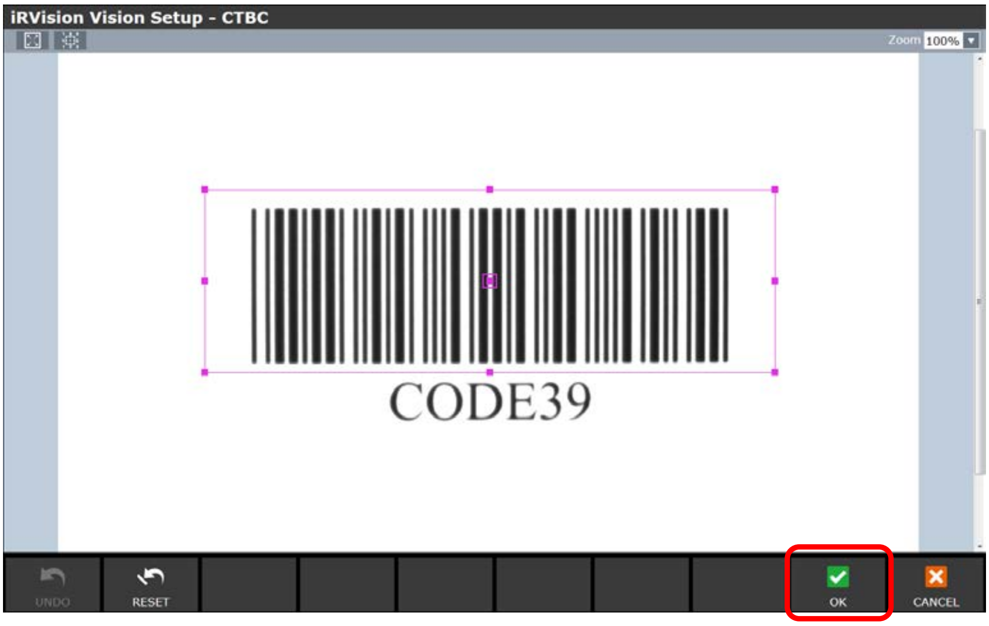
Specify the window that the 1-D barcode tool searches for the specified barcode. The smaller the search window is, the faster the location process runs.

Search Window Setup

The search window teaching is performed using the following procedure.

1 Click [LIVE] in the 1-D barcode tool edit screen.
  It will be switched to live image display.
2 Place the 1-D barcode near the center of the camera view.
3 Click [STOP] and then click [SNAP] to snap the image of the 1-D barcode.
4 Click the [SET] button.
5 Enclose the 1-D barcode within the red rectangle that appears, and click [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, refer to "Setup: 1.8.8 Window Setup".

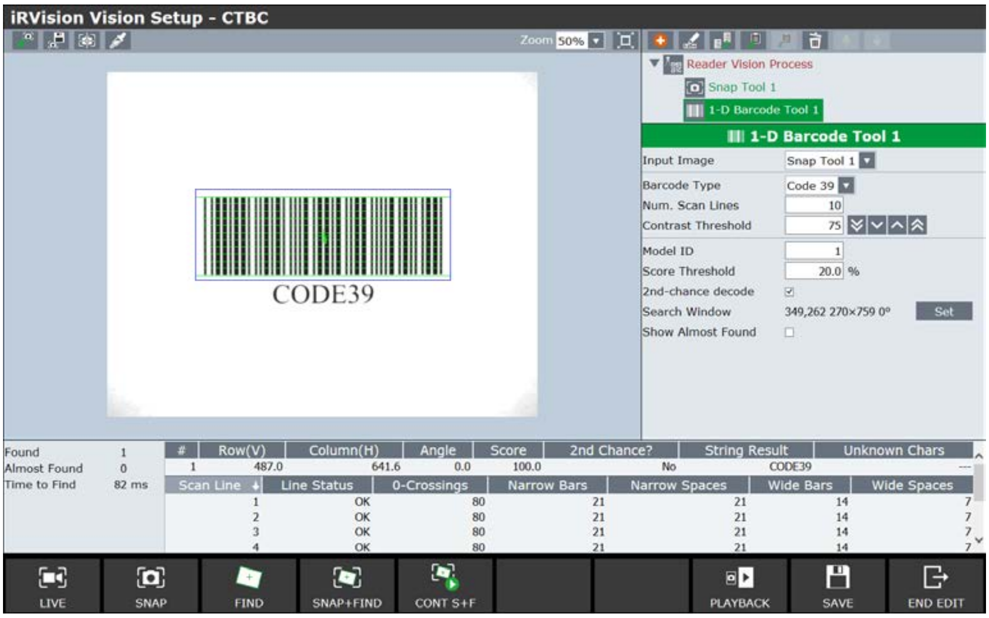


[Show Almost Found]

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.

4.11.2 Running a Test

Click [FIND] to run a test and see if the 1-D barcode was properly found.



After executing a test, the following items are displayed in the result display area.

[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.

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

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.

[2nd Chance?]

If the barcode decoded by using the second chance decode algorithm, [YES] is displayed. [NO] is displayed in the following cases.

- [2nd-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.

[Scan Line]
The index of the scan line. If the barcode decoded by using the second chance decode algorithm, it will not be displayed.

[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. If the barcode decoded by using the second chance decode algorithm, it will not be displayed.

[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]. If the barcode decoded by using the second chance decode algorithm, it will not be displayed.

[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]. If the barcode decoded by using the second chance decode algorithm, it will not be displayed.

[Bar Elements]
The number of found bars on the scan line. This column is displayed only when [Barcode Type] is [EAN / UPC]. If the barcode decoded by using the second chance decode algorithm, it will not be displayed.

[Space Elements]
The number of found spaces on the scan line. This column is displayed only when [Barcode Type] is [EAN / UPC]. If the barcode decoded by using the second chance decode algorithm, it will not be displayed.

4.11.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.11.4 Terminologies

This section explains some terminologies for 1-D barcode tool.

4

ITF

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.

Interleaved 2-of-5 is a variable-length barcode. Keeping the narrow bar to be at least 3 pixels in width, 1-D Barcode Tool can decode up to 20 characters of Interleaved 2-of-5 in a 640x480 image. It is recommended to make applicability test in advance because the readable number of characters may change according to conditions.

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.

Code 39 is a variable-length barcode. Keeping the narrow bar to be at least 3 pixels in width, 1-D Barcode Tool can decode up to 8 characters of Code 39 in a 640x480 image. It is recommended to make applicability test in advance because the readable number of characters may change according to conditions.

NW-7(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.

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. NW7 is variable-length barcode. The first and last of the decoded string have always one character from A to D.

NW7 is variable-length barcode. Keeping the narrow bar to be at least 3 pixels in width, 1-D Barcode Tool can decode up to 11 characters of NW7 in a 640 x 480 image. It is recommended to make applicability test in advance because the readable number of characters may change according to conditions.

EAN

EAN is used worldwide for various consumer products. The following figure shows an example of EAN.

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].

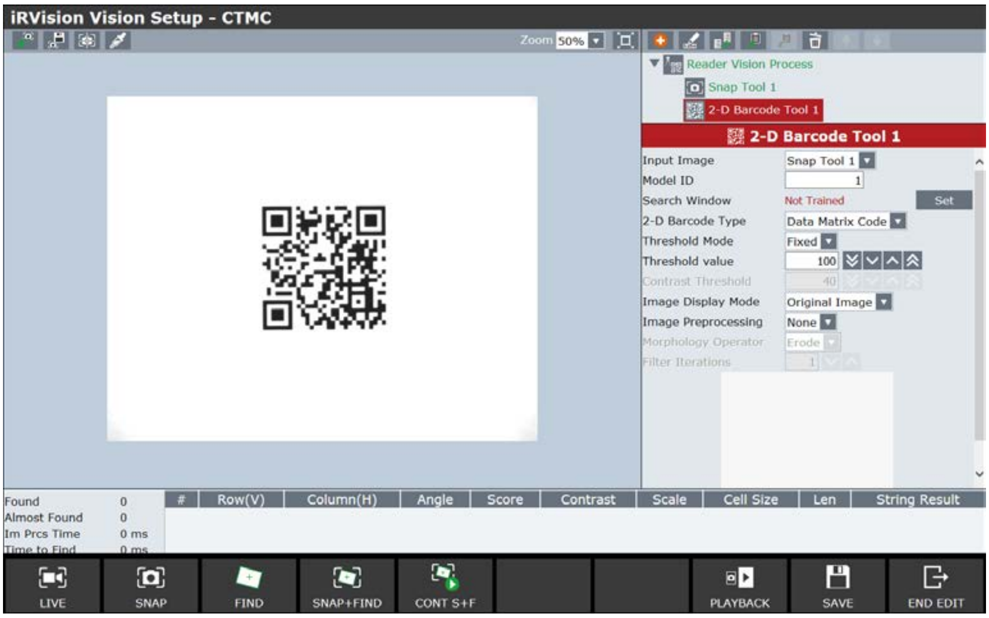
UPC

UPC is used for marking products in the North American markets. The following figure shows an example of UPC.

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.

4.12 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.

The following 2-D barcode are supported.

- Data Matrix Code
- QR Code

4.12.1 Setup Items

Set the barcode parameters.

[Input Image]

Select an image which is used for training search area and detection 2-D Barcode. When the vision process has an 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 "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

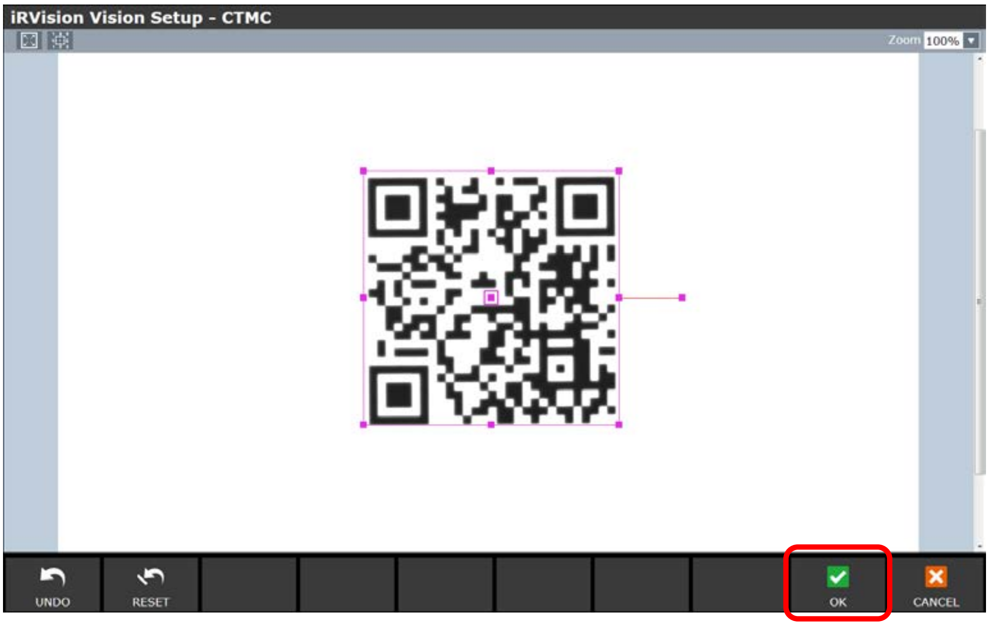
[Model ID]

When you have taught multiple 2-D barcode tools and intend to identify which 2-D barcode tool found each barcode, assign a distinct model ID to each locator 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.

[Search Window]

Specify the area in the image where you want to find a 2-D barcode. The smaller the range, the faster the processing will be.
Specify the area of the image to be searched as follows.

1 Click [LIVE] in the 2-D barcode tool edit screen.
  It will be switched to live image display.
2 Place a 2-D barcode near the center of the camera view.
3 Click [STOP] and then click [SNAP] to snap the image of the 2-D barcode.
4 Click the [SET] button.
  A full-screen image will be displayed, and a window that has control points for rotation (reddish purple rectangle) will appear.
5 Enclose the 2-D barcode within the red rectangle that appears, and click [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, refer to "Setup: 1.8.8 Window Setup".



[2-D Barcode Type]

The types of 2-D barcodes supported by the 2-D barcode tool. Select one of the following:
Refer to "Setup: 4.12.4 Terminologies".

- Data Matrix Code
- QR Code

[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 clicking 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 clicking and buttons. The default value is 40. The minimum value is 0. If a small value is set, objects that cannot be seen clearly can be

detected, but processes will take time.
This can be selected when [Barcode Type] is [QR Code].

[Image Display Mode]

Select the image display mode for the Setup Page.

[Original Image]
The image selected in [Input Image] will appear.

[Morphing Image]
Displays the image that was selected in [Input Image] and applied preprocessing filter.

[Binary Image]
The image that is selected in [Input Image] and is binarized using a value set in [Threshold value] will appear. This is a parameter that appears when [Data Matrix Code] is selected in [Barcode Type].

[Image + Edges]
The image selected in [Input Image] and features in the image will appear. This is a parameter that appears when [QR Code] is selected in [Barcode Type].

[Image Preprocessing]

Select the filter to be applied to the image from the options listed below.

[None]
Do not perform Image processing filter.

[Blur]
Applies the blur filter to the image that was selected in [Input Image]. It reduces image noise.

[Median]
Applies the median filter to the image that was selected in [Input Image]. It reduces image noise without blurring the edges too much. However, if you set the aforementioned [Filter Iterations] to 2 or more, the processing time may be longer.

[Sharpen]
Applies the sharpening filter to the image that was selected in [Input Image]. It sharpens the contrast of the image.

[Morphology Operator]
Performs morphology operation to the black area in the image that was selected in [Input Image]. Specify a type in [Morphology Operator].

[Morphology Operator]

Select the type of morphology from the drop-down box. This is a parameter that appears when [Morphology Operator] is selected in [Image Preprocessing].

[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.

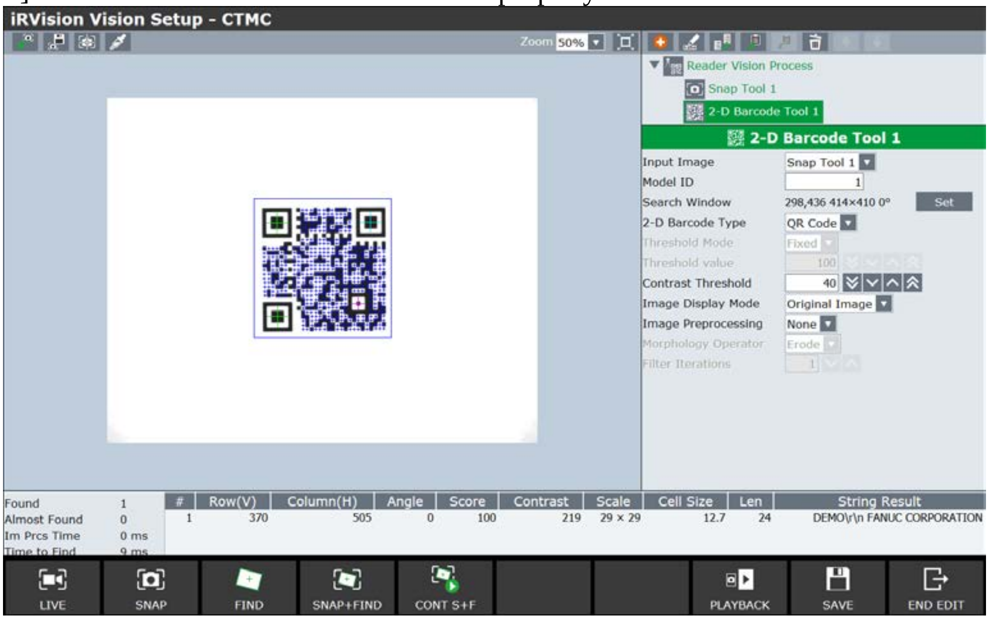
[Close]
Dilates the white area then erodes it. This will connect black blobs that are close to touching or disconnect white blobs that are slightly touching.

[Filter Iterations]
The number of iterations to perform on the selected filter. It will appear when anything but [None] is selected in [Image Preprocessing].

[Grayscale Histogram]
It displays the grayscale histogram when [2-D Barcode Type] is [Data Matrix Code]. It also displays a vertical green line to indicate the binary threshold.

4.12.2 Running a Test

Click [FIND] to run a test and see if the barcode was properly found.



After executing a test, the following items are displayed in the result display area.

[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

[Image Preprocessing]
The time it took to perform the image processing. The units are milliseconds.

[Time to Find]
The time it takes to find a 2-D barcode will appear. The units are milliseconds.

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

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].

[Angle]

He found angle of the barcode in degrees. The units are degrees.

[Score]

The relative number of bit errors that were corrected when reading the code. A 2-D barcode has redundancy, and it has capacity to recover error bits to some extent if there are ones in reading. 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.

[Contrast]

The average contrast between dark cells and light cells. If an image is generally dark or looks blurred due to being out of focus, etc., the value will be lower.

[Scale]

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.

4.12.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override

4.12.4 Terminologies

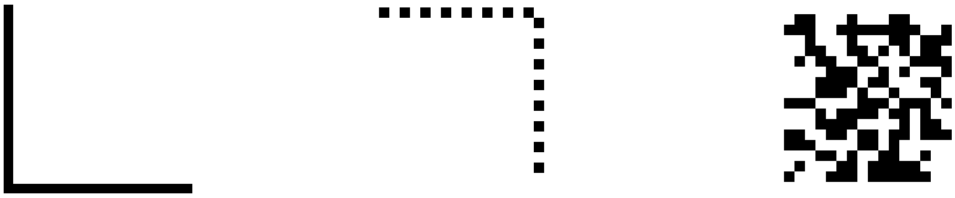
This section explains terminologies of 2-D barcode tool.

[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.

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**

Composition of Data Matrix Code

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 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 640 x 480 *i*RVision image to be found reliably.

For example, the 36 x 16 Data Matrix Code shown in the example image would require minimum pixel dimensions of 95 x 45 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		Row	Col
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

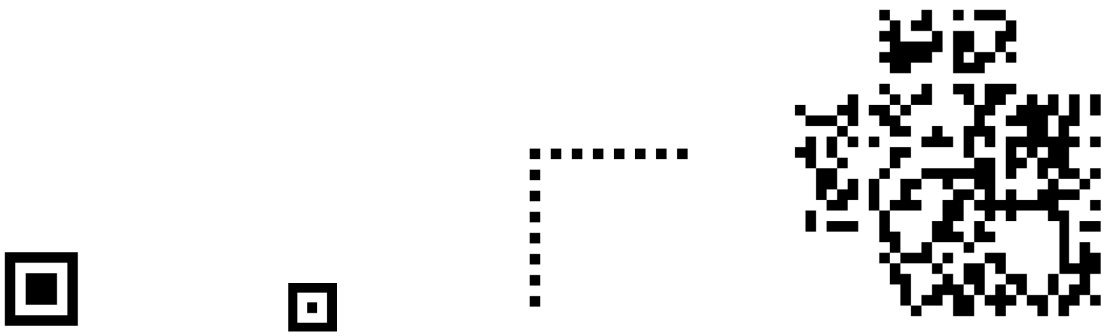
Data Matrix Code size (unit: the number of cell)		The Maximum number of characters	The minimum size of Data Matrix Code (unit: pixel)	
Row	Col		Row	Col
72	72	736	185	185
80	80	912	205	205
88	88	1152	225	225
96	96	1392	245	245
104	104	1632	265	265
120	120	2100	305	305
132	132	2608	335	335
144	144	3116	365	365
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.

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.



Composition of QR Code

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 640 x 480 *i*RVision image to be found reliably.

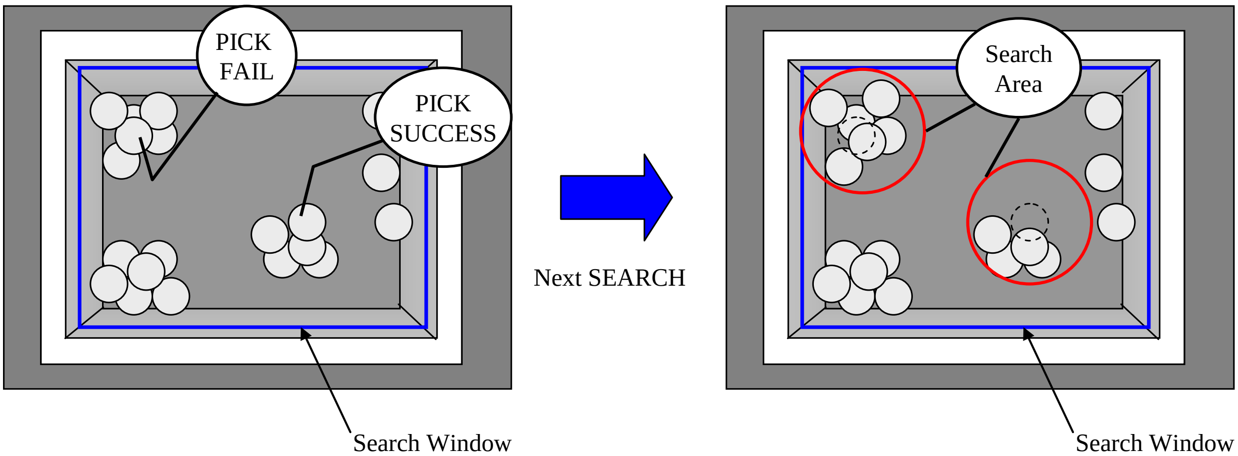
For example, the 29 x 29 QR Code shown in the example image would require minimum pixel dimensions of 83 x 83 to be found reliably.

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

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**
173	173	39	443	443
177	177	40	453	453

4.13 SEARCH AREA RESTRICTION TOOL

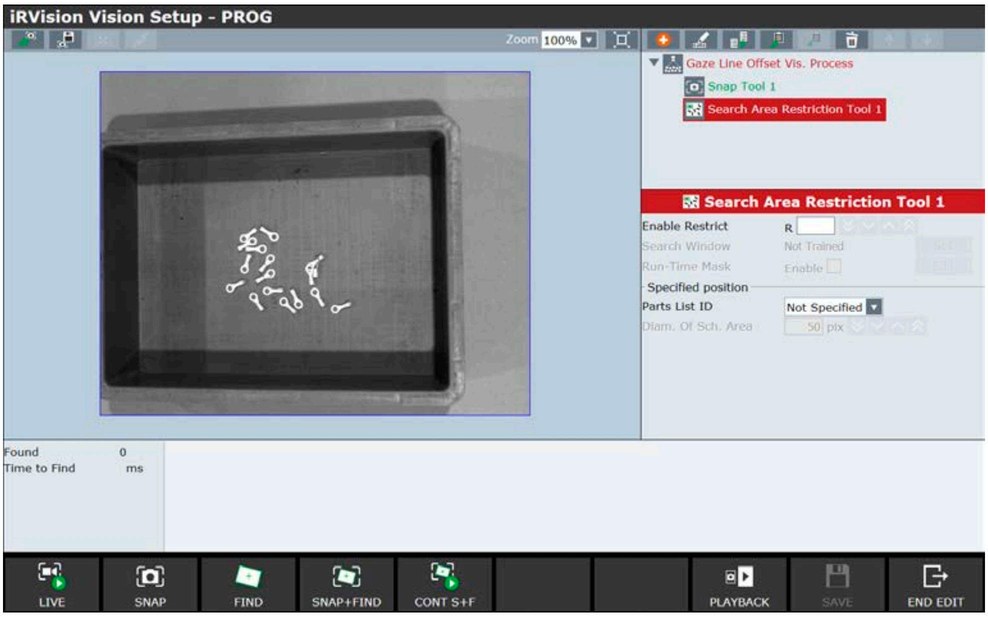
The Search Area Restriction tool enables a search vision process for bin picking to process only small limited areas of the input image where states of plies of workpieces have just been changed. By processing only the small areas, the processing time can be reduced. The search area restriction tool is used with the workpiece management function that is included in the *i*RVision Bin Picking option.



Functions of Search Area Restriction Tool

In such cases, further set a search area that is limited to the location close to where the states of piles of workpieces have been changed (the circles at the right figure above), within the search window to enclose the whole container that has already been set. By searching for a workpiece within these limited search areas, the processing time of vision process can be reduced. *i*RVision provides the search area restriction tool. This section describes the setup methods for the search area restriction tool. You can use the Search Area Restriction Tool only when the Gaze Line Offset Vision Process or 3D Area Sensor Vision process.

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.

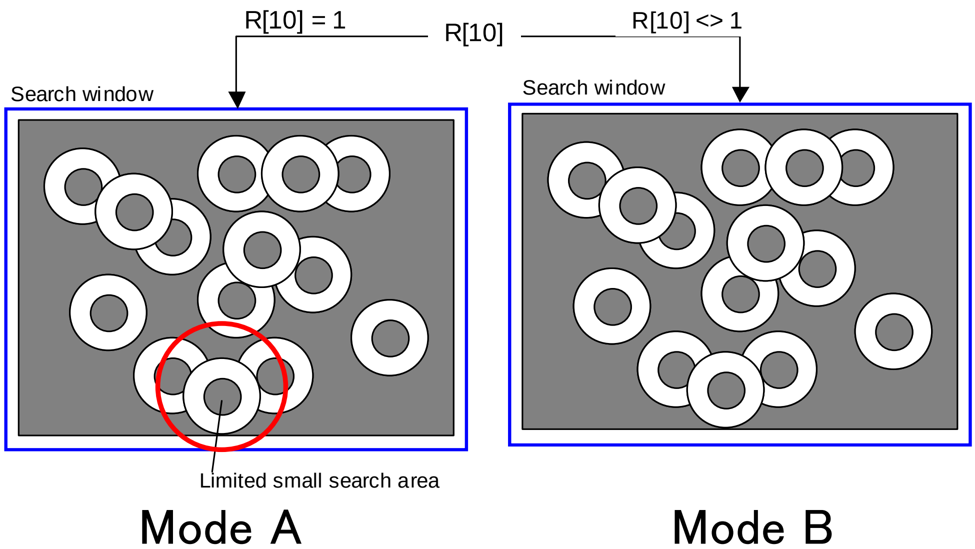


4.13.1 Setup Items

Set the parameters.

[Enable Restrict]

You can externally turn on/off the search area restriction. Specify the index number of the register you want to use to change these. Input a value or change the value with the button.
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.
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. After this status continues, you may have to execute another find process for a whole search window. By changing the register value that is specified here, such processes are switched voluntarily.



Turn on/off the search area restriction using register numbers

[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, click the [Set] button. When a rectangle appears on the image, change the search window. For detailed information about the operation method, refer to "Setup: 1.8.8 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, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

[Specified position]

Restricts the search area at the set location.

[Parts List ID]

Specify a parts list ID to use.

[Diam. Of Sch. Area]

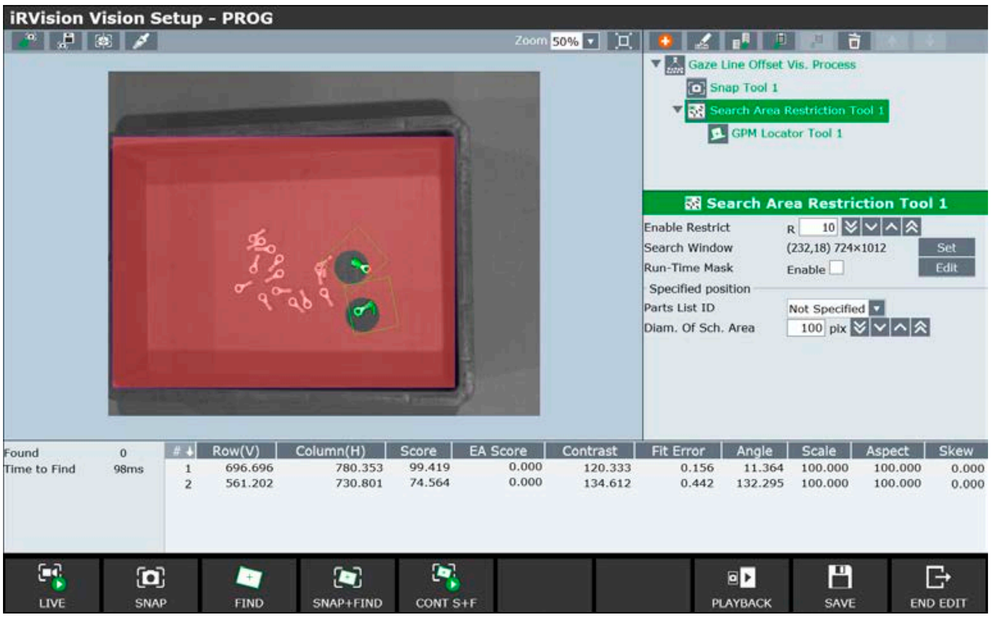
Specify the size of limited search area set at a poison where states of piles of workpieces have been changed.

4.13.2 Setting a Position where Plied Workpieces State Changed

When to set a position where the states of piles of workpieces is the time of executing IPSETTARPOS.PC. For this KAREL programs, please refer to "*i*RVision Bin Picking Application OPERATOR'S MANUAL B-83914EN-6".

4.13.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]
The number of found workpieces is displayed.

[Time to Find]
The time the location process took is displayed in milliseconds.

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.

4.13.4 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.14 3D DATA PREPROCESS TOOL

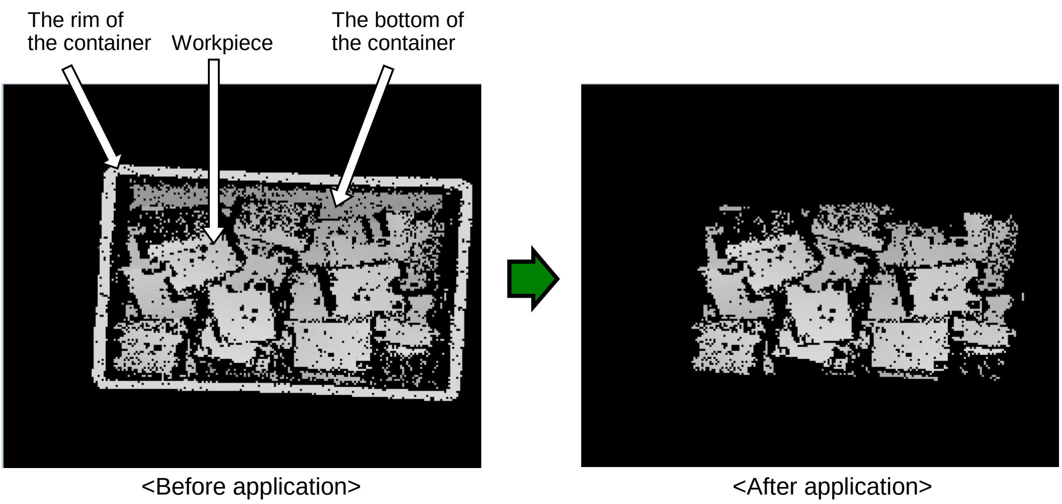
The 3D Data Preprocess tool is a tool to preprocess 3D data for search. 3D data is three-dimensional data that are used by 3D locator tools including the 3D Blob Locator Tool.
The 3D data preprocess tool mainly performs two processes as follows.

- Remove unnecessary 3D points from 3D data.
- Calculate a normal vector at each 3D point in 3D data.

An unnecessary 3D point refers to the 3D point that is obtained from something that is other than a workpiece, such as a container that contains it or 3D point that is judged as an outlier. Because such 3D point causes incorrect result, it is necessary to appropriately remove them by using 3D Data Preprocess Tool.

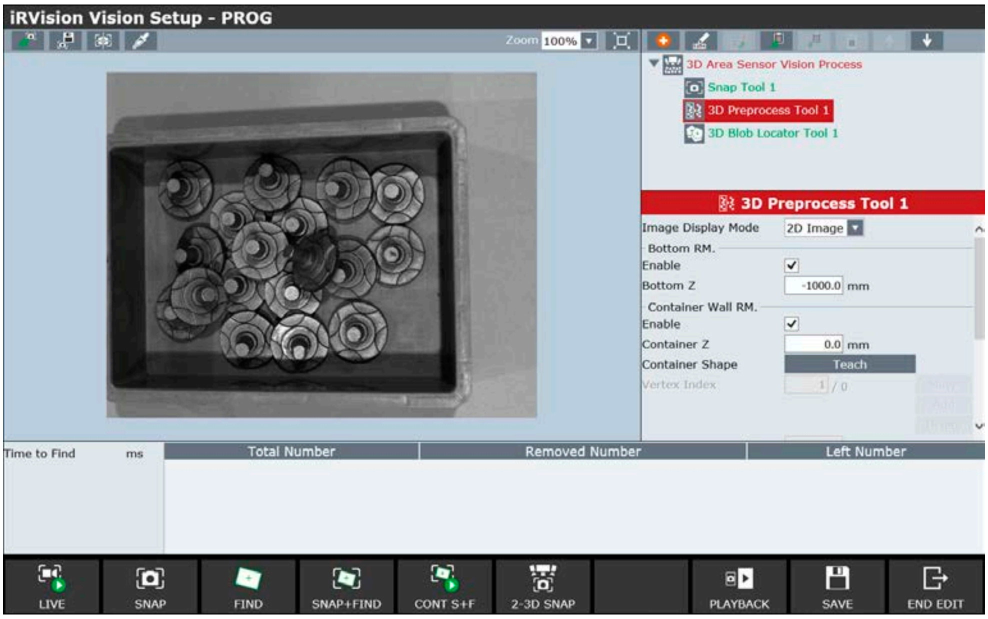
- Bottom Removal : The function to remove 3D points on the container bottom
- Container Removal : The function to remove 3D points on the container rim and wall
- Outlier Removal : The function to remove 3D points considered as outliers

The 3D data preprocess tool can be used only in the 3D Area Sensor Vision Process.



The result of removal by the 3D Data Preprocess tool

If you select the [3D Data Preprocess Tool] l in the tree view of the setup page for the vision process, a setup page like the one shown below appears.



4.14.1 Setup Items

The 3D Data Preprocess Tool has the following parameters.

[Image Display Mode]

Select the image display mode for the Setup Page.

[2D Image]

Display 2D image.

[2D Image + Result]

Display 2D images and the results of removal of 3D points. Removed 3D points will appear in red color and 3D points where the calculation of normal vectors failed will appear in orange color.

[3D Data]

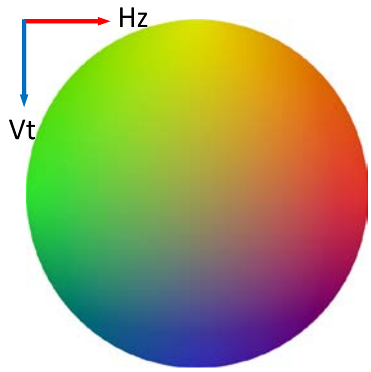
Display a 3D data.

[3D Data + Result]

Display the results of removal in a 3D data. Removed 3D points will appear in red color and 3D points where the calculation of normals failed will appear in orange color.

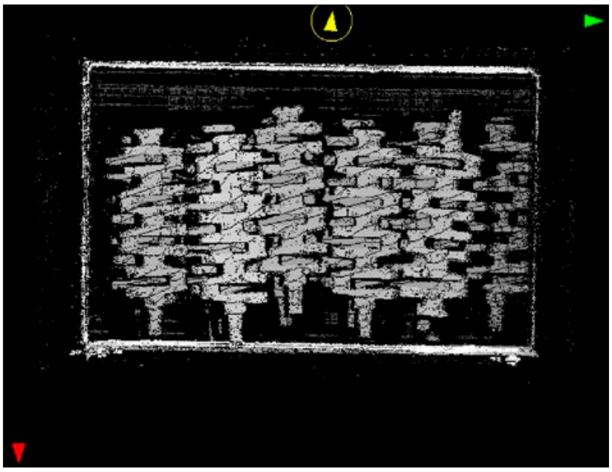
[Normal]

Display 3D points with color classification in accordance with the normal direction. As the figure below shows, red is strong when the normal direction tilts to the Hz forward direction, and blue is strong when the normal direction tilts to the Vt forward direction.



[Height Map]

Height map (an image in which 3D points are projected to X-Y plane) will be displayed. Height map is not displayed if [Container Wall RM.] is disabled.



A value of each pixel represents Z height. A red arrow and a green arrow show X direction and Y direction of the offset frame respectively, and a yellow arrow represents the direction of which the robot is located.

[Bottom RM.]

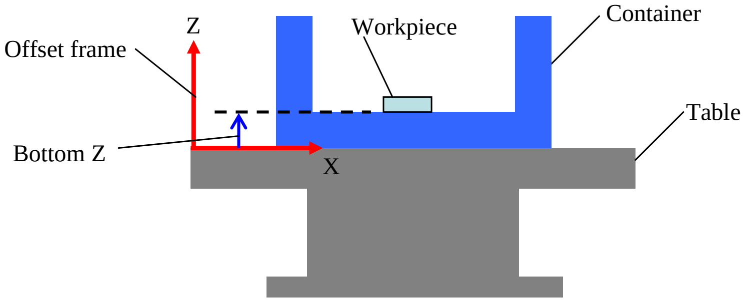
Set the parameters to remove 3D points on the container bottom.

[Enable]

If the checkbox is checked, some 3D points on the container bottom are removed.

[Bottom Z]

Set the height of the bottom of the container (units: mm). This value is the height of the container bottom from the XY plane of [Offset Frame] of the vision process. If the Z height of a 3D point is lower than the value of [Bottom Z], the 3D point is removed.



Bottom Z

[Container Wall RM.]

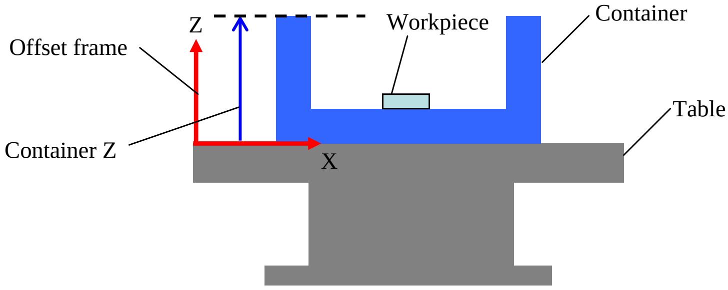
Set the parameters to remove 3D points on the container rim and wall.

[Enable]

If the checkbox is checked, some 3D points on the container rim or wall are removed.

[Container Z]

Set the height of the container rim (unit: mm). This value is the height of the container rim from the XY plane of [Offset Frame] of the vision process.

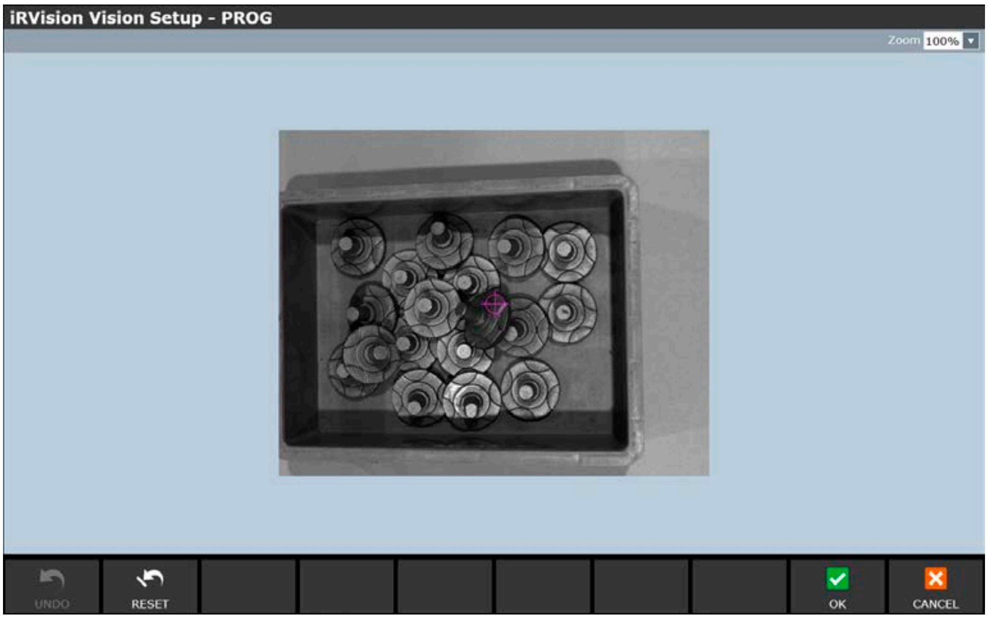


Container Z

[Container Shape]

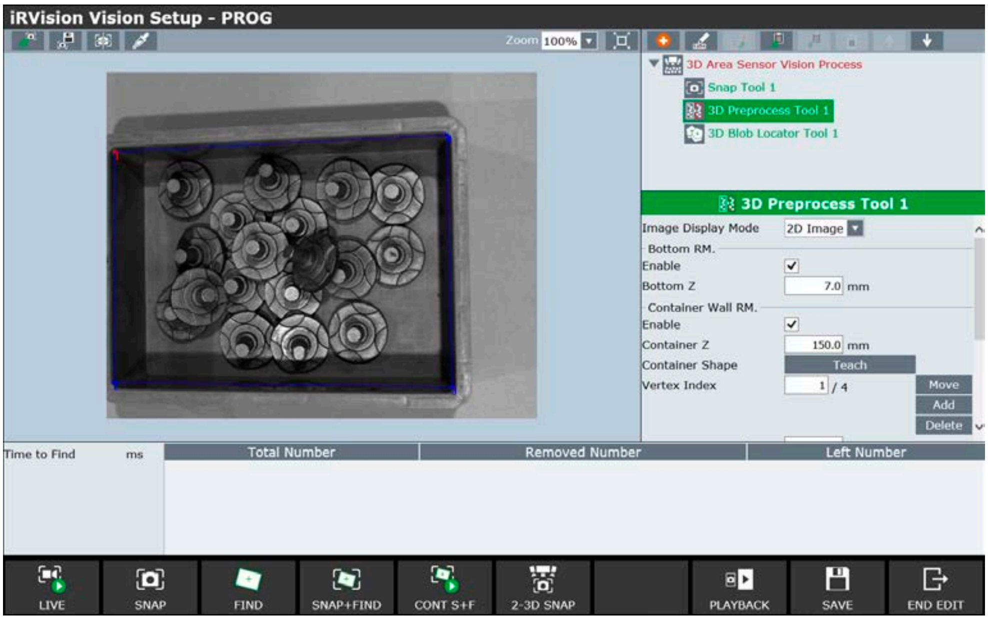
Set the container shape as follows.

1 Place the container near the center of the camera view.
2 Click 2-3D SNAP to snap the image of the workpiece and acquire its 3D Data.
3 Click the [Teach] button of [Container Shape], then a pointer in magenta ⊕ is displayed on a 2D image as shown below.
4 Move the pointer to the position of a vertex (corner) of the container rim and click the [OK]. Then, the position is set and the pointer is displayed again.



5 Move the pointer to the position of the next unset vertex of the container and click the [OK]. Then, the position is set and the pointer is displayed again.

6 This operation is done repeatedly to enclose the container shape as follows. Then the container shape can be set.
Up to 30 positions of the vertices can be set.



[Vertex Index]

This is the index of each vertex of [Container Shape]. For the vertex specified by the textbox of [Vertex Index], the following operations can be executed to change [Container Shape].

1 Enter a numerical value in the [Vertex Index] text box.

2 Click the [Move], [Add] or [Delete] button.

- Clicking the [Move] button will display the screen to change the vertex location that was entered in [Vertex Index]. Move to a desired position.
- Clicking the [Add] button will add a new vertex behind the vertex that was entered in [Vertex Index].
- Clicking [Delete] button will delete the vertex that was entered in [Vertex Index].

[Ref. 2D Pos]

The reference position on a camera image is displayed when a preceding window shift tool that is at the same level as this tool is set and the window shift tool is set to shift a search window by using a result of 2D Locator Tool such as GPM Locator Tool.

[Ref. 3D Pos]

The reference position in [Offset Frame] of the vision process is displayed when a preceding window shift tool that is at the same level as this tool is set and the window shift tool is set to shift a search window by using a result of another vision process.

[Margin from Wal]

Set the margin of [Container Shape] (units: mm). The margin is the distance between the wall of the container and the border of the measurement area set inside [Container Shape]. 3D points outside the measurement area are removed. Specify a number between 0 and 1000.

[Outlier RM.]

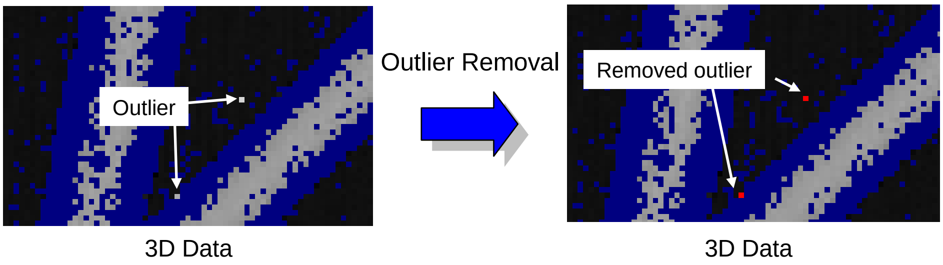
Set the parameters to remove 3D points considered as outlier

[Enable]

If the check box is checked, some 3D points considered as outlier are removed.

[Filter Size]

Select the filter size for removing some 3D points considered as outliers. For example. If the value is F, the filter is the area whose base is a '2F + 1' square parallel with the XY plane of the 3D data. And if each 3D point whose Z height is far different from the heights of the other 3D points in the filter whose center is the 3D point, the 3D point is removed as an outlier. Specify a number between 1 and 10.



Example of finding by the outlier removal filter

[Threshold]

Set the threshold which is used for judging if a 3D point is outlier (units: mm). If the difference between the 3D point and the median of the Z heights of all the other 3D points in the filter whose center is the 3D point is larger than the set value, the 3D point is removed as an outlier. Specify a number between 0 and 1000.

[Min. Num. Around]

Set the minimum required number of 3D points around each 3D point not removed as an outlier. If the number of 3D points which are not at the center of the filter but in the filter is lower than the set number, the center 3D point of the filter is removed as an outlier. If a value F was set as [Filter Size], specify a number between 1 and (2F + 1)^2 -1. The larger the value, the more 3D points are removed.

[Normal Calculation]

Set the size of the range to calculate a normal vector of a 3D point.

[Enable]

In order to set parameters for the normal vector calculation, check [Enable].
Depending on the setup status of [Enable] of the normal calculation and the status of the vision process, the following messages will appear.

- Normal Calc. is necessary
  This message appears when the normal vector calculation is disabled and this vision process has a command tool that requires normal data.
  Check [Enable] of the normal calculation.

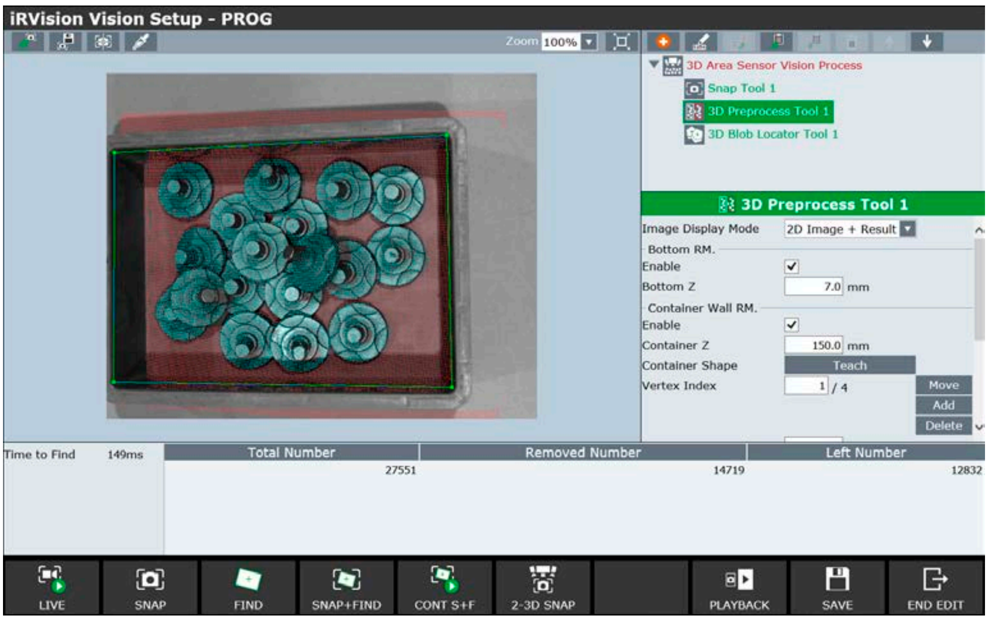
- Normal Calc. isn't necessary
  This message appears when the normal vector calculation is enabled and this vision process does not have a command tool that requires normal data. Normal calculation can be executed, but it takes longer process time.

[Filter Size]

Set the filter size that is used for normal vector calculation. Select a value from 1 to 5 from the drop-down box.
Against the setting value F, calculate normals in square areas with each side being 2 F +1 and centered on each 3D point in a 3D data.

4.14.2 Running a Test

Click [FIND] to run a test and see if the tool can remove 3D points on the container and outliers, which lead to incorrect results, from a 3D data.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time which the process removing 3D points on the container and outliers took is displayed (units: ms)

Also, in the result display area list view, the following values are displayed.

[Total Number]

Total number of 3D points in a 3D data.

[Removed Number]
Number of 3D points removed as 3D points on the container or outliers.

[Left Number]
Number of 3D points not removed.

4.14.3 Overridable Parameters

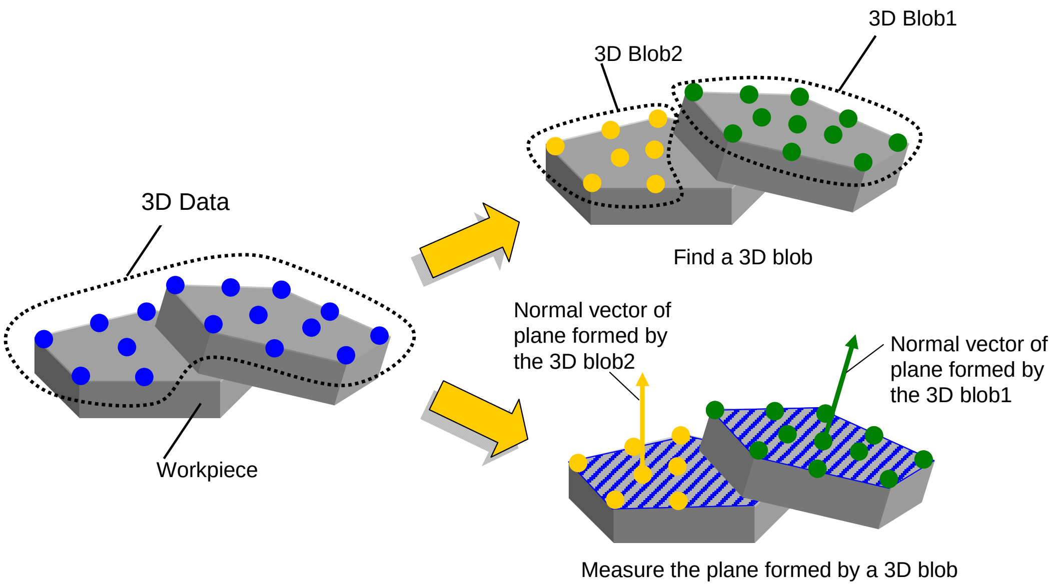
This command tool has the following overridable parameters that can be overridden with Vision Override. For details of vision overrides, refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE".

[Bottom Z]
Set a value between -4000 and 4000. This will appear when [Bottom RM.] is enabled.

[Margin from Wall]
Specify a number between 0 and 1000. This will appear when [Container Wall RM.] is enabled.

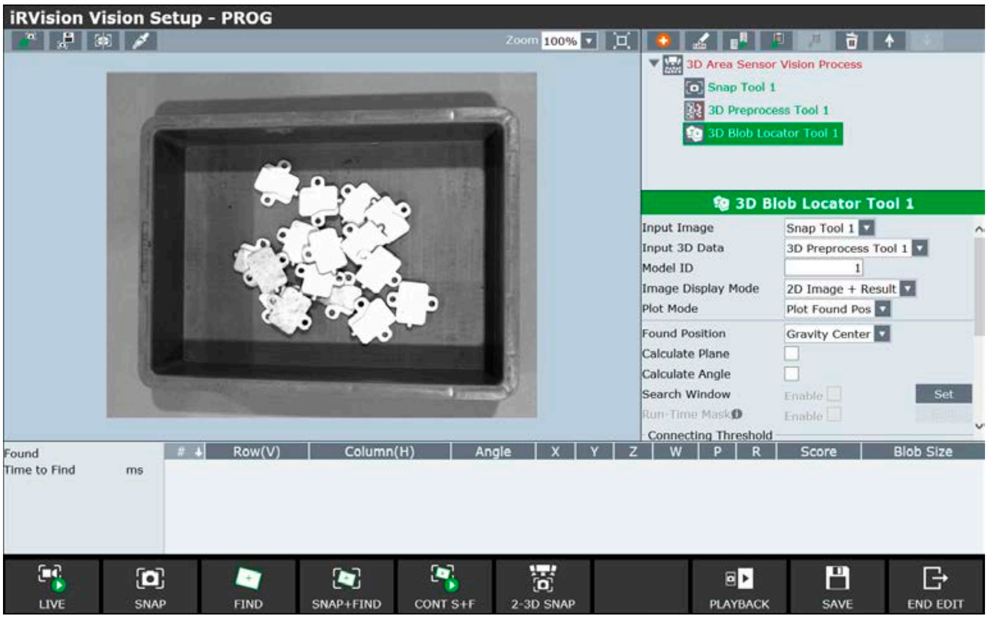
4.15 3D BLOB LOCATOR TOOL

The 3D Blob Locator tool finds a set of 3D points which are continuously-distributed on a 3D Data and outputs its found position. Hereafter, the set of 3D points is referred to as 3D blob. It can also measure the plane formed by the 3D blob. To use the 3D Blob Locator tool, some 3D points which derive incorrect results and waste the processing time must be removed by the 3D Data Preprocess tool.



Finding by the 3D Blob Locator Tool

If you select the 3D Blob Locator Tool in the tree view of the vision process edit screen, the following screen will appear.



4.15.1 Setup Items

The 3D Blob Locator Tool has the following parameters.

[Input Image]

Select an image which is used for 3D blob detection. When the vision process has an Image Filter Tool or an Image Arithmetic Tool, you can select a filtered image as the input image to this 3D Blob Locator Tool, instead of the camera snapped original image. For details, please refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL"

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess tool is set. This parameter is not normally needed to be changed.

If there is a different preceding locator tool in the tree view, by specifying the tool, you can use 3D data in which 3D points that match the found result have been removed.
This has the effect that reduces time to find, or prevents the output of found results which overlap in the same workpiece.

The following command tools at the same level that precedes this tool can be selected.

- 3D Data Preprocess Tool
- 3D Cylinder Locator Tool
- 3D Box Locator Tool
- 3D One-Sight-Model Locater. Tool

Also the following command tools which are set as a child tool of the 3D Data Preprocess Tool can be selected.

- 3D Blob Locator Tool
- 3D One-Sight-Model Locator Tool

[Model ID]

Enter the value for the Model ID in the text box.
When you have taught two or more 3D Blob Locator tools and want to identify which tool detected each workpiece, assign a distinct model ID to each tool.

[Image Display Mode]

Select the image display mode for the Setup Page.

[2D Image + Points]

Acquired 3D points will be shown on 2D image.

[2D Image + Result]

Found results will be displayed on 2D image.

[2D Image + Edges]

A camera image and features of the image is displayed.
This is a parameter that appears when you check [Enable] in [Contrast] of [Connecting Threshold].

[2D Image + Postproc.]

Postprocess results will be displayed on 2D image. 3D points that have not been removed by this locator tool are plotted in cyan color.

[3D Data]

A 3D data is displayed.

[3D Data + Result]

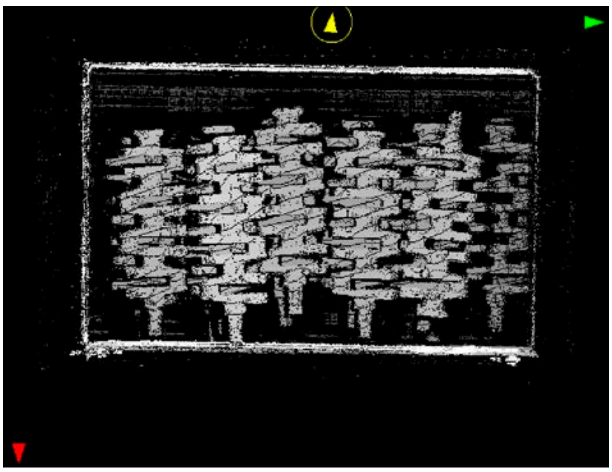
A 3D data is displayed.

[3D Data + Postproc.]

Postprocess results will be displayed on 3D data. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[Height Map]

Height map (an image in which 3D points are projected to X-Y plane) will be displayed. Height map is not displayed if [Search Window] is disabled.



A value of each pixel represents Z height. A red arrow and a green arrow show X direction and Y direction of the offset frame respectively, and a yellow arrow represents the direction of which the robot is located.

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run.

[Plot Found Pos]

"+" is displayed at the found position of a 3D blob in green.

[Plot Found Pos + Points]

In addition to the found position, 3D points which compose a 3D blob are also plotted. 3D point that has relatively higher score among the found results is plotted in red while the one that has lower score is in blue. If [Calculate Plane] is checked, 3D point that is not on the calculated plane is plotted in purple.

> ⚠**Caution**
>
> Setting [Plot mode] to [Plot Found Pos. + Points] may stop the system due to lack of memories. We recommend that you set it to [Plot Found Pos. + Points] for teaching and adjusting vision processes and [Plot Found Pos.] for when a process is run.

[Found Position]

Select the type of found positions from the followings:

[Gravity Center]

The center of gravity of 3D points which compose a 3D blob is output as a found position. If the checkbox of [Calculate plane] is checked, the center of gravity is calculated only from 3D points on the plane.

[Minimum Rectangle Center]

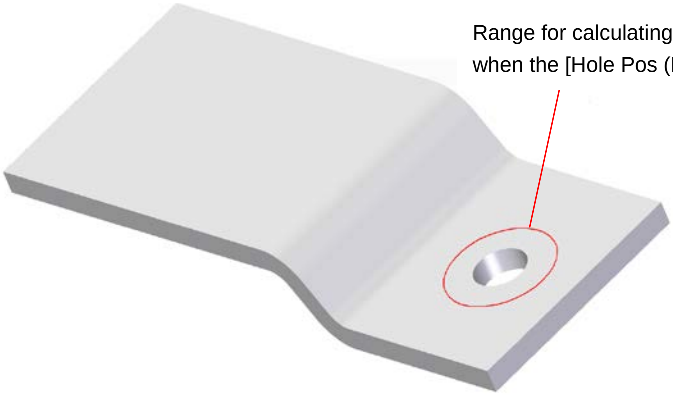
The center of the minimum bounding rectangle surrounding each 3D blob is output as the found position of the 3D blob. When the [Minimum Rectangle Center] is selected as the [Found Position], the checkbox of [Calculate Plane] is automatically checked and cannot be unchecked because each minimum bounding rectangle is calculated in the plane calculated from a 3D blob. Calculating minimum bounding rectangles make the centers of the workpieces easy to be found stably even if the number and accuracy of 3D points are not enough because of rough surfaces of workpieces.

[Dense Pos]

The area where the density of 3D points is the highest in a 3D blob is found and the center position of the area is output as a found position. Densities are calculated in areas whose radii are defined by [Density Meas. Radius]. If the checkbox of [Calculate plane] is checked, the densities are calculated only from 3D points on the plane.

[Hole Pos (Hole Posture)]

Calculates the hole position and posture only from 3D positions around the found hole and set it as a found position. This function should be enabled when a hole does not exist on the main plane of a 3D blob as the following figure.



Hole Pos (Hole Posture)

[Hole Pos (Part Posture)]

The center of hole on a 3D blob is output as a found position. If the checkbox of [Calculate Plane] is checked, the center of the hole is calculated only from 3D points on the plane.

[Calculate Plane]

If the checkbox is checked, the plane from 3D points of 3D blob after finding the 3D blob will be calculated.

[Fit Error Threshold]

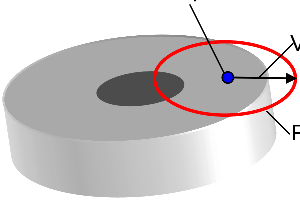
Set a threshold of distance from a plane when the checkbox of [Calculate Plane] is checked (units: mm). When the distance of a 3D point from a found plane is smaller than this value, the tool judges that the 3D point is on the found plane. Set a value between 0 and 1000. By setting a large value to the parameter, it is easy to succeed a finding but degraded accuracy 3D blob might be output.

[Min. Num Valid Points]

Set the minimum number of 3D points on a measured plane when the checkbox of [Calculate Plane] is checked. Set a value between 3 and 10000000. If the number of 3D points on a measured plane of a found 3D blob is lower than this value, the found 3D blob is removed from the found results. By setting a small value to the parameter, it is easy to succeed a finding but degraded accuracy 3D blob might be output.

[Density Meas. Radius]

Set the radius of measurement area for calculating densities. Set a value between 0 and 1000. This appears when [Dense Pos] is selected in [Found Position].



Value to be Density Meas. Radius.

[Hole Diameter]

When [Hole Pos(Hole Posture)] or [Hole Pos (Part Posture)] is selected in [Found Position], set the diameter of a hole to detect (units: mm). Set a value between 15 and 1000. Find a hole with a diameter

closest to the set value.
This appears when [Hole Pos (Hole Posture)] or [Hole Pos (Part Posture)] is selected in [Found Position].

[Calculate Angle]

Specify whether or not to calculate the orientation of the found 3D blob. Once checked, the longer direction of 3D Blob from Vt direction is outputted as the found angle.

[Search Window]

From the 3D data, set the 3D points area to be used for finding on the height map.

By default, search window is disabled and all 3D points included in the 3D data are used.
Normally, this does not need to be changed since unnecessary 3D points such as those on a container will be removed by 3D Data Preprocess tool and so on, but when you want to find restricted to a part of the area in the container, for example, click the [Set] button in [Search Window] to set the search window. When search window appears on the height map in a rectangle, adjust the rectangle. For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

If the search window setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by search window is disabled.

[Run-Time Mask]

Specify a 3D point area of the search window that is not used to find, with an arbitrary geometry. This can be set when search window is enabled. For example, when a workpiece is sectioned with partitions in the container, this is effective for removing the partitions from search target. Click the [Edit] button to use the Run-Time Mask. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

If the run-time mask setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by the run-time mask is disabled.

[Connecting Threshold]

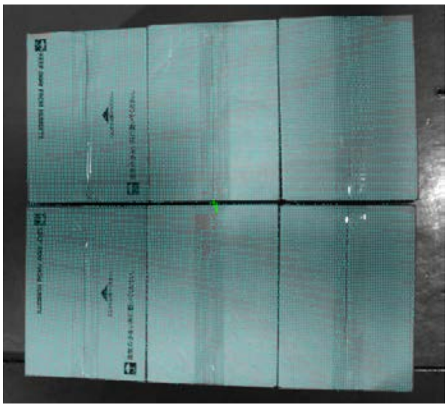
Set the threshold value for judging the connection of adjacent 3D points in the 3D data.

[Connecting Threshold – Z Height]

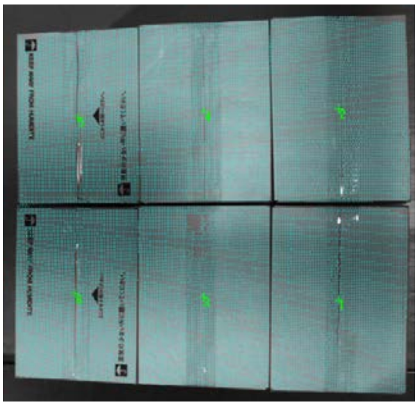
Set the threshold of the difference between Z heights of 3D points (units: mm). If the difference between Z heights of adjacent 3D points is larger than this threshold, the adjacent 3D points are not connected with each other. Set a value between 0 and 100000.

[Connecting Threshold – Contrast]

Specify whether or not to use features of 2D image when judging the connection of the 3D points constituting the 3D blob. If the checkbox is checked, those image features whose contrast is higher than the threshold are used for judging the connection of the 3D points constituting the 3D blob.
Set a value between 1 and 200.
In the case that same size workpieces are located densely as shown in the figure below, the connection judgment by using Z height of 3D data causes to be found one 3D blob including some workpieces. But the connection judgment by using Z height of 3D data and features of 2D image causes to be found a 3D blob corresponding to each workpiece.



Connection judgment by
Z height of 3D map

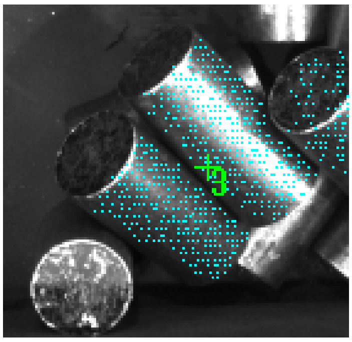


Connection judgment by
Z height of 3D map + image feature

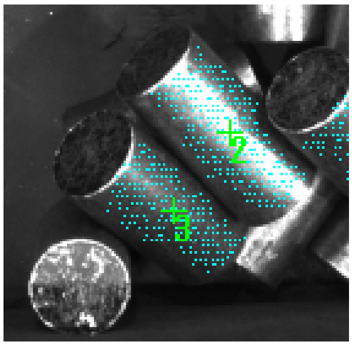
Example of using the image features for judging the connection of 3D points of the 3D blob

[Connecting Threshold – Normal Direction]

Specify whether or not to use the normal directions of 3D points when judging the connection of the 3D points constituting the 3D blob. When the checkbox is checked, if the angle between the normal directions of adjacent 3D points are larger than the threshold, the 3D points are not connectied with each other. Set a value between 0 and 180 degrees.



Connection judgment by
Z height of 3D map



Connection judgment by
Z height of 3D map +
Normal Vectors of 3D map

Example of connection judgment

[DOF]

Set the DOF of 3D Blobs. Once the DOF is set, the 3D blob only in the DOF will be outputted as the found result.

[Blob Size]

Enter the value in the [Min.] and [Max.] text boxes. Outputs the 3D blob of the blob size in the specified area as a found result.

[3D Blob Length]

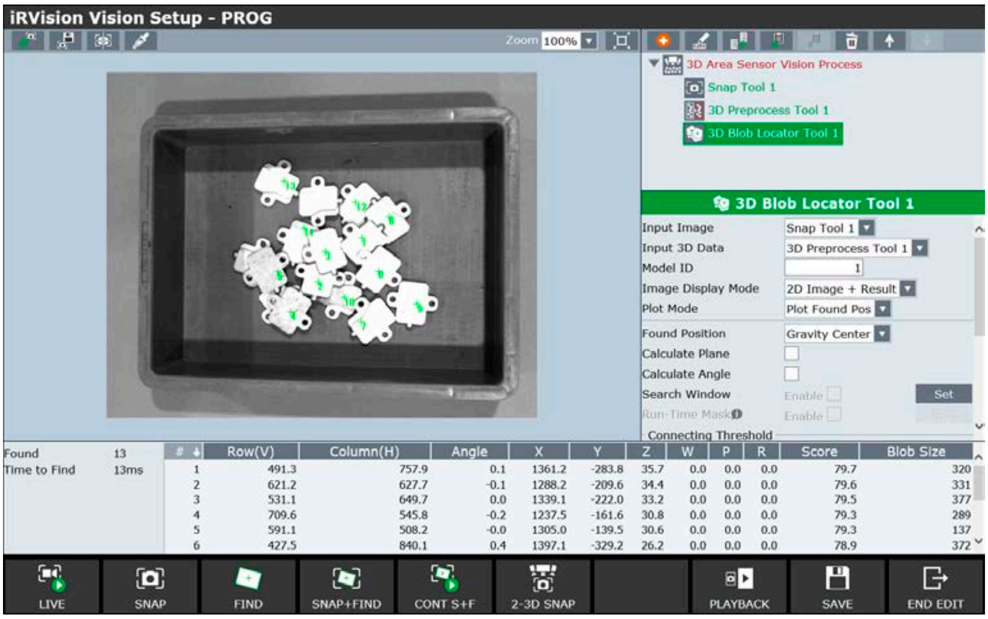
When [Enable] is checked, enter the value in [Min.] and [Max.] text boxes. The units are millimeters. Outputs the 3D blob of the blob length in the specified area as a found result. Outputs the length of the 3D blob along the direction of the major axis as the 3D blob length.

[3D Blob Width]

When [Enable] is checked, enter the value in [Min.] and [Max.] text boxes. The units are millimeters. Outputs the 3D blob of the blob width in the specified area as a found result. Outputs the length of the 3D blob along the orthogonal direction to the direction of the major axis as the 3D blob width.

4.15.2 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]
The number of found 3D blobs is displayed.

[Time to Find]
Time to find is displayed (units: ms).

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]
Found position of 3D blob on camera image.

[Angle]
Angle of 3D blob orientation. The units are degrees (°).

[X], [Y], [Z], [W], [P], [R]
Coordinate values of the found result. The units are mm or degrees (°).

[Score]
Score of found 3D blob. Outputs the relative Z height of the found position for [Meas. Z Range] of the 3D Area Sensor Vision Process as the score.

[Blob Size]
The number of 3D points of found 3D blob.

[Num. Plane Valid Points]
The number of 3D points on the measured plane from 3D points of found 3D blob. This item is displayed only when the checkbox of [Calculate Plane] is checked.

[Plane Fit Error]

The average of distance valid points from measured plane. This item is displayed only when the checkbox of [Calculate Plane] is checked.

[Density]

Density of 3D points around found position (units: %). This item is displayed when [Dense Pos] is selected in [Found Position].

[Hole Diameter]

Diameter of hole in found 3D blob. This item is displayed when [Hole Pos (Hole Posture)] or [Hole Pos (Part Posture)] is selected in [Found Position].

[Plane Distance]

Distance from plane to found position. This item is displayed when the checkbox of [Calculate Plane] is checked

[3D Blob Length (mm)]

Length of found 3D blob along the longer direction of the 3D blob. This item is displayed when the checkbox of the [Calculate Angle] is checked.

[3D Blob Width (mm)]

Length of found 3D blob along the orthogonal direction to the longer direction of the 3D blob. This item is displayed when the checkboxes of the [Calculate Angle] and the [Calculate Plane] are checked.

4.15.3 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Z Height Threshold]

Specify a number between 0 and 100000.

[Min Blob Size]

Specify a number between 1 and 45888.

[Max Blob Size]

Specify a number between the minimum blob size and 10000000.

[Min 3D Blob Length]

Specify a number between 1.0 and the maximum blob length. It will be displayed when [3D Blob Length] of [DOF] is enabled.

[Max 3D Blob Length]

Specify a number between the minimum blob length and 100000.0. It will be displayed when [3D Blob Length] of [DOF] is enabled.

[Min 3D Blob Width]

Specify a number between 1.0 and the maximum blob width. It will be displayed when [3D Blob Width] of [DOF] is enabled.

[Max 3D Blob Width]

Specify a number between the minimum blob width and 100000.0. It will be displayed when [3D Blob Width] of [DOF] is enabled.

[Min Num. Valid Points on Plane]

Set a value between 3 and 10000000. It will be displayed when [Calculate Plane] is enabled.

[Plane Fit Error Threshold]

Specify a number between 0 and 1000. It will be displayed when [Calculate Plane] is enabled.

[Hole Diameter]

Specify a number between 15 and 1000. It will be displayed when [DOF] is [Hole Pos (Hole Posure)] or [Hole Pos (Part Posture)].

[Contrast Threshold]

Specify a number 1 and 200 when the checkbox of [Contrast] is checked.

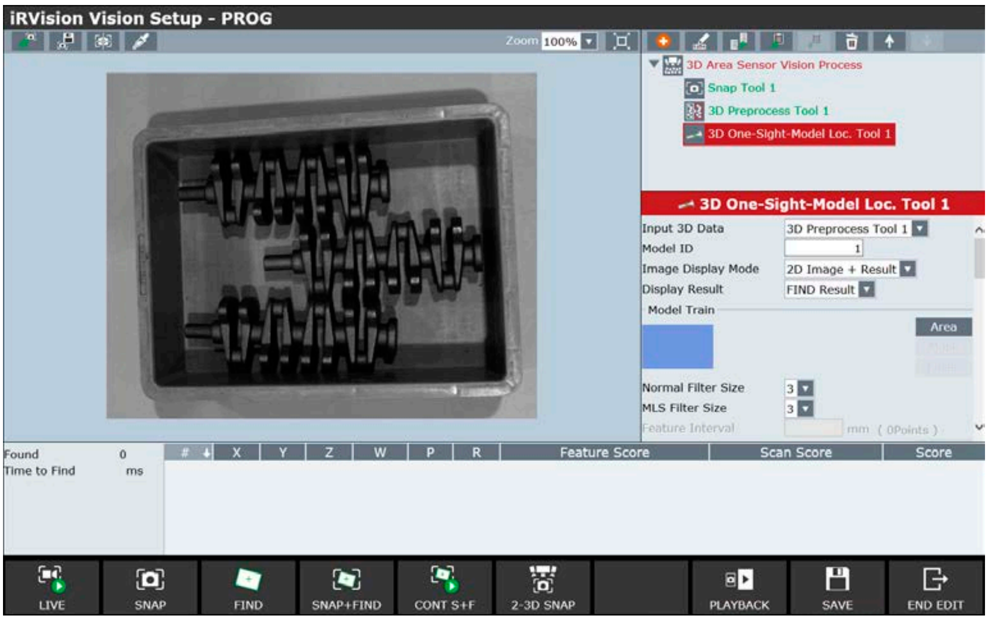
[Normal Direction Threshold]

Set a value between 0 and 180. It will be displayed when [Normal Direction] of [Connecting Threshold] is enabled.

4.16 3D ONE-SIGHT-MODEL LOCATOR TOOL

The 3D One-Sight-Model Locator Tool finds a 3D model which has been taught in advance for one face of a workpiece from 3D data and outputs the 3D position and posture.
The 3D One-Sight-Model Locator Tool can only be used in the 3D Area Sensor Vision Process.

If you select the 3D One-Sight-Model Locator Tool in the tree view of the vision process edit screen, the following screen will appear.



4.16.1 Setup Items

The 3D One-Sight-Model Locator Tool has the following parameters.

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess tool is set. This parameter is not normally needed to be changed.

If there is a different preceding locator tool in the tree view, by specifying the tool, you can use 3D data in which 3D points that match the found result have been removed.
This has the effect that reduces time to find, or prevents the output of found results which overlap in the same workpiece.

The following command tools at the same level that precedes this tool can be selected.

- 3D Data Preprocess Tool
- 3D Cylinder Locator Tool
- 3D Box Locator Tool
- 3D One-Sight-Model Locater. Tool

Also the following command tools which are set as a child tool of the 3D Data Preprocess Tool can be selected.

- 3D Blob Locator Tool
- 3D One-Sight-Model Locator Tool

[Model ID]

Enter the value for the Model ID in the text box.
When you have taught two or more 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.

[Image Display Mode]

Select the image display mode for the setup page.

[2D Image + Points]
Acquired 3D points will be shown on 2D image.

[2D image + Result]
Found results will be displayed on 2D image.

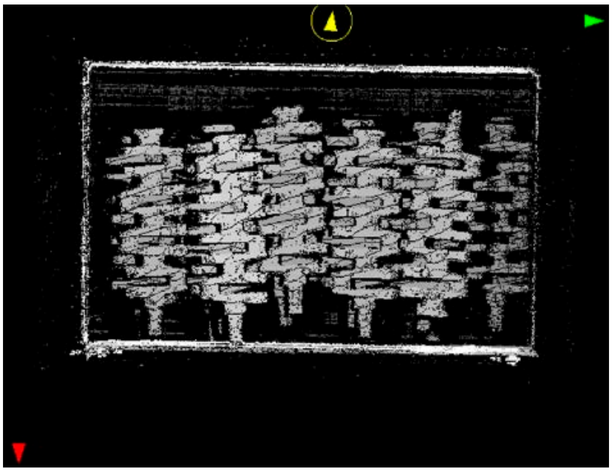
[2D Image + Postproc.]
Postprocess results will be displayed on 2D image. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[3D Data]
Display a 3D data.

[3D Data＋Postproc.]
Postprocess results will be displayed on 3D data. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[Height Map]

Height map (an image in which 3D points are projected to X-Y plane) will be displayed.



A value of each pixel represents Z height. A red arrow and a green arrow show X direction and Y direction of the offset frame respectively, and a yellow arrow represents the direction of which the robot is located.

[Model]

Displays the image set in the model area. The model 3D points are plotted in cyan, and features in green.

[Model Height Map]

Displays the model 3D points on the height map. The model origin is displayed as '+' in green, and X-axis direction as an arrow in cyan.

[Display Result]

Select the mode for displaying the found results on the image from the drop-down box. Once a test is run, [Display Results] will automatically switch to [FIND Result].

[FIND Result]

Displays the found results on 2D image.

[Discarded in Align]

Displays the results which were discarded as a result of alignment or incongruous points in red. Displays the discarded results in the list view in red as well.

[Search Result]

Displays the result on the measured position by the search process of [FIND Results] and [Discarded in Align]. Use this mode when you tuning search parameters.

[Model Train]

Set the area for model train.

[Area]button

Set the model area. For details, refer to "Setup: 4.16.2.1 Setting the Model Area".

[Mask]button

If there are 3D points in an area that is not targeted for finding within the model area, click the [Edit] button in [Mask] to set a mask area. For details, refer to "Setup: 4.16.2.3 Masking the Unnecessary Area".

[Faces] button

After teaching the model area, set parameters so that the workpiece surfaces are divided into each smoothly successive face. For details, refer to "Setup: 4.16.2.2 Dividing the Model Faces".

[Feature Interval]

Set the interval of features. For details, refer to "Setup: 4.16.2.4 Setting the Model Features".

[Emphasis Area]

Use an emphasis area when the position cannot be determined correctly unless attention is paid to a characteristic part of the model. For the area set as an emphasis area, feature score will be calculated only in the emphasis area, and the results where the feature score of the emphasis area is below [Feature Score Threshold] will not be outputted. For details, refer to "Setup: 4.16.2.5 Setting the Emphasis Area".

[Model X-Axis]

This tool sets the search posture range for each XYZ frame axis of the frame held by the model. Here, set the direction of X-axis of the frame held by the model. The direction of Z-axis of [Offset Frame] at the time of model teaching is used for the Z-axis as it is. The direction of Y-axis is calculated from the directions of X-axis and Z-axis. For details, refer to "Setup: 4.16.2.6 Setting the Model X-Axis".

[Search Parameter]

In 3D One-Sight-Model Locator Tool, calculating the approximate position of the workpiece by using the model features is called 'search'. Set the search parameters.

[Feature Score Treshold]

Enter the percentage used for judging that the model features and 3D data are properly corresponding at the time of search in the text box. If the feature score of the found part is less than the specified value, it will not be outputted as the found result.

[Normal Check]

When [Enabled] is checked, this command tool matches feature points to a 3D data with normal directions. In the case that normal directions are stable, detection processes can be shortened by this function.
When you use [Normal Check], you need to set so that the normal calculation will be performed in the 3D Data Preprocess Tool in the vision process. For details of the 3D Data Preprocess Tool, refer to "Setup: 4.14 3D DATA PREPROCESS TOOL".

[Search Interval]

Specify a distance interval in search process. The default value is calculated at the time of model train and set it to [Search Interval] automatically. As this item becomes larger, the detection time becomes shorter. As it becomes smaller, searched location becomes more precisely. The following item, Search Angle Interval, is a parameter which is automatically calculated. Ideally Search Angle Interval should be about 5 to 10 degree. Please confirm that the value is not so far off.

[Search Angle Interval]

The angle search used for search. This is automatically calculated from [Search Interval] and set it to [Search Angle Interval].

[Overlap Threshold]

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.

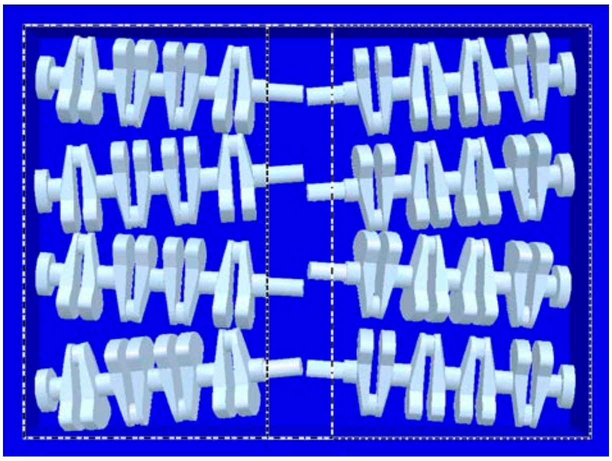
MEMO

'Search Score' is the percentage of area where the model matches 3D data at the position and posture of search result. Once a test is run, search scores for each found result will be displayed in the result plotting area list view. The search score tends to be higher in value than the score because the search process judges the conformity with a criterion that is less strict than alignment.

[Search Area]

This command tool can possess multiple search areas. For each search area, teach 'Search Window' which is the area of position to be searched and 'Search Posture Area' which is the area of posture of the workpiece to be searched.

For example, when workpieces are lined in two lines in roughly two postures in the measurement area as shown below, you can find the workpieces in shorter process time by teaching two search areas with search windows indicated in dotted lines and setting the appropriate search posture areas for each, than setting one large search area.



Two search areas

[Search Area Number]

Select from the drop-down box when switching the search area to be displayed on the setup screen.

Adding Search Area

The steps to add a search area are as follows.

1 Click the button
New search area number will be added.
2 Select the number added in [Search Area Number] and teach the search area.

Deleting Search Area

The steps to delete the search area are as follows.

1 Select the search area number to be deleted in [Search Area Number].
2 Clicking button will delete the search area selected in the step 1.

Copying Search Area

The steps to copy and add the current search area are as follows.

1 Click the  button
The currently selected search area will be added.
2 Train the search area of the added number.

[Search Window]

3D One-Sight-Model Locator Tool finds a workpiece by searching the model in the search window. Specify the area for searching the model on the height map. The smaller the area, the faster the processing will be.
Click the [Set] button to teach the area. Set the search window in a rectangle. Set the rectangle so that it encloses the area where the entire model can exist. For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".
Indicated as [Trained] if it is already trained, and [Not Trained] if it is not yet trained. You can check the search window by changing [Image Display Mode] to [Height Map].

[Angle Search Ranges]

Set the posture range of the model to be searched for each set search area.

[X-Axis]

Enter [Min. Angle] and [Max. Angle] around the X-axis in the text box. The units are degrees (°).

[Y-Axis]

Enter [Min. Angle] and [Max. Angle] around the Y-axis in the text box. The units are degrees (°).

[Z-Axis]

Enter [Min. Angle] and [Max. Angle] around the Z-axis in the text box. The units are degrees (°).

[Align Parameter]

Set the parameters for alignment.

[Matching Level]

Select the matching level for alignment from the drop-down box.

[Fast]

Reduces the alignment processing.

[Standard]

Medium setting between [Fast] and [Fine].

[Fine]

Performs accurate alignment but takes longer process time.

[Align Method]

Select how to align the workpiece from the drop-down box. By default, [Min Point-to-Plane] is selected. The detection accuracy may be improved by switching depending on the workpiece status of the target.

[Min Point-to-Point]

By default, [Min Point to Plane] is selected. This option is effective when normal directions cannot be calculated stably because of few 3D points on the workpiece. When this option is selected, this command tool aligns to decrease distance between 3D points of the model and those of the 3D data.

[Min Point-to-Plane]

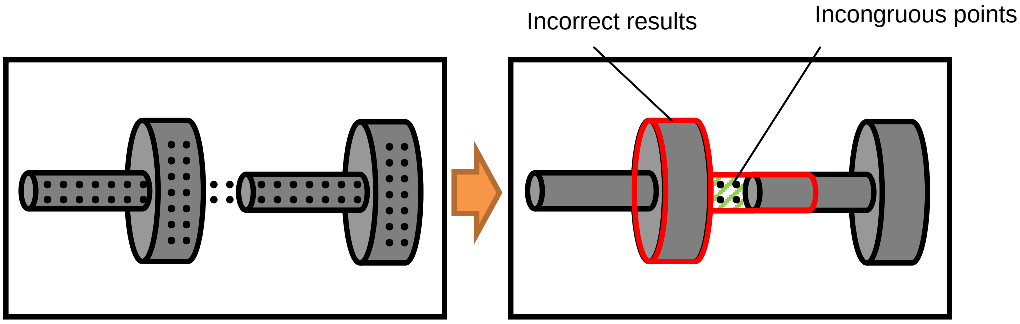
When normal direction can be calculated stably, this option is more effective than [Min Point to Point] in most cases. To use this option, you must change the 3D Data Preprocess Tool so that the tool calculates normal directions. For details of the 3D Data Preprocess Tool, refer to "Setup: 4.14 3D DATA PREPROCESS TOOL".

[Score Threshold]

This command tool calculates a ratio by which a found result matches to a 3D Data in the align process. The units are %. If the score is lower than the threshold, the workpiece is not detected.

[Incongruous Points]

When this checkbox is checked, incongruous 3D points which contradict a detected workpiece are counted. If the number of incongruous points are larger than [Inc. Points Thresh], the workpiece is not detected. It leads less misdetection.



2D camera image + 3D points **Incorrect results + Incongruous points**

Incongruous Point

[Inc. Points Thresh]

This item is available when [Enabled] is checked in [Incongruous Points]. If the number of incongruous points is larger than the threshold, the workpiece is not detected.

[Time-out]

Enter the time for detection process in the text box. If the location process takes longer than the time specified here, the command tool ends the process without finding all of the workpieces.

[3D Data Post Process]

Sets the parameter of the post process that is performed for 3D data.

[RM. Score Thresh.]

After finding workpieces, enter the threshold value of the score of found result whose 3D points are removed from 3D Data in the text box.

[Param. Evaluation]

This command tool tests detection parameters by executing detection, internally, with model data. When [Execute] is clicked, the internal detection is executed and the following items are displayed.

[Position Error Ave.]

Average of position errors which are estimated by the internal detection.

[Posture Error Ave.]

Average of posture errors which are estimated by the internal detection.

[Proc. Time Ave.]

Average of processing time to align one workpiece which is estimated by the internal detection.

[Success Rate]
The success rate in the internal detection. If this item does not reach the 100%, [Score Threshold] or [Search Interval] will be improper.

4.16.2 Teaching the Model

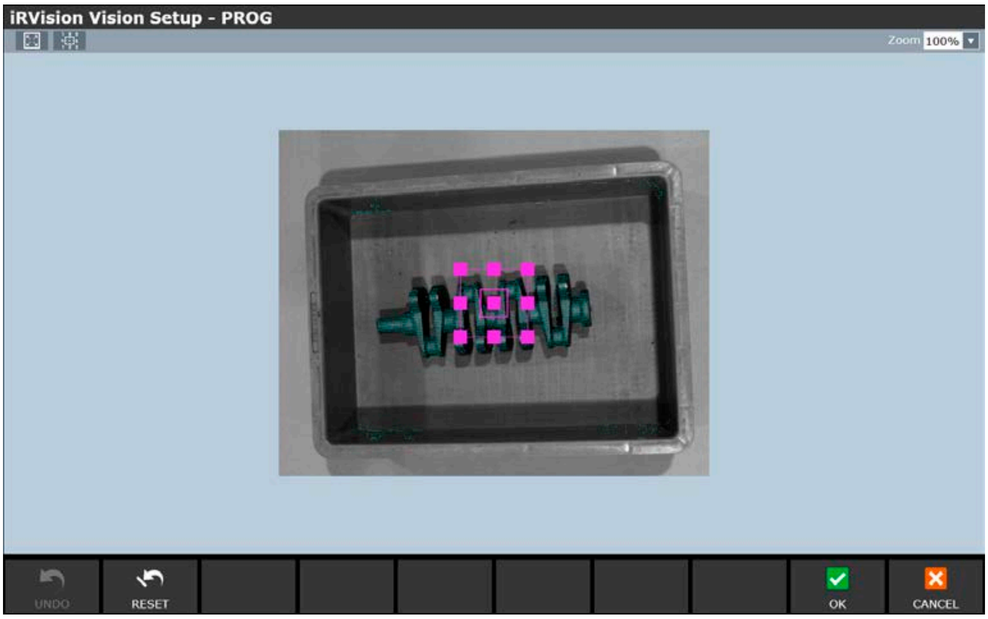
Teach the model pattern of the workpiece you want to find.
Teach the model pattern as follows.

- Setting the Model Area
- Dividing the Model Faces
- Masking the Unnecessary Area (Mask)
- Setting the Model Features
- Setting the Emphasis Area
- Setting the Model X-axis

4.16.2.1 Setting the model area

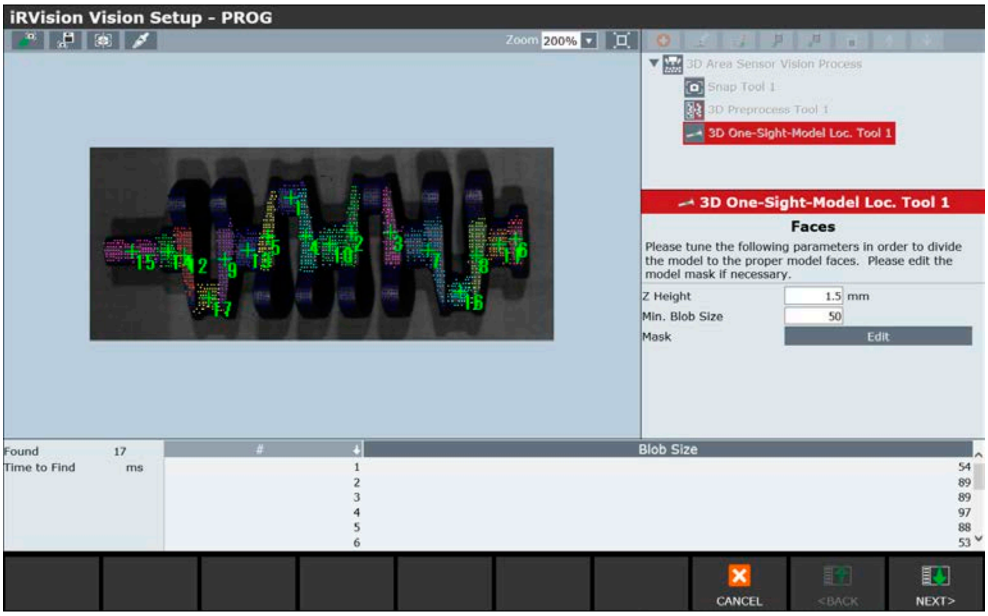
Set the model area as follows.

1 Place the workpiece to be found near the center of the camera view.
2 Click [2-3D SNAP] to snap the workpiece and acquire 3D data.
3 Click the [Area] button in the setup item area of the 3D One-Sight-Model Locator Tool edit screen. A full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
4 Enclose the area to use as a model within the displayed window, and click [OK]. 'Dividing the Model Faces' screen will appear. For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".



4.16.2.2 Dividing the model faces

When [OK] is clicked after teaching the model area, 'Dividing the Model Faces' screen as shown below will appear.



Set the following parameters so that the workpiece surfaces are divided into each smoothly successive face.

[Z Height]

A threshold to determine whether 3D points are continuous or not. The units are millimeters.
Two 3D points are assumed that they belong to different faces when the difference of their height is larger than it.

[Min. Blob Size]

A threshold of the size of continuous faces. Continuous faces are recognized as blobs of 3D points. When their size is smaller than this parameter, feature points, mentioned below, are not generated on the face.

[Mask]

If there are 3D points in an area that is not targeted for finding within the model area, click the [Edit] button in [Mask] to set a mask area. For details, refer to "Setup: 4.16.2.3 Masking the Unnecessary Area".

Click [NEXT>] after adjusting so that the workpiece surfaces are divided into each smoothly successive face. 'Setting the Model Features' screen will appear.

> ⚠ **CAUTION**
> The model features will be extracted at the time when [NEXT>] is clicked. Depending on the model, it may take several tens of seconds for feature extraction process.

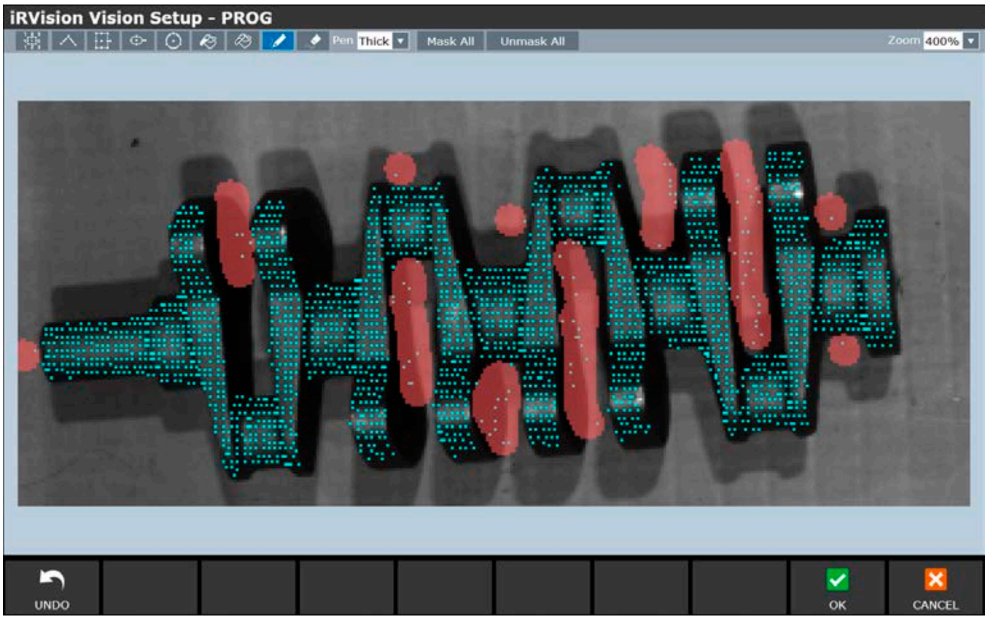
4.16.2.3 Masking the unnecessary area

Set the masks for areas that are not targeted for finding within the model area as required. Remove from the model by masking the unnecessary parts such as background and areas where 3D points cannot be measured stably even if they are on the workpiece.

1 Click the [Mask] button of [Model Train] in the setup item area of the 3D One-Sight-Model Locator Tool edit screen, the screen for editing masking area will appear.
The model pattern will appear in the Image View Area.

It will appear similarly by clicking the [Edit] button of [Mask] while displaying the [Dividing the Model Faces] as well.

2 Fill the section that is not necessary in the model pattern with the color of red.
For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

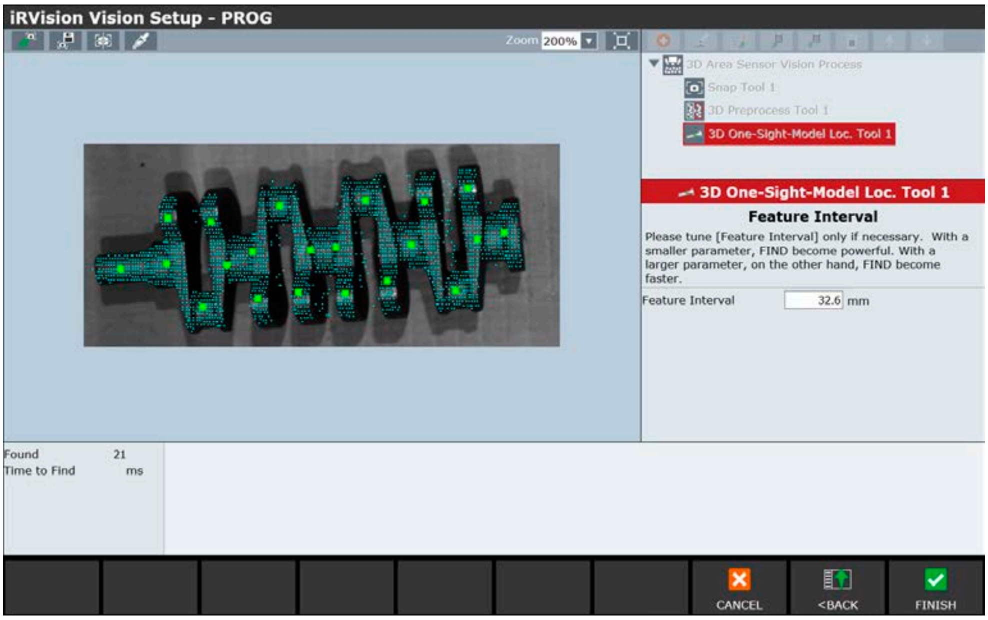


3 Click [OK] to return to the 3D One-Sight-Model Locator Tool edit screen.
If you move from the [Dividing the Model Faces] screen, returns to the original screen.

4.16.2.4 Setting the model features

When [Next>] is clicked after dividing the model face, 'Setting the Model Features' screen, as shown below will appear.

Sets the model features to be used for search.



For fast detection, this command tool extracts feature points from the model data and deals with them as priority. Feature points are automatically extracted from each faces which are determined in the previous step.

Feature points are plotted in green in the image display. Adjust the following parameters and adjust the distribution of features for calculation.

[Feature Interval]

Set the interval of features. The units are millimeters.
You can also set it by inputting into the [Feature Interval] text box in the setup item area of the 3D One-Sight-Model Locator Tool edit screen.

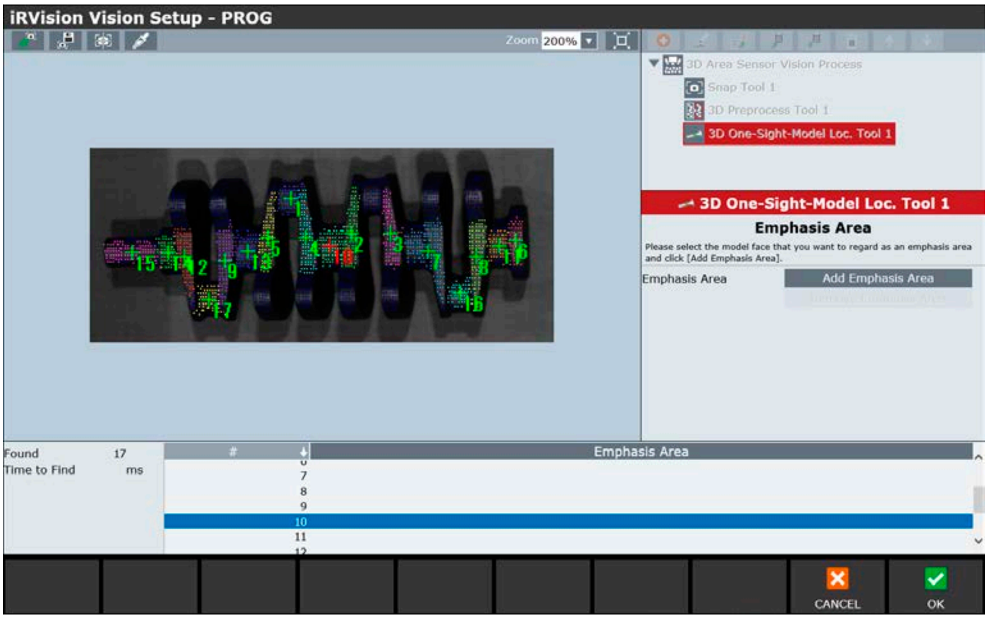
When [Feature Interval] is changed, the distribution and number of features will change.
More feature points lead less misdetection but also longer detection time. Feature points of 10 to 30 points will be suitable. If you want to prioritize the processing time, set the feature interval so that the features become about 10.

Once setup of the model features is complete, click [FINISH]. Return to the 3D One-Sight-Model Locator Tool edit screen.

4.16.2.5 Setting the emphasis area

Set the emphasis area as required.

When the [Set] button of [Emphasis Area] is clicked in the setup item area of the 3D One-Sight-Model Locator Tool edit screen, the following screen will appear to set the emphasis area.

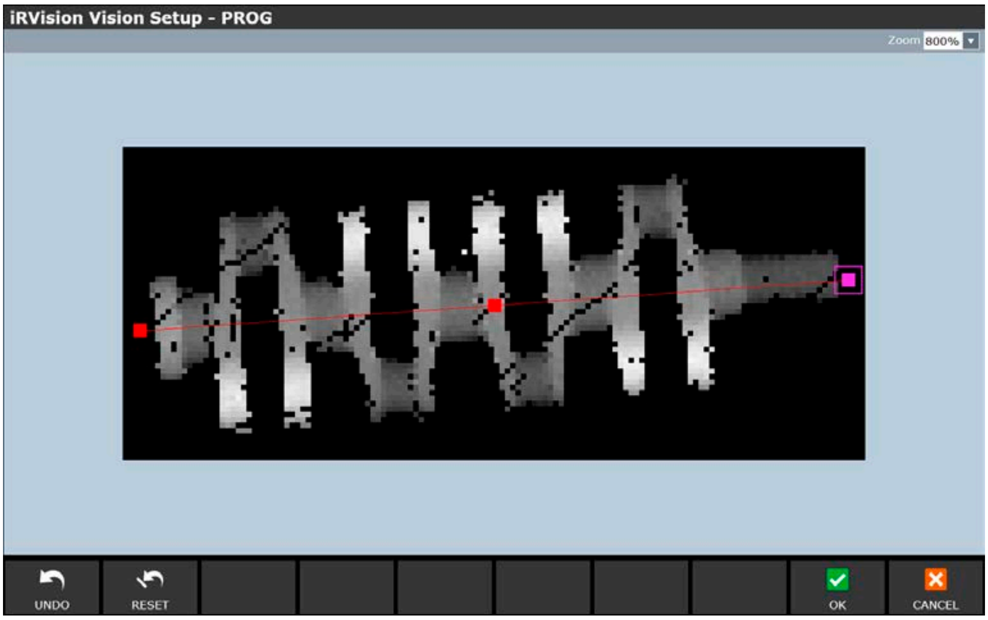


When adding an emphasis area, select a face to be emphasis area in the list view, and click the [Add Emphasis Area] button. When deleting the added emphasis area, select a face that has been set as the emphasis area in the list view and click the [Remove Emphasis Area] button.
Once setup of the emphasis area is finished, click [OK].

4.16.2.6 Setting the model X-axis

3D One-Sight-Model Locator Tool sets the search posture range for each XYZ frame axis of the frame held by the model. Here, set the X axis of the coordinate. The Z axis corresponds to that of the [Offset frame]. Y axis is calculated from X and Z axis.

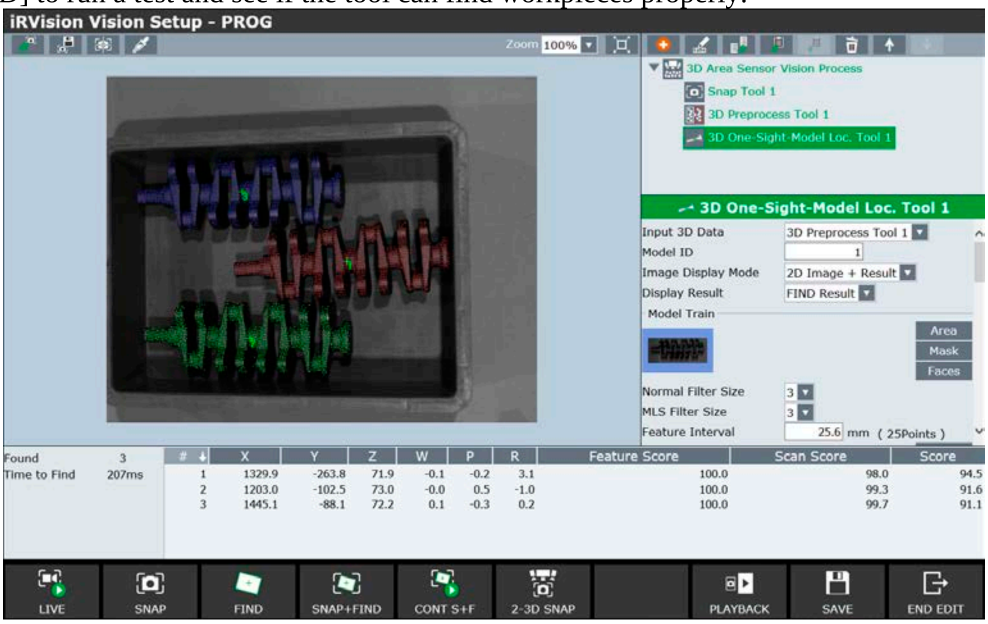
1 Click the [Set] button on the [Model X-Axis] line. When the [Set] button is clicked, the following screen is displayed.
2 Set the single line displayed in the image view so that it will be parallel to the direction of the model X-axis.



3 Click [OK] after setting.
For operation methods for the lines, refer to "Setup: 1.8.9 Single Line Setup".

4.16.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the location process took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[X], [Y], [Z], [W], [P], [R]

Coordinate values of the found 3D blob.(units: mm, degrees).

[Feature Score]

The percentage that the model features and 3D data are properly corresponding at the time of search.

[EA Care Feature Score]

The percentage that the model features included in the emphasis area and 3D data are properly corresponding at the time of search. It will not be displayed when the emphasis area is not used.
When the emphasis area is used, only the results where both [Feature Score] and [EA Care Feature Score] are above [Feature Score Threshold] are outputted.

[Search Score]

Search score is the ratio by which the search result matches to a 3D data.
The search score tends to be higher in value than the score because the search process judges the conformity with a criterion that is less strict than alignment.

[Score]

The percentage that the model which is transformed by the position and posture calculated by the alignment process matches 3D data.

[Incongruous Points]

The number of incongruous points of the found result. It will not be displayed when [Incongruous Points] is not enabled.

4.16.4 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override. For details of vision overrides, refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE".

[Feature Score Treshold]

The percentage used for judging that the model features and 3D data are properly corresponding at the time of search. Set a value between 30 and 100.

[Search Interval]

Interval in search process. Set a value between 1 and 100.

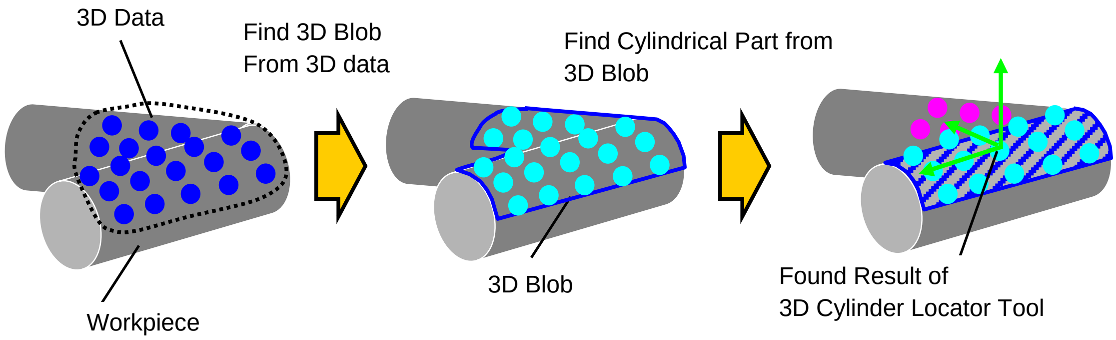
[Score Threshold]

The percentage that the model which is transformed by the position and posture calculated by the alignment process matches 3D data. Set a value between 30 and 100.

4.17 3D CYLINDER LOCATOR TOOL

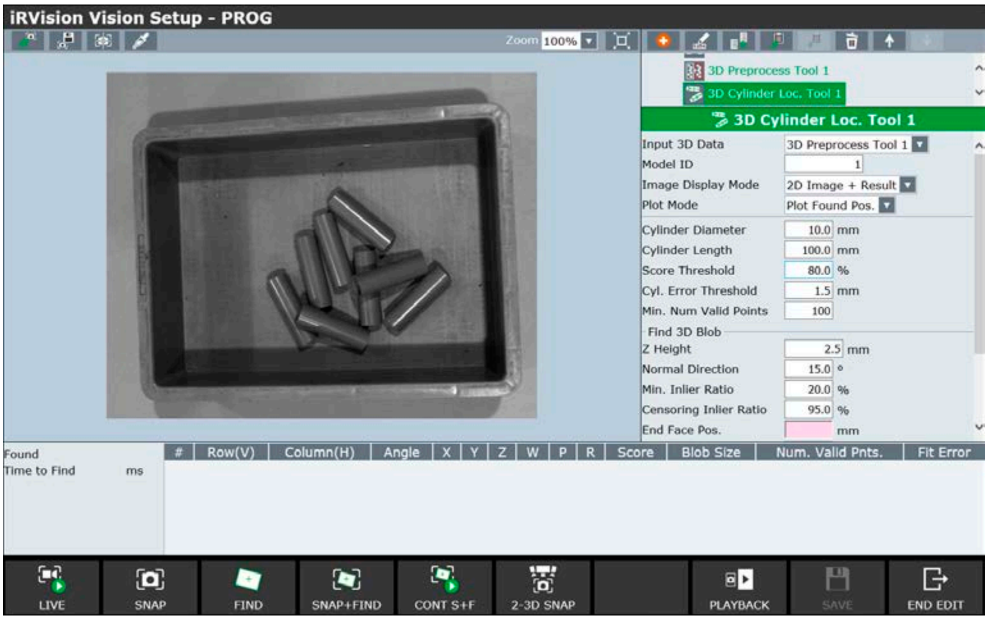
The 3D Cylinder Locator Tool finds some cylinder parts from a 3D data. The 3D Cylinder Locator Tool finds some cylinder parts in the following two steps.

1 Find 3D Blob from a 3D Data.
2 Find a cylinder part from a found 3D Blob.



Find a cylinder workpiece

If you select the 3D Cylinder Locator Tool in the tree view of the vision process edit screen, the following screen will appear.



4.17.1 Setup Items

The 3D Cylinder Locator Tool has the following parameters.

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess Tool is set. This parameter is not normally needed to be changed.

If there is a different preceding locator tool in the tree view, by specifying the tool, you can use 3D data in which 3D points that match the found result have been removed.

This has the effect that reduces time to find, or prevents the output of found results which overlap in the same workpiece.

The following command tools at the same level that precedes this tool can be selected.

- 3D Data Preprocess Tool
- 3D Cylinder Locator Tool
- 3D Box Locator Tool
- 3D One-Sight-Model Locator Tool

Also the following command tools which are set as a child tool of the 3D Data Preprocess Tool can be selected.

- 3D Blob Locator Tool
- 3D One-Sight-Model Locator Tool

[Model ID]

Enter the value for the Model ID in the text box.
When you have taught two or more 3D Cylinder Locator Tools and want to identify which tool detected each workpiece, assign a distinct model ID to each tool. Because the model ID is output with offset data, robot programs can identify the model ID.

[Image Display Mode]

Select the image display mode for the Setup Page.

[2D Image + Points]
Acquired 3D points will be shown on 2D image.

[2D Image + Result]
Found results will be displayed on 2D image.

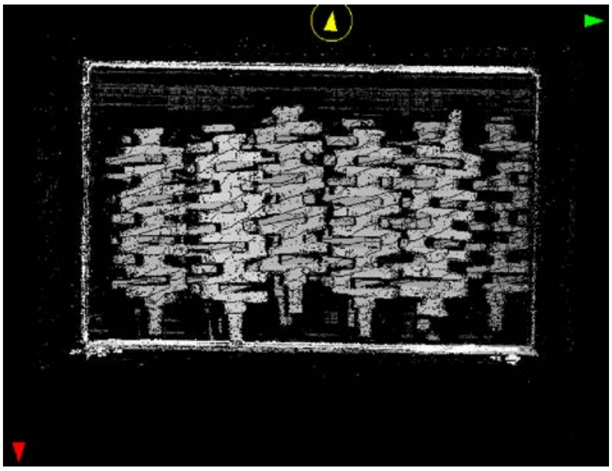
[2D Image + Postproc.]
Postprocess results will be displayed on 2D image. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[3D Data]
Display a 3D data.

[3D Data＋Result]
Found results will be displayed on 3D data.

[3D Data＋Postproc.]
Postprocess results will be displayed on 3D data. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[Height Map]
Height map (an image in which 3D points are projected to X-Y plane) will be displayed. Height map is not displayed if [Search Window] is disabled.



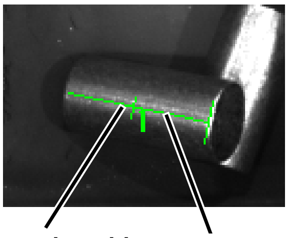
A value of each pixel represents Z height. A red arrow and a green arrow show X direction and Y direction of the offset frame respectively, and a yellow arrow represents the direction of which the robot is located.

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run.

[Plot Found Pos.]

"+" is displayed at the found position of a cylinder in green.



Example of the plot mode (found position)

[Plot Found Pos. + Points]

In addition to the found position, the points on a curved surface of a cylinder composing the 3D blob are displayed from red to blue according to the order of the found results, and points that are not on the curved surface of the cylinder are plotted in purple.

> ⚠**CAUTION**
> Setting [Plot Mode] to [Plot Found Pos. + Points] may stop the system due to lack of memories. We recommend that you set it to [Plot Found Pos. + Points] for teaching and adjusting vision processes and [Plot Found Pos.] for when a process is run.

[Cylinder Diameter]

Set the diameter of the cylinder to find. The units are mm.

[Cylinder Length]

Set the length of the cylinder to find. The units are mm.

[Score Threshold]

The accuracy of the found result is expressed by a score, with the highest score being 100. The target cylinder is successfully found if its score is equal to or higher than this threshold value. If the score is lower, the found result is not output. Enter a number between 10 and 100 in the text box.

[Cyl. Error Threshold]

Set a threshold of distance from a cylinder. When the distance of a 3D point from the curved surface of a found cylinder is smaller than this value, the tool judges that the 3D point is on the curved surface of the found cylinder. By setting a large value to the parameter, it is easy to succeed a finding but degraded accuracy result might be output. The units are mm. Enter a number between 0.1 and 1000 in the text box.

[Min Num. Valid Points]

Set the minimum number of 3D points on a found cylinder. If the number of 3D points on a found cylinder is lower than this value, the found 3D blob is removed from the found results. By setting a small value to the parameter, it is easy to succeed a finding but degraded accuracy results might be output. Enter a number between 10 and 10000 in the text box.

[Find 3D Blob]

Set the parameters for finding 3D blobs.

[Z Height]

Specify a number between 0 and 100000. The units are mm.
If the difference between Z heights of adjacent 3D points in 3D data is equal to or lower than this threshold, the adjacent 3D points are connected as 3D points in one 3D blob.

[Normal Direction]

Specify a number between 0 and 180. The units are degrees (°). Enter a number between 0 and 180 in the text box.
If the difference between normal directions adjacent 3D points is equal to or lower than this threshold, the adjacent 3D points are connected as 3D points in one 3D blob.

[Search Window]

From the 3D data, set the 3D points area to be used for finding on the height map.

By default, search window is disabled and all 3D points included in the 3D data are used.
Normally, this does not need to be changed since unnecessary 3D points such as those on a container will be removed by 3D Data Preprocess Tool and so on, but when you want to find restricted to a part of the area in the container, for example, click the [Set] button in [Search Window] to set the search window.
When search window appears on the height map in a rectangle, adjust the rectangle. For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

If the search window setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by search window is disabled.

[Run-Time Mask]

Specify a 3D point area of the search window that is not used to find, with an arbitrary geometry. This can be set when search window is enabled. For example, when a workpiece is sectioned with partitions in the container, this is effective for removing the partitions from search window.

Click the [Edit] button to use the run-time mask. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

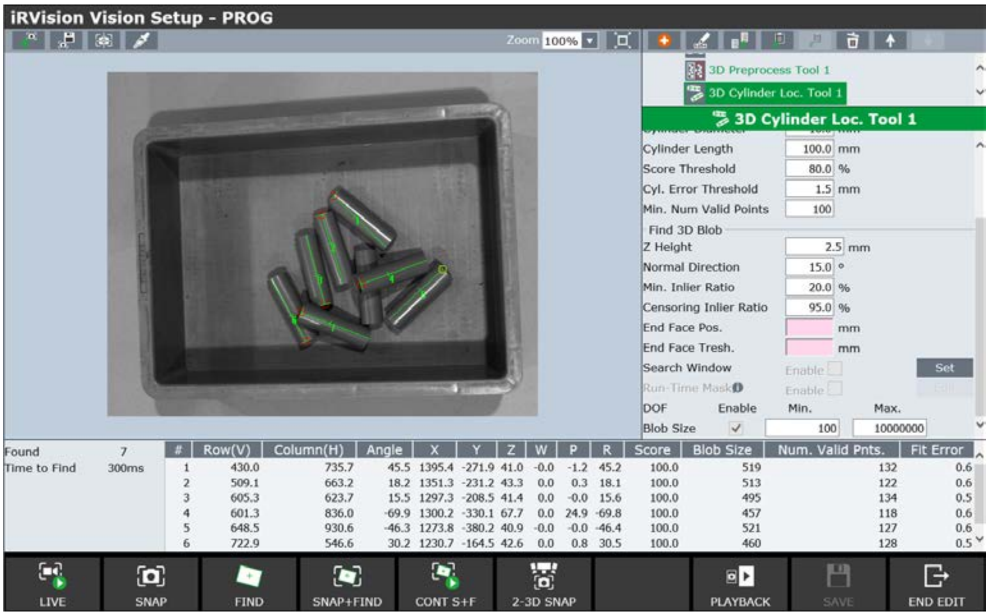
If the run-time mask setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by the run-time mask is disabled.

[Blob Size]

Check [Enable] and enter values in [Min.] and [Max.] text boxes. This tool finds cylinder workpieces using the 3D blob of the blob size within the specified range.

4.17.2 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found results is displayed.

[Time to Find]

Time to find is displayed (units: ms).

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

Found position of found result on camera image.

[Angle]

Angle of found result orientation on camera image. The units are degrees (°).

[X], [Y], [Z], [W], [P], [R]

Coordinate values of the found result (units: mm, degrees).

[Score]

Score of found result.

[Blob Size]
The number of 3D points of found 3D Blob.

[Num. Valid Pnts.]
The number of 3D points on the found cylinder from 3D points of found result.

[Fit Error]
The average of distance valid points from found cylinder.

4.17.3 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override.
Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Cylinder Diameter]
Set a value between 10 and 1000.

[Cylinder Length]
Set a value between 10 and 7000.

[Z Height Threshold]
Specify a number between 0 and 100000.

[Normal Direction Threshold]
Specify a number between 0 and 180.

[Score Threshold]
Specify a number between 10 and 100.

[Min Blob Size]
Specify a number between [Min. Num. Valid Points] and 10000.

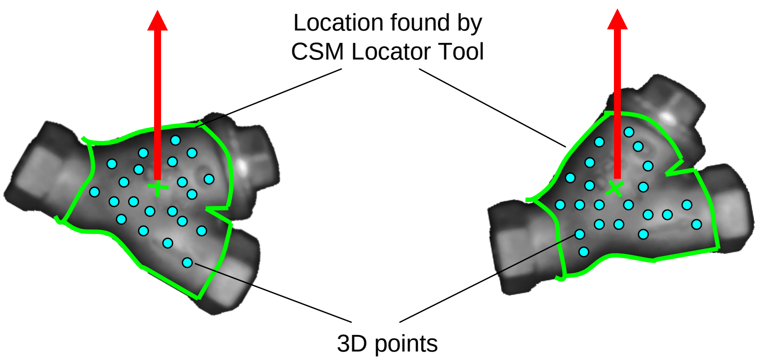
[Max Blob Size]
Specify a number between the minimum value of the blob size and 10000000.

[Min Num. Valid Points]
Specify a number between 10 and 10000.

[Cyl. Error Threshold]
Specify a number between 0.1 and 1000.

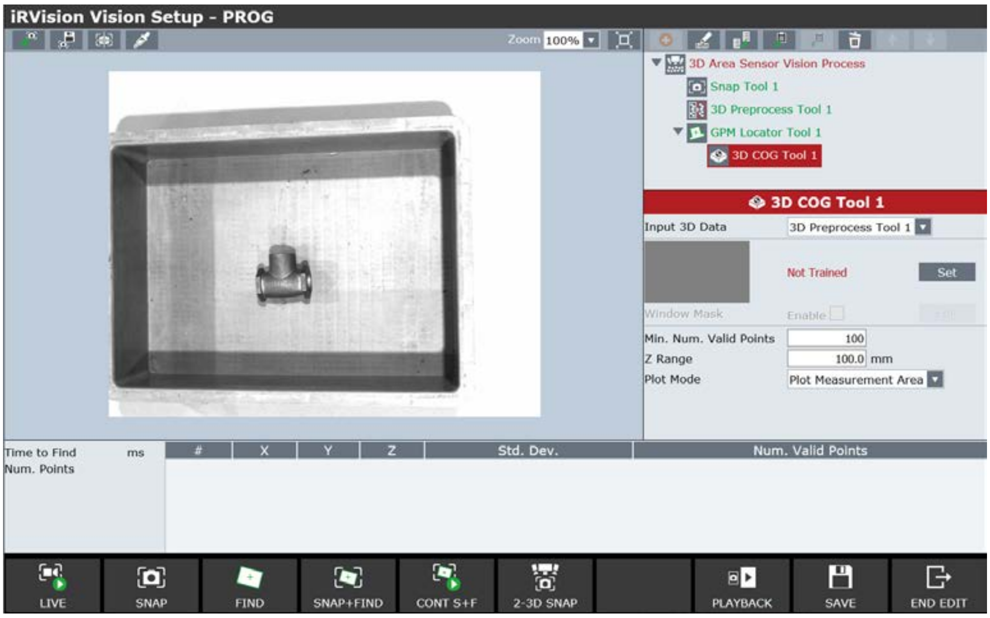
4.18 3D COG MEASUREMENT TOOL

The 3D COG Measurement Tool finds a center of gravity (COG) point from a 3D data. It calculates the center of gravity point with 3D point data in a measurement area that is predefined relatively to the location found by the parent tool as GPM or CSM.
The 3D COG Measurement Tool can only be used in the 3D Area Sensor Vision Process.



Measure the COG using 3D points

If you select [3D COG Measurement Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.18.1 Setup Items

The 3D COG Measurement Tool has the following parameters.

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess tool is set. This parameter is not normally needed to be changed.

[Set] button

Set the measurement area as follows. For details, refer to "Setup: 4.18.2 Teaching the Measurement Area".

[Window Mask]

By clicking the [Edit] button in [Window Mask], set window mask to the area that you want to exclude from the measurement area. The 3D point set here is not used for measuring the center of gravity even if it is inside the measured area. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".
When [Enable] is unchecked, the window mask does not work even if the window mask has already set.

[Min. Num. Valid Points]

Set the minimum number of 3D points to measure the center of gravity. The valid point means a 3D point that is included in the measurement area excluding the window mask and is selected by [Z-Range] described below. When the number of valid 3D points in the measurement area is lower than this value, a finding of a center of gravity point is failed. Set a value between 1 and 45888. If a finding is failed because the measurement area is narrow, set a small value to succeed the finding.

[Z Range]

Set the available Z range of 3D points. Under the condition the set value is dZ, height of COG Zg and the Z height of 3D point is Z, 3D point selection and COG measurement are executed so as to all 3D point of are $| Z - Zg | \leq dZ / 2$. Specify the value between 0 and 8000(units: mm).

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run.

[Plot Nothing]
Nothing is plotted.

[Plot Measurement Area]
The measurement area is plotted in blue. When test running, the measurement area is plotted in red if the finding is failed.

[Plot Points]
3D points in valid area are plotted. Points used for measuring center are plotted in cyan; other points not used are magenta. When test running, all points are plotted in magenta if the finding is failed.

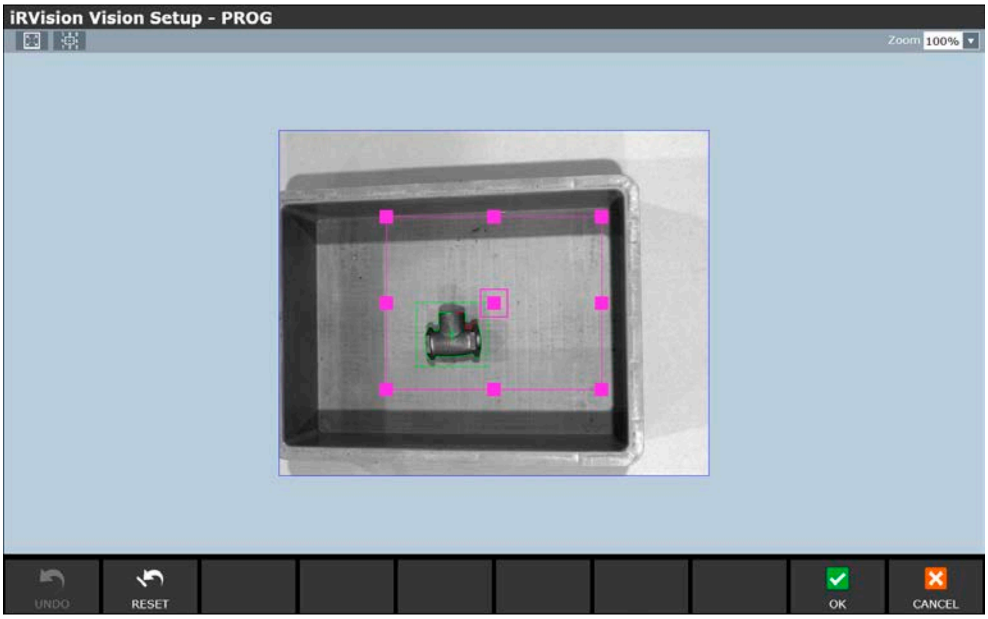
[Plot Everything]
Measurement area and points are plotted.

> ⚠**CAUTION**
> Setting [Plot Mode] to a mode including plot points may stop the system due to lack of memories. We recommend that you set it to [Plot Points] or [Plot Everything] for teaching or adjusting vision processes, and anything other than those for when a process is run.

4.18.2 Teaching the Measurement Area

Teach the measurement area in the 3D COG Measurement Tool.

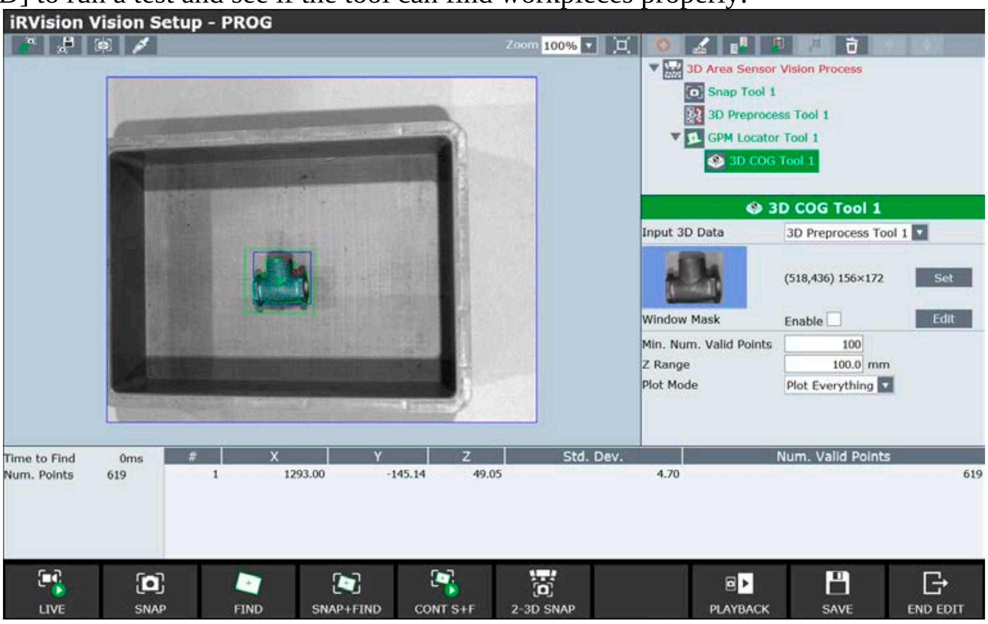
1 Place the workpiece near the center of the camera view.
2 Click [2-3D SNAP] to snap the image of the workpiece and acquire its 3D data.
3 Click the [Set] button. Then, a setup page like one shown below appears.
Enclose the workpiece to be taught within the displayed red rectangle, and click [OK].



4 Enclose the workpiece to teach within the displayed window, and click [OK].
The measurement area will be set. When the teaching for measurement area is complete, an area size will appear in the setting items area.
For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

4.18.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]
Time to find is displayed (units: ms).

[Num. Points]
The number of 3D points in measurement area excluding window mask is displayed.

Also, in the result display area list view, the following values are displayed.

[X], [Y], [Z]
Coordinate values of the found center of gravity point (unit: mm).

[Std. Dev.]
The standard deviation of the 3D points used for finding a center of gravity.

[Num. Valid Points]
The number of 3D points used for finding center of gravity.

4.18.4 Overridable Parameter

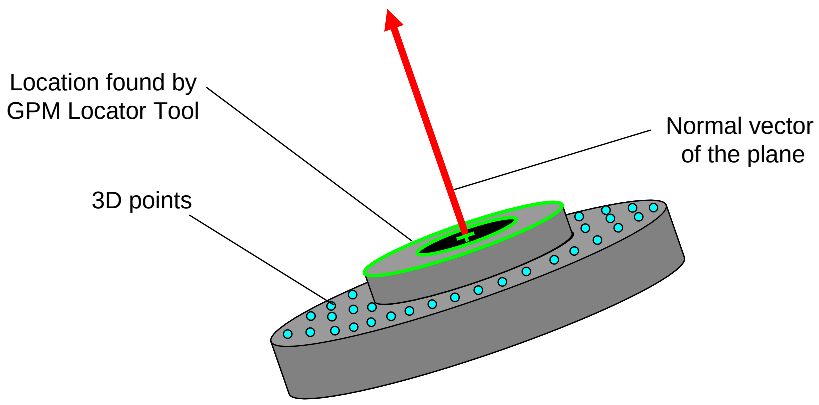
This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Min Num. Valid Points]
Specify a number between 1 and 45888.

[Z Range]
Specify a number between 0.0 and 8000.0.

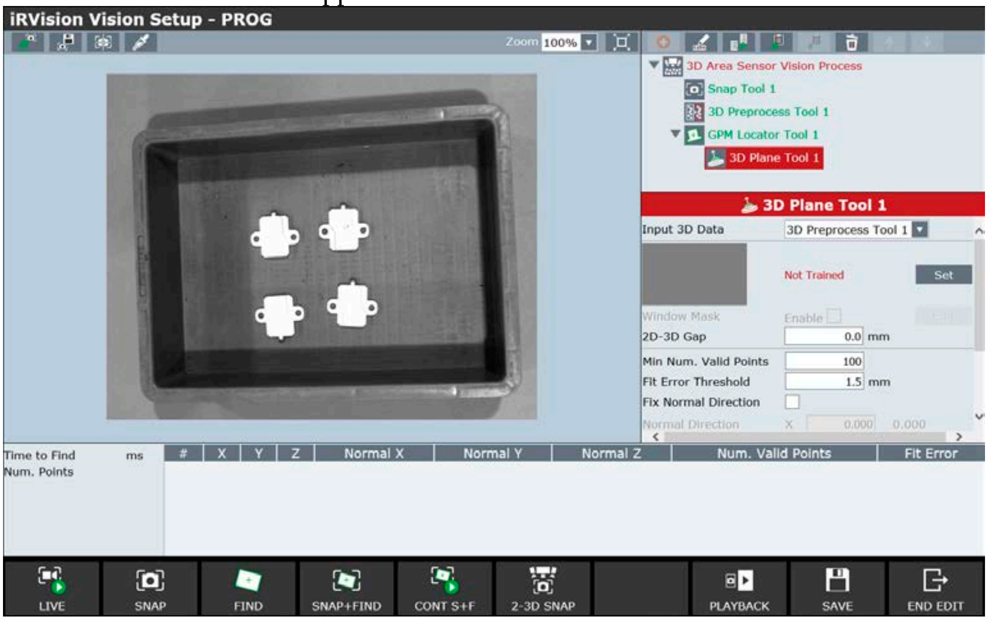
4.19 3D PLANE MEASUREMENT TOOL

The 3D Plane Measurement Tool finds a plane from a certain area in 3D data. It calculates a plane with 3D points in a measurement area that is predefined relatively to the location found by the parent locator tool as GPM Locator Tool or CSM Locator. The image feature for the locator tools do not have to be on the same plane.



Measure a plane using 3D points

If you select [3D Plane Measurement Tool] in the tree view of the setup page for the vision process, a setup page like the one shown below appears.



4.19.1 Setup Items

The 3D Plane Measurement Tool has the following parameters.

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess Tool is set. This parameter is not normally needed to be changed.

[Set] button

Set the measurement area as follows. For details, refer to "Setup: 4.19.2 Teaching the Measurement Area".

[Window Mask]

By clicking the [Edit] button in [Window Mask], set window mask to the area that you want to exclude from the measurement area. The 3D point set here is not used for measuring a plane if it is inside the measured area. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks"
When [Enable] is unchecked, the window mask does not work even if the window mask has already set.

[2D-3D Gap]

Enter the distance moved in the normal direction of the plane when the result of the parent tool is projected on the plane. The units are millimeters.
Set the positive value in this setup item when the result of the parent 2D locator tool is upper side of Z direction looking from the measured plane.

[Min. Num Valid Points]

Set a minimum number of 3D points to use for measuring plane. The valid point means a 3D point that is included in the measurement area excluding the window mask and is on a plane. When the number of valid 3D points in the measurement area is lower than this value, a finding of a plane is failed. Set a value between 3 and 45888. By setting a small value to the parameter, it is easy to succeed a finding but measurement accuracy is likely to degrade.

[Fit Error Threshold]

Set a threshold of the distance from the plane (units: mm). When the distance of a 3D point from a found plane is smaller than this value, the tool judges that the 3D point is on the found plane. Set a value between 0 and 1000. By setting a large value to the parameter, it is easy to succeed a finding but measurement accuracy is likely to degrade.

[Fix Normal Direction]

Set whether find or not a plane with a specified normal vector. When the checkbox is checked, a plane with a specified normal vector is found. The parameter works effectively when normal direction of a plane to find is oriented to a determined direction such as depalletizing system of cardboard boxes.

[Normal Direction]

Set the normal direction in 3 textboxes when the [Fix Normal Direction] is checked. The 3 textboxes for X, Y and Z are for normal vector value of offset frame. The normalized unit vectors are indicated at the side of the boxes.

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run.

[Plot Nothing]
Nothing is plotted.

[Plot Measurement Area]
The measurement area is plotted in blue. When test running, the measurement area is plotted in red if the finding is failed.

[Plot Points]
3D points in valid area are plotted. Points used for measuring a plane are plotted in cyan; other points not used are magenta. When test running, all points are plotted in magenta if the finding is failed.

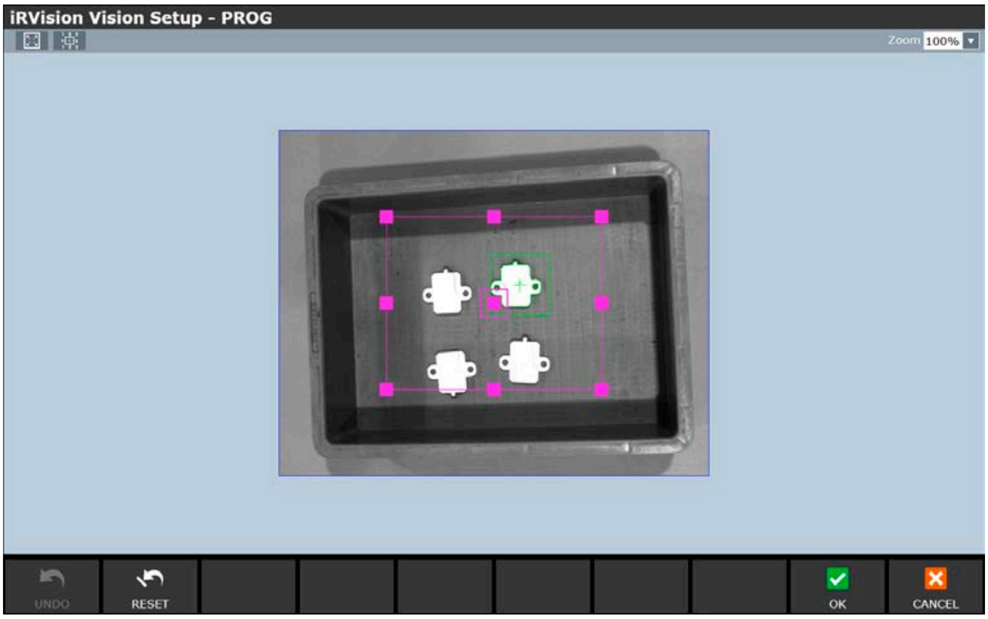
[Plot Everything]
Measurement area and points are plotted.

> ⚠**CAUTION**
> Setting [Plot Mode] to a mode including plot points may stop the system due to lack of memories. We recommend that you set it to [Plot Points] or [Plot Everything] for teaching or adjusting vision processes, and anything other than those for when a process is run.

4.19.2 Teaching the Measurement Area

Teach the model of a workpiece to measure using the 3D Plane Measurement Tool.

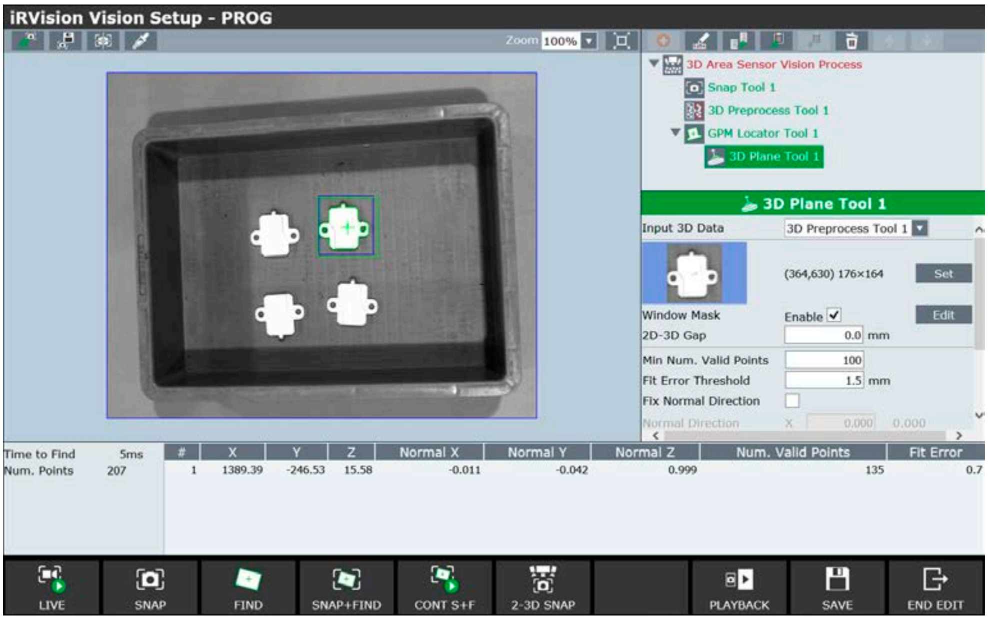
1 Place the workpiece near the center of the camera view.
2 Click [2-3D SNAP] to snap the image of the workpiece and acquire its 3D data.
3 Click the [Set] button. Then, a setup page like one shown below appears.



4 Enclose the workpiece to be taught within the displayed red rectangle, and click [OK].
The measurement area will be set. When the teaching for measurement area is complete, an area size will appear in the setting items area.
For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

4.19.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

Time to find is displayed (units: ms).

[Num. Points]

The following values are displayed.

Also, in the result display area list view, the following values are displayed.

[X], [Y], [Z]
Coordinate values of the position of the found plane (units: mm). This position is located on the found plane.

[Normal X], [Normal Y], [Normal Z]
Normal vector to the found plane.

[Num. Valid Points]
The number of 3D points used for measuring the plane.

[Fit Error]
Average of distance between the 3D points used for measuring and the plane.

4.19.4 Overridable Parameter

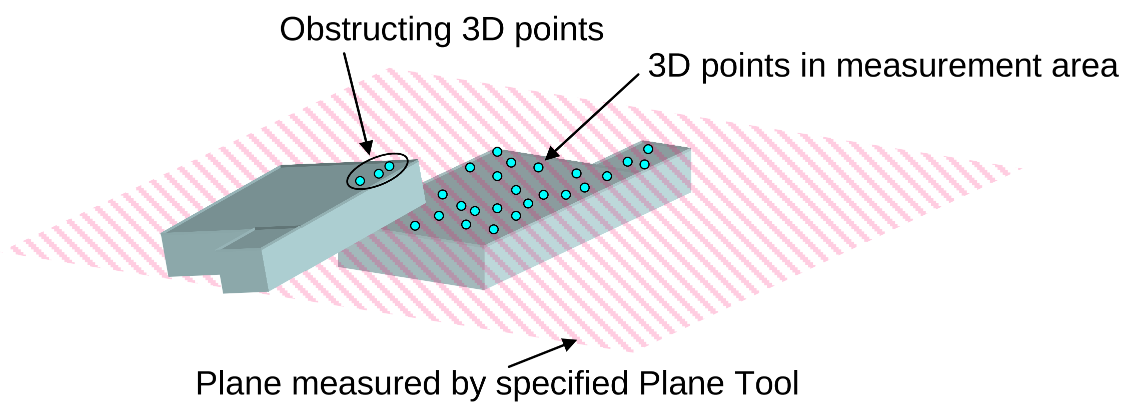
This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Min Num. Valid Points on Plane]
Specify a number between 3 and 45888.

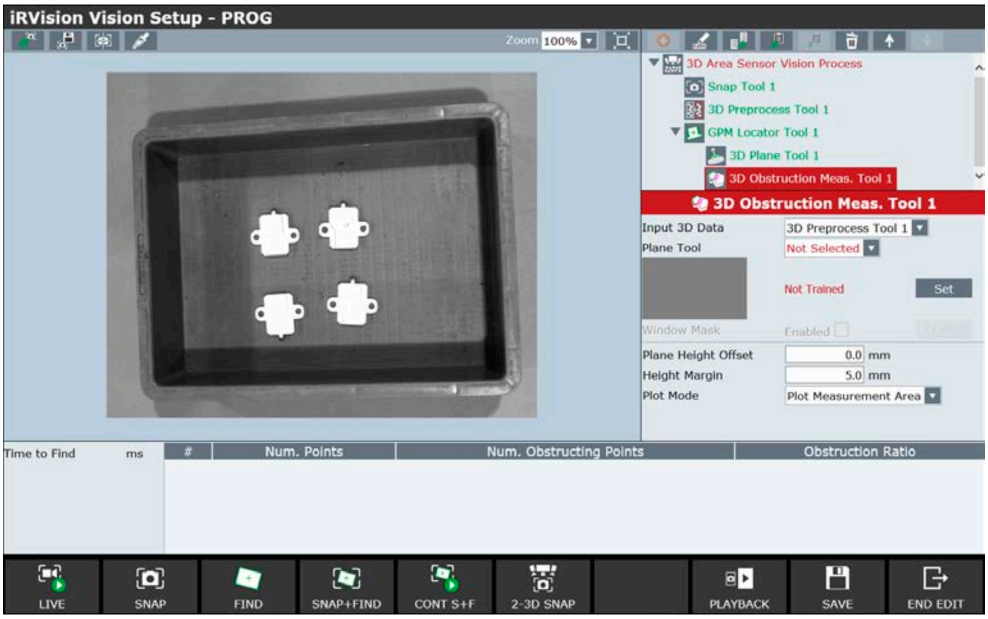
[Fit Error Threshold]
Specify a number between 0 and 1000.

4.20 3D OBSTRUCTION MEASUREMENT TOOL

The 3D Obstruction Measurement Tool can obtain the number of obstructing 3D points and obstruction ratio for calculation. Obstructing points mean higher 3D points in measurement area over a plane measured by specified Plane Tool. And the obstruction ratio means the ratio of obstructing points to the 3D points in measurement area.



If you select an [3D Obstruction Meas. Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.20.1 Setup Items

The 3D Obstruction Measurement Tool has the following parameters.

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess Tool is set. This parameter is not normally needed to be changed.

[Plane Tool]

Select the 3D Plane Measurement tool to use from the drop-down box.

[Set] button

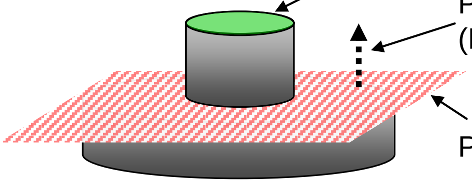
Set the measurement area as follows. For details, refer to "Setup: 4.20.2 Teaching the Measurement Area".

[Window Mask]

By clicking the [Edit] button in [Window Mask], set window mask to the area that you want to exclude from the measurement area. The 3D point set here is not used for measuring obstructing points even if it is inside the measured area. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks"
When [Enable] is unchecked, the window mask does not work even if the window mask has already set.

[Plane Height Offset]

If there is a distance in height between plane measured by specified Plane Tool and area to measure obstruction, set the distance here. By setting a value to the [Plane Height Offset], the plane to decide obstruction is shifted by the value from plane measured by specified Plane Tool in normal direction to the plane. Set positive value if the area to measure obstruction is on the normal vector direction of plane measurement by specified Plane Tool, set negative value that is on the inverse direction.



Plane Height Offset

[Height Margin]

Set a distance for deciding that 3D points which are in the measure area and are higher than the plane to decide obstruction are on other obstructing object or not. If a 3D point is more than this margin value away from the plane to decide obstruction in the Z positive direction, it is regarded as an obstructing point. If the [Plane Height Offset] is set to 0.0, the plane to decide obstruction is completely same as the plane measured by specified Plane Tool. If the [Plane Height Offset] is set to a value other than 0.0, the plane to decide obstruction is shifted from plane measured by specified Plane Tool in normal direction to the plane.

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run.

[Plot None]
Nothing is plotted.

[Plot Measurement Area]
The measurement area is plotted in blue. When test running, the measurement area is plotted in red if the finding is failed.

[Plot Points]
3D points in valid area are plotted. Points judged as obstructing 3D points are plotted in magenta; other points not regarded as ones are cyan.

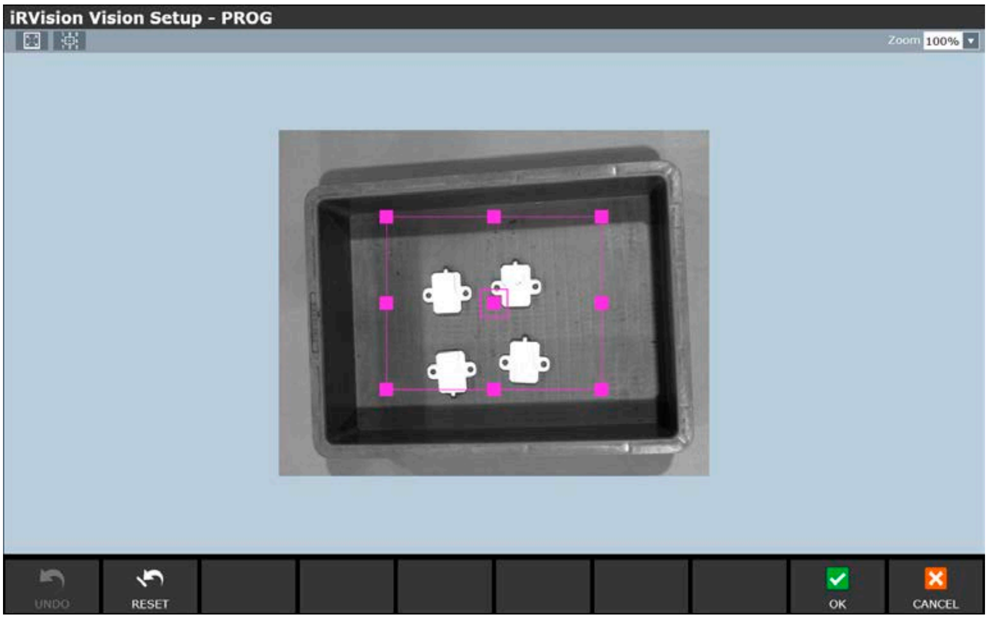
[Plot Everything]
Measurement area and points are plotted.

> ⚠**CAUTION**
> Setting [Plot Mode] to a mode including plot points may stop the system due to lack of memories. We recommend that you set it to [Plot Points] or [Plot Everything] for teaching or adjusting vision processes, and anything other than those for when a process is run.

4.20.2 Teaching the Measurement Area

Teach the measurement area in the 3D Obstruction Measurement Tool.

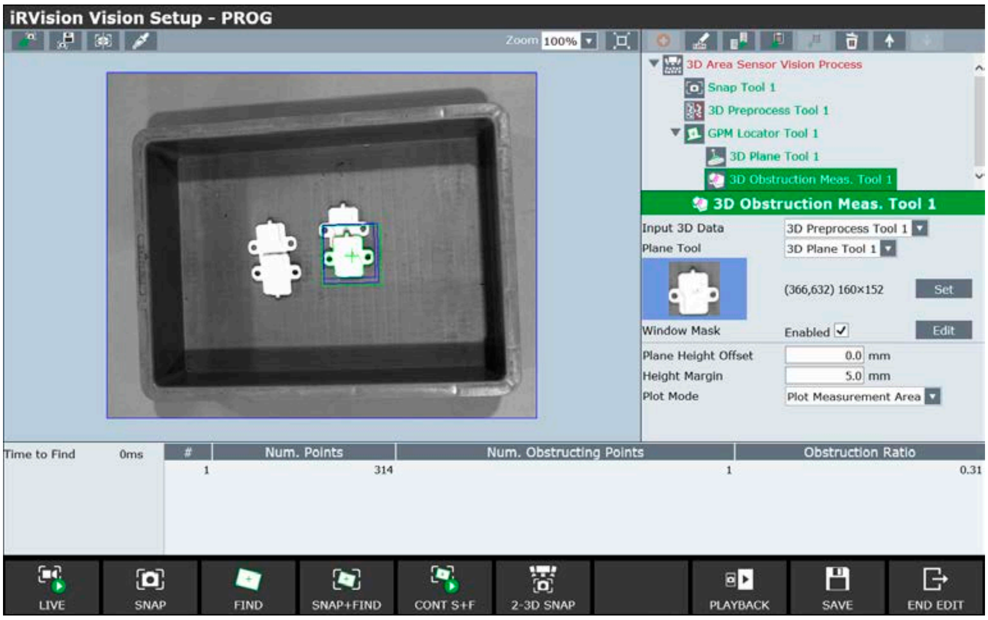
1 Teach GPM locator tool or a CSM locator tool which will be the parent tool.
2 Teach the measurement area for 3D Plane Measurement Tool which is placed before this tool.
3 Click [3D Obstruction Meas. Tool] in the tree view in the vision process.
4 Select [3D Plane Measurement Tool] in [Plane tool] in the setting items area.
5 Click the [Set] button.
A window that has a 2D image and control points (reddish purple rectangle) like one shown below appears.



6 Enclose the measurement area for overlap within the displayed window, and click [OK].
The measurement area will be set. When the teaching for measurement area is complete, an area size will appear in the setting items area.
For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

4.20.3 Running a Test

Click [FIND] to run a test and see if the tool operates properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

Time to find is displayed (units: ms).

Also, in the result display area list view, the following values are displayed.

[Num. Points]

The number of 3D points which are in the measurement area and not masked.

[Num. Obstructing Points]

The number of 3D points which are judged as on other obstructing objects.

[Obstruction Ratio]

The ratio of "Num. Obstructing Points" against "Num. Points".

4.20.4 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Plane Height Offset]

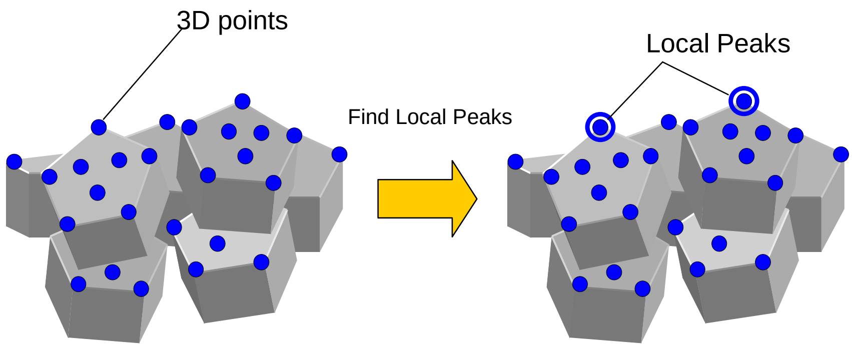
Specify a number between -10000 and 10000.

[Height Margin]

Specify a number between 0 and 1000.

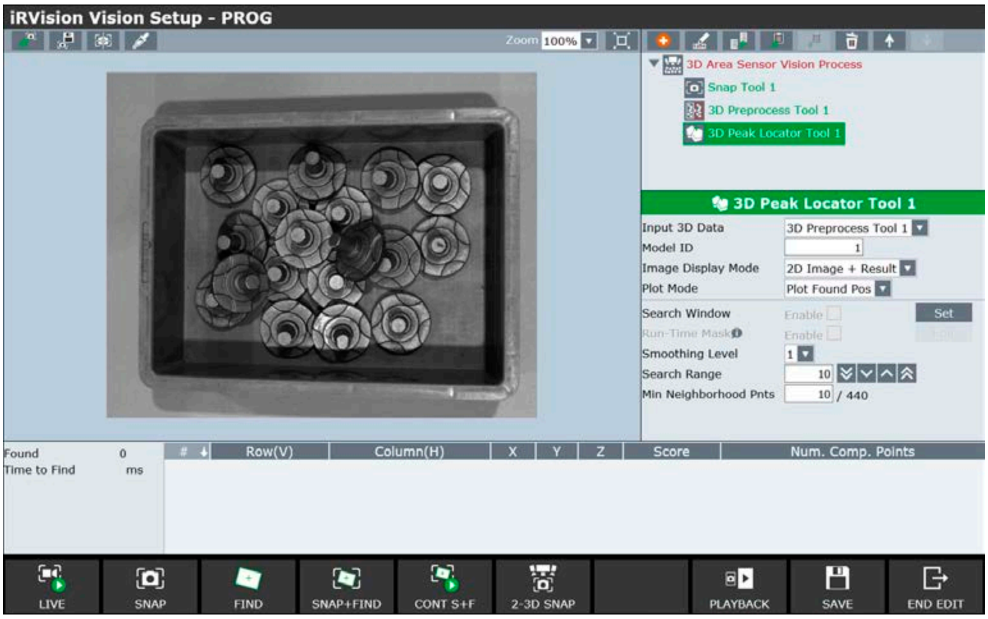
4.21 3D PEAK LOCATOR TOOL

The 3D Peak Locator Tool finds the regional highest 3D point in a 3D data acquired by a 3D area sensor (local peaks) from a 3D data. By using the 3D Peak Locator Tool, the robot can pick up the workpieces in descending order of height.
The 3D Peak Locator Tool can only be used in the 3D Area Sensor Vision Process.



Find Local Peaks from 3D points

If you select [3D Peak Locator Tool] in the tree view of the vision process edit screen, a setup page like the one shown below appears.



4.21.1 Setup Items

The 3D Peak Locator Tool has the following parameters.

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess Tool is set. This parameter is not normally needed to be changed.

If there is a different preceding locator tool in the tree view, by specifying the tool, you can use 3D data in which 3D points that match the found result have been removed.
This has the effect that reduces time to find, or prevents the output of found results which overlap in the same workpiece.

The following command tools at the same level that precedes this tool can be selected.

- 3D Data Preprocess Tool
- 3D Cylinder Locator Tool
- 3D Box Locator Tool
- 3D One-Sight-Model Locator Tool

Also the following command tools which are set as a child tool of the 3D Data Preprocess Tool can be selected.

- 3D Blob Locator Tool
- 3D One-Sight-Model Locator Tool

[Model ID]

Enter the value for the Model ID in the text box.
When you have taught two or more 3D Peak Locator Tools and want to identify which tool detected each workpiece, assign a distinct model ID to each tool. Because the model ID is output with offset data, robot programs can identify the model ID.

[Image Display Mode]

In the drop-down box, select the image display mode for the Setup Page.

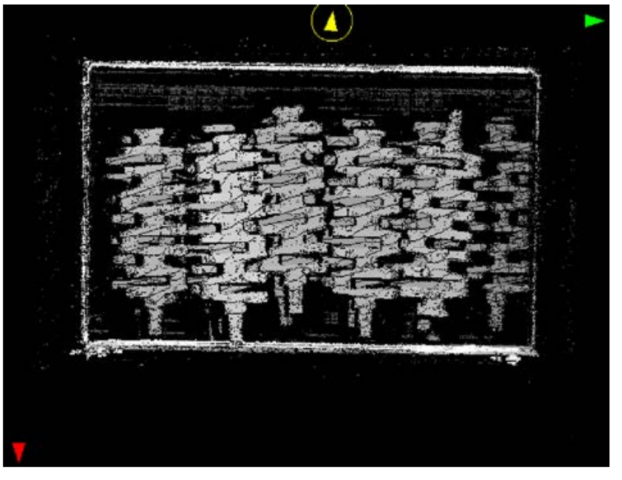
[2D Image + Points]
Acquired 3D points will be shown on 2D image.

[2D Image + Result]
Found results will be displayed on 2D image.

[3D Data]
Display a 3D data.

[3D Data + Result]
Found results will be displayed on 3D data.

[Height Map]
Height map (an image in which 3D points are projected to X-Y plane) will be displayed. Height map is not displayed if [Search Window] is disabled.



A value of each pixel represents Z height. A red arrow and a green arrow show X direction and Y direction of the offset frame respectively, and a yellow arrow represents the direction of which the robot is located.

[Plot Mode]

Select the found result plotting mode from the dropdown box.

[Plot Found Pos]
A cross in green is displayed at the found position of this tool.

[Plot Found Pos+Search Range]
In addition to the found position, local peak search area is displayed.

[Plot Found Pos+Neighbor Points]
In addition to the found position, neighbor points are displayed.

[Search Window]

From the 3D data, set the 3D points area to be used for finding on the height map.

By default, search window is disabled and all 3D points included in the 3D data are used.
Normally, this does not need to be changed since unnecessary 3D points such as those on a container will be removed by 3D Data Preprocess Tool and so on, but when you want to find restricted to a part of the area in the container, for example, click the [Set] button in [Search Window] to set the search window.

When search window appears on the height map in a rectangle, adjust the rectangle. For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

If the search window setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by search window is disabled.

[Run-Time Mask]

Specify a 3D point area of the search window that is not used to find, with an arbitrary geometry. This can be set when search window is enabled. For example, when a workpiece is sectioned with partitions in the container, this is effective for removing the partitions from search window.

Click the [Edit] button to use the Run-Time Mask. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

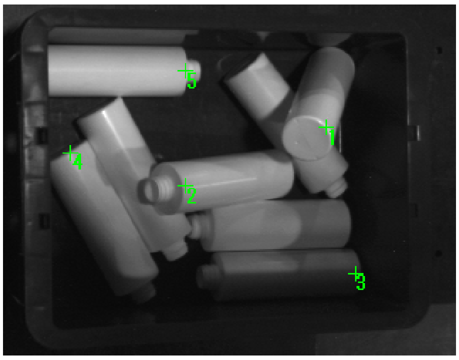
If the run-time mask setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by the run-time mask is disabled.

[Smoothing Level]

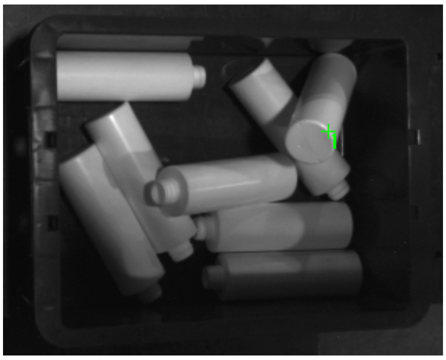
Select the level of smoothing a 3D data in the drop-down box. The larger the value is, the smoother the 3D data is. If there is a lot of noises in the 3D data, when detecting local peaks whose heights are same in real space, the found Z heights of the local peaks vary widely. Then, set a larger value to [Smoothing Level].

[Search Range]

Set the size of the searching range to find local peaks. Input a value in the text box or change the value with the button. Specify a number between 1 and 192.
If the set value is R, the searching range is the range whose base is a '2R + 1' square parallel to XY plane on the 3D data. In the searching range whose center is a local peak, there exists no other local peak.
As shown in the figures below, the smaller number to make the search range narrow, the more local peaks are found. Besides, enough a large number was specified, the highest 3D point of the whole 3D data is found as a local peak. If a target workpiece is long, specify a number which is roughly half of the width of the workpiece as the set value. Otherwise, specify a number which is roughly half of the size of the workpiece.



Search Range: Narrow

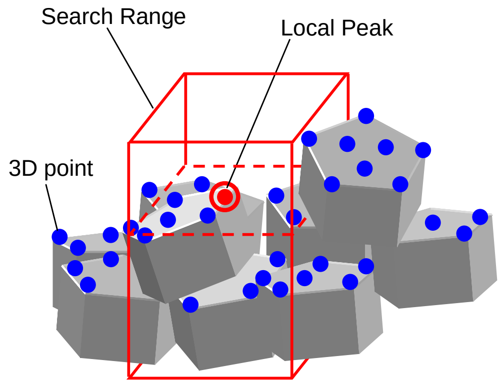


Search Range: Wide

Example of finding by different Local Peak Search Range

[Min. Neighborhood Pnts]

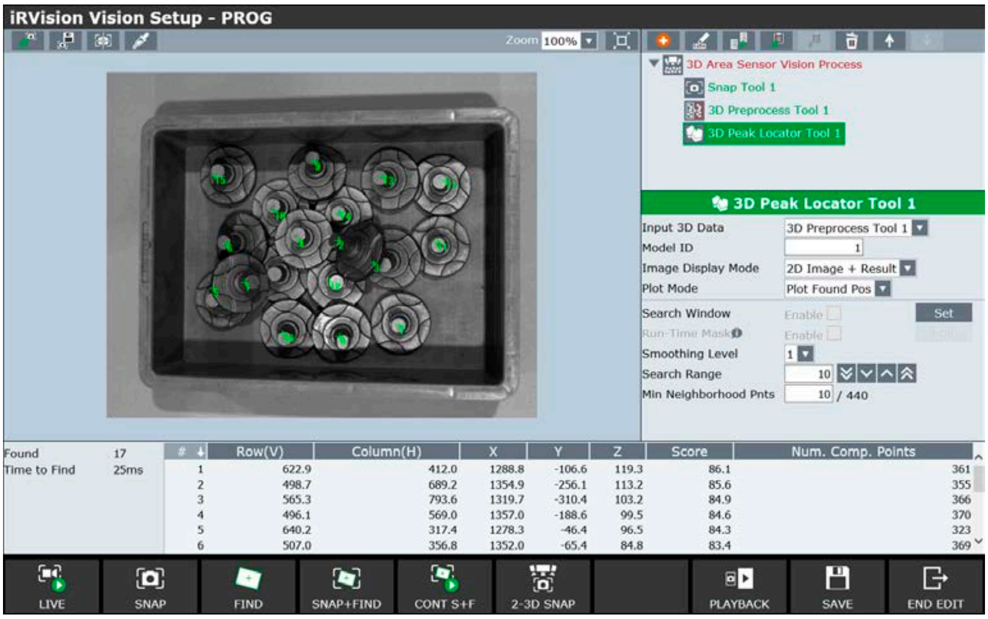
Enter the minimum permissible number of 3D points around each local peak in the text box. If the number of 3D points which are not at the center of the search range but in the search range is lower than the set number, the center 3D point of the search range cannot be detected as a local peak. If a number R is set as [Search Range], specify a number between 1 and $(2R + 1)^2 - 1$.



Example of Local Peak Search Range and Local Peak

4.21.2 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found local peaks is displayed.

[Time to Find]

The time the inspection took is displayed (units: milliseconds).

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

Found local peak position on a camera image.

[X], [Y], [Z]

Coordinate values of the found local peak (units: mm).

[Score]

It represents the Z height of a found position from 0 to 100, and when the Z height is the Z upper limit of [Meas. Z Range] of the 3D Area Sensor Vision Process, it will be 100, and when the Z height is the Z lower limit, it will be 0.

[Num. Comp. Points]

The number of 3D points within the area whose center position is on the found local peak and size is specified by the [Search Range].

4.21.3 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Local Peak Search Range]

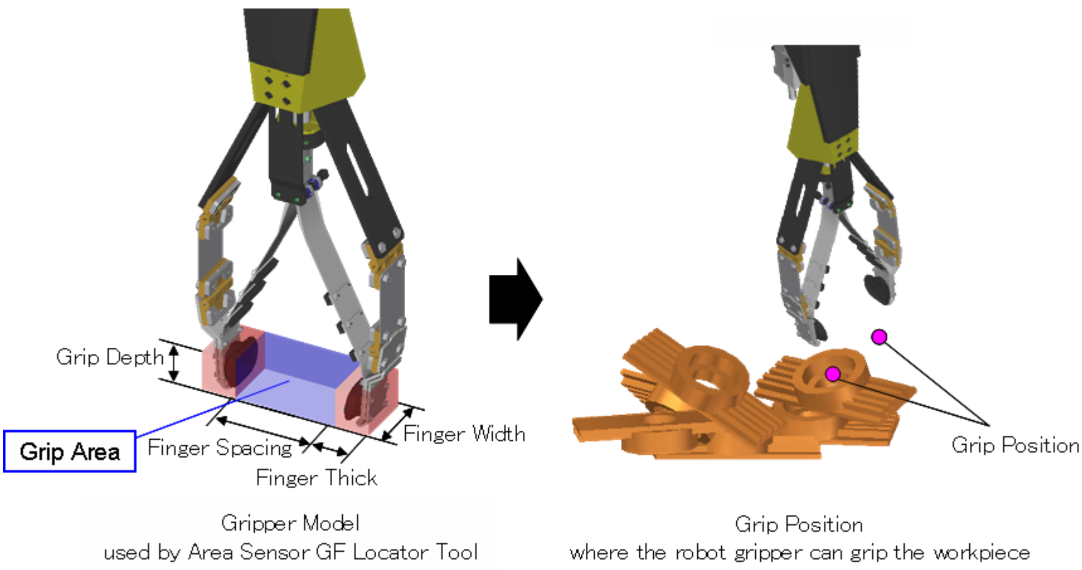
Specify a number between 1 and 192.

[Num. Neighborhood Points]

Specify a number between 1 and (2 Local Peak Search Range + 1)^2 – 1.

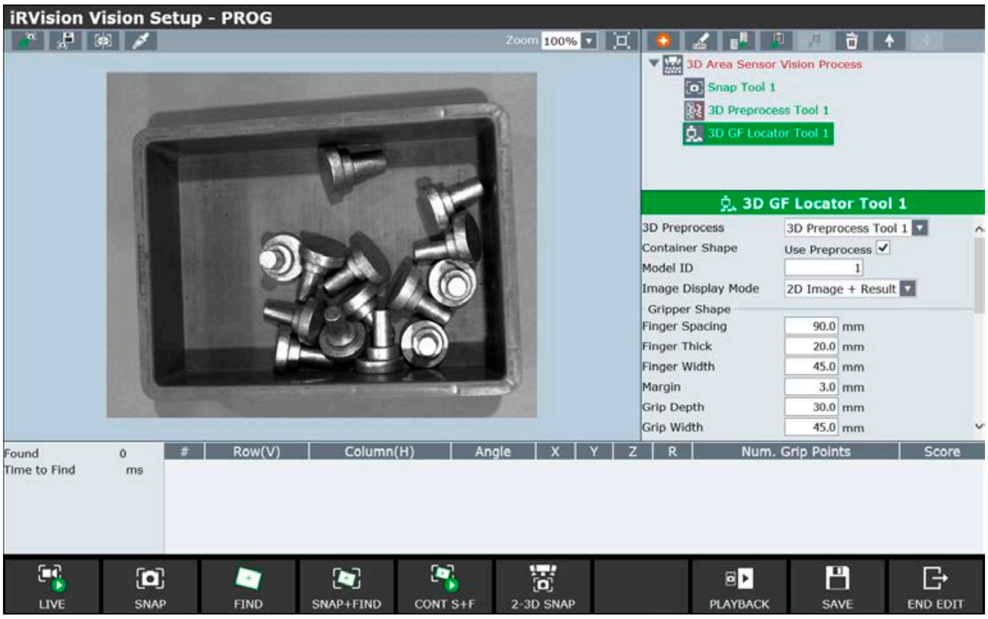
4.22 3D GF LOCATOR TOOL

The 3D GF Locator Tool finds grip positions easy for a robot gripper to grip workpieces using the gripper model and 3D Data acquired by 3D Area Sensor.
The 3D GF Locator Tool can only be used in the 3D area sensor vision process.



Usage Examples of 3D GF Locator Tool

If you select [3D GF Locator Tool] in the tree view of the vision process edit screen, a setup page like the one shown below appears.



4.22.1 Setup Items

The 3D GF Locator Tool has the following parameters.

[3D Preprocess]

In the drop-down box, select the 3D Data Preprocess Tool which is used for detection.

[Container Shape]

If [Use Preprocess] is checked, the found grip positions are limited within the container taught in the 3D Data Preprocess Tool selected on [3D Preprocess].
[Use Preprocess] generally should be checked if the robot picks up workpieces placed randomly inside a container and you need to teach [Container Shape] on the setup page of the 3D Data Preprocess Tool. If the robot picks up workpieces stacked on a pallet, [Use Preprocess] should be unchecked.

[Model ID]

Enter the value for the Model ID in the text box.
When you have taught two or more 3D GF Locator Tools and want to identify which tool detected each grip position, assign a distinct model ID to each tool. Because the model ID is output with offset data, robot programs can identify the model ID.

[Image Display Mode]

In the drop-down box, select the image display mode for the Setup Page.

[2D Image + Points]

Acquired 3D points will be shown on 2D image.

[2D Image + Result]

Found results will be displayed on 2D image.

[3D Data]

Display a 3D data.

[Height Map]

Height map will be displayed. Height map is an image in which 3D points are projected to X-Y plane of [Offset Frame] and the values of pixels show the Z height. 3D GF Locator Tool finds a gripping position on this height map. The sizes of pixels in the height map is the value set in [XY Interval].

[Gripper Shape]

Set the gripper shape.

[Finger Spacing]

Enter the size of the spacing between two fingers in the text box (units: mm).
For details, refer to the first figure in this section, "Usage Examples of 3D GF Locator Tool".

[Finger Thick]

Enter the size of the finger thick in the text box (units: mm).
For details, refer to the first figure in this section, "Usage Examples of 3D GF Locator Tool".

[Finger Width]

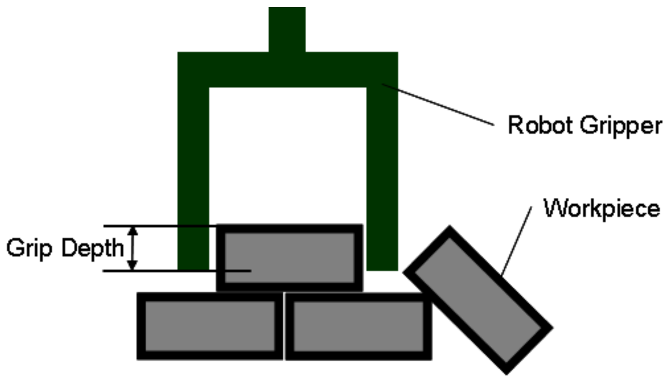
Enter the size of the finger width in the text box (units: mm).
For details, refer to the first figure in this section, "Usage Examples of 3D GF Locator Tool".

[Margin]

Enter the margin of Gripper Model in the text box (units: mm).
The 3D GF Locator Tool internally creates a new gripper model adding the value of [Margin] to [Finger Thick] and [Finger Width].

[Grip Depth]

Enter the value of the grip depth in the text box (units: mm). The grip depth is the distance from the front edge of the gripper to the top side of the workpiece when the gripper is at the grip position as the following figure shows.



Example of Grip Depth

[Search Interval]

Set the value for the interval and range for searching the grip positions.

[XY Interval]

Enter the value of the XY interval in the text box (units: mm) to search the grip positions.
If the value of [XY Interval] is small, the 3D GF Locator Tool searches the grip positions finely and might be able to find grip positions which can’t be found by coarse search. Besides, the interference check which is executed in the 3D GF Locator Tool internally becomes higher accurate with the smaller [XY Interval].

However, the processing time becomes much larger when you set the smaller value on [XY Interval]. Please adjust the value considering the accuracy and the processing time. We recommend to set the value 2.0 mm to 4.0 mm.

[R Range]

Enter the minimum and maximum values of R range in the text box (units: degrees).
If workpieces are aligned and you would like to limit the R range of the grip positions, please adjust this parameter.

[R Interval]

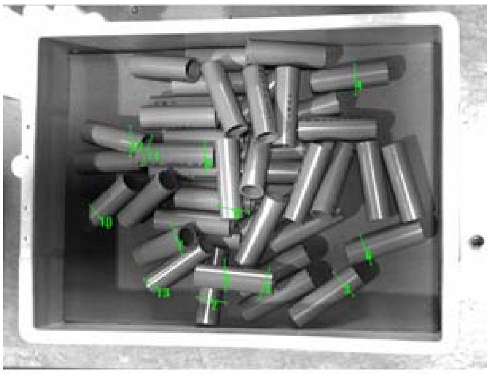
Enter the value of the R interval in the text box (units: degrees) to search the grip positions.

[Min. Num. Grip Points]

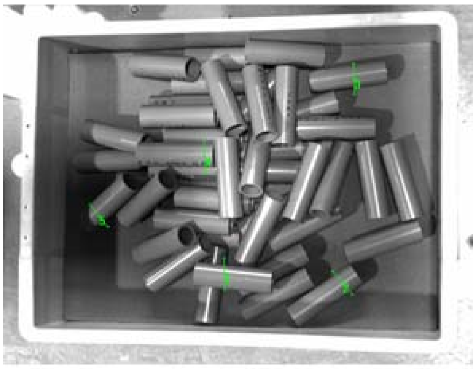
Enter in the text box the minimum permissible number of 3D points in each "Grip Area" in the first figure in this section, "Usage Examples of 3D GF Locator Tool".

[Overlap Check Area]

Enter the area size in the text box to check whether the grip positions are overlapped or not (units: mm). Grip positions are [Overlap Check Area] away from each other. As shown in the figures below, the smaller number you set on [Overlap Check Area], the more grip positions are found. However, with narrow [Overlap Check Area], multiple grip positions might be found on one workpiece. Please specify a number which is roughly half of the size of the workpiece.



Overlap Check Area: Narrow



Overlap Check Area: Wide

Example of found results by overlap check area

4.22.2 Running a Test

Click [FIND] to run a test and see if the tool can find grip positions properly.

After executing a test, the following items are displayed in the result display area.

[Found]
The number of found grip positions is displayed.

[Time to Find]
The time the inspection took is displayed (units: milliseconds).

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]
Found results position on a camera image.

[Angle]
Found results angle on a camera image (units: degrees).

[X], [Y], [Z], [R]
Coordinate values of the found grip position (units: mm, degrees).

[Num. Grip Points]
The number of 3D points within Grip Area.

[Score]
Score of the found grip position. The possibility to succeed in gripping is calculated by the 3D GF Locator Tool and the possibility is output as Score. The value is between 0 and 100.

4.22.3 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

Finger Spacing

Specify a number between [XY Interval] and 1000.

Finger Thick

Specify a number between [XY Interval] and 500.

Finger Width

Specify a number between [XY Interval] and 500.

Finger Margin

Specify a number between 0 and 500.

Grip Depth

Specify a number between 1 and 500.

XY Interval

Specify a number between 1 and 20.

R-Mimimum

Specify a number between ([R-Maximum] – 180) and [R-Maximum].

R-Maximum

Specify a number between [R-Minimum] and ([R-Minimum] + 180).

R Interval

Specify a number between 5 and 180.

Min. Num. Grip Points

Specify a number between 1 and 1000.

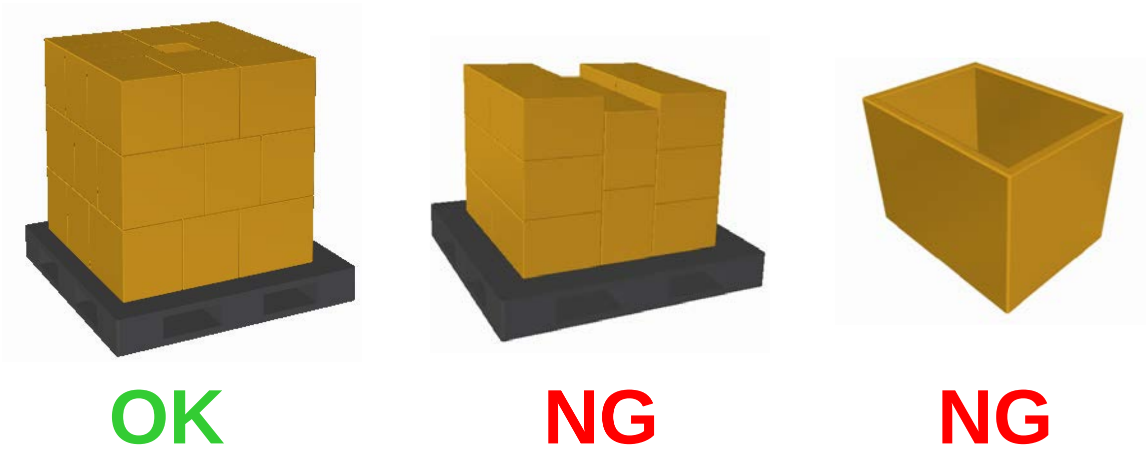
Overlap Check Area

Specify a number between 10 and 1000.

4.23 3D BOX LOCATOR TOOL

The 3D Box Locator Tool finds boxes which are palletized orderly. It uses the size of boxes to find and finds their upper surface by referring to a 3D data and a camera image. To find boxes correctly, the following conditions should be satisfied.

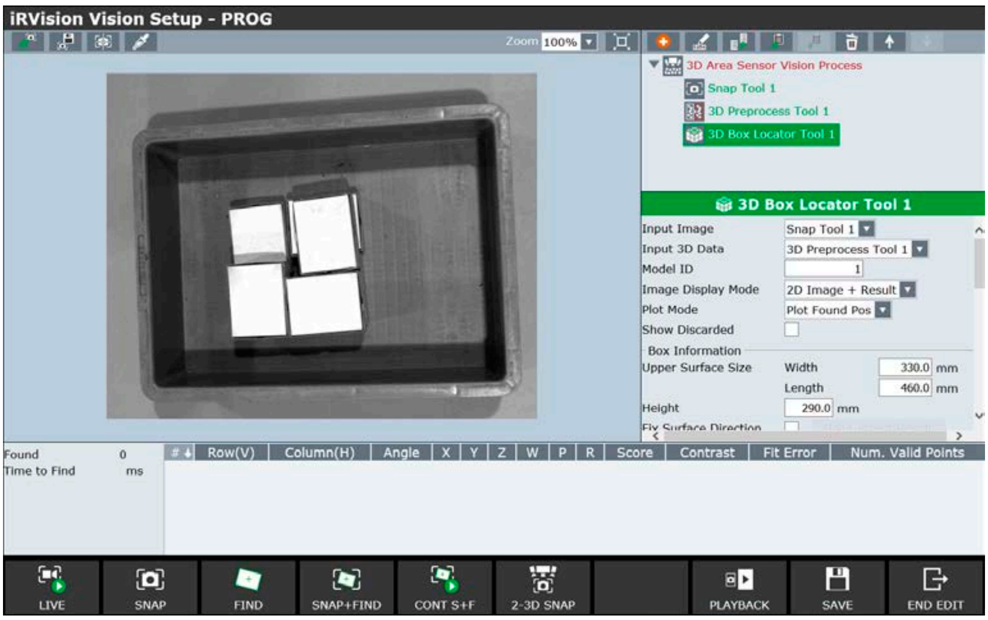
- All objects to find are same sized cuboids.
- For the all palletized objects, the object surface which is facing to the 3D area sensor must be same size. (The size of the surface should be set as "Upper Surface" on the setup page.)
- The upper surfaces are planar. If the upper surfaces are opened as follows, this tool cannot find them.



Examples of workpieces that can be found by 3D Box Locator Tool

The 3D Box Locator Tools can be created as a child of the 3D Area Sensor Vision Process or as a child of the Multi-locator tool which is a child of the 3D Area Sensor Vision Process. The 3D Box Locator Tool uses a 3D data but it does not require high density of 3D points. If you want to shorten detection time, please select "Coarse" as [3D Map Density] on the setup page of 3D Area Sensor. To use the 3D Box Locator Tool, some 3D points which cause incorrect results and waste the processing time must be removed by the 3D Data Preprocess Tool.

If you select [3D Box Locator Tool] in the tree view of the vision process edit screen, a setup page like the one shown below appears.



4.23.1 Setup Items

The 3D Box Locator Tool has the following parameters.

[Input Image]

Select an image to use for detection by 3D Box Locator Tool from the drop-down box.
If detection is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If detection is to be performed using preprocessed images, select the tool that performs the image preprocessing.
For details of the tools that perform image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Input 3D Data]

Select the tool for acquiring 3D data from the drop-down box.
By default, 3D Data Preprocess Tool is set. This parameter is not normally needed to be changed.

If there is a different preceding locator tool in the tree view, by specifying the tool, you can use 3D data in which 3D points that match the found result have been removed.
This has the effect that reduces time to find, or prevents the output of found results which overlap in the same workpiece.

The following command tools at the same level that precedes this tool can be selected.

- 3D Data Preprocess Tool
- 3D Cylinder Locator Tool
- 3D Box Locator Tool
- 3D One-Sight-Model Locator Tool

Also the following command tools which are set as a child tool of the 3D Data Preprocess Tool can be selected.

- 3D Blob Locator Tool
- 3D One-Sight-Model Locator Tool

[Model ID]

Enter the value for the Model ID in the text box.
When you have taught two or more locator tools and want to identify which tool detected each workpiece, assign a distinct model ID to each tool. Because the model ID is output with offset data, robot programs can identify the model ID.

[Image Display Mode]

Select the image display mode for the Setup Page from the drop-down box.

[2D Image + Points]
Acquired 3D points will be shown on 2D image.

[2D Image + Result]
Found results will be displayed on 2D image.

[2D Image + Edge]
A camera image and features are displayed.

[2D Image + Postproc.]

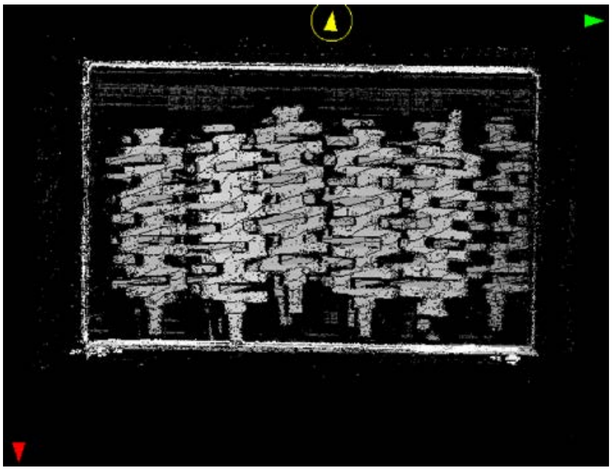
Postprocess results will be displayed on 2D image. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[3D Data]
Display a 3D data.

[3D Data + Result]
Found results will be displayed on 3D data.

[3D Data + Postproc.]
Postprocess results will be displayed on 3D data. A postprocess result is a 3D data which this tool outputs when other tool specifies this tool as [Input 3D Data], and the 3D points that match the result found by this tool are removed.

[Height Map]
Height map (an image in which 3D points are projected to X-Y plane) will be displayed. Height map is not displayed if [Search Window] is disabled.



A value of each pixel represents Z height. A red arrow and a green arrow show X direction and Y direction of the offset frame respectively, and a yellow arrow represents the direction of which the robot is located.

[Plot Mode]

Select how the found results are to be displayed on the image after the process is run.

[Plot Found Pos]
"+" is displayed at the found position in green.

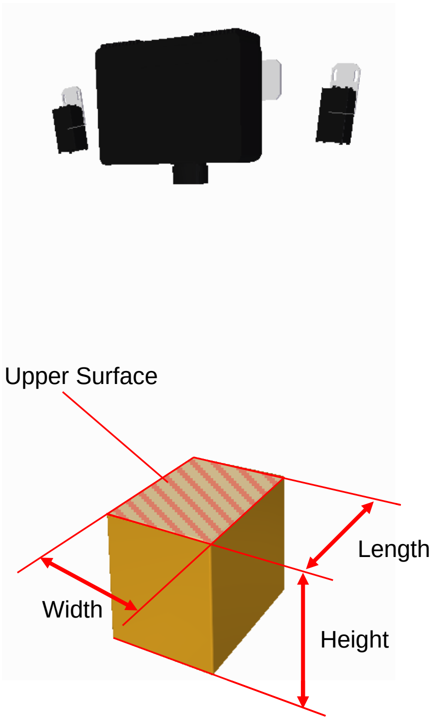
[Plot Found Pos + Edges]
In addition to [Plot Found Pos], contours of found boxes are also plotted in green.

[Show Discarded]

When this checkbox is checked, discarded results are displayed in red. There are 2 kinds of discarded results. One is discarded by overlapping with other results. It is meeting the detection parameters. The other is discarded because it fell just short of meeting the detection parameters. The latter does not output "Num. Valid Points" in a result table.

[Box Information]

Specify the size of the box to find.



How to determine the parameters set to the box size

[Upper Surface Size]

Set the size of a surface on the sensor side. Specify the sizes in the width and the length direction (units: mm).

[Height]

Set the size in the vertical direction against the upper surface. Specify the size in the height direction (units: mm).

[Fix Surface Direction]

Set whether use specified normal vector or not to find boxes. When the checkbox is checked, normal directions of upper surfaces become same as the direction set at [Normal Direction]. This function works effectively, when the robot has only 5axis or when 3D points from upper surface are not on an ideal plane.

[Use Current Result]

Using a found result which is currently kept, the normal direction can be set. When this button is pushed, the [Fix Normal Direction] turns to checked and new values which are computed from the upper surface of the found result are set to [Normal Direction].

[Plot Found Pos]
"+" is displayed at the found position in green.

[Plot Found Pos + Edges]
In addition to [Plot Found Pos], contours of found boxes are also plotted in green.

[Normal Direction]

Set the normal direction in 3 textboxes. The 3 textboxes for X, Y and Z are for normal vector value of the offset frame. Each element of the normalized unit vector is indicated at the side of the textboxes. The setting items will appear when [Fix Surface Direction] is checked.

[2D Location Parameters]

Set a threshold value and a limit value of the GPM locator tool.

[Score Threshold]

Enter in the text box the score threshold for a pattern to be found. 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 80. Setting a small value might lead to inaccurate location and long detection.

[Contrast Threshold]

Enter in the text box the threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. 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 detection process. Those image features whose contrast is lower than the threshold are ignored. Selecting the [2D Images + Edges] in [Image Display Mode] lets you check the image features extracted based on the current threshold. Set a value to detect contour of the object as edges in the image.

[Elasticity]

Specify the tolerance of fitting error between the box model which is specified at [Upper Surface Size] and features in an image. The default value is 5 pixels. The range of this item changes according to [Search Density]. The minimum value is 0.1 / (the value specified at [Search Density]). The maximum value is 5.0 / (the value specified at [Search Density]). 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]

From the 3D data, set the 3D points area to be used for finding on the height map.

By default, search window is disabled and all 3D points included in the 3D data are used.
When you want to find from multiple boxes placed on a pallet by restricting the area, click the [Set] button in [Search Window] to set the Search Window.
When search window appears on the height map in a rectangle, adjust the rectangle. For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

If the search window setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by search window is disabled.

[Run-Time Mask]

Specify a 3D point area of the search window that is not used to find, with an arbitrary geometry. This can be set when search window is enabled.

Click the [Edit] button to use the Run-Time Mask. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

If the run-time mask setting is complete, [Enable] is checked automatically. When [Enable] is unchecked, the 3D points area restriction by the run-time mask is disabled.

[Search Density]

Specify the interval of search for the box model which is specified at [Upper Surface]. The default value is 100%. Set a value between 30 and 150. Setting a large value enables the tool to reduce misdetection but it leads longer detection. On the other hand, setting a small value enables the tool to reduce detection time but it leads misdetection and inaccurate location.

[Overlap Threshold]

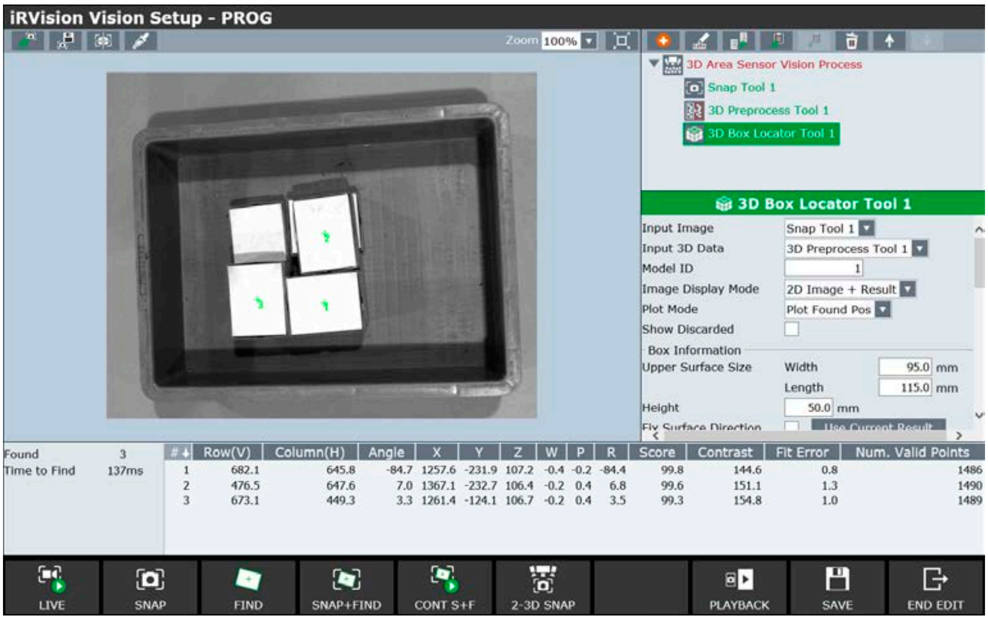
Enter in the text box the limit of overlap ratio of a found object against other objects. The default value is 10%. Set a value between 0 and 20. If the overlapping ratio is higher, the target object is not found. Setting a large value enables the tool to find more target objects but it leads illegal overlap between found objects and other objects.

[Time-out]

Enter the time limit for detection process in the text box. If the detection process takes longer than the time specified here, the tool ends the process without finding all of the objects.

4.23.2 Running a Test

Click [FIND] to run a test and see if the tool can find grip positions properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found results is displayed.

[Time to Find]

Time to find is displayed (units: ms).

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

Coordinate values of the center of the box upper surface on a camera image (units: pixel).

[Angle]

Orientation of the found results on a camera image (units: degrees).

[X], [Y], [Z], [W], [P], [R]

Coordinate values of the found result position (units: mm, degrees).

[Score]
Calculates the accuracy of a pattern found by the 3D Box Locator Tool and outputs as a score.

[Contrast]
Contrast of the found pattern.

[Fit Error]
Deviation of the found results from the model pattern (units: pixels).

[Num. Valid Points]
The number of 3D points used for measuring the plane.

4.23.3 Overridable Parameter

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Box Width]
Specify a number between 10 and 10000.

[Box Length]
Specify a number between 10 and 10000.

[Box Height]
Specify a number between 10 and10000.

[Score Threshold]
Specify a number between 10 and 100.

[Contrast Threshold]
Specify a number between 1 and 200.

[Elasticity]
Specify a number between 0.1 / (the value specified at [Search Density]) and 5. / (the value specified at [Search Density])

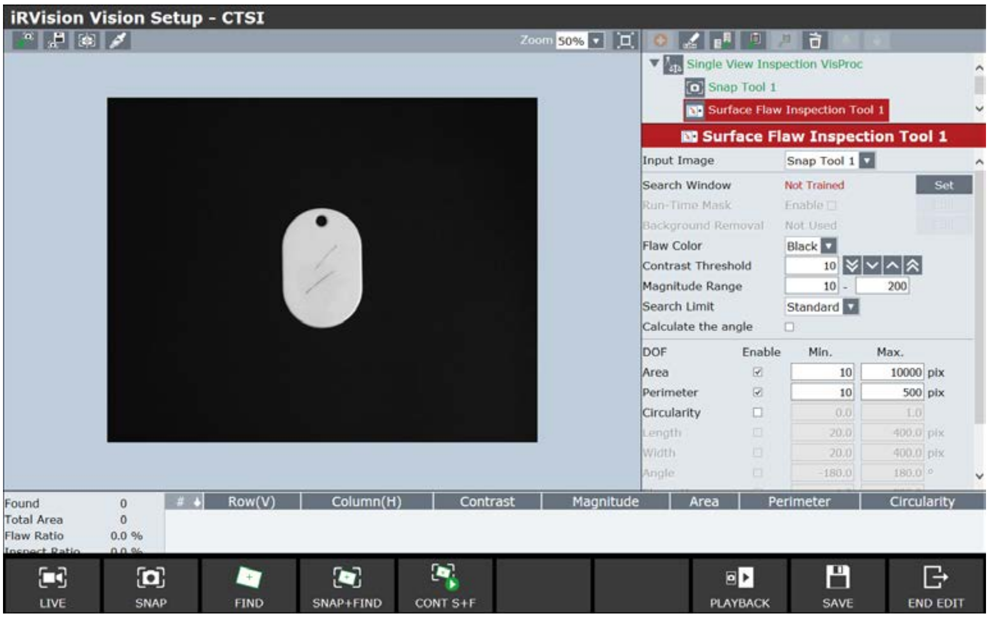
[Overlap Ratio]
Specify a number between 0 and 20.

[Search Density]
Specify a number between 30 and 150.

4.24 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 [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.



4.24.1 Setup Items

The surface flaw inspection tool has the following parameters.

[Input Image]

In the drop-down box, select an image which is used for training area to inspection.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[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 Click [LIVE] in the surface flaw inspection tool edit screen.
It will be switched to live image display.
2 Place a workpiece near the center of the camera view.
3 Click [STOP] to stop the live image, and then click [SNAP] to snap the image of the workpiece.
The image of the workpiece is snapped.
4 Click [Set].
A full-screen image will appear, and a window that has control points (reddish purple rectangle) will appear.
5 Select the inspection area within the displayed window, and click [OK].
The inspection area will be set.
For detailed information about the window operation, refer to "Setup: 1.8.8, Window Setup".

[Run-Time Mask]

Specify a 3D point area of the search window that is not used to find, with an arbitrary geometry. This can be set when search window is enabled. For example, when a workpiece is sectioned with partitions in the container, this is effective for removing the partitions from search target. Click the [Edit] button to use the Run-Time Mask. For the operation method for the mask, refer to "Setup: 1.8.13 Editing Masks".

[Background Removal]

Process an image to make it easy to find flaws. For details, refer to "Setup: 4.24.2 Background Removal".

[Flaw Color]

In the drop-down box, select the color of the flaw to be found from the following options:

[White]
Finds white flaws.

[Black]
Finds black flaws.

[Contrast Threshold]

Specify the threshold for how much contrast (difference between light and dark) is required in the image to identify something as a feature. Input a value or change the value with the buttons. The default value is 10, and the specifiable range is from 1 to 200.
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 "flaws" are not found when a higher threshold value is specified, and only apparent flaws are found. If the contour of a flaw is fuzzier than you expected it would be, increase this value.

[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]

From the drop-down box, select this parameter to adjust the extent of the individual flaw contour. This parameter is not normally needed to be changed.

[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.

[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.

[DOF]

The found regions based on the specified flaw color are examined to determine whether each region should be considered as a flaw. Measurements without a check in the [enabled] checkbox will not be used to evaluate whether the found regions are flaw or not.

[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 800.

[Plot Mode]

In the drop-down box, 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]

In the drop-down box, select the image to display from the following options:

[Original]
The image selected in [Input Image] will appear.

[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 [VTYPE] of the background removal method is “Dynamic.”

[BG Removed]
Displays the background removed image.

[Processed Image]
Displays an image with both background removal and filters applied, if any.

[Processed Image + Result]
Displays an image with both background removal and filters applied, and the results if any.

4.24.2 Background removal

Background Removal is a function that removes features that seems to be a part of the background.

1. Click the [Set] button on [Background Removal] in the surface flaw inspection tool edit screen.
   The setting items for background removal appear in the setting items area.
2. Set each items for background removal.
   The items to set are described later.
3. Once setup is finished, click [OK].
   Returns to the surface flaw inspection tool edit screen after saving the changes.
   Click [CANCEL] to discard all changes for the background removal setup and returns to the surface flaw inspection tool editing screen.

Background Removal Setup

Set each item for background removal.

[Method]

Select the method of background removal in the drop-down box:

[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 image selected in [Input 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 image selected in [Input 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 image selected in [Input Image].

[Shading]

The gradual grayscale changes in the image due to uneven lighting are 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 M]

It is the parameter displayed when [Static] or [Shading] is selected in [Method] of Background Removal. Registers an image selected in [Input Image] as a master image. When a master image is already registered, the text on the button becomes [Apnd M]. When the [Apnd M] button is clicked, 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 M]

Clears the registered master image. The button is disabled when a master image is not registered.

[Dynamic Size]

It is displayed when [Dynamic] is selected in [Method] of Background Removal.
Dynamic size is a parameter used to generate a pseudo-master image in the dynamic background removal method. 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.

[Run-Time 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, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

[Image Display Mode]

In the drop-down box, select the mode to display an image in the background removal setup:

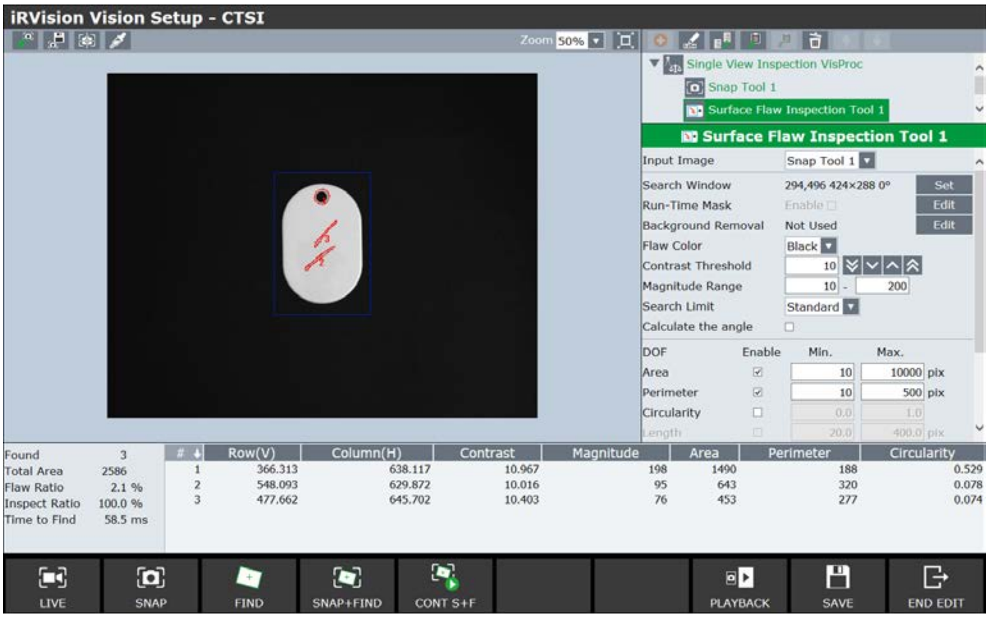
[Original]
Images that are selected in [Input Image] will appear.

[Master]
Displays the registered master image. A pseudo-master image is displayed when the background removal method is [Dynamic].

[BG Removed]
Displays the background removed image.

4.24.3 Running a Test

Click [FIND] to run a test and see if the tool can find flaws properly.



After executing a test, the following items are displayed in the result display area.

[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 (units: percents).

[Inspect Ratio]

The ratio of the area inspected and the area supposed to be inspected is displayed (units: percents).

[Time to Find]
The time the inspection took is displayed (units: milliseconds).

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]
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.

4.24.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Flaw Color]
Specify 1 for black flaw or 0 for white flaw.

[Contrast Threshold]
Specify a number between 1 and 200.

[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. Specify 0 for disabling checking or 1 for enabling. Minimum area and maximum area can be specified. Specify a number equal to or larger than 0 for minimum and maximum area.

[Perimeter]
Enable/disable selection for perimeter checking. Specify 0 for disabling checking or 1 for enabling. Minimum perimeter and maximum perimeter can be specified. Specify a number equal to or larger than 0 for minimum and maximum perimeter.

[Circularity]
Enable/disable selection for circularity checking. Specify 0 for disabling checking or 1 for enabling. Minimum circularity and maximum circularity can be specified. Specify a number between 0 and 1 for minimum and maximum circularity.

[Length]
Enable/disable selection for length checking. Specify 0 for disabling checking or 1 for enabling. Minimum length and maximum length can be specified. Specify a number equal to or larger than 0 for minimum and maximum length.

[Width]
Enable/disable selection for width checking. Specify 0 for disabling checking or 1 for enabling. Minimum width and maximum width can be specified. Specify a number equal to or larger than 0 for minimum and maximum width.

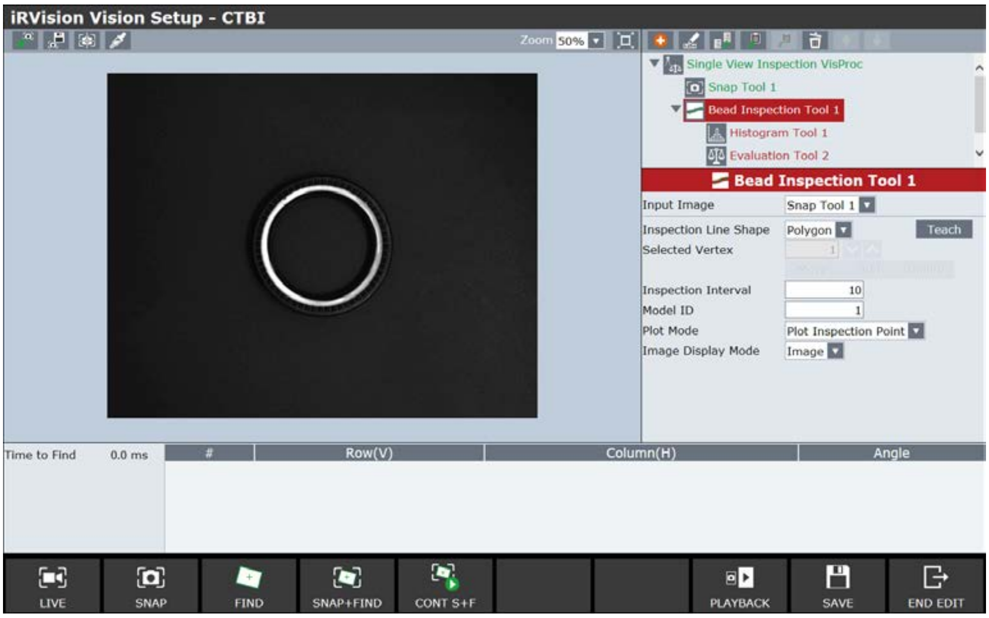
[Orientation]
Enable/disable selection for angle checking. Specify 0 for disabling checking or 1 for enabling. Minimum angle and maximum angle can be specified. Specify a number between –180 and 180 for minimum and maximum angle.

[Elongation]
Enable/disable selection for elongation checking. Specify 0 for disabling checking or 1 for enabling. Minimum elongation and maximum elongation can be specified. Specify a number equal to or larger than 0 for minimum and maximum elongation.

4.25 BEAD INSPECTION TOOL

Bead Inspection Tool provides a function to inspect a bead-formed object, such as sealant and adhesive. Bead Inspection Tool generates many inspection points along a specified inspection line on an image. The inspection line can be specified as a polygon, a circle or an arc. Inspection is performed by predefined child tools for each inspection point. You only need to train the center line of the bead and inspection interval. This tool is only available with the Single-view Inspection vision process.

If you select [Bead Inspection Tool] in the tree view of the setup page for the vision process, a setup page like the one shown below appears.



4.25.1 Setup Items

The bead inspection tool has the following parameters.

[Input Image]

Select an image to be used for inspection from the drop-down box.
If image processing is to be performed using an image taken by a camera as it is without any changes, select a snap tool. If image processing is to be performed after pre-processing of the images that have been taken, select the command tool that will be used for pre-processing.
For details of the command tools that can be used for image processing, refer to "Setup: 4.38 IMAGE FILTER TOOL", "Setup: 4.39 COLOR EXTRACTION TOOL", "Setup: 4.40 COLOR COMPONENT TOOL", "Setup: 4.41 IMAGE ARITHMETIC TOOL", "Setup: 4.42 FLAT FIELD TOOL", and "Setup: 4.43 IMAGE SHRINK TOOL".

[Inspection Line Shape]

Teach the inspection line so the inspection line runs through the center line of the bead to be inspected. For details, refer to "Setup: 4.25.2 Setting up an Inspection Line".

[Selected Vertex]

Select a vertex of the inspection line to edit. Refer to "Setup: 4.25.2 “Setting up an Inspection Line” for details.

[Inspection Interval]

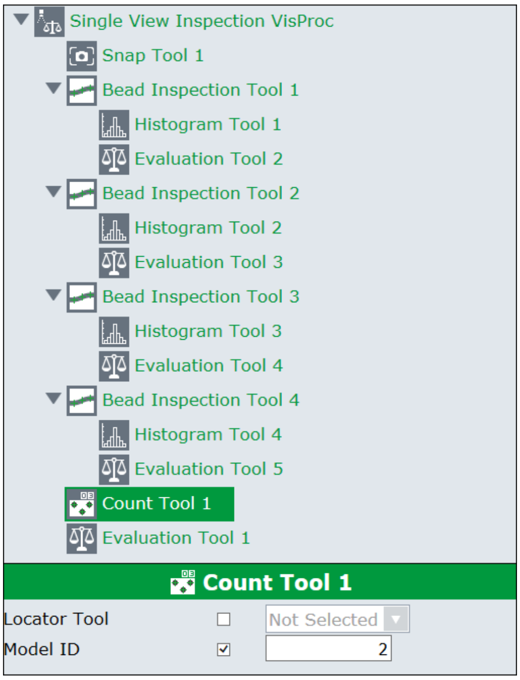
Specify the interval of the inspection points to be generated. The unit is pixels. A value between 1 and 100 can be specified.

> ⚠CAUTION
> Inspection points are not always generated exactly at the specified inspection interval. If the taught inspection line cannot be divided equally at the specified inspection interval, inspection points are generated by automatically fine-tuning the inspection interval so that the inspection line can be divided equally.

4

[Model ID]

When you have taught two or more Bead Inspection Tools and want to identify which tool was used to generate the inspection point, assign a distinct model ID to each tool. You can set the values between -2147483647 and 2147483646. It is useful when you want to count results of some Bead Inspection Tools. For example, assume a vision process has four Bead Inspection Tools "A", "B", "C" and "D", the model ID of "A" is set to 1, and the model ID of "B", "C" and "D" is set to 2. Then you can count number of passed/failed inspection points from Bead Inspection Tool "B", "C" and "D" (namely excluding "A") by configuring a Count Tool to count results with model ID set to 2.



[Plot Mode]

In the drop-down box, select how the results are displayed after the process is run from the following options.

[Not Plot Inspection Point]
Nothing will be displayed.

[Plot Inspection Point]
The inspection points will be displayed.

[Image Display Mode]

In the drop-down box, select the image display mode for the setup page:

[Image]
Only images that are selected in [Input Image] will appear.

[Insp.Line]
Images and inspection lines that are selected in [Input Image] will appear.

[Insp.Line + Vertex]
Images, inspection lines and vertexes that are selected in [Input Image] will appear.

[Insp.Line + Vertex + Index]
Images, inspection lines, vertex positions and the vertex indexes that are selected in [Input Image] will appear.

4.25.2 Setting up an inspection line

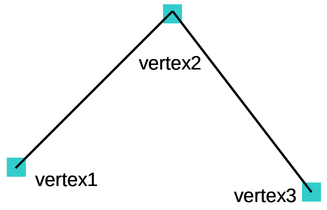
Teach the inspection line so the inspection line runs through the center line of the bead you want to inspect.

Inspection Line Shape

Select the inspection line shape to be taught in [Inspection Line Shape] from the drop-down box. One of the following can be selected:

[Polygon]

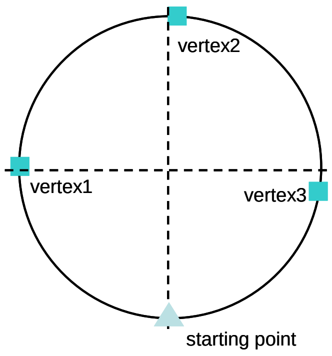
Teach the inspection line as a polygonal line that connects multiple vertices. In the case of the following figure, the starting point of the inspection line is vertex1 and the ending point of the inspection line is vertex3.



Inspection Line Shape (Segmented-line)

[Circle]

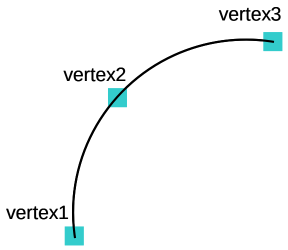
Teach the inspection line as a circle that passig through three vertices. The starting point of the inspection line is the bottom point of the circle.



Inspection Line Shape (Circle)

[Arc]

Teach the inspection line as an arc that passes through three vertices. The starting point of the inspection line is vertex1 and the ending point of the inspection line is vertex3.



Inspection Line Shape (Arc)

[Vertex Index]

Select a vertex of the inspection line to edit. Select a vertex of the inspection line to edit. Specify an index number of the vertex that you want to edit. A polygon is composed of two or more vertices. A circle and an arc are composed of three vertices.

> **MEMO**
> When the bead cannot be depicted with a single shape of inspection line, use multiple Bead Inspection Tools.

Teaching Inspection Line

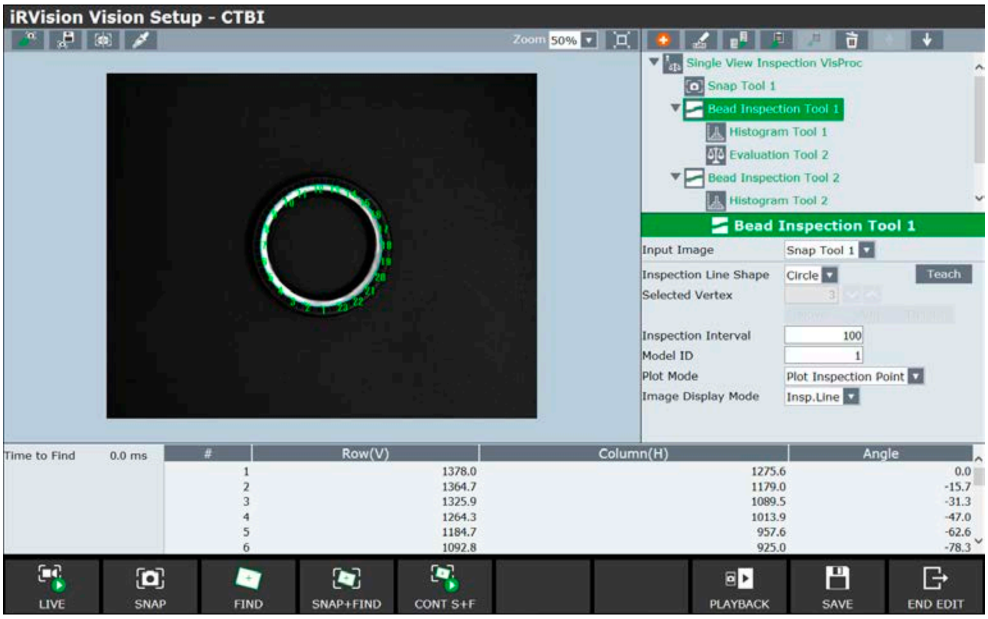
Teach the inspection line as follows:

1 On the bead inspection tool edit screen, select the inspection line type in the [Inspection Line Shape] drop-down box.
2 Click the [Teach] button.
After starting inspection line, the [Teach] button changes to [Finish].
3 Select the vertex you would like to adjust by clicking button on the right of the [Selected Vertex] textbox or entering a value in the [Selected Vertex] textbox.
4 Click any of the [Move], [Add] or [Delete] button.
- Clicking the [Move] button displays the at the current position of the selected vertex on the image. Move the to the position you would like to move the vertex to.
- Clicking the [Add] button displays the at the midpoint of the selected vertex and the next vertex on the image. When the last vertex is selected, the is displayed at the center of the image. Move the to the position you would like to add the new vertex.
- Clicking the [Delete] button deletes the selected vertex.

For the detailed information about the operation method of the , refer to "Setup: 1.8.7 Point Setup".
5 Click [OK].
Editing vertex finishes. Clicking [CANCEL] will discard the editing of vertex and returns to the original screen.
6 Repeat the step 3 to 5 so that the inspection line runs along the center line of the bead you would like to inspect.
7 Click the [Finish] button to finish editing the inspection line.

4.25.3 Running a Test

Click [FIND] to run a test and see if the tool can generate inspection points properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the bead inspection tool took is displayed in milliseconds.

Also, in the result display area list view, the following values are displayed.

[Row(V)], [Column(H)]

Coordinate values of the generated inspection point (units: pixels).

[Angle]

Orientation of the generated inspection point (units: degrees).

4.25.4 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

[Inspection Interval]

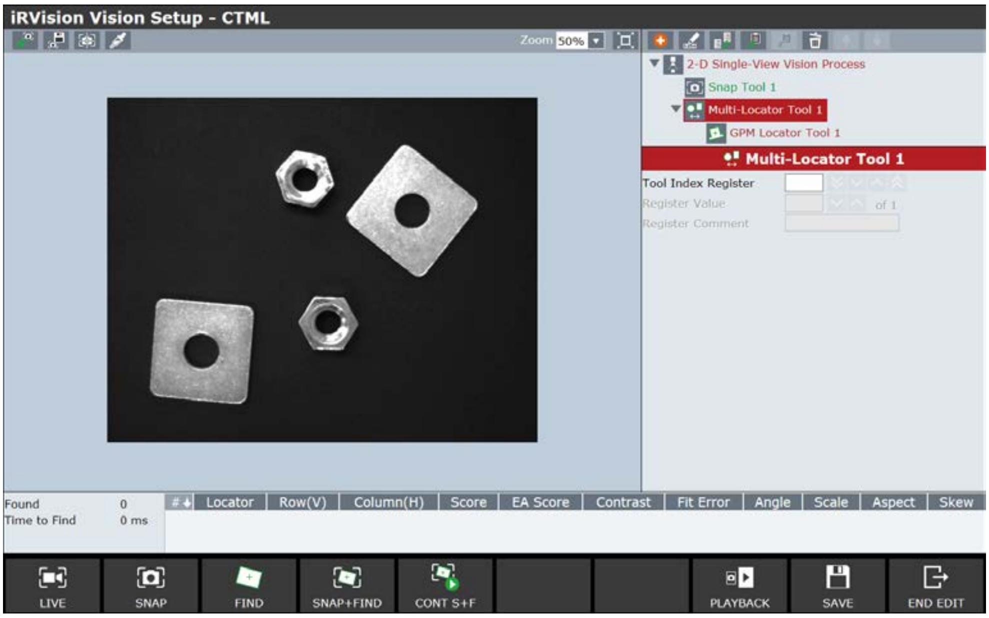
Specify the interval of inspection points. A number between 1 and 100 can be specified. The unit is pixels.

> **MEMO**
> For specific usage examples of combined application of the Bead Inspection Tool and available command tools, refer to the description of Bead Inspection in "R-30*i*B Plus/R-30*i*B Mate Plus CONTOLLER *i*RVision Inspection Application OPERATOR'S MANUAL". For examples of application, refer to "R-30*i*B Plus/R-30*i*B Mate Plus CONTOLLER *i*RVision Inspection Application OPERATOR'S MANUAL".

4.26 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.



4.26.1 Setup Items

The multi-locator tool has the following parameters.

[Tool Index Register]

Specify the number of the register you want to use to change the tool.

[Register Value]

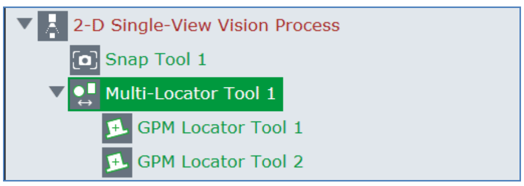
The value currently set in the register is displayed. When the value is changed, the value of the register of the robot controller is also updated automatically. This function is useful when you change the locator tool and run a test.

[Register Comment]

The comment currently set for the specified register is displayed.

4.26.2 Adding Child Tools

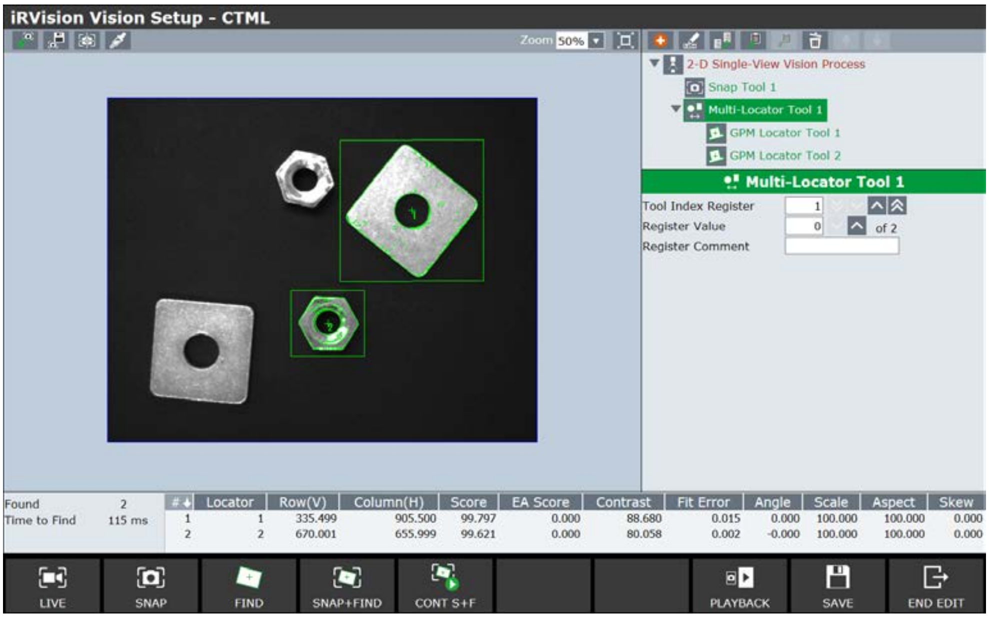
Add locator tools you want to use according to the value of the register as child tools of the Multi-Locator Tool. In the figure below, GPM Locator Tool 1 is executed when the register value is 1; GPM Locator Tool 2 is executed when it is 2.



> ⚠ **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.

4.26.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found workpieces is displayed. The units are pieces.

[Time to Find]

The time the location process took is displayed in milliseconds.

The results displayed in the result display area list view differ depending on the setting of child tool allocated for the multi-locator tool.
For the result display area, refer to the section on each locator tool.

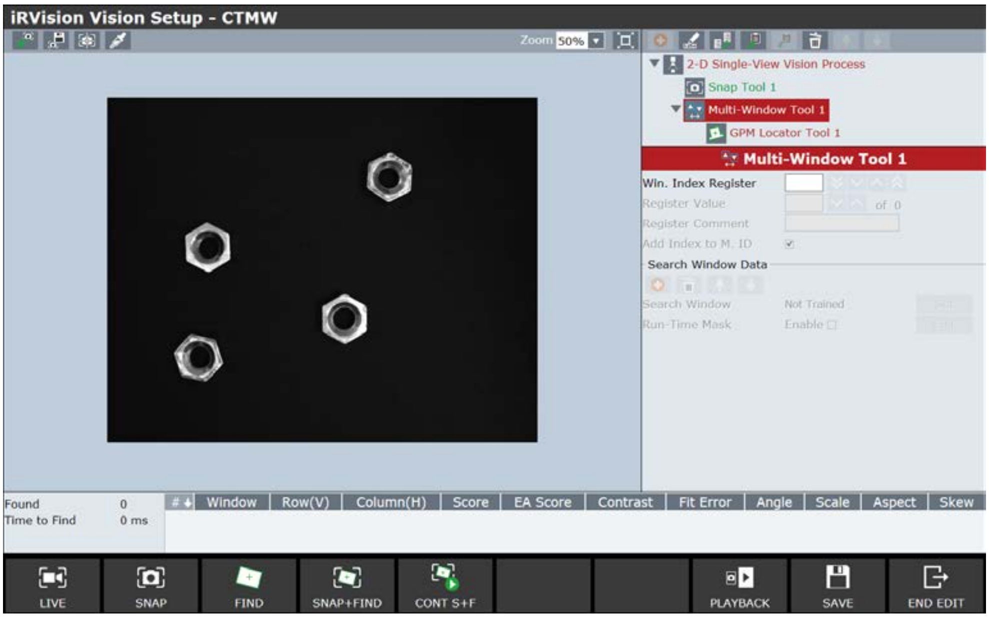
4.26.4 Overridable Parameters

This command tool does not have any parameters that can be re-written using vision override from a robot program during runtime.

4.27 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.



4.27.1 Setup Items

The multi-window tool has the following parameters.

[Win. Index Register]

Specify the number of the register you want to use to change the window. Input the value or change the value using buttons.

[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. When [0] is specified in [Register Value], detection will be executed for all windows. You can correspond the found result and the windows by using along with [Add Index to M. ID] mentioned below.

[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.

4.27.2 Setting a Search Window

Set a search window.

Here, the following parameter is set.

[Search Window]

Specify the range of the area of the image to be searched.
To change the search window, click the [Set] button. When a rectangle appears on the image, change the search window. For detailed information about the operation method, refer to "Setup: 1.8.8 Window Setup".

Add Search Windows

1 In the setup item area, click button.
A full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.
2 Enclose the search area within the displayed window, and click [OK].
The search window is set.
For the operation method for the window, refer to "Setup: 1.8.8 Window Setup".

Delete Search Windows

1 Click the window to be deleted in the information list view of the search window.
2 Click button.
The window is deleted.

Change the order of Search Windows

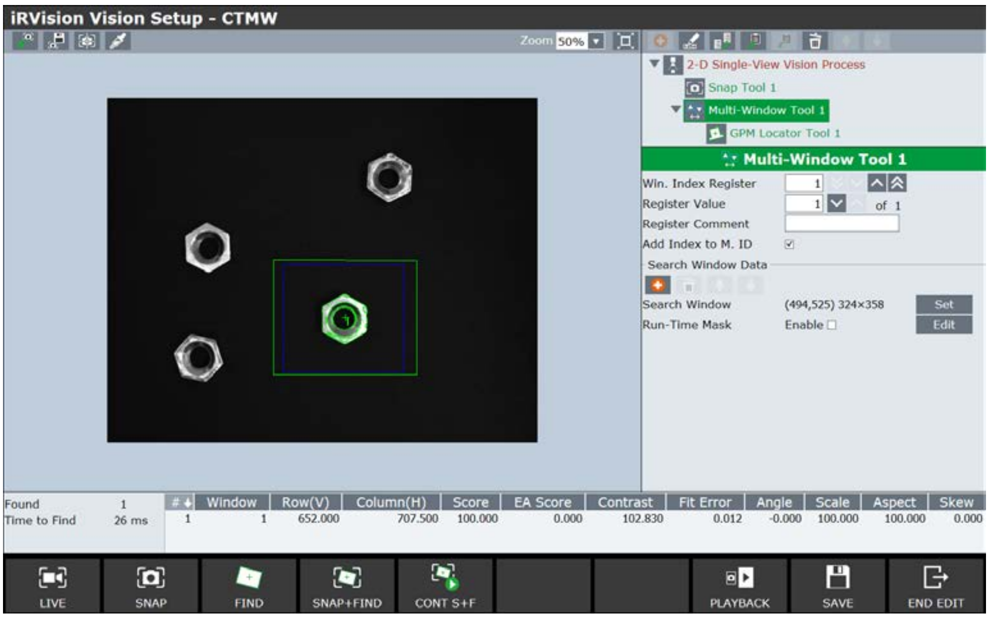
1 Click the window to be moved in the information list view of the search window.
2 Click or button to change the order.

[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, click the [Edit] button. For detailed information about the operation method, refer to "Setup: 1.8.13 Editing Masks".

4.27.3 Running a Test

Click [FIND] to run a test and see if the tool can find workpieces properly.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the location process took is displayed in milliseconds.

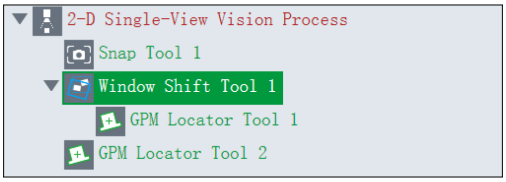
The results displayed in the result display area list view differ depending on the setting of child tool allocated for the multi-window tool.
For the result display area, refer to the section on each tool.

4.27.4 Overridable Parameters

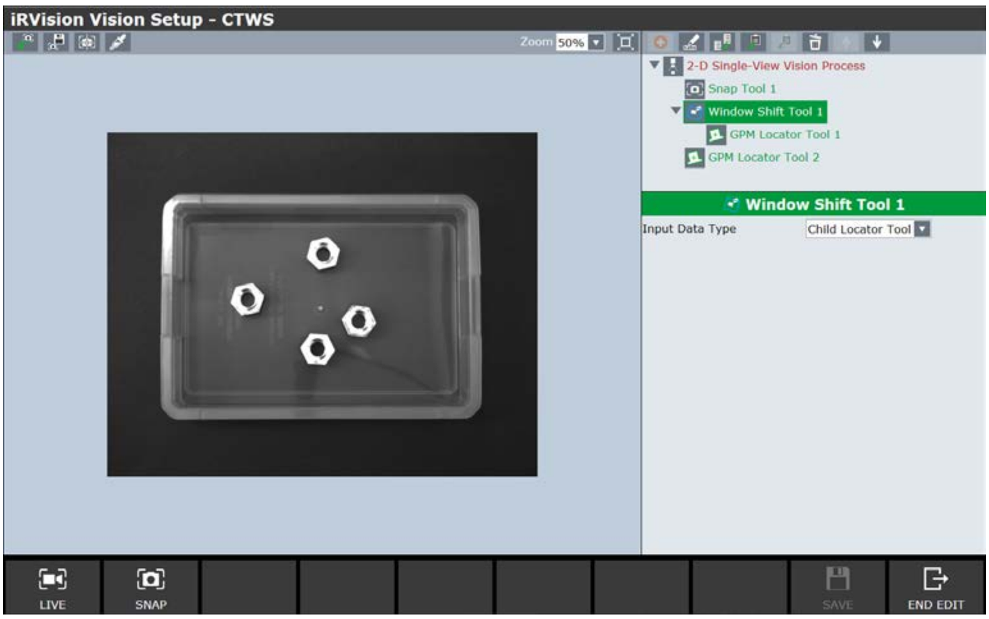
This command tool has no overridable parameters that can be overridden with Vision Override.

4.28 WINDOW SHIFT TOOL

The window shift tool dynamically shifts the windows of locator tools or measurement tools based on the result of a locator tool or another vision process. For example, when you use an application that retrieves workpieces from a container or rack, you may set the tool to shift the search window of the locator tool based on the position of the container or rack, thereby preventing objects outside the container or rack from being found inadvertently.
The window shift tool is allocated right under the vision process and behind the Snap Tool and command tools for image preprocessing (Image Filter Tool, etc.). The windows of the locator tools and measurement tools that are at the same level and that are inserted below this 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.



4.28.1 Setup Items

The window shift tool has the following parameters.

[Input Data Type]

Select the type of data to be used from the drop-down box.

[Child Locator Tool]

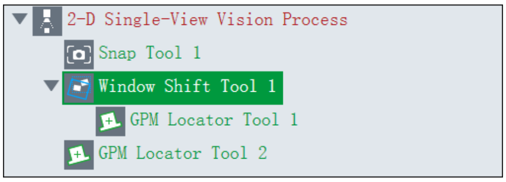
A locator tool is placed as a child tool of the window shift tool, which in turn shifts windows based on the found results of that locator tool. Use this mode when the locator tool can find the container and the workpieces in the same field of view.

[Other VP Result]

The tool shifts windows based on the value of the vision register that has the found result of a vision process different from the one in edit stored. For example, when a vision process for detecting a container is prepared aside from the vision process for detecting a workpiece, the tool shifts windows based on the value of the vision register that has the found result of the vision process for detecting a container stored. Use this mode when you want to use different exposure times when finding the container then when finding the workpieces in it.
In cases where the position of the container 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 container only when the container is replaced.

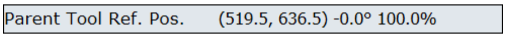
4.28.1.1 Shifting windows based on a locator tool's results

When windows are shifted based on the found results of a locator tool, the only parameter to set is the [Input Data Type], 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).



4.28.1.2 Shifting windows based on another vision process' results

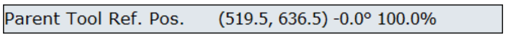
When shifting windows based on another vision process' results, make the settings as follows.

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 container and the workpieces are calibrated to the same [Application User Frame].

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).



> ⚠ **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 container, the tool cannot shift the window properly. Run the vision process for finding the container to make sure that the latest information about the container 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.

4.28.2 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.

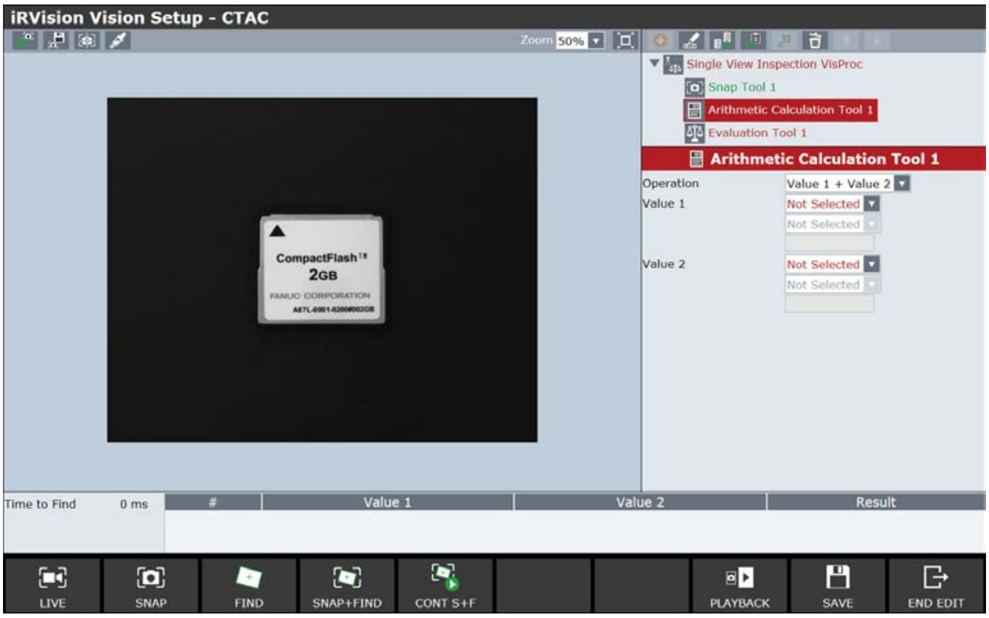
4.28.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.29 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 calculated result may be used to determine in the conditional execution tool and stored in the robot register in the measurement output tool.

When you select [Arithmetic Calculation Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.29.1 Setup Items

The arithmetic calculation tool has the following parameters.

[Operation]

Select what kind of calculation is to be performed, by using [Value 1] and [Value 2] from the drop-down box.

[Value 1 + Value 2]
Add Value 1 and Value 2.

[Value 1 - Value 2]
Subtract Value 2 from Value 1.

[Value 1 * Value 2]
Multiply Value 1 and Value 2.

[Value 1 / Value 2]
Divide Value 1 by Value 2.

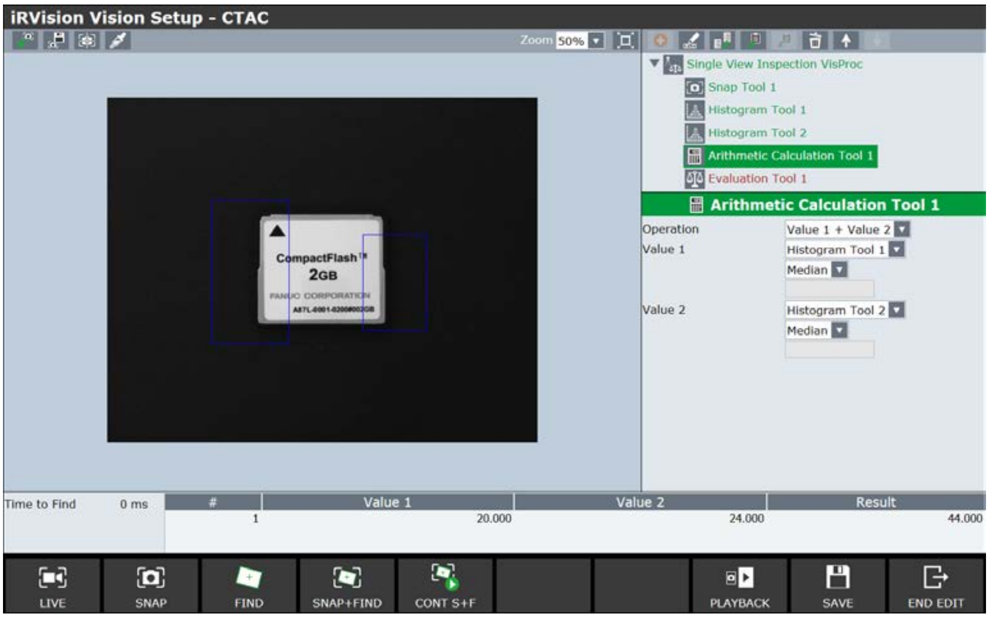
[Value 1 Mod Value 2]
The operator Mod calculates the residue. Value 1 Mod Value 2 calculates the residue of Value 1 divided by Value 2. The residue can be a decimal fraction. When Value 1 is a negative value, the result of a calculation is also a negative value. The sign of the Value 2 is ignored.

[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.

4.29.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the arithmetic calculation tool process took is displayed. The units are milliseconds.

Also, in the result display area list view, 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.

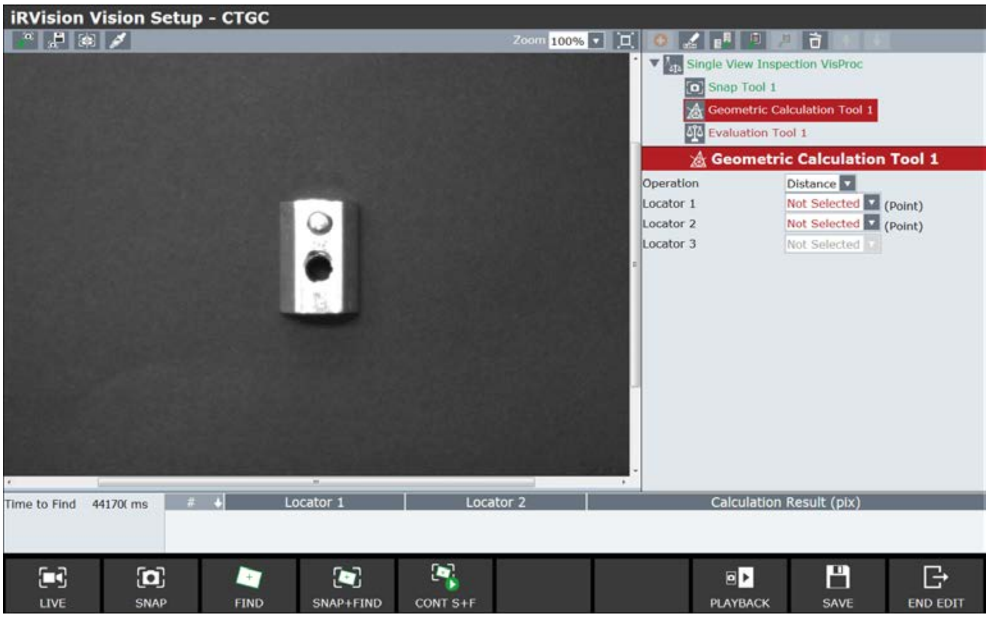
4.29.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.30 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 calculated result may be used to determine in the conditional execution tool and stored in the robot register in the measurement output tool.

When you select [Geometric Calculation Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.30.1 Setup Items

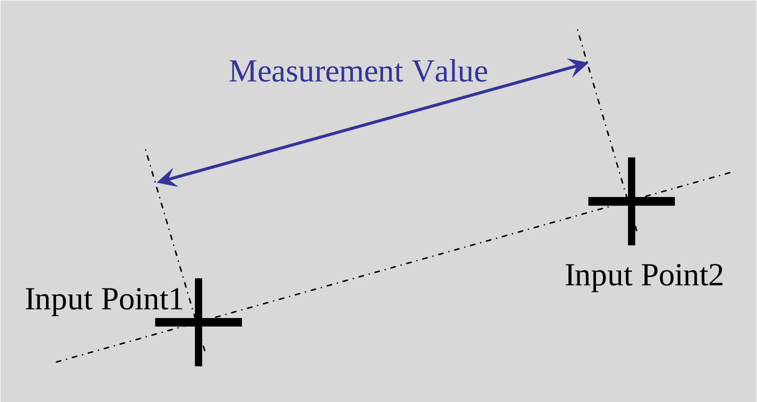
The geometric calculation tool has the following parameters.

[Operation]

Select the contents of the geometric calculation to be performed from the drop-down box. One of the following can be selected:

[Distance]

Considering the points found by [Locator 1] and [Locator 2] as the input point 1 and 2 individually, the geometric calculation tool calculates the distance between the two points.

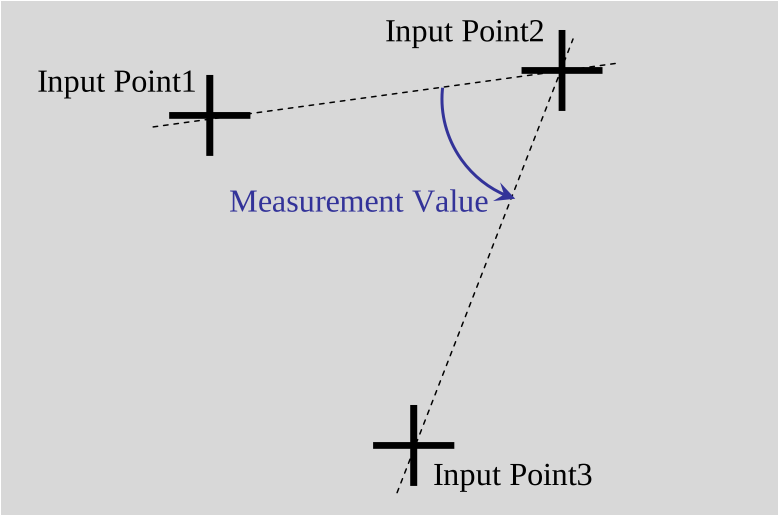


Distance

The resulting value is in pixels by default, but in mm if [Measurements in mm] in the vision process is checked.

[3-Point Angle]

Considering the points found by [Locator 1], [Locator 2] and [Locator 3] as the input point 1, 2 and 3 individually, the geometric calculation tool calculates the angle generated by the three points, as shown in the figure below.



3-Point Angle

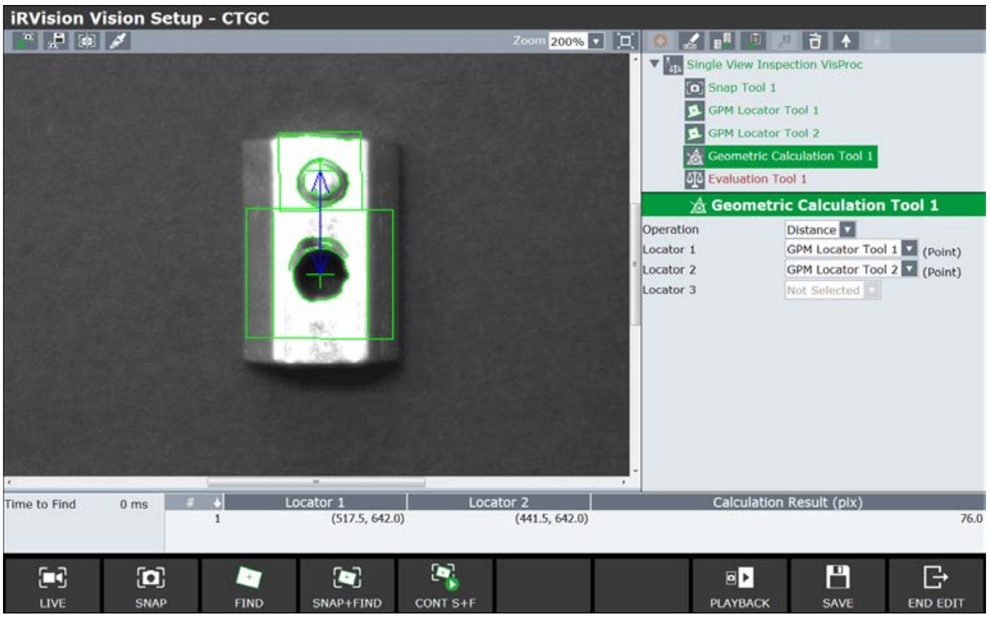
The resulting value is in degrees. When the input point 3 is on the right of the line passing from the input point 1 to the input point 2, the resulting value is a positive value. Otherwise, it is a negative value.

[Locater 1] ~ [Locator 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].

4.30.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Time to Find]
The time the geometric calculation tool process took is displayed. The units are milliseconds.

Also, in the result display area list view, the following values are displayed.

[Locater 1] ~ [Locator 3]
The positions used for the calculation are displayed. The unit is the pixel.

[Calculation Result]
The values used for the calculation are displayed.

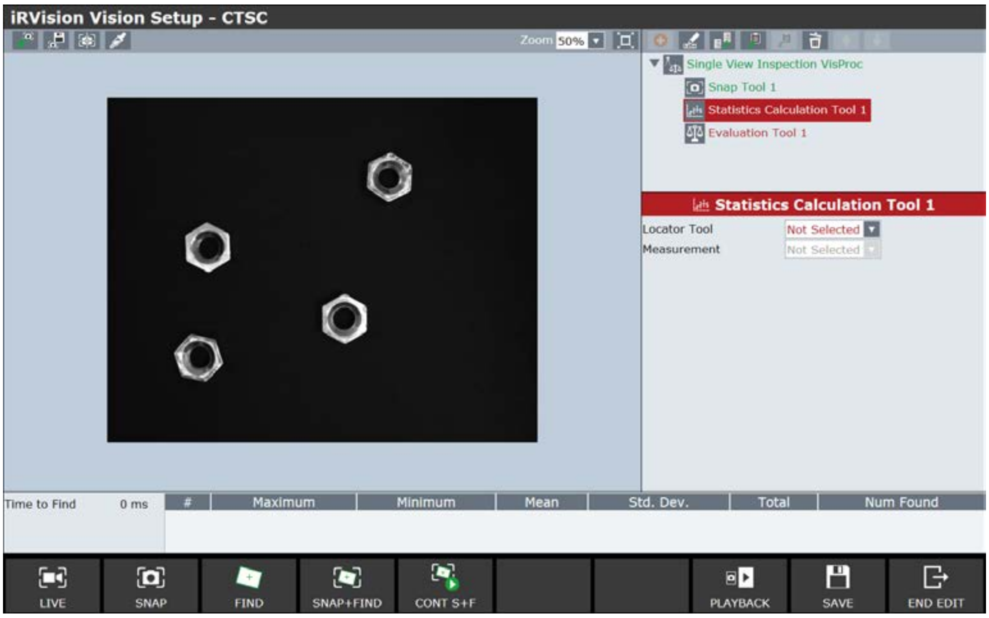
4.30.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.31 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 six blobs, it can calculate the average area or standard deviation of the six blobs. The calculated result may be used to determine in the conditional execution tool and stored in the robot register in the measurement output tool.

When you select [Statistics Calculation Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.31.1 Setup Items

Set the following parameters in the statistics calculation tool.

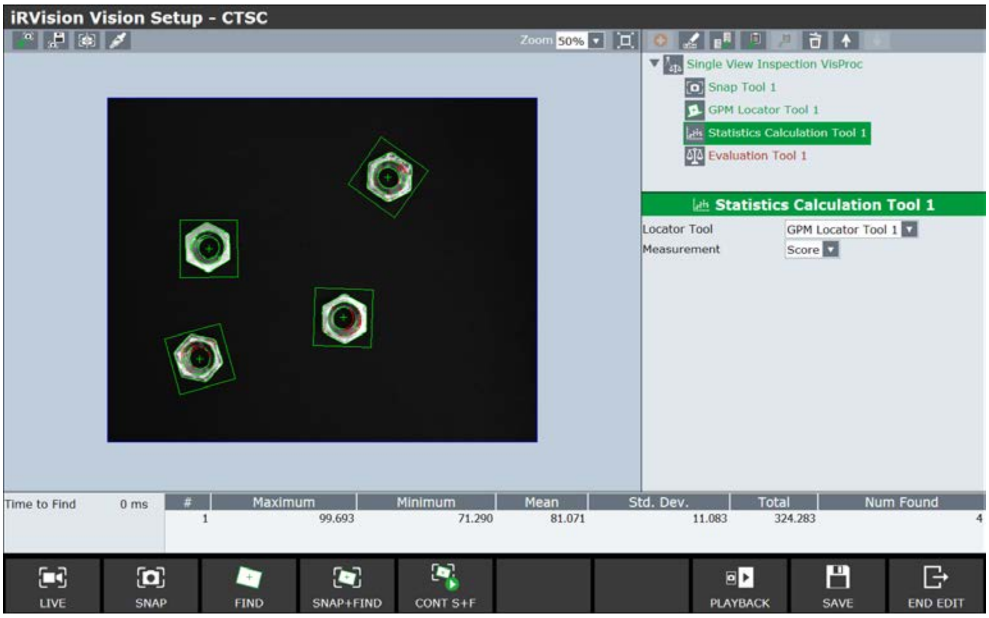
[Locator Tool]
Select the locator tool name for obtaining measurement values from the drop-down box. Only a locator at the same level and above the statistical calculation tool can be selected.

[Measurement]

Select the measurement value for calculating the statistics from the drop-down box. The choices depend on the locator tools selected in [locator tool].

4.31.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing test on the statistics calculation tool, the following items are displayed in the result display area.

[Time to Find]

The time the statistics calculation tool process took is displayed. The units are milliseconds.

Also, in the result display area list view, 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.

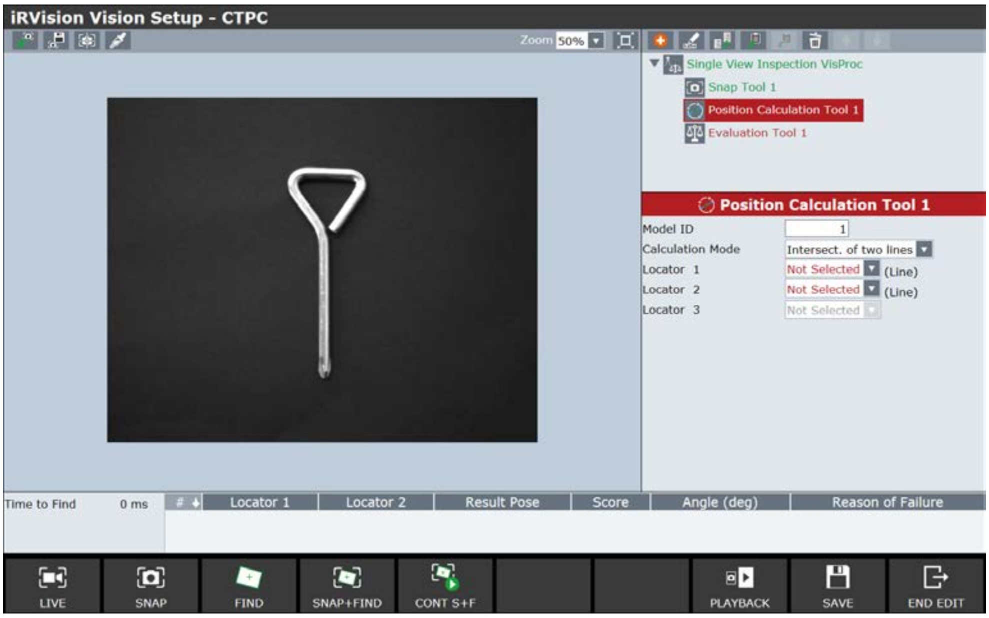
4.31.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.32 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.

When you select [Position Calculation Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.32.1 Setup Items

The position calculation tool has the following parameters.

[Model ID]

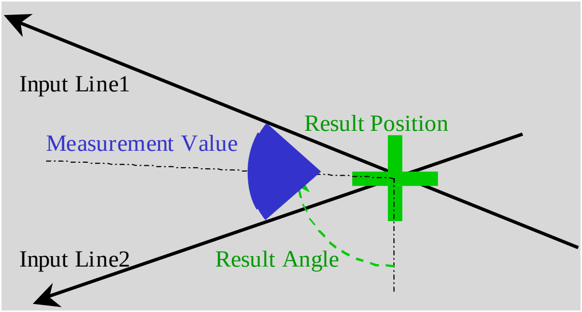
When you have taught two or more position calculation tools and want to identify which tool was used to calculate the position, assign a distinct model ID to each tool. The model ID of the tool, which calculated the positions, is reported to the robot controller along with offset data. This enables a robot program to identify the type of the calculated position.

[Calculation Mode]

Select the contents of the position calculation to be performed from the drop-down box. According to [Calculation Mode], locator tools that you can select from the drop-down boxes of [Locator 1] to [Locator 3] are 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.

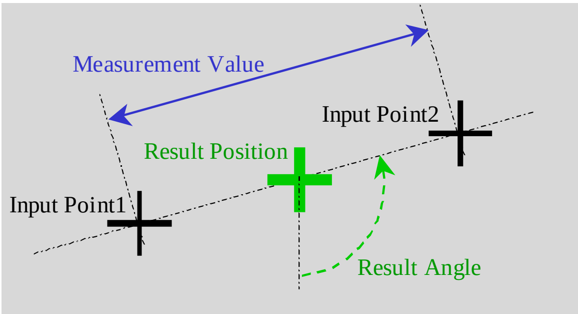


Position of the Intersection of two lines

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.

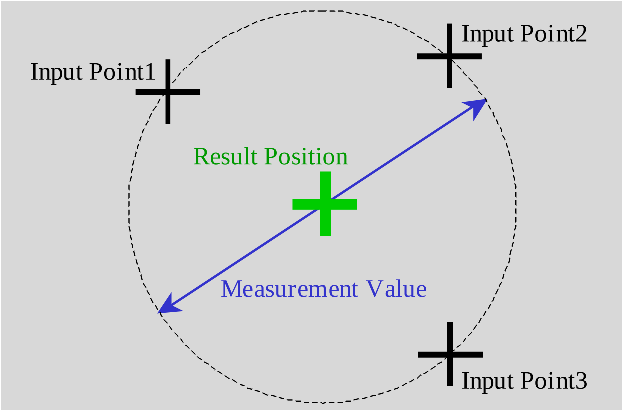


Position of the Midpoint of two points

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 pixel by default, but in mm if [Measurements in mm] in the vision process is checked.
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]

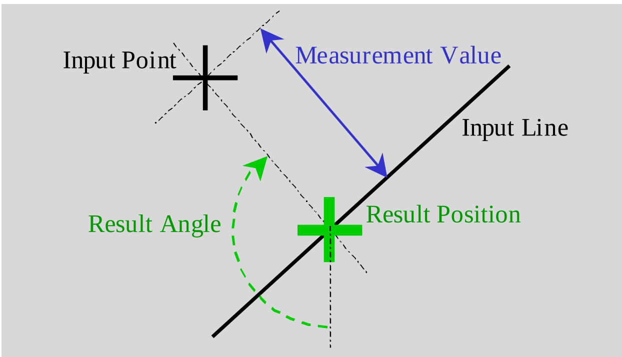
A center of a circle that passes through three input points is calculated from three input points.



Position of the center of a circle that passes through three 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 pixel by default, but in mm if [Measurements in mm] in the vision process is checked.
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 a perpendicular]
A foot of perpendicular which drops down from a point to a line is calculated from an input point and an input line.

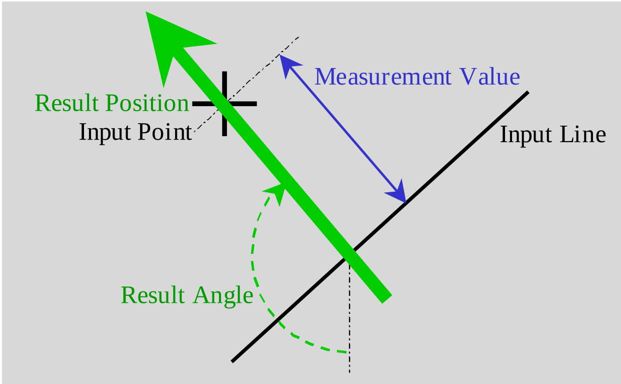


Position of the Foot of Perpendicular

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 pixel by default, but in mm if [Measurements in mm] in the vision process is checked.
If [Foot of a 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 a 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.



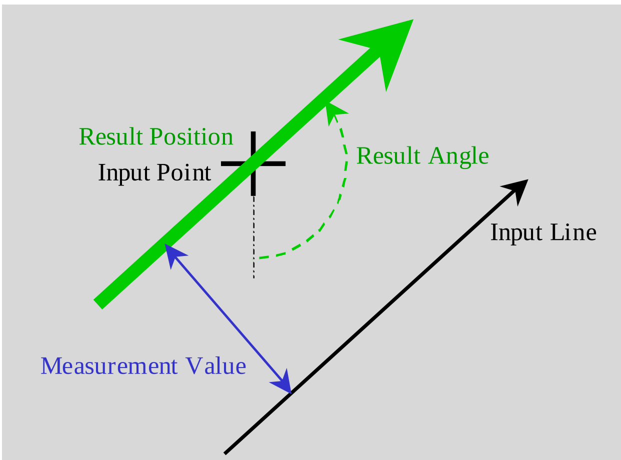
Perpendicular line to an input line

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 pixel by default, but in mm if [Measurements in mm] in the vision process is checked.

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.

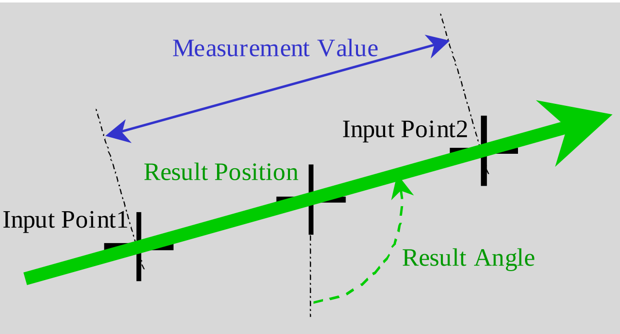


Parallel line to an input line

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 pixel by default, but in mm if [Measurements in mm] in the vision process is checked.
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.



Line through two points

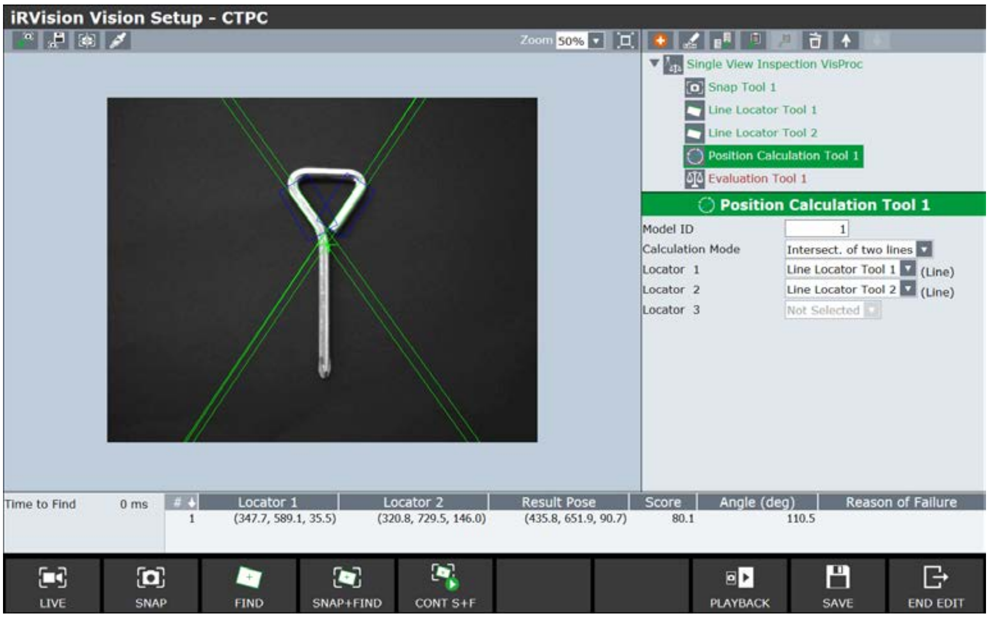
The middle point of two input points is used as a point on the line. The result angle is the direction from the input point 1 to the input point 2. In addition, the distance between two points is calculated as its measurement value. The measurement value is in pixel by default, but in mm if [Measurements in mm] in the vision process is checked.
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.

[Locater 1] ~ [Locator 3]

Select the locator tool to be used for calculation from the drop-down box. Parent tool or preceding locator tools that are at the same level as this tool 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].

4.32.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the position calculation tool process took is displayed. The units are milliseconds.

Also, in the result display area list view, the following values are displayed.

[Locater 1] ~ [Locator 3]

The input positions and angles to the position calculation tool are displayed. The positions are in pixels, and the angle is in degrees. Only when [Center of circle] is selected for [Calculation mode], the column of [Locator 3] is displayed.

[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].

[Angle]

This is displayed when [Intersect. of two line] is selected for [Calculation Mode]. The units are degrees.

[Distance]

This is displayed when [Midpoint of two points] or [Line through two points] is selected for [Calculation Mode]. The units are pixels or mm.

[Diameter]

This is displayed when [Center of circle] is selected for [Calculation Mode]. The units are pixels or mm.

[Perpendicular Distance]

This is displayed when [Foot of a perpendicular], [Perpendicular line], [Parallel line] is selected for [Calculation Mode]. The units are pixels or mm.

Popup alarm display 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.

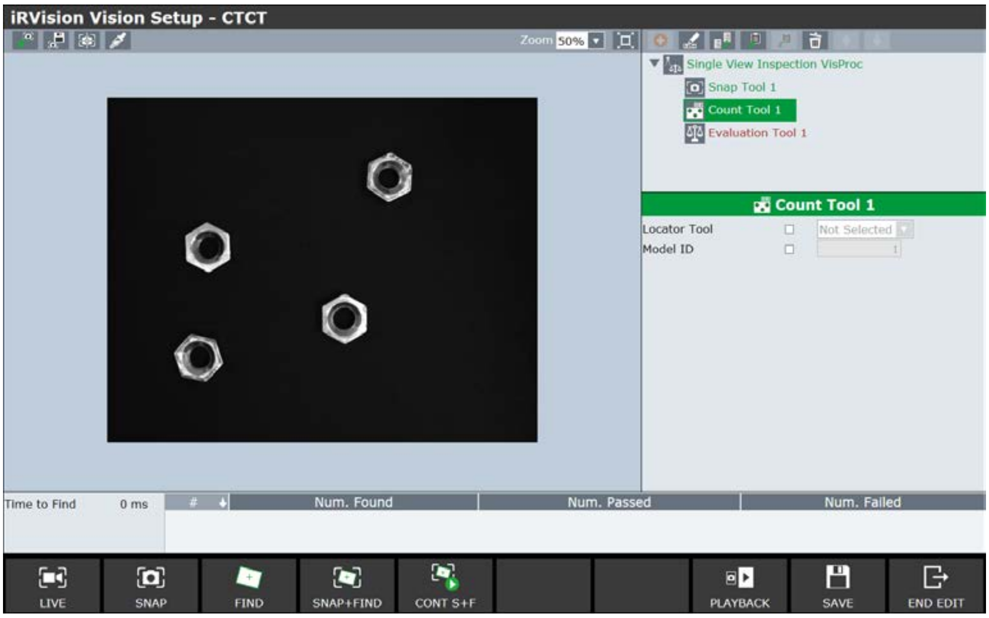
4.32.3 Overridable Parameters

This command tool does not have any parameters that can be re-written using vision override from a robot program during runtime.

4.33 COUNT TOOL

The count tool counts the number of targets found by locator tools that are at the same level as the count tool. In addition, it can also count the number of found targets having a specific model ID. The counted result may be used to determine in the conditional execution tool and stored in the robot register in the measurement output tool.

When you select [Count Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.33.1 Setup Items

The count tool has the following parameters.

[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 from the drop-down box, 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]

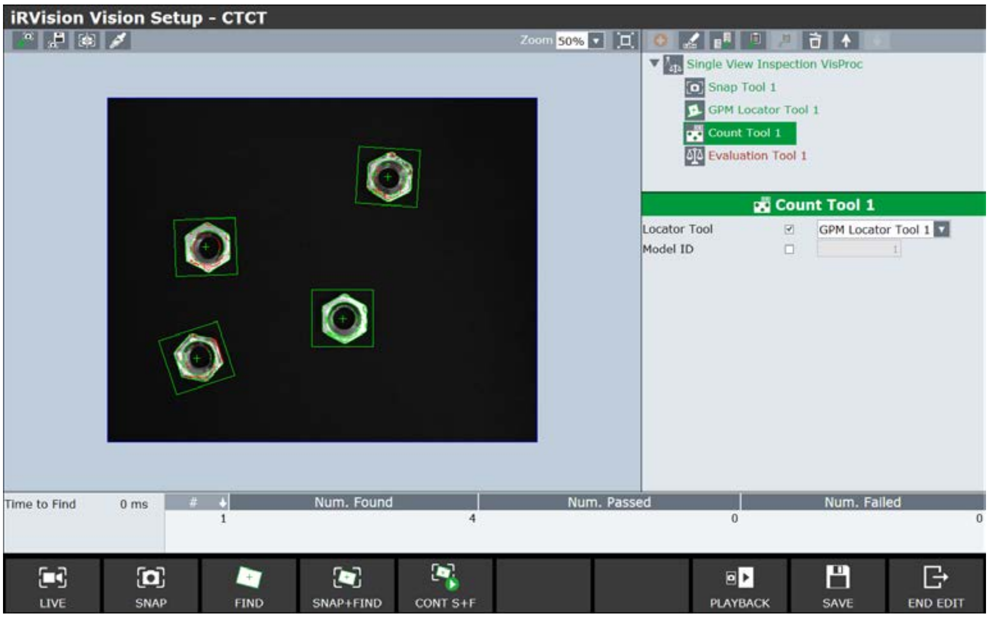
Specify this item when you want to count the number of found results having a specific model ID. If you check the box and specify a model ID, the count tool counts the number of found results having that specified model ID. If you leave the box unchecked, the count tool counts the total number of found results, irrespective of the model ID.

MEMO

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.

4.33.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The time the count tool process took is displayed. The units are milliseconds.

Also, in the result display area list view, the following values are displayed.

[Num. Found]

Number of targets found.

[Num. Passed]

Number of targets that the evaluation tool judged as [OK]. This is shown only for a single-view inspection vision process.

[Num. Failed]

Number of targets that the evaluation tool judged as [Fail]. This is shown only for a single-view inspection vision process.

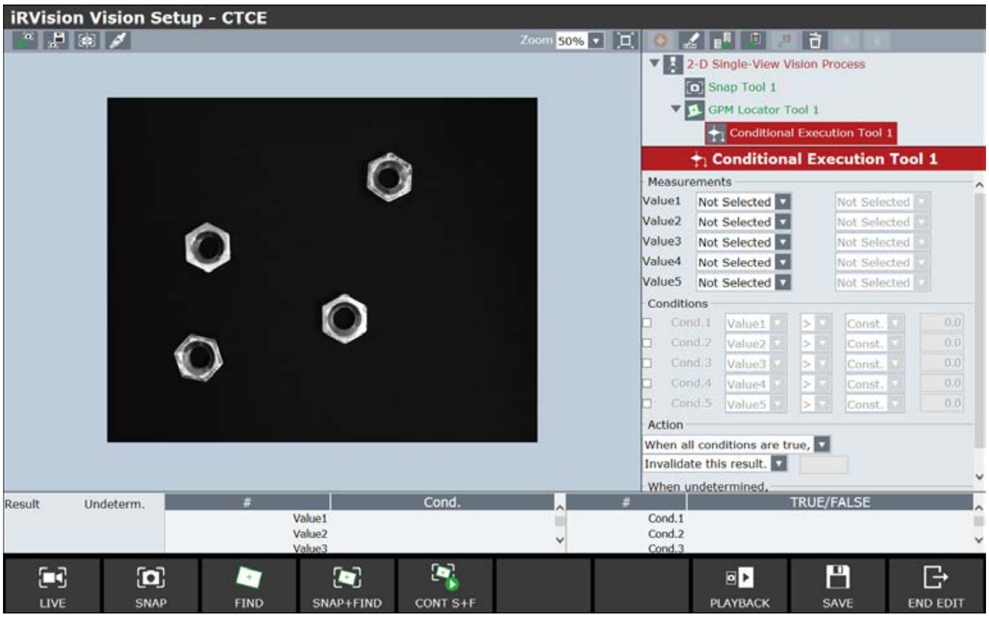
4.33.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.34 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.

When you select [Conditional Execution Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.34.1 Setup Items

The conditional execution tool has the following parameters.

[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.
  The parent tool or preceding command tools that are at the same level as this tool can be selected.
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].
  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.
From the top drop-down box, select the logic to be used for process.

[When all conditions are true,]
  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.]

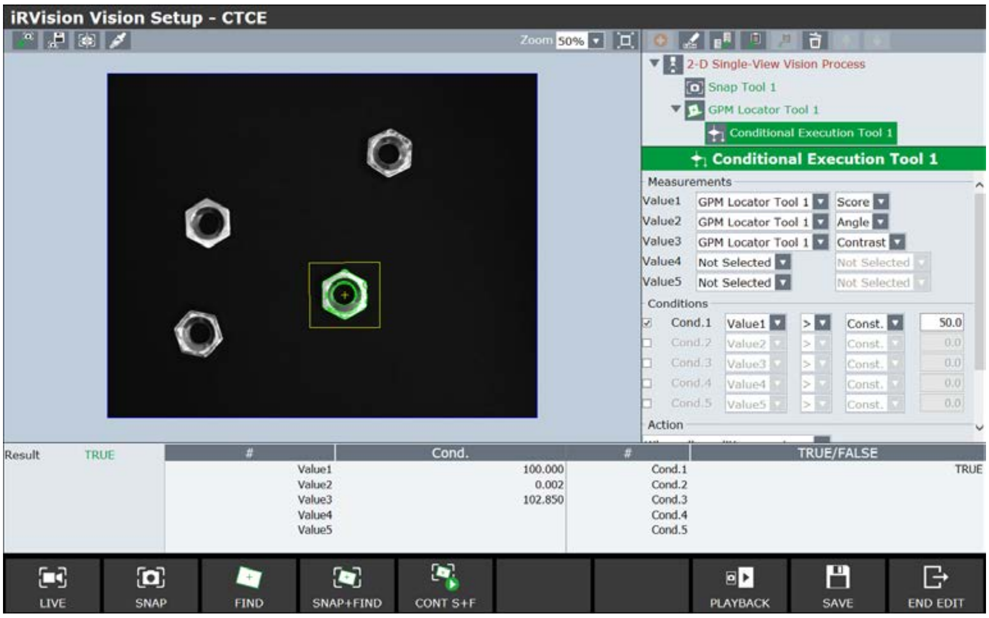
Invalidate this position.

[Add the following value to model ID:]

Add the specified value to the model ID.

4.34.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[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.

Also, in the result display area list view, the following values are displayed.

[Cond.]

The measurement values [Value 1] ~ [Value 5] are displayed.

[TRUE / FALSE]

The results of true/false for [Condition 1] ~ [Condition 5] are displayed.

4.34.3 Overridable Parameters

This command tool has the following overridable parameters that can be overridden with Vision Override. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE" for details.

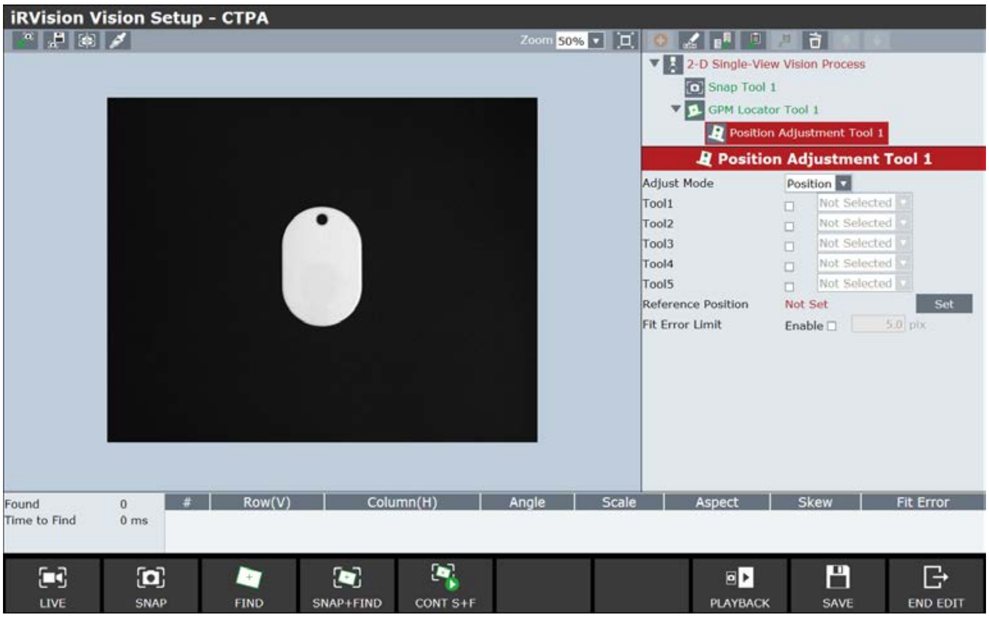
[Constant 1 – 5]

Specify a number between -9999.999 and 9999.999.

4.35 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.

When you select [Position Adjustment Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.35.1 Setup Items

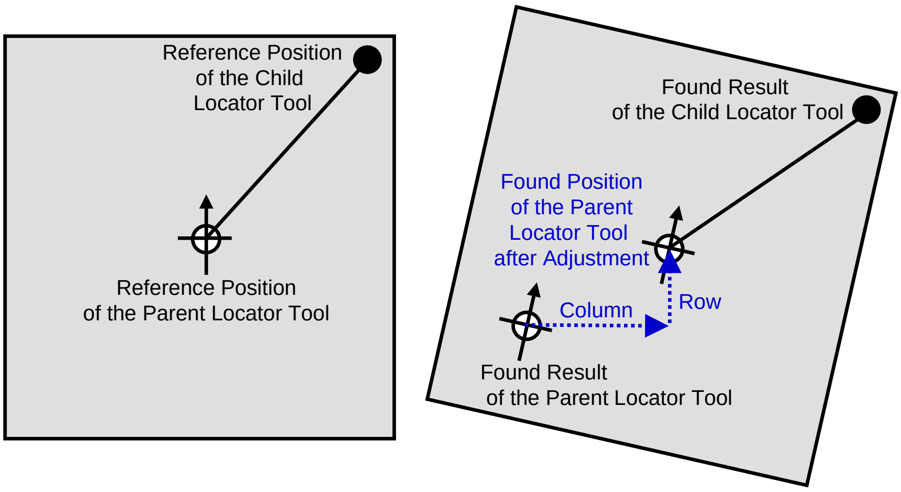
The position adjustment tool has the following parameters.

[Adjust Mode]

Select the type to be adjusted in the position data from the drop-down box.

[Position]

Found position (Row and Column) of the parent locator tool are adjusted.

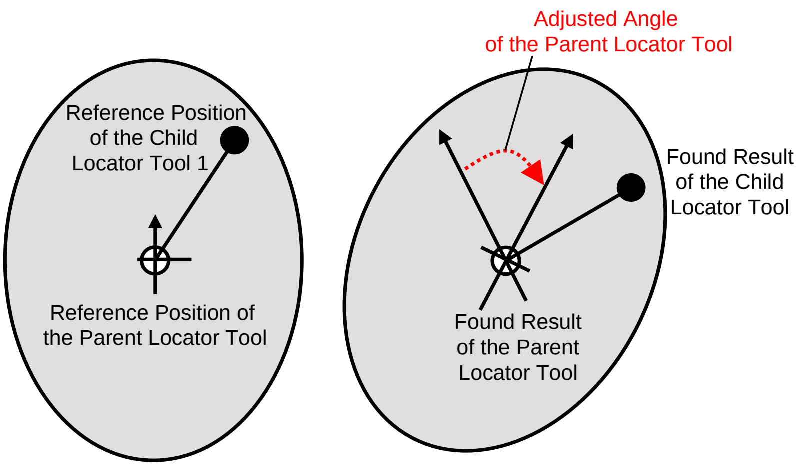


Adjusting the found position of the parent locator tool

Found position (Row and Column) of the parent locator tool is adjusted so that the relative position of the parent locator tool's result and the child locator tool's results becomes the same as the one trained as the reference position. The adjustment of Row is positive when adjusted to the underside, and the adjustment of Column is positive when adjusted to the right.

[Angle]

Found angle found of the parent locator tool is adjusted.

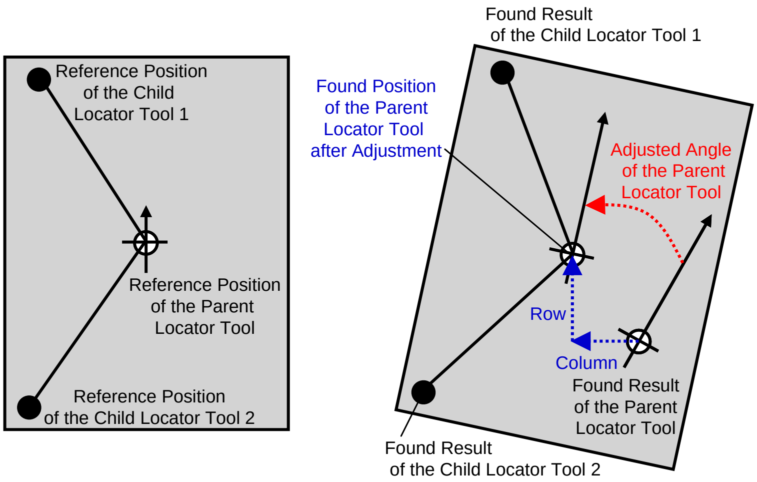


Adjusting the angle of the parent locator tool

Found angle of the parent locator tool is adjusted so that the relative position of the parent locator tool's result and the child locator tool's results becomes the same as the one trained as the reference position. The adjusted angle is positive when adjusted counterclockwise.

[Position and Angle]

Found position (Row and Column) and found angle of the parent locator tool is adjusted.



Adjusting the found position and angle of the parent locator tool

Found position (Row and Column) and found angle of the parent locator tool are adjusted so that the relative position of the parent locator tool's result and the child locator tool's result becomes the same as the one trained as the reference position. The adjustment of Row is positive when adjusted to the underside, and the adjustment of Column is positive when adjusted to the right. The adjusted angle is positive when adjusted counterclockwise.

⚠ **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.

[Tool 1] ~ [Tool 5]

Select the child locator tool to be used for position adjustment from the drop-down box. Preceding locator tools that are at the same level as this tool can be selected. Up to five tools can be specified.

[Ref. Pos. Status]

After selecting the locator tool to be used for adjustment, click the [Set] button to actually perform detection and set the reference position.

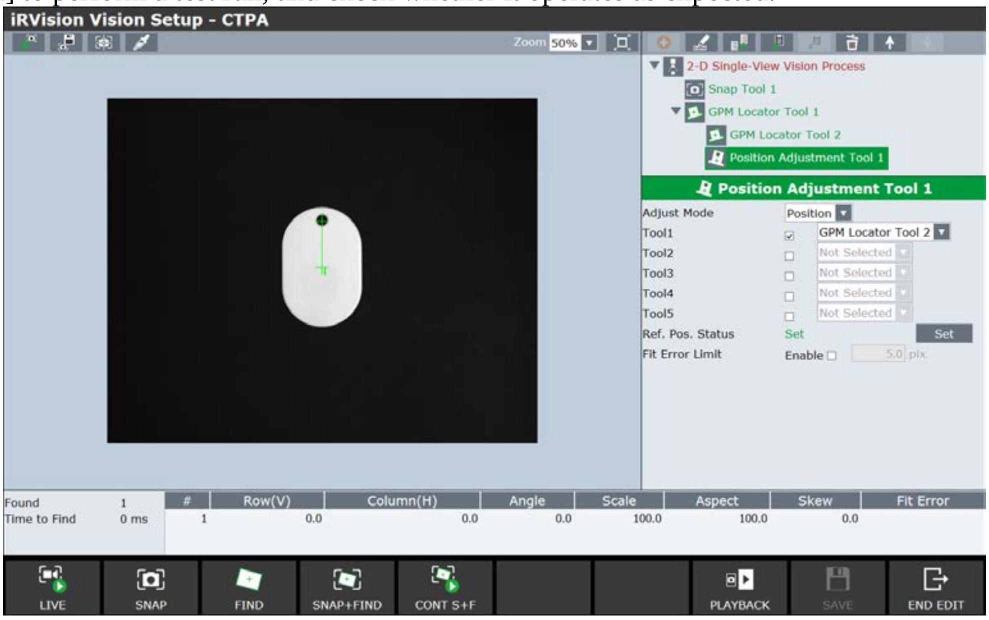
[Fit Error Limit]

Sets the threshold for the combine error between the position found by each locator tool when the reference position is set and the found position actually found when the detection process is executed. The units are pixels.

If the combine error exceeds this threshold, the workpiece is not found. When this check box is unchecked, the combine error is not checked.

4.35.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Found]

The number of found workpieces is displayed.

[Time to Find]

The time the location and position adjustment amount calculation processes took is displayed. The units are milliseconds. It does not include the time taken for loading images.

Also, in the result display area list view, the following values are displayed.

[Row(V)]

Adjustment amount in the virtual direction in the window (units: pixels).

[Column(H)]

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).

4.35.3 Overridable Parameters

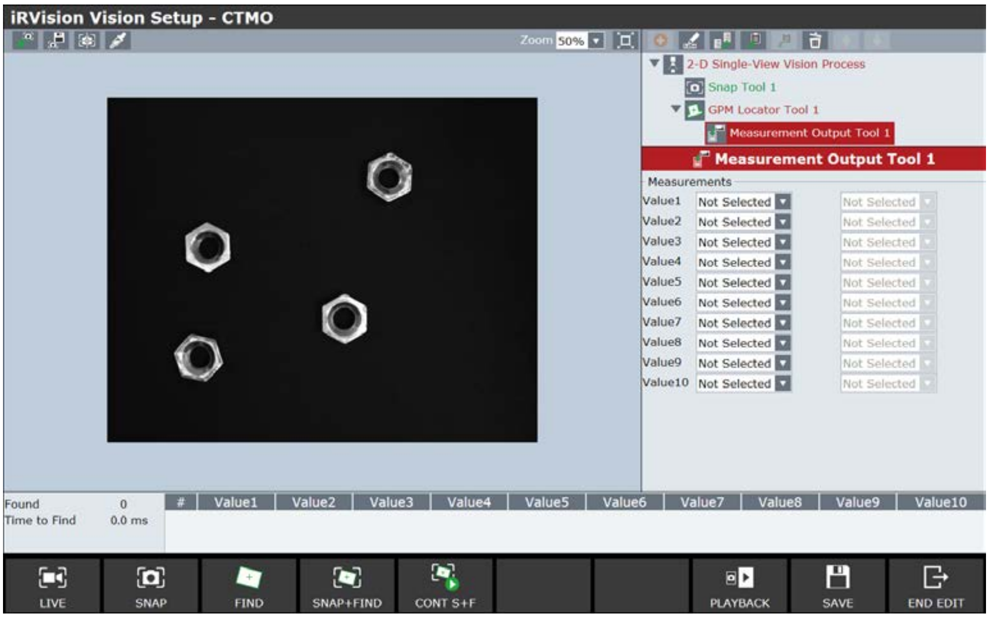
This command tool has no overridable parameters that can be overridden with Vision Override.

4.36 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 "Setup: 6.1 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.

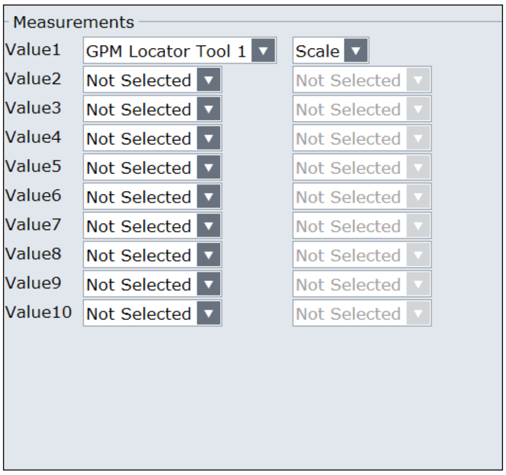


4.36.1 Setup Items

The measurement output tool has the following parameters.

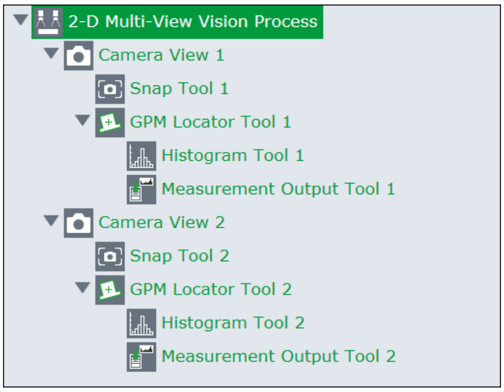
[Measurements]

Select values to be set in a vision register. Up to 10 values can be specified.



1 From the drop-down box on the left, select a tool.
The parent tool or preceding command tools that are at the same level as this tool can be selected.
2 From the drop-down box on the right, select a measurement value.

For a vision process such as “2D 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.



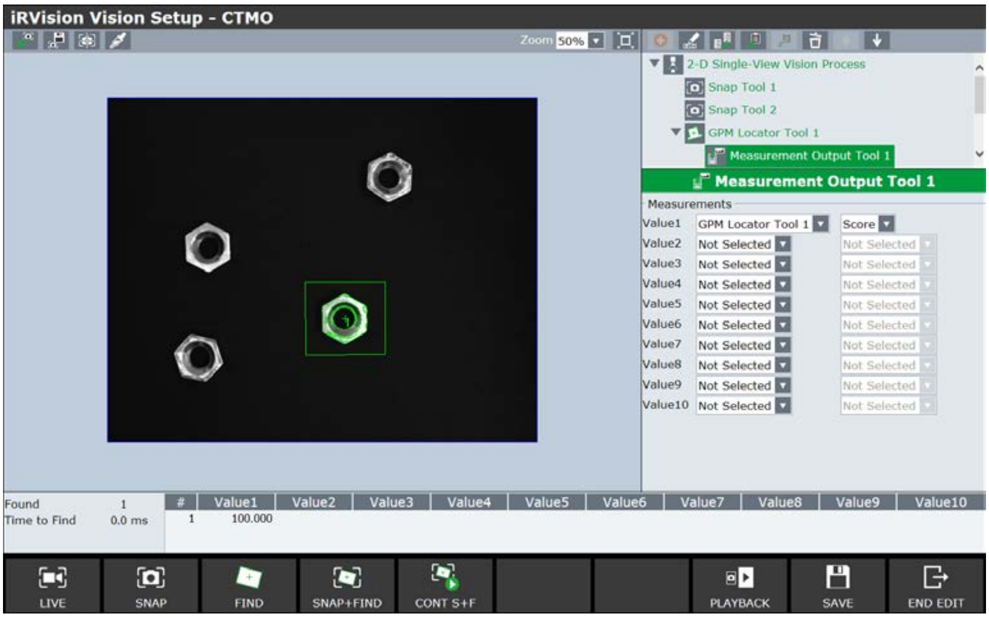
In this case, the values from Measurement Output Tool 1 and Measurement Output Tool 2 are output to the vision register. For example, when [Value 1] to [Value 5] are specified in the Measurement Output Tool 1 and [Value 6] to [Value 10] are specified in the Measurement Output Tool 2, the measurement 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.

4.36.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Found]
The number of found workpieces is displayed. The units are pieces.

[Time to Find]
Displays that time that was taken to find. The units are milliseconds.

Also, in the result display area list view, the following values are displayed.

[Value 1] to [Value 10]
The measurement values are displayed.

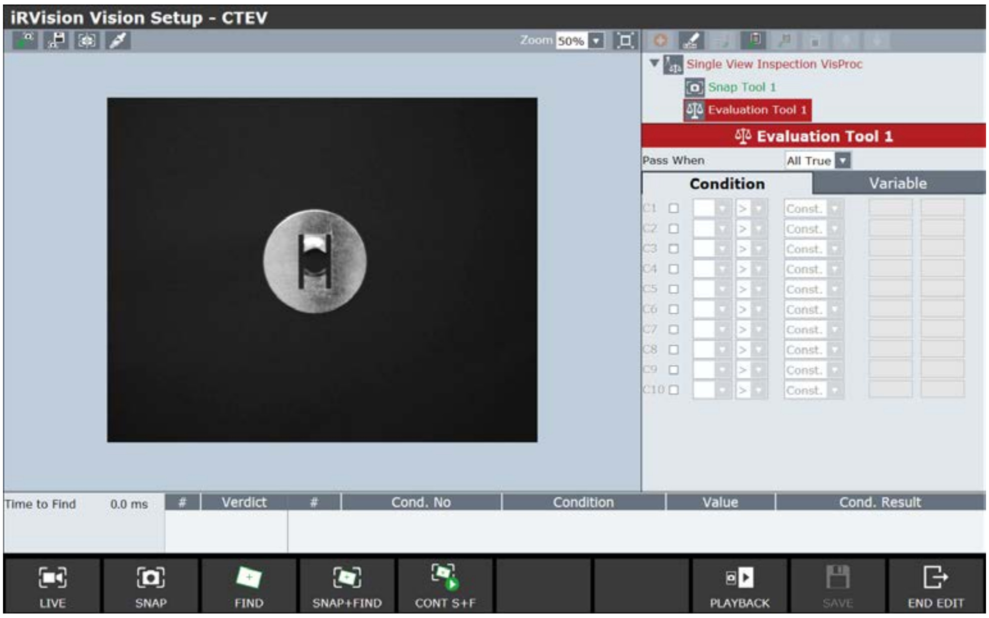
4.36.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.37 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.

When you select [Evaluation Tool] in the tree view of the vision process edit screen, the following screen will appear.

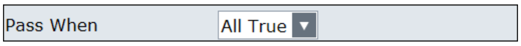


4.37.1 Setup Items

The evaluation tool has the following parameters.

[Pass When]

Select the 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 from the drop-down box.



[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]

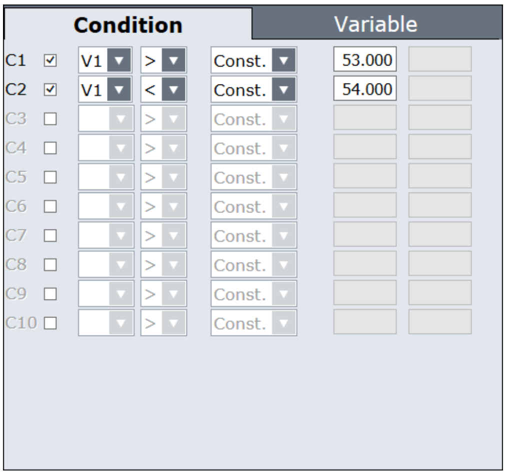
The workpiece is judged to have "passed" if any of the specified conditional expressions is "false" or to have "failed" if all the specified conditional expressions are "true". [Undetermined] is displayed if there are no "false" conditions and there is at least one condition that cannot be evaluated. 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.

[Condition 1] to [Condition 10]

Selecting the [Condition] tab displays a screen like the one shown below.
Set a conditional expression. Up to 10 conditional expressions can be specified.

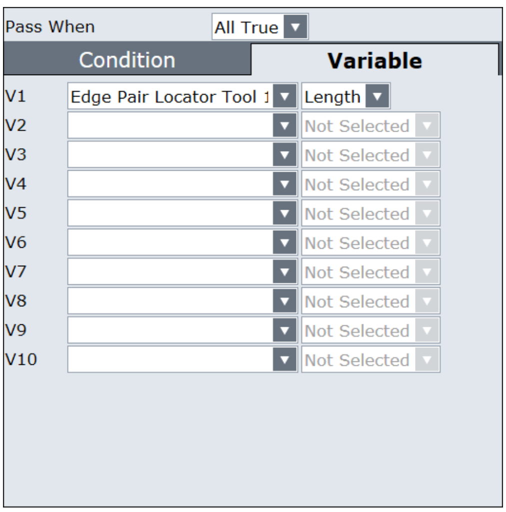


1 Enable the condition by checking the check box.
2 From the leftmost drop-down list, select the value to be evaluated, from the following:
- [Value 1] to [Value 10]
- Result of a conditional expression preceding this conditional expression

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:
- [Constant]
  If you select [Const], enter a constant value in the text box on the right side.
- [Value 1] to [Value 10]
- Result of a conditional expression preceding this conditional expression

[Value 1] to [Value 10]

Selecting 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.
The parent tool or preceding command tools that are at the same level as this tool can be selected.
2 From the drop-down box on the right, select a measurement value to be evaluated.

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”.

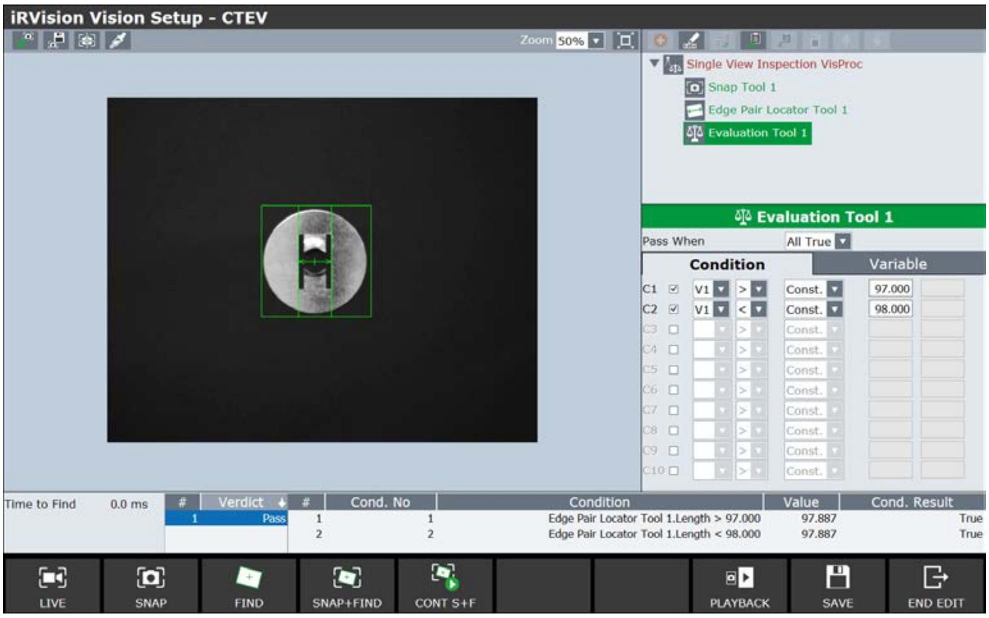
[AND]
The expression is “true” if both the evaluation target value and the comparison value are “true”; otherwise, it is “false”.

[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”.

4.37.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

Displays the time that was taken for evaluation. The units are milliseconds.

Also, in the result display area list view, the following values are displayed.

[Verdict]

The overall evaluation result of the evaluation tool is 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.

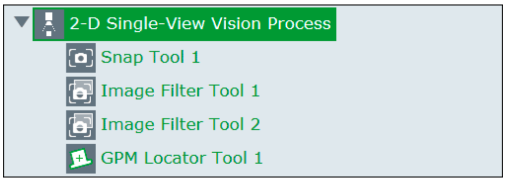
4.37.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4

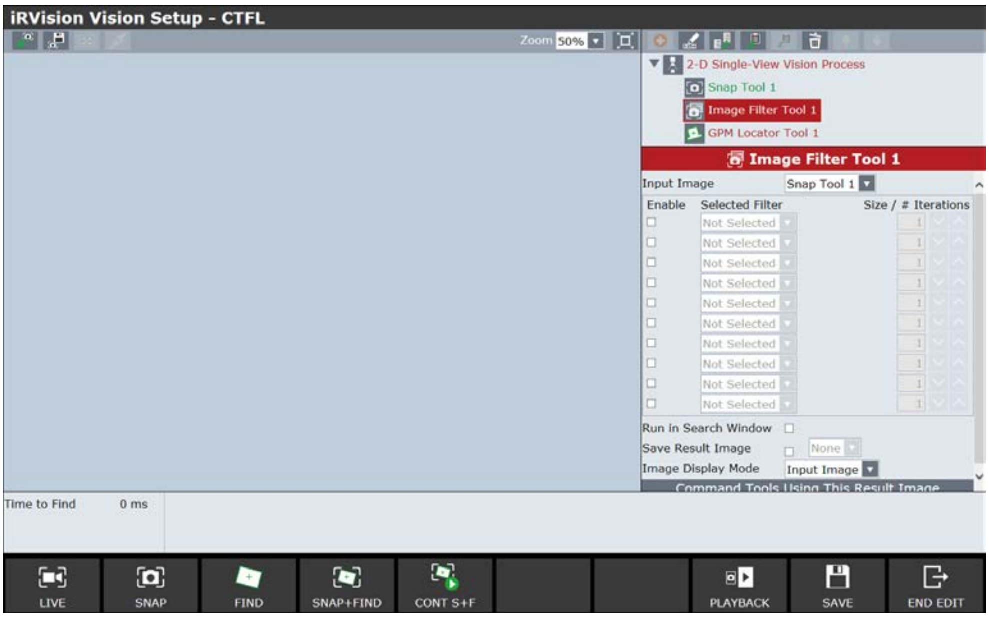
4.38 IMAGE FILTER TOOL

Image Filter Tool executes image processing (e.g., Blur and Sharpen and so on) with respect to the image which is snapped with the Snap Tool. Image Filter Tool is allocated right under the Snap Tool.
As shown in the following image, by adding several Image Filter Tools, several different filtered images can be used in each command tool.



To use the result image created by Image Filter Tool in a command tool, open the setup page of the command tool and then select the name of Image Filter Tool in the drop-down box of [Input Image].

When you select [Image Filter Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.38.1 Setup Items

The Image Filter Tool has the following parameters.

[Input Image]

Select an image to be filtered from the drop-down box.

[Snap Tool]

Select when an image snapped with the snap tool is used.
If there are multiple snap tools allocated, select the applicable snap tool name.

[Image Register]

Select when an image stored in the Image Register is used.
An image can be stored in an image register by executing an Image Filter Tool with [Save Result Image] being set, or by calling IRVSNAP from a TP program. When no image registers have been allocated, this option will not appear.

[Tool Name]

Select when a result image filtered by the specified tool is used.
The available tool is a command tool that performs preprocessing of an image preceding this tool and at the same level (Image Filter Tool, Color Extraction Tool, Color Component Tool Image Arithmetic Tool, Flat Field Tool or Image Shrink Tool).

Filter list

You can configure up to 10 image filters to run one after another.

[Enable]

The enabled filters will run in sequence. It is OK to have disabled filters in-between enabled filters.

[Selected Filter]

Select a filter to be used from the drop-down box. For the details of each filter, refer to "Setup: 4.38.4 Filters".

[Size / Iterations]

Set the filter size or the number of the iterations about the selected filter. For the details, refer to "Setup: 4.38.4 Filters".

[Run in Search Window]

By default, Image Filter Tool processes the entire image. But if this item is checked, Image Filter Tool processes only inside the search window of the command tools which use the result image. According to the number of found, processing only inside the search window may reduce the processing time of Image Filter Tool.

Note that Image Filter Tool processes inside the search window only in the following cases. In the other cases, Image Filter Tool processes the entire image even if the item is checked.

- When executing the vision process from a TP program
- When running a test on the setup page

[Save Result Image]

If this item is checked, the result image is stored in the selected image register. When there is no image register, an error message is displayed. For details of the image register, refer to "Setup: 6.2.1 IRVSNAP, IRVNFIND".

[Image Display Mode]

Select the image display mode for the Setup Page from the drop-down box.

[Input Image]

Images that are selected in [Input Image] will appear.

[Result Image]

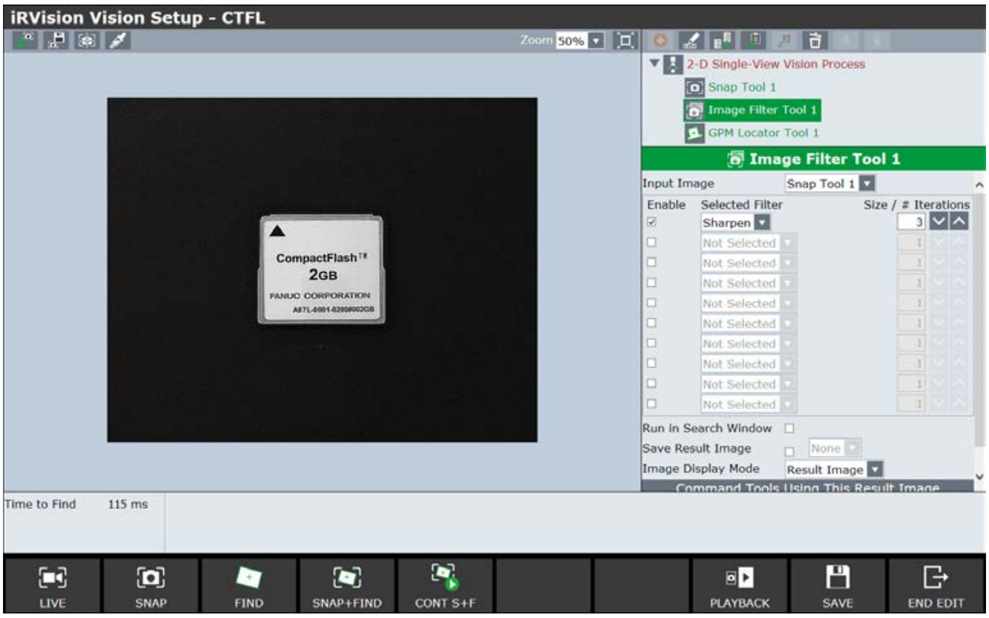
Display the result image.

[Command Tools Using This Result Image]

The name of command tools which use the result image of this Image Filter Tool is displayed. When this Image Filter Tool is changed, verify that these command tools still operate as intended.

4.38.2 Running a Test

Click [Find] to perform a test run, and check whether it operates as expected.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The processing time the Image Filter Tool took is displayed. The units are milliseconds.

4.38.3 Overridable Parameters

This command tool has no overridable parameters that can be overridden with Vision Override.

4.38.4 Filters

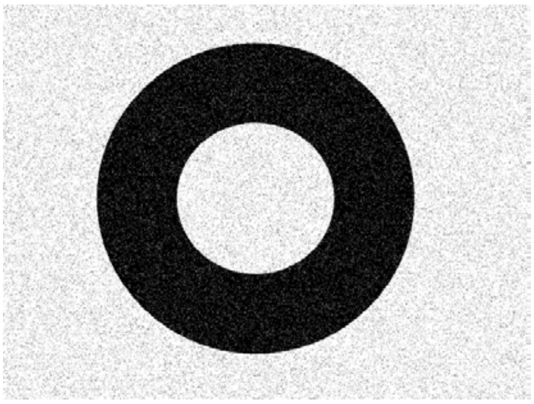
This section shows examples of how to use each type of filter.

[Blur]

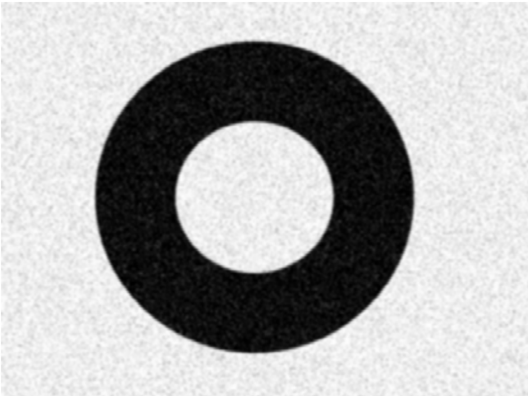
Blur filter can be used to smooth out fine surface texture or image noise. Blur filter is very similar to Gaussian Blur filter. Blur filter is suitable to process the whole image, and Gaussian Blur filter is suitable to remove the noise of the image.

[Size]

As the filter size of Blur filter becomes larger, the image is blurred stronger.



Input Image



Result Image (Blur with N=3)

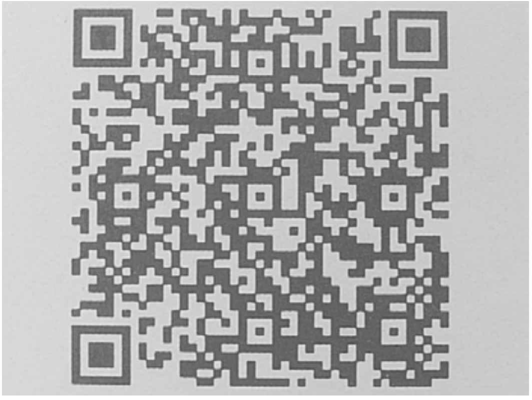
[Sharpen]

Sharpen filter can be used to enhance the contrast of the edges in the image. As a filter similar to Sharpen filter, you can use Gaussian Sharpen filter. When you give priority to processing time, Sharpen filter is suitable. And when you want to use the filter many times, Gaussian Sharpen filter is suitable.

[Size]

As the filter size of Sharpen filter becomes larger, the outlines become sharper.

Input Image



Result Image (Sharpen with N=1)

[Erode]

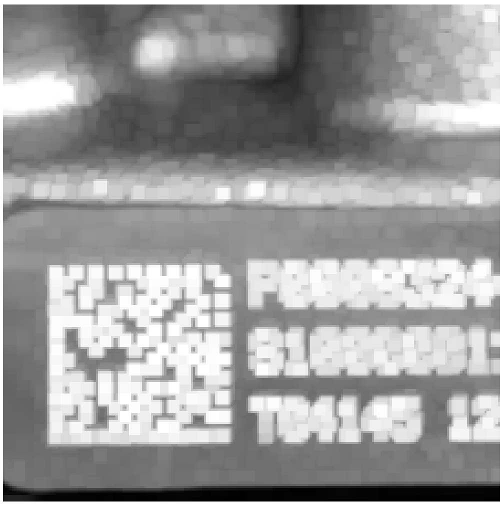
Erode filter can be used to expand the light areas and shrink the dark areas in the image.

[Iterations]

As the number of the iterations of Erode filter becomes larger, the dark areas in the image become smaller.

In the example below, Erode filter expands the white circles in Data Matrix code, so that the Data Matrix code can be read easily.

Input Result



Result Image (Erode with N=2)

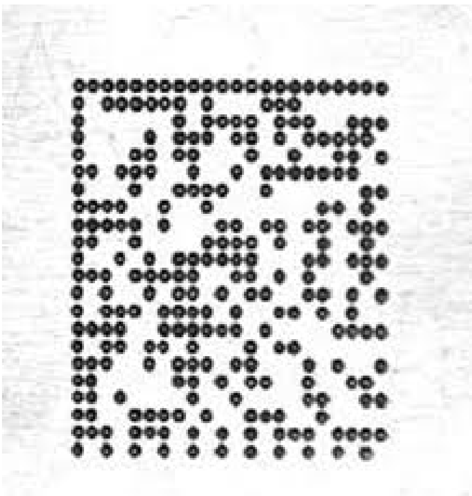
[Dilate]

Dilate filter is used to expand the dark areas and shrink the light areas in the image.

[Iterations]

As the number of the iterations of Dilate filter becomes larger, the dark areas in the image become larger.

In the example below, Dilate filter expands all of the black circles, so that Data Matrix code can be read easily.



Input Image

Result Image (Dilate with N=2)

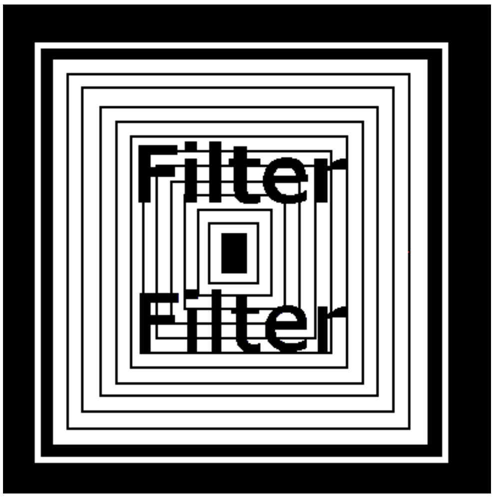
[Open]

Open filter performs Dilate filter after Erode filter. Open filter can erase the small dark area.

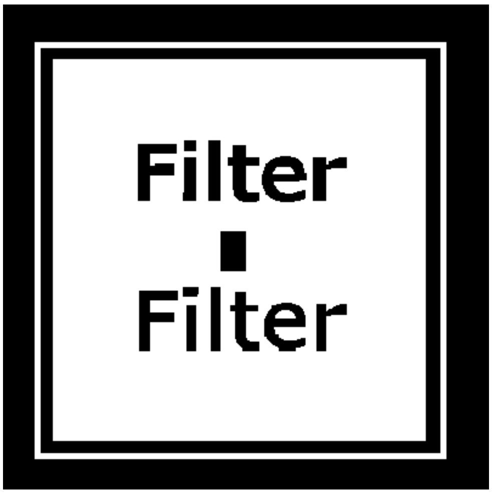
[Iterations]

As the number of the iterations of Open filter becomes larger, the larger dark areas in the image can be erased.

In the example below, Open filter erases thin dark lines.



Input Result



Result Image (Open with N=1)

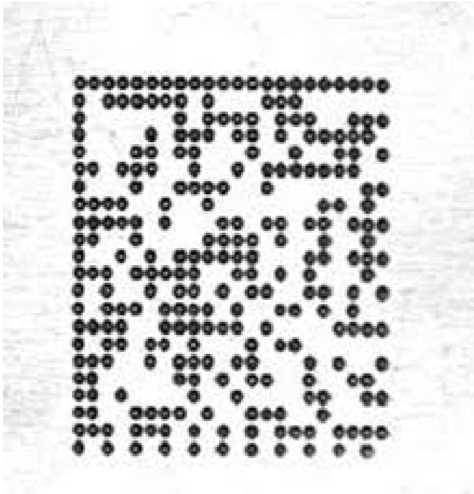
[Close]

Close filter performs Dilate filter after Erode filter. Close filter can be used to erase light areas.

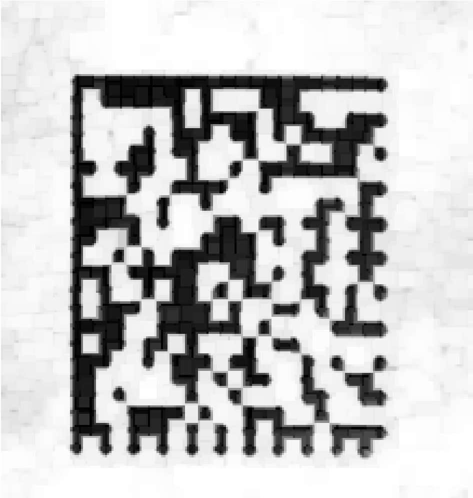
[Iterations]

As the number of the iterations of Close filter becomes larger, the larger light areas in the image can be erased.

In the example below, Close filter connects the black circles and fills in their light centers.



Input Image



Result Image (Close with N=2)

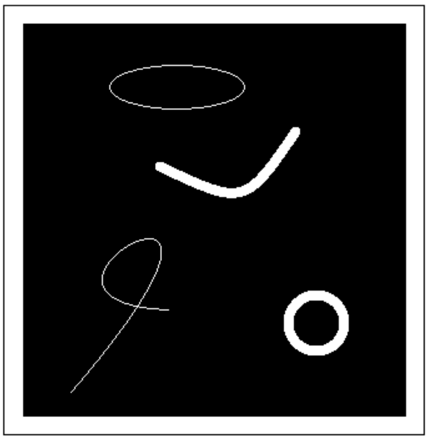
[Top Hat]

Top Hat filter can be used to extract thin light lines and the small light holes of the image.

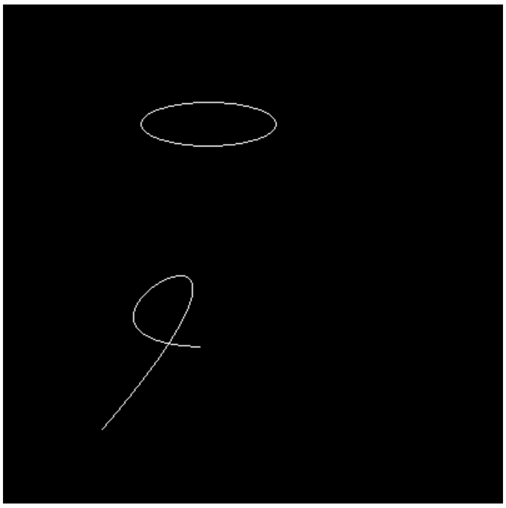
[Size]

As the filter size of Top Hat filter becomes larger, the bolder white lines in the image can be extracted.

In the example below, Top Hat filter extract thin white lines.



Input Image



Result Image (Top Hat with N=1)

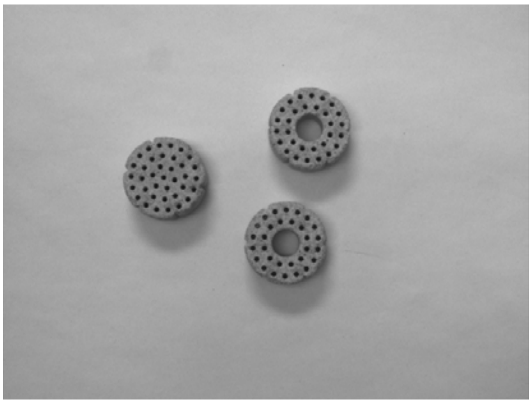
[Bottom Hat]

Bottom Hat filter is used to extract thin dark lines and small dark holes.

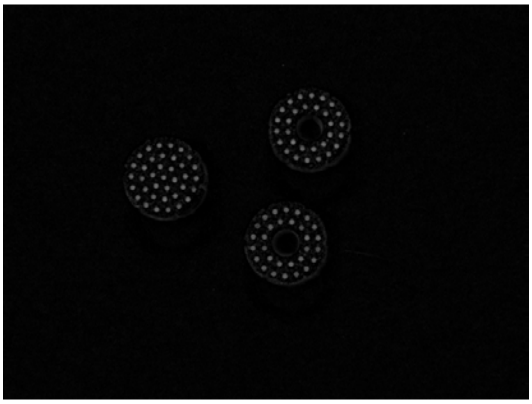
[Size]

As the filter size of Bottom Hat filter becomes bigger, the bolder dark lines can be extracted.

In the example below, Bottom Hat filter extracts small dark holes.



Input Image



Result Image (Bottom Hat with N=3)

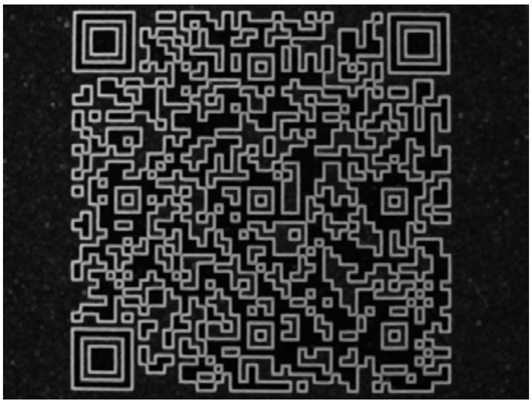
[Edge Magnitude]

Edge Magnitude filter is used to output the image that shows difference from the results of Erode filter and Dilate filter. Edge Magnitude filter can be used to extract highlight edges of the image.

[Iterations]

As the number of the iterations of Edge Magnitude filter becomes larger, the highlight edges become bolder.

Input Image



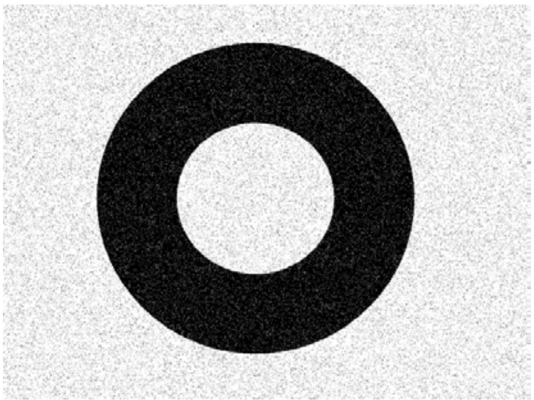
Result Image (Edge Magnitude with N=2)

[Median]

Median filter output featured pixels and its neighborhood. Median filter can be used to remove image "salt and pepper" noise without affecting the edges in the image.

[Size]

As the filter size of Medial filter becomes bigger, noises can be removed strongly.



Input Image

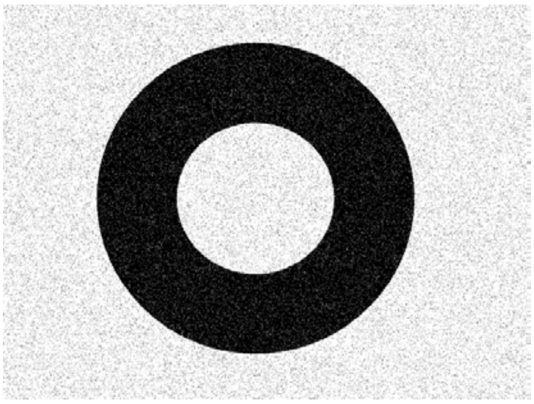
Result Image (Median with N=3)

[Gaussian Blur]

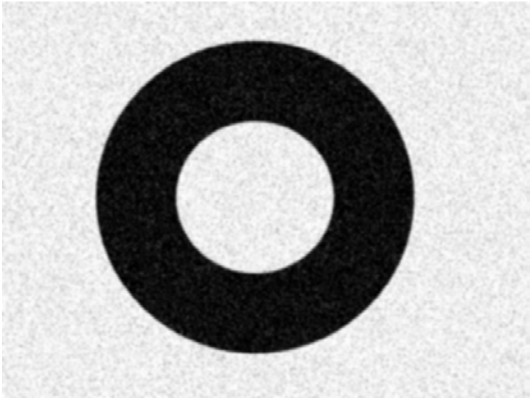
Gaussian Blur filter can be used to smooth out the fine surface texture or the image noise. Gaussian Blur filter is very similar to Blur filter. Blur filter is suitable to process the whole image, and Gaussian Blur filter is suitable to remove the noise of the image.

[Size]

As the filter size of Gaussian Blur filter becomes bigger, the image can be blurred strongly.



Input Image



Result Image (Gaussian Blur with N=3)

[Gaussian Sharpen]

Gaussian Sharpen filter is used to emphasize the highlight edges by increasing the contrast of the input image. When you give priority to processing time, Sharpen filter is suitable. And when you want to use the filter many times, Gaussian Sharpen filter is suitable.

[Size]

As the filter size of Gaussian Sharpen filter becomes larger, the highlight edges are more emphasis.

Input Image

Result Image (Gaussian Sharpen with N=2)

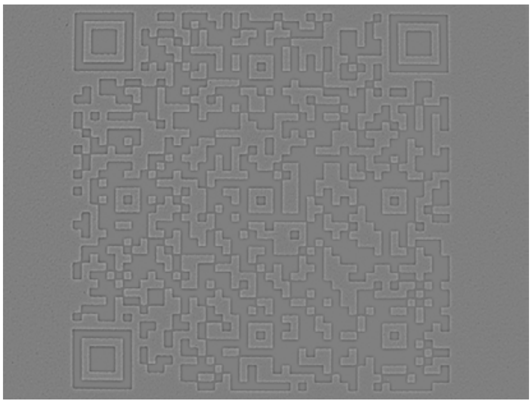
[Gaussian High Pass]

Gaussian High Pass filter is used to extract a high frequency component of the image.

[Size]

As the filter size of Gaussian High Pass filter becomes larger, lower frequency component is erased and high frequency component is left.

Input Image



Result Image (Gaussian High Pass with N=3)

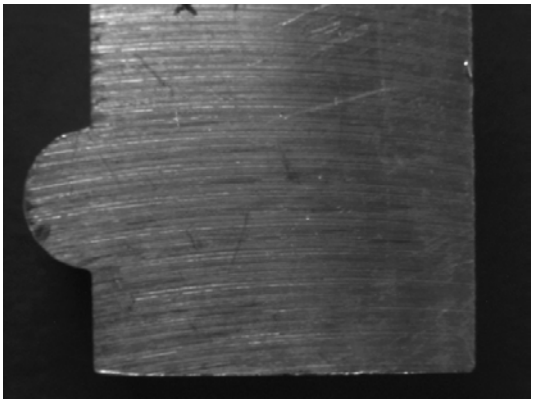
[Vertical Gradient]

Vertical Gradient filter can be used to highlight horizontal edges and texture in the image.

[Size]

As the filter size of Vertical Gradient filter becomes larger, the smaller shade can be neglected and the bigger shade can be extracted.

In the example below, it extracts horizontal processing marks.



Input Image

Result Image (Vertical Gradient with N=1)

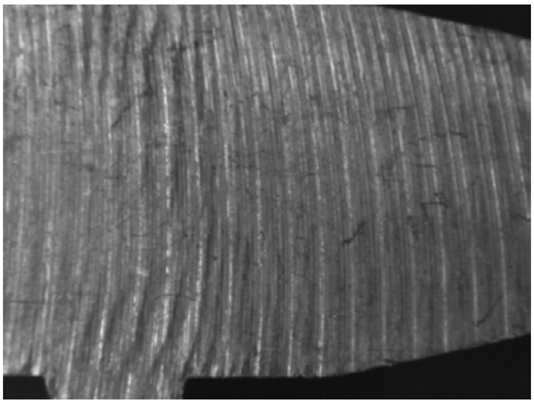
[Horizontal Gradient]

Horizontal Gradient filter can be used to highlight vertical edges and texture in the image.

[Size]

As the filter size of Horizontal Gradient filter becomes larger, the smaller shade can be neglected and the bigger shade can be extracted.

In the example below, it extracts the vertical processing marks.



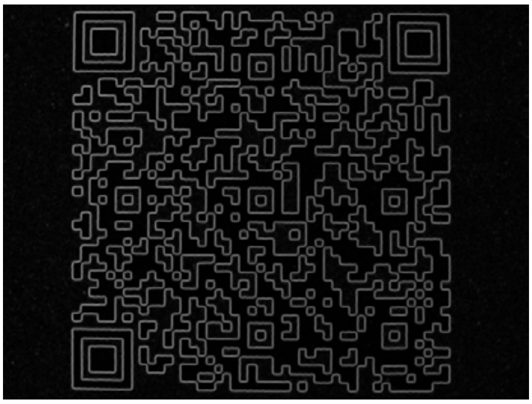
Input Image

Result Image (Horizontal Gradient with N=1)

[Gradient Magnitude]

Gradient Magnitude filter is used to output the magnitude of the shade gradient in images. Gradient Magnitude filter cannot designate the filter size or the number of the iterations.

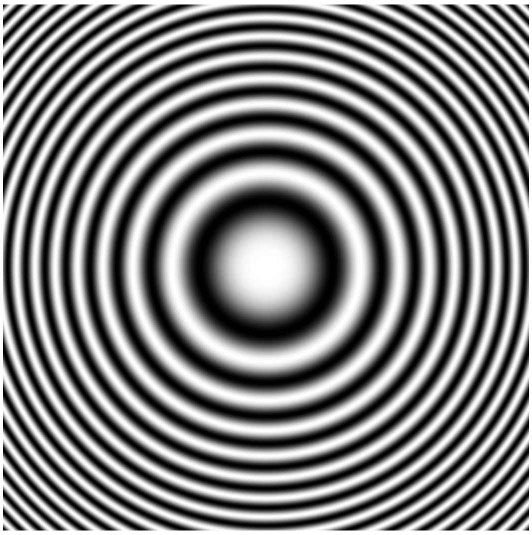
Input Image



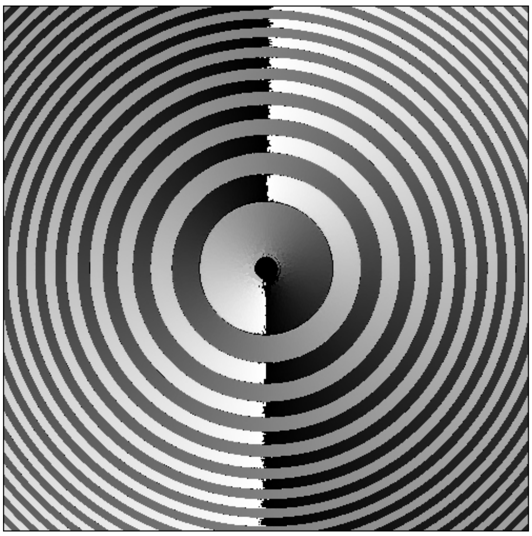
Result Image (Gradient Magnitude)

[Gradient Direction]

Gradient Direction filter is used to output the direction of the shade gradient in images. Direction of the shade gradient that becomes dark as it goes down (downward) is assigned to 128. Shade gradient number 64 means left, and 192 means right. Upward shade gradient is assigned to near 0 and near 255. Gradient Direction filter cannot designate the filter size or the number of the iterations.



Input Image



Result Image (Gradient Direction)

[Negative]

Negative filter can be used to reverse the light and shade to make dark areas bright and bright areas dark of Input Image. Negative filter cannot designate the filter size or the number of the iterations.

Input Image

Result Image (Negative)

[Contrast Equalization]

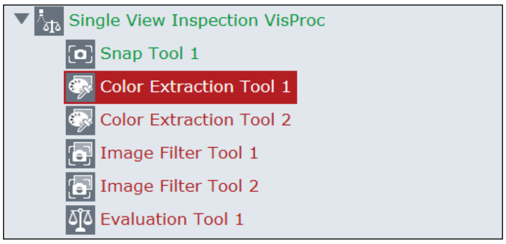
Contrast Equalization filter adjusts the brightness of the entire image to certain value to make entirely dark image bright and bright image dark. Because the brightness gets a certain value, it can easily configure the threshold of the command tools. Contrast Equalization filter cannot designate the filter size or the number of the iterations.

Input Image

Result Image (Contrast Equalization)

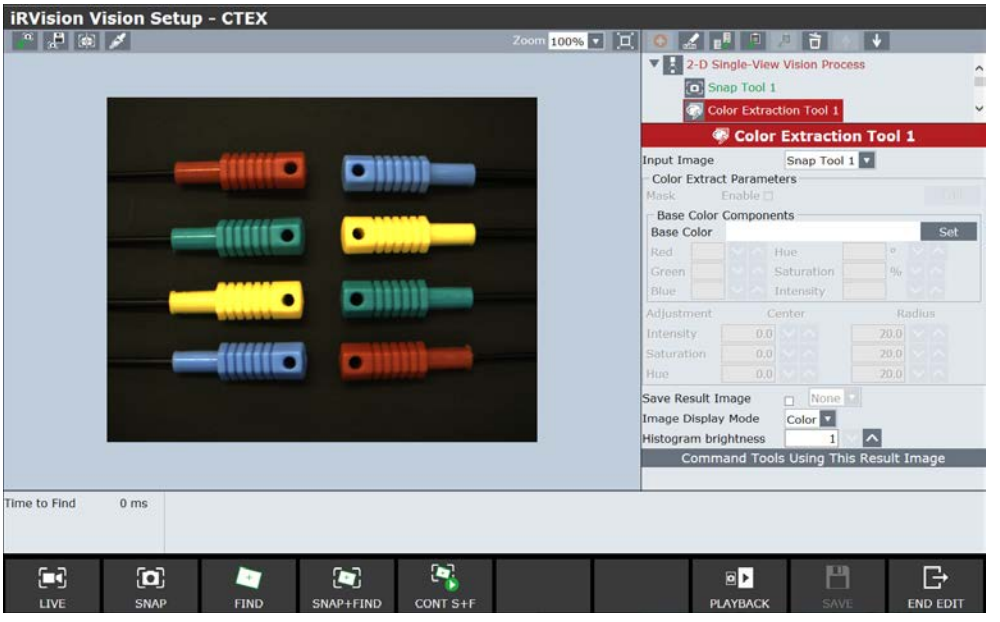
4.39 COLOR EXTRACTION TOOL

Color Extraction Tool creates the color extracted image from a color image snapped with the Snap Tool on the basis of the color extraction parameters. Image Extraction Tool is allocated right under the snap 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 Color Extraction Tools as follows, Color Extraction Tools create the color extracted images based on different color extraction parameters and each command tool can use a different color extracted image.



To use the result image created by Color Extraction Tool in a command tool, open the setup page of the command tool and then select the name of Color Extraction Tool in the drop-down box of the [Input Image].

If you select [Color Extraction Tool] in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



4.39.1 Setup Items

The Color Extraction Tool has the following parameters.

[Input Image]

Select an image to use in color extraction from the drop-down box.
If there are multiple snap tools allocated, select the applicable snap tool name.

[Mask]

When the rectangle specified for Base Color contains other colors than the one to be extracted, click the [Edit] button to mask the unexpected colors. When the [Enable] check box is unchecked, the mask is ignored.

[Base Color Components]

Set and adjust the base color.

[Base Color]

Click the [Set] button and enclose the area of the color to be extracted with the rectangle. When the base color is trained, it is displayed on the left side of the [Set] button. For details, refer to "Setup: 4.39.2 Training the Color Extraction Parameters". Red, Green, and Blue (RGB) components and Hue, Saturation, and Intensity (HSI) components of the base color are displayed. They can be individually adjusted. RGB components have the range of 0-255. Hue is an angle from 0° to 360°. 0° is red, 120° is green, and 240° is blue. Saturation has the ranges from 0% to 100%. Intensity has the ranges from 0 to 255.

[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).

[Save Result Image]

If this item is checked, the result image is stored in the selected image register. When there is no image register, an error message is displayed. For the details of the image register, refer to "Setup: 6.2.1 IRVSNAP, IRVNFIND".

[Image Display Mode]

Select the image display mode from the following choices.

[Color]

Display the input color image.

[Gray scale Image]

Display the input image as a grayscale image.

[Color Extracted]

Display the color extracted image which is bright in areas that match the trained color and dark everywhere else.

[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 Hue, Saturation, and Intensity (HSI) color space. This mode is enabled only after training the base color.

[Histogram brightness]

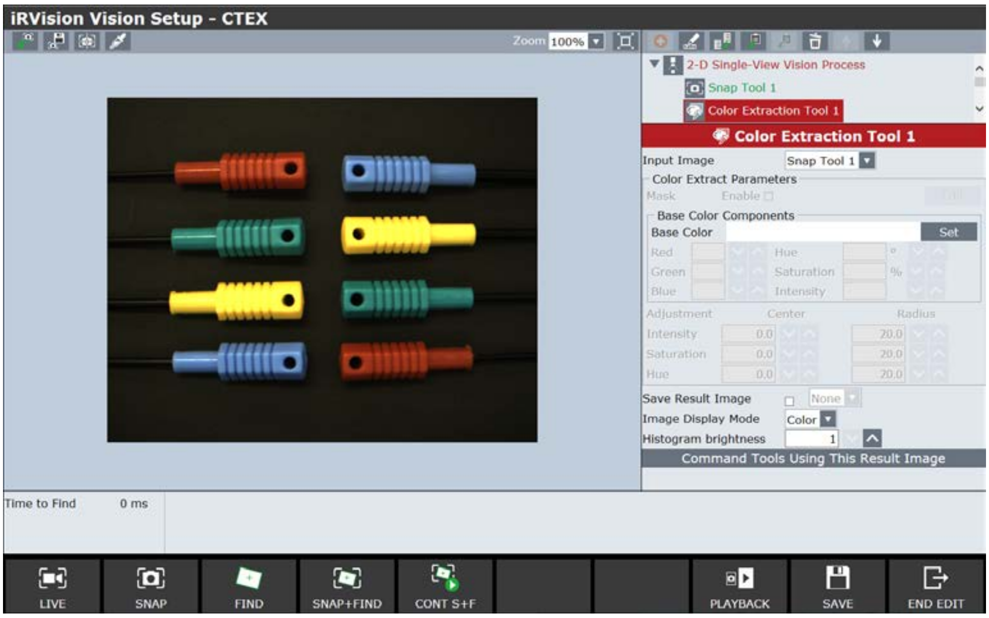
Adjust the intensity of the histogram. Input the value or change the value using buttons. This appears when [Histogram] is selected in [Image Display Mode].

[Command Tools Using This Result Image]

The name of command tools which use the result image of this Color Extraction Tool is displayed. When this Color Extraction Tool is changed, verify that these command tools still operate as intended.

4.39.2 Training the Color Extraction Parameters

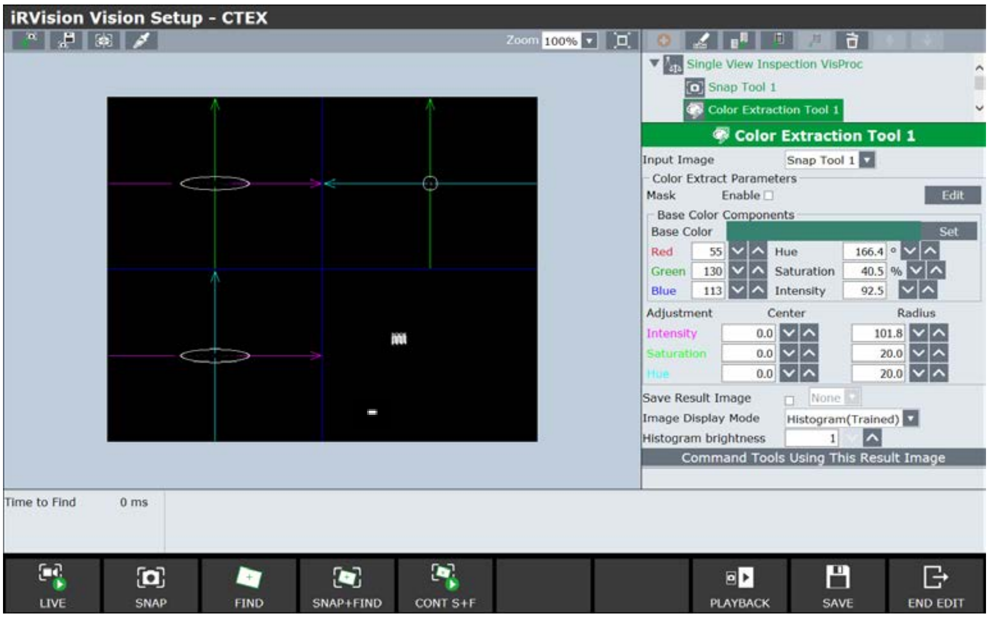
Here is an example of the training procedure for extracting blue.



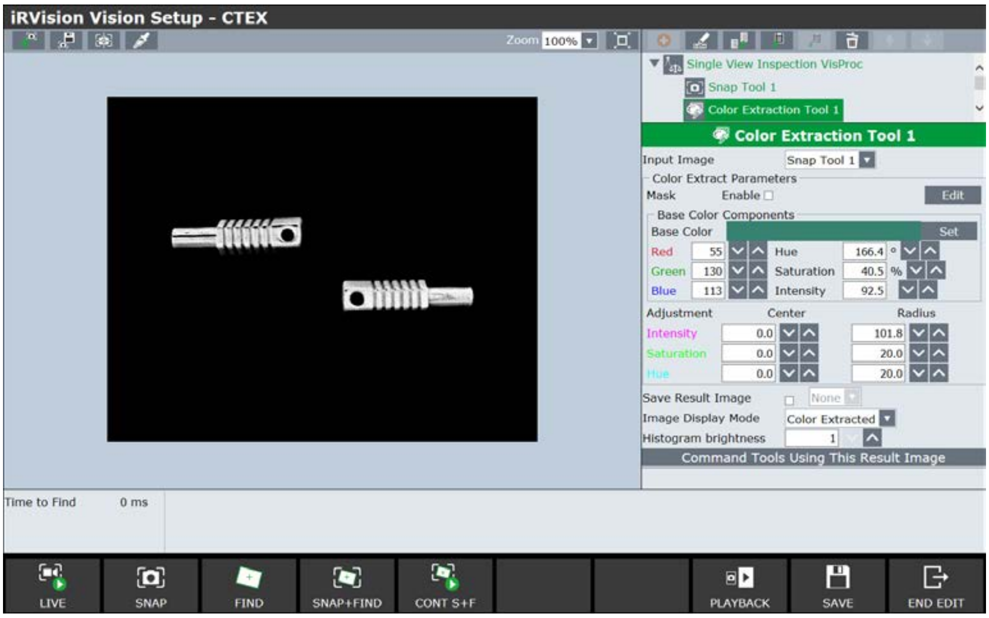
1 Click the [Set] button in [Base Color] in the Color Extraction Tool edit screen.
A full-screen image will be displayed, and a window that has control points (reddish purple rectangle) will appear.

2 Enclose the color to be extracted with the displayed window.

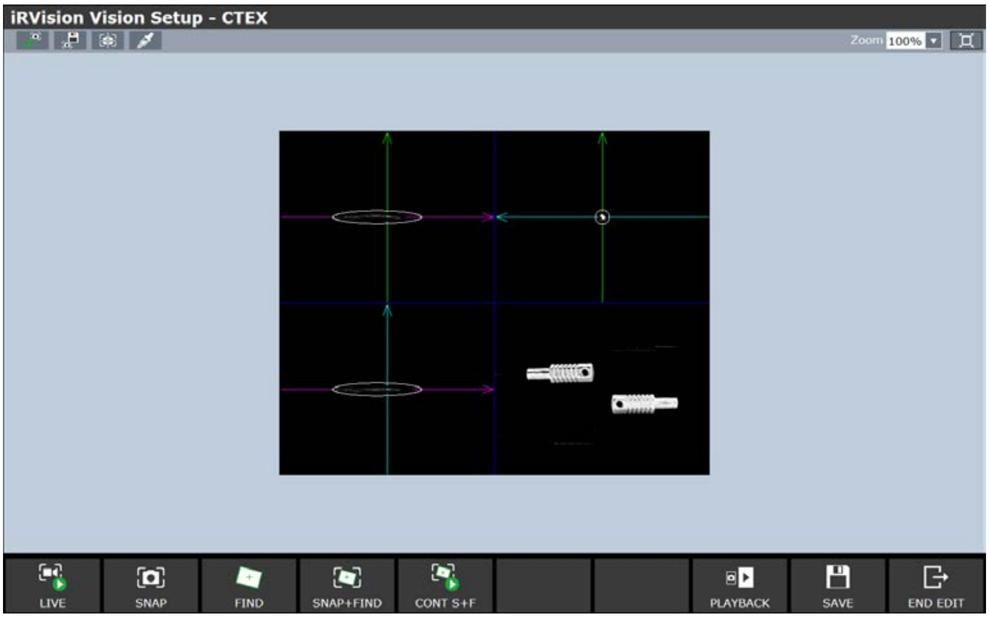
3 Click [OK], then the average color in the specified rectangle is set to [Base Color].



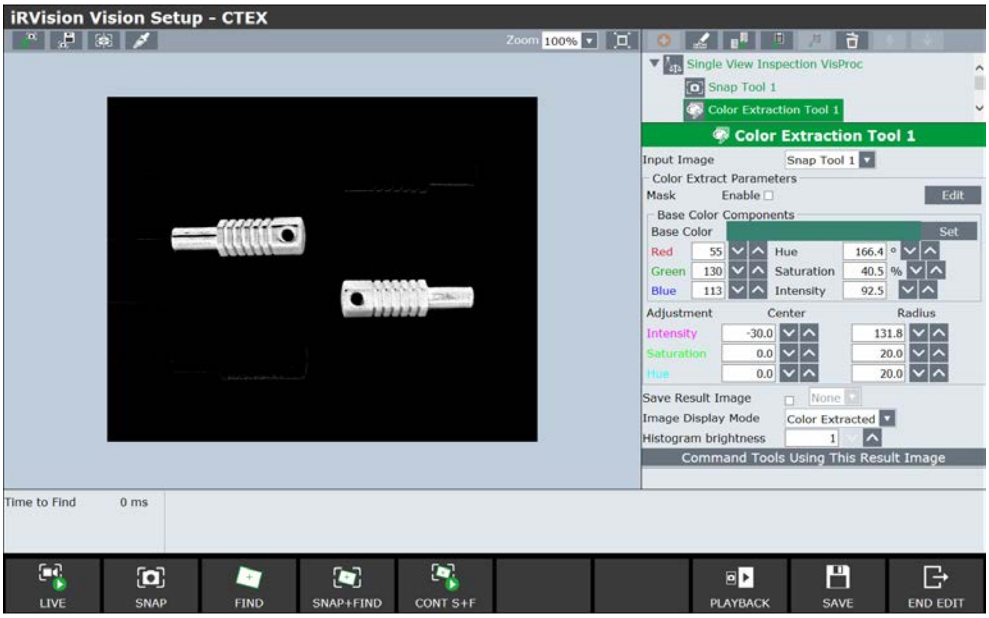
4 Change [Image Display Mode] to [Color Extracted]. You can see that the area trained as [Base Color] and their neighborhoods are extracted clearly but a part of the blue cap is not extracted clearly.



5 Increase [Radius] of [Intensity] to enclose more of the range of the blue cap color. You can also change the [Radius] of the [Hue] and [Saturation] if necessary, depending on the image.

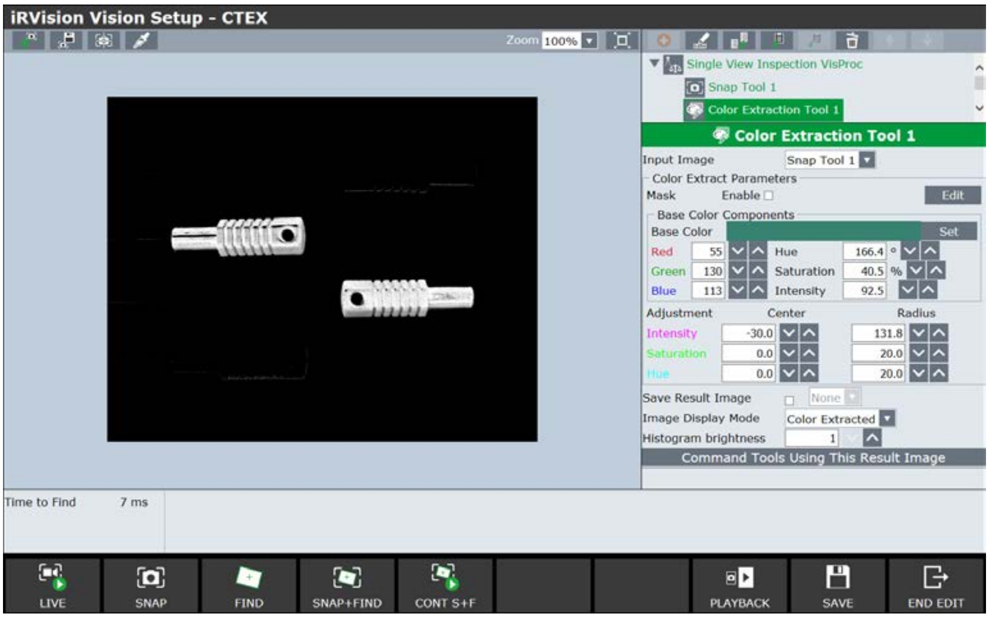


6 Change [Image Display Mode] to [Color Extracted]. You can see that more of the green cap area is now extracted clearly.



4.39.3 Running a Test

Click [FIND] to run a test and see if the color extraction tool operates properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

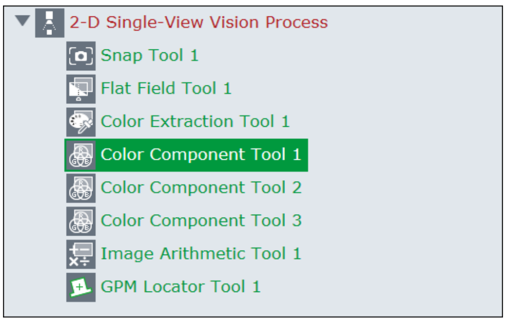
The time the Color Extraction Tool took is displayed in milliseconds.

4.39.4 Overridable Parameters

This command tool has no parameters that can be overridden with Vision Override.

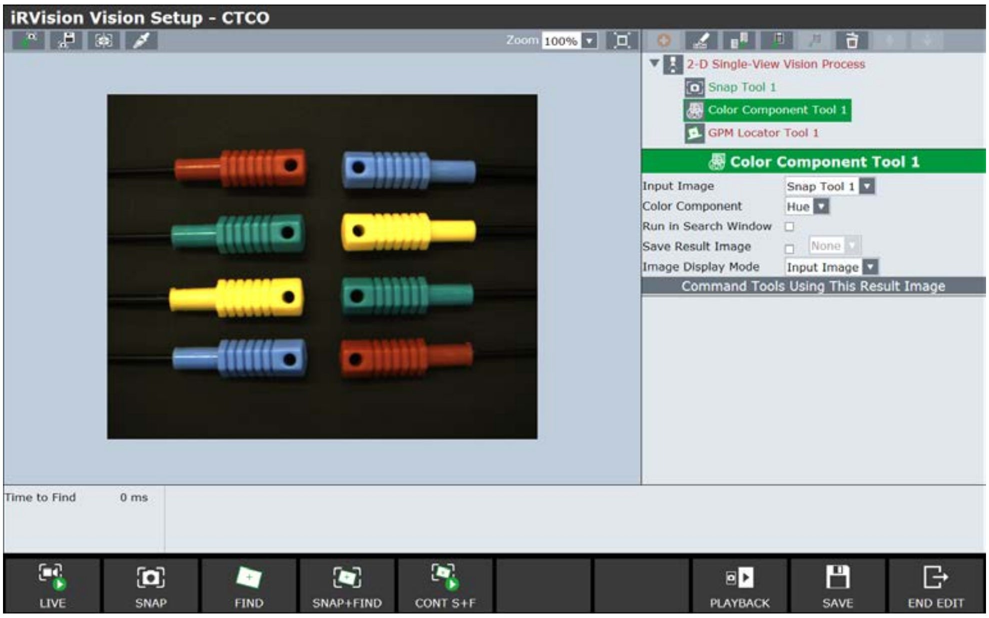
4.40 COLOR COMPONENT TOOL

Color Component Tool creates a grayscale image containing the specified color component of the color image snapped with the snap tool. Image component extraction tool is allocated right under the snap tool. Tool and only if the camera is a color camera. By adding multiple Color Component Tools, command tools can select different color components to use.



To use the result image created by Color Component Tool in a command tool, open the setup page of the command tool and then select the name of the Color Component Tool in the drop-down box of the [Input Image].

If you select [Color Component Tool] in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



4.40.1 Setup Items

The Color Component Tool has the following parameters.

[Input Image]

Select an image to use in color component extraction from the drop-down box.
If there are multiple snap tools allocated, select the applicable snap tool name.

[Color Component]

Select the color component which is extracted from the color image.

[Red]、[Green]、[Blue]

The red, green or blue of the color image is extracted respectively.

[Cyan]、[Magenta]、[Yellow]

The average of the green and the blue, the blue and the red, or the red and the green is extracted respectively.

[Hue]

The color hue of each pixel is extracted.　The hue of some color is below.

- 0 – Red
- 43 – Yellow
- 85 – Green
- 128 – Cyan
- 171 – Blue
- 213 – Magenta

[Saturation]

The color saturation of each pixel is extracted.　0 represents a shade of gray and 255 represents a pure spectral color.　Values in-between represent intermediate degrees of color saturation.

[Intensity]

The equivalent grayscale image is extracted. This image has all of the color removed by setting the saturation to 0.

[Run in Search Window]

By default, Color Component Tool processes the entire image. But if this item is checked, Color Component Tool processes only inside the search window of the command tools which use the result image. According to the number of found, processing only inside the search window may reduce the processing time of Color Component Tool.

Note that Color Component Tool processes inside the search window only in the following cases. In the other cases, Color Component Tool processes entire image even if the item is checked.

- When executing the vision process from a TP program
- When running a test on the setup page

[Save Result Image]

If this item is checked, the result image is stored in the selected image register. When there is no image register, an error message is displayed. For the details of the image register, refer to "Setup: 6.2.1 IRVSNAP, IRVNFIND".

[Image Display Mode]

Select [Save Result Image] for the image display mode in the edit screen.

[Input Image]

Images that are selected in [Input Image] will appear.

[Result Image]

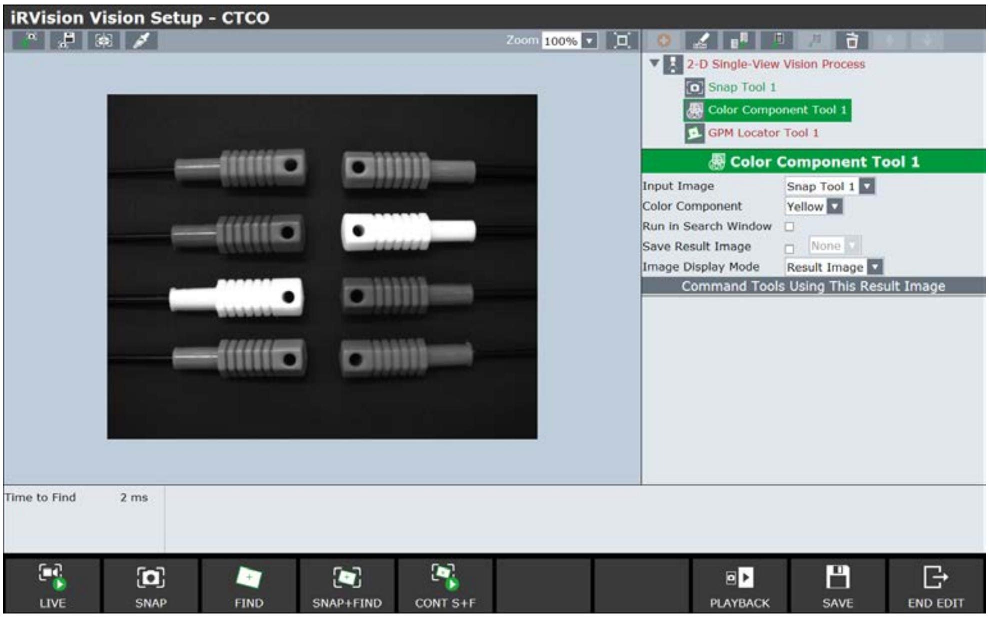
Display the result image.

[Command Tools Using This Result Image]

The name of command tools which use the result image of this Color Component Tool is displayed. When this Color Component Tool is changed, verify that these command tools still operate as intended.

4.40.2 Running a Test

Click [FIND] to run a test and see if the Color Component Tool operates properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

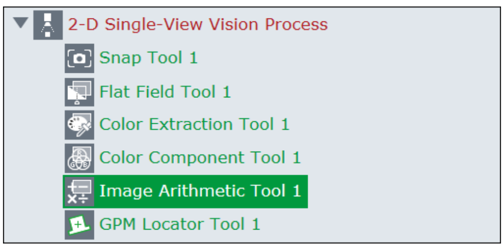
The time the Color Component Tool took is displayed in milliseconds.

4.40.3 Overridable Parameters

This command tool has no parameters that can be overridden with Vision Override.

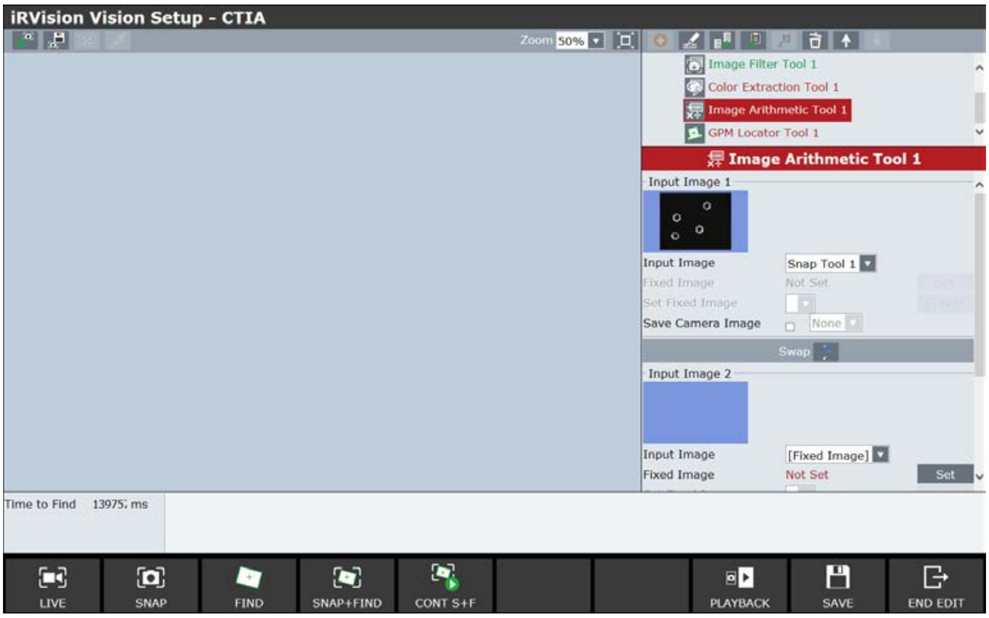
4.41 IMAGE ARITHMETIC TOOL

Image Arithmetic Tool performs simple arithmetic functions on two input images. This tool can be inserted only under Image Preprocess Tool.



To use the result image created by Image Arithmetic Tool in a command tool, open the setup page of the command tool and then select the name of Image Arithmetic Tool in the drop-down box of the [Input Image].

If you select [Image Arithmetic Tool] Tool in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



In the Image Arithmetic Tool edit screen, two input images are displayed as thumbnails ([Image 1] and [Input Image 2]). The images displayed as thumbnails will switch as shown below.

- When an image of operation result is displayed in the image view, the image used for creating the result image is displayed in the thumbnail.
- When an image of operation result is not displayed in the image view, the image planned to be used for creating the result image in next detection is displayed in the thumbnail.

Also, when [Image Display Mode] described below is [Result Image], the 2D image will not be displayed in the image view even when [SNAP] is clicked.

4.41.1 Setup Items

The Image Arithmetic Tool has the following parameters.

[Input Image]

Select an image to be used for operation from the drop-down box. Select for [Input Image 1] and [Input Image 2] each.

[SNAP]

Select when an image snapped with the Snap Tool is used.
If there are multiple snap tools allocated, select the applicable snap tool name.

[Image Register]

Select when an image stored in the specified Image Register is used.
An image can be stored in an image register by clicking [SNAP] while [Save Camera Image] is checked, or by calling IRVSNAPfrom a TP program. When no image registers have been allocated, this option will not appear.

[Fixed Image]

Every time the fixed image is used. Click the [SET] button to set the fixed image to the current camera image.

[Not Used]

No image. Image Arithmetic Tool only applies the scale and offset to Input Image 1. This option is only available for [Input Image 2].

[Tool Name]

Select when a result image filtered by the specified tool is used.
The available tool is a command tool that performs preprocessing of an image preceding this tool and at the same level (Image Filter Tool, Color Extraction Tool, Color Component Tool Image Arithmetic Tool, Flat Field Tool or Image Shrink Tool).

[Fixed Image]

Click the [SET] button to teach the Fixed Image. This is a parameter that appears when [Fixed Image] is selected in [Input Image].

[Set Fixed Image]

Select the image to be set as the Fixed Image from the drop-down box. It will be displayed once the fixed image is taught in [Fixed Image].

[SNAP]

Select when an image snapped with the snap tool is used.
If there are multiple snap tools allocated, select the applicable snap tool name.

[Image Register]

Select when an image stored in the specified Image Register is used.
An image can be stored in an image register by clicking [SNAP] while [Save Camera Image] is checked, or by calling IRVSNAPfrom a TP program. When no image registers have been allocated, this option will not appear.

[Tool Name]

Select when a result image filtered by the specified tool is used.
The available tool is a command tool that performs preprocessing of an image preceding this tool and at the same level (Image Filter Tool, Color Extraction Tool, Color Component Tool Image Arithmetic Tool, Flat Field Tool or Image Shrink Tool).

[None]

Select this when a fixed image is not used.

[Save Camera Image]

If this item is checked, the snapped image is stored in the image register selected from the drop-down box. When there is no image register, an error message is displayed. For the details of the image register, refer to "Setup: 6.2.1 IRVSNAP, IRVNFIND".

[Swap]

This button swaps [Input Image 1] for [Input Image 2].

[Operation]

Select the operation from the drop-down list to perform on each pixel of the input images. After the operation, the resulting grayscale value is multiplied or divided by the scale factor and then the offset is added to it. The most common scale and offset values are automatically selected as the default values when the operation is changed.
The range for the pixel values of the result image remains from 0 to 255. Result pixels below 0 will be set to 0 and result pixels above 255 will be set to 255.

[+]

Add Input Image 1 and Input Image 2 as shown below.

$$\frac{I_1 + I_2}{A} + B$$

The default scale A is 2 and the default offset B is 0. The default result is the average of the two images.

[-]

Subtract Input Image 2 from Input Image 1 as shown below.

$$\frac{I_1 - I_2}{A} + B$$

The default scale A is 2 and the default offset B is 128. The area where the image 1 is brighter than the image 2 has the value more than 128, and the area where the image 1 is darker than the image 2 has the value less than 128.

[*]

Multiply Input Image 1 and Input Image 2 as shown below.

$$\frac{I_1 \times I_2}{A} + B$$

The default scale A is 255 and the default offset B is 0.

[/]

Divide Input Image 1 by Input Image 2 as shown below.

$$\frac{I_1}{A \times I_2} + B$$

The default scale A is 128 and the offset B is 0.

[Max.]

Compute the maximum of Input Image 1 and Input Image 2 as shown below.

$$\frac{\max(I_1, I_2)}{A} + B$$

The default scale A is 1 and the offset B is 0.

[Min.]

Compute the minimum of Input Image 1 and Input Image 2 as shown below.

$$\frac{\min(I_1, I_2)}{A} + B$$

The default scale A is 1 and the offset B is 0.

[Result = (I1 +I2)]

The equation which is calculated at each pixel is shown.

[*] [/]

Select the operation to multiply or divide by the scale factor.

[Magnification]

Set the scale A in the above equations.

[Offset]

Set the offset B in the above equations.

[Run in Search Window]

By default, Image Arithmetic Tool processes the entire image. But if this item is checked, Image Arithmetic Tool processes only inside the search window of the command tools which use the result image. According to the number of found, processing only inside the search window may reduce the processing time of Image Arithmetic Tool.

Note that Image Arithmetic Tool processes only inside the search window in the following cases. In the other cases, Image Arithmetic Tool processes entire image even if the item is checked.

- When executing the vision process from a TP program
- When running a test on the setup page

[Save Result Image]

If this item is checked, the result image is stored in the selected image register. When there is no image register, an error message is displayed. For the details of the image register, refer to "Setup: 6.2.1 IRVSNAP, IRVNFIND".

[Image Display Mode]

Select the image display mode for the Setup Page.

[Input Image 1]
[Input Image 1] is displayed.

[Input Image 2]
[Input Image 2] is displayed.

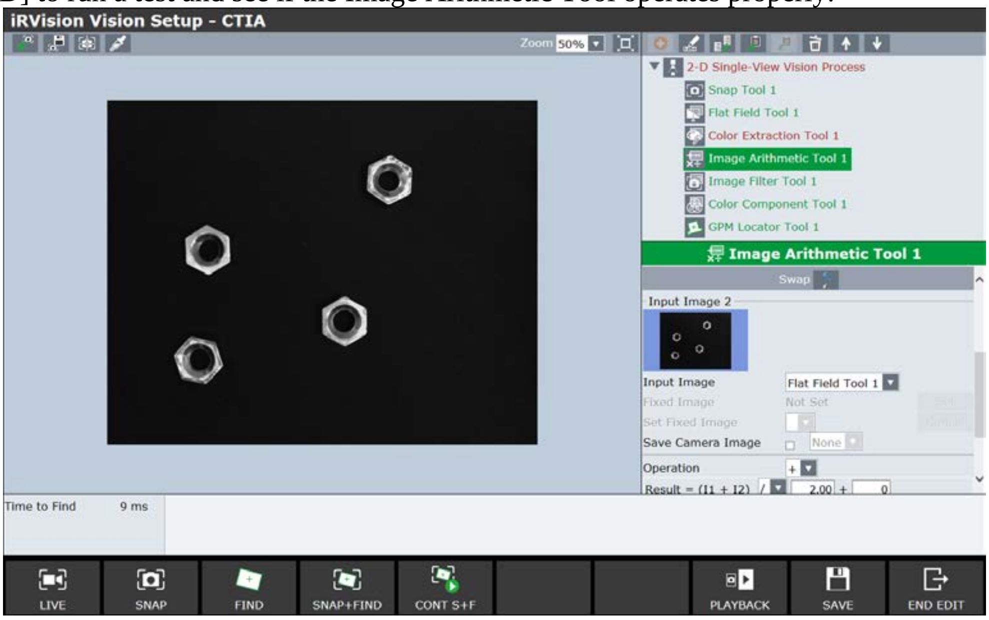
[Result Image]
Display the result image.

[Command Tools Using This Result Image]

The name of command tools which use the result image of this Image Arithmetic Tool is displayed. When this Image Arithmetic Tool is changed, verify that these command tools still operate as intended.

4.41.2 Running a Test

Click [FIND] to run a test and see if the Image Arithmetic Tool operates properly.



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The execution time of the Image Arithmetic Tool is displayed in milliseconds.

4.41.3 Overridable Parameters

This command tool has no parameters that can be overridden with Vision Override.

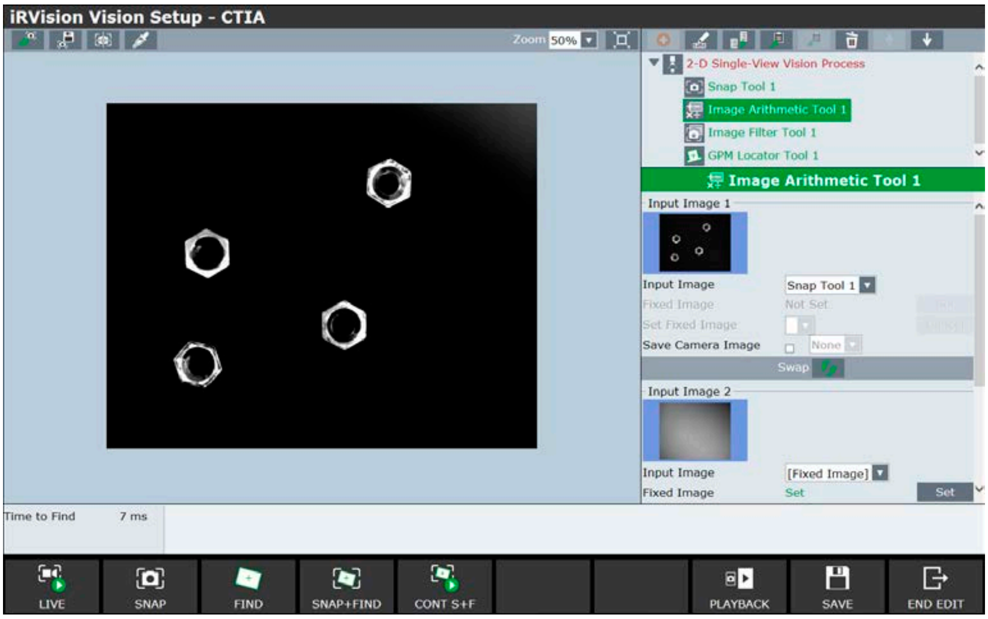
4.41.4 Examples

This section shows the application examples of Image Arithmetic Tool.

Background Removal

When the background does not change, the background can be removed by subtracting the fixed image from the camera image.

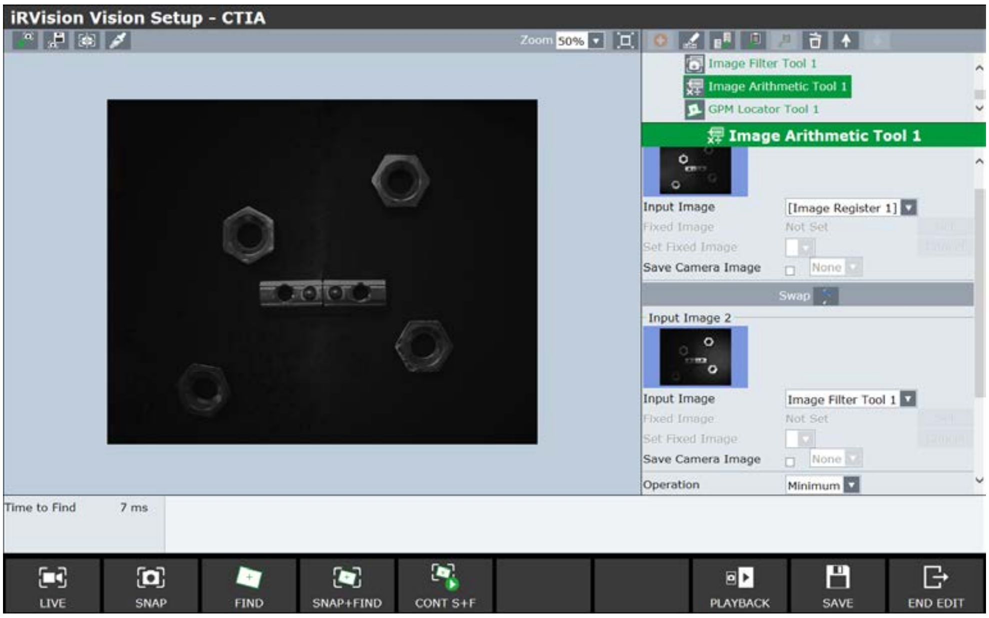
1 Select [SNAP] in [Input Image] of [Input Image 1].
2 Select [Fixed Image] in [Input Image] of [Input Image 2].
3 Remove workpieces from the camera view. Click the [Set] button of [Fixed Image] in [Input Image]. Snap the fixed image.
4 Select [–] as the [Operation].



Glare Removal

The glare can be removed by using two images that are acquired under the different lighting condition.

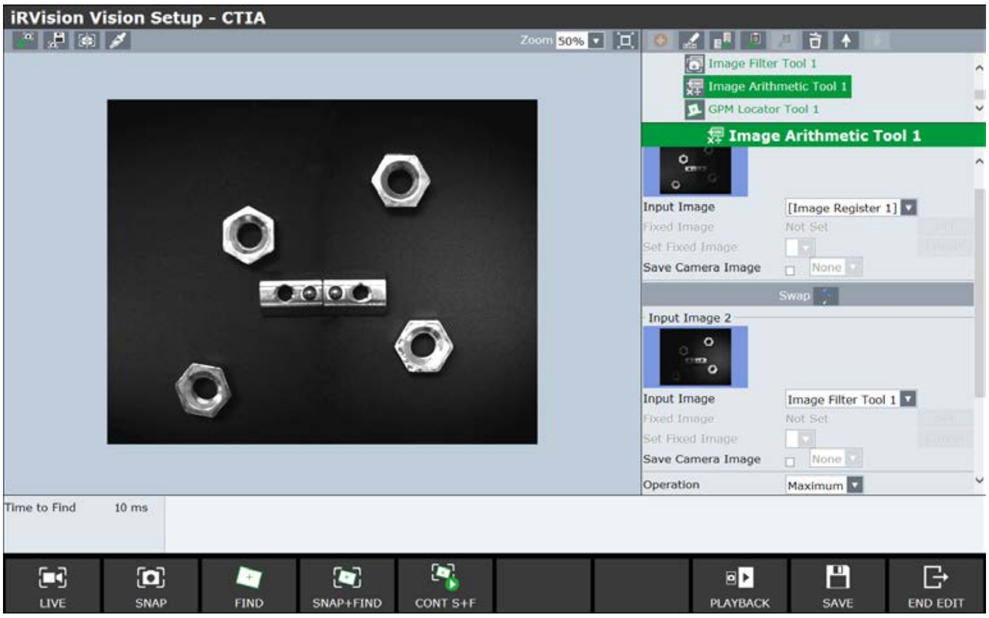
1 Turn on the light.
2 Run IRVSNAP and store the image to the image resister.
3 Turn on the other light.
4 Select [SNAP] in [Input Image] of [Input Image 1].
5 Select [Image Register] in [Input Image] of [Input Image 2].
6 Select [Minimum] as the [Operation].



Shadow Removal

The shadow can be removed by using two images that are acquired under the different lighting condition.

1 Turn on the light.
2 Run IRVSNAP and store the image to the image resister.
3 Turn on the other light.
4 Select [SNAP] in [Input Image] of [Input Image 1].
5 Select [Image Register] in [Input Image] of [Input Image 2].
6 Select [Maximum] as the [Operation].



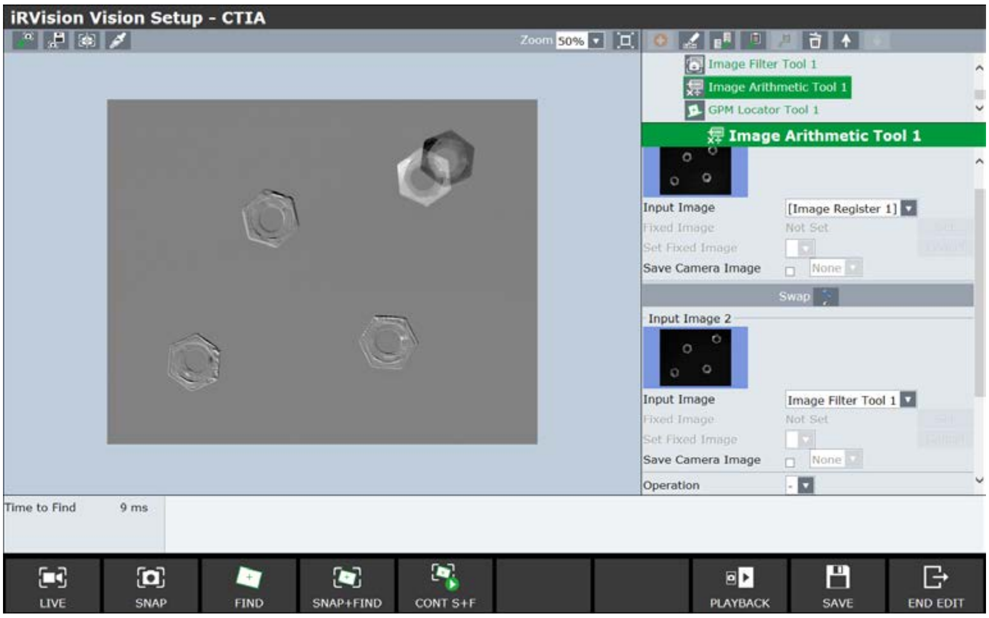
Motion Detection

The moving object can be detected by using two images that are acquired at different time.

1 Run IRVSNAP and store the image to the image resister.
2 Select [SNAP] in [Input Image] of [Input Image 1].
3 Select [Image Register] in [Input Image] of [Input Image 2].

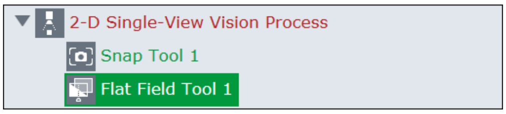
4 Select [-] as the [Operation].

In the example below, dark workpiece represents current location and bright workpiece represents previous location.



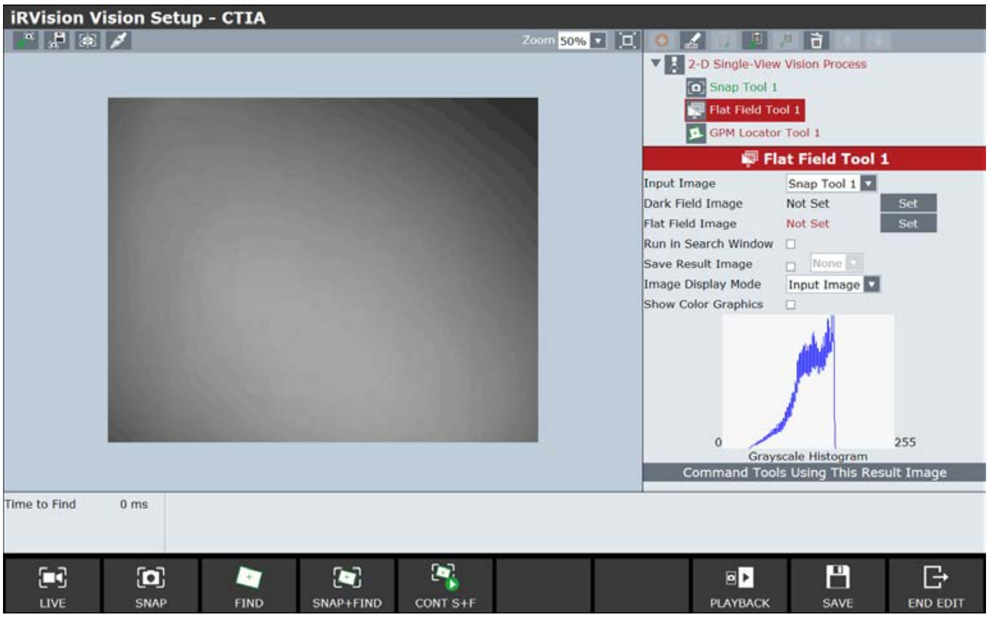
4.42 FLAT FIELD TOOL

Flat Field Tool corrects for uneven lighting and uneven image sensor response. This tool can be inserted only under Image Preprocess Tool. Only one Flat Field Tool can be created per vision process.



To use the result image created by Flat Field Tool in a command tool, open the setup page of the command tool and then select the name of Flat Field Tool in the drop-down box of the [Input Image].

If you select [Flat Field Tool] in the tree view of the setup page of the vision process, a setup page like the one shown below appears.



4.42.1 Setup Items

The Flat Field Tool has the following parameters.

[Input Image]

Select an image to be used in flat field from the drop-down box.
If there are multiple snap tools allocated, select the applicable snap tool name.

[Dark Field Image]

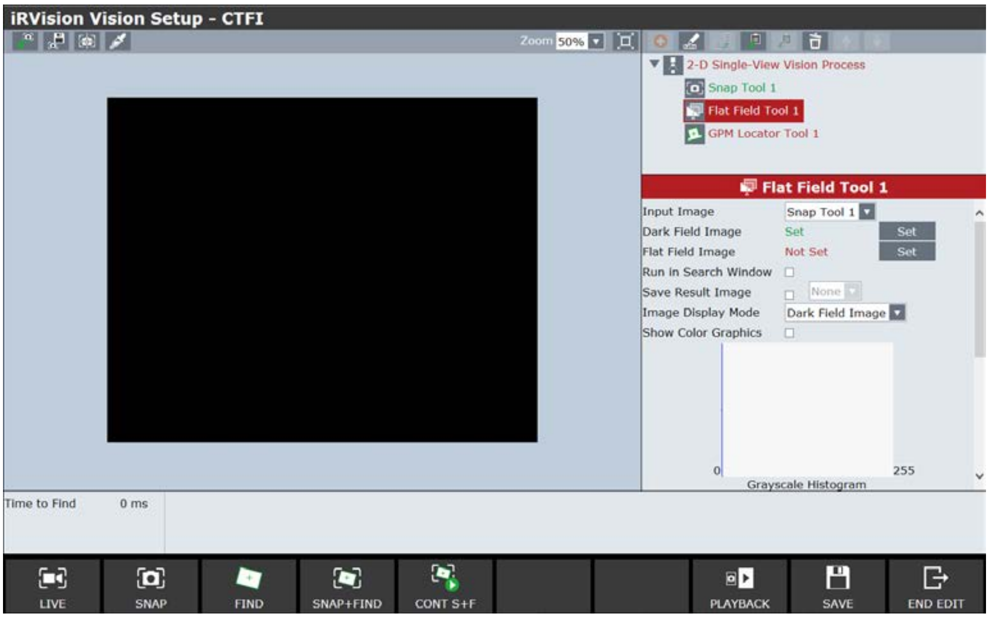
The zero level of the image is recorded as Dark Field Image. When the value of the pixel in the input image is less than that in Dark Field Image, its value in the result image is set to 0. It is useful when the high camera gain is used. When Dark Field Image is trained, Flat Field Image should be retrained.

Train Dark Field Image with the following procedures:

1 Block the camera view with lens cover not to enter the light
2 Click [Set] button to record the Dark Field Image.

After when Dark Field Image has been successfully set, the recorded Dark Field Image displays in the image display and its histogram displays in a graph and a table.

The following image is an example of Dark Field Image.



[Flat Field Image]

The image of the flat non-textured plane is recorded as Flat Field Image. The result image is output as the subtracted image between Flat Field Image and Input Image.

Train Flat Field Image with the following procedures:

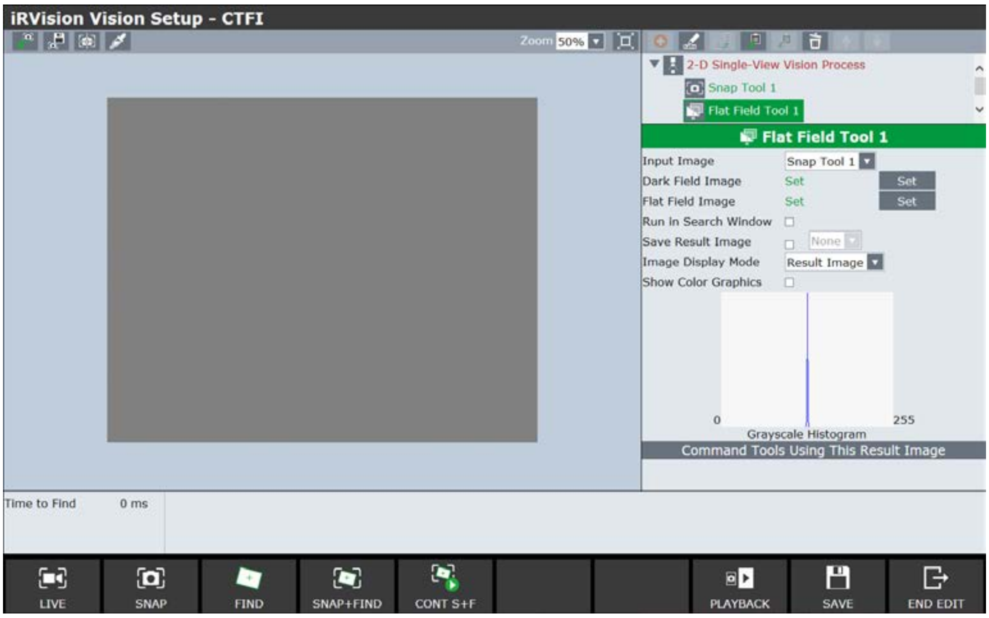
1 Set the flat non-textured plane in front of the camera.
2 Adjust the exposure time in order that the peak of the histogram is at the center of the histogram and the maximum value of the pixel is less than 255.
3 Click [Set] button to record [Flat Field Image]. After when Flat Field Image is trained, Flat Field Image displays in the image display and its histogram displays in the graph and the table.
4 Switch [Image Display Mode] to [Result Image].
5 Make sure that the uneven lighting is corrected in the result image.

MEMO
When the layout or the intensity of the lighting is changed, Flat Field Image should be retrained.

The following figure shows an example.

Input Image

Flat Filed Image



Result Image

[Run in Search Window]

By default, Flat Field Tool processes the entire image. But if this item is checked, Flat Field Tool processes only inside the search window of the command tools which use the result image. According to the number of found, processing only inside the search window may reduce the processing time of Flat Field Tool.

Note that Flat Field Tool processes only inside the search window in the following cases. In the other cases, Flat Field Tool processes entire image even if the item is checked.

- When executing the vision process from a TP program
- When running a test on the setup page

[Save Result Image]

If this item is checked, the result image is stored in the selected image register. When there is no image register, an error message is displayed. For the details of the image register, refer to "Setup: 6.2.1 IRVSNAP, IRVNFIND".

[Image Display Mode]

Select the image display mode from the following choices:

[Input Image]

[Input Image] is displayed.

[Dark Field Image]

[Dark Field Image] is displayed.

[Flat Field Image]

[Flat Field Image] is displayed.

[Result Image]

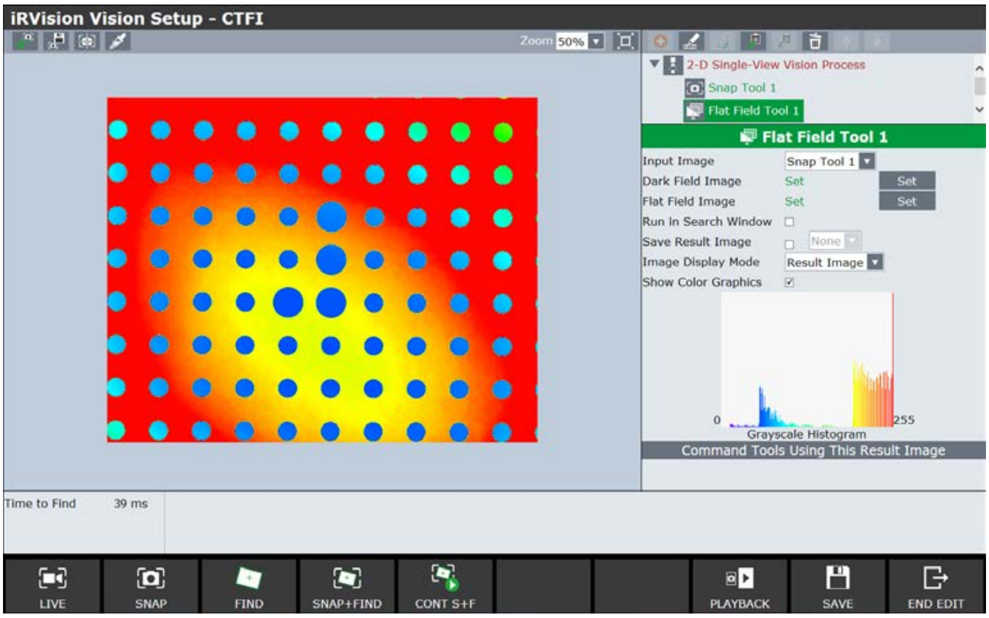
[Result Image] is displayed.

[Show Color Graphics]

The color graphics displays in the image display. The pixels that have the same value show in the same color.

The violet shows the darkest ("coldest") pixels in the current image. In order of brightness, the pixel shows blue, green, yellow, orange, and red respectively. The red shows the brightest ("hottest") pixels in the current image.

The following example shows the image with color graphics:



Grayscale Histogram

The histogram of the current image displays as the graph and the table.

[Command Tools Using This Result Image]

The name of command tools which use the result image of this Flat Field Tool is displayed. When this Flat Field Tool is changed, verify that these command tools still operate as intended.

4

4.42.2 Running a Test

Click [FIND] to run a test and see if the Flat Field Tool operates properly.

After executing a test, the following items are displayed in the result display area.

[Time to Find]

The execution time of the Flat Field Tool took is displayed in milliseconds.

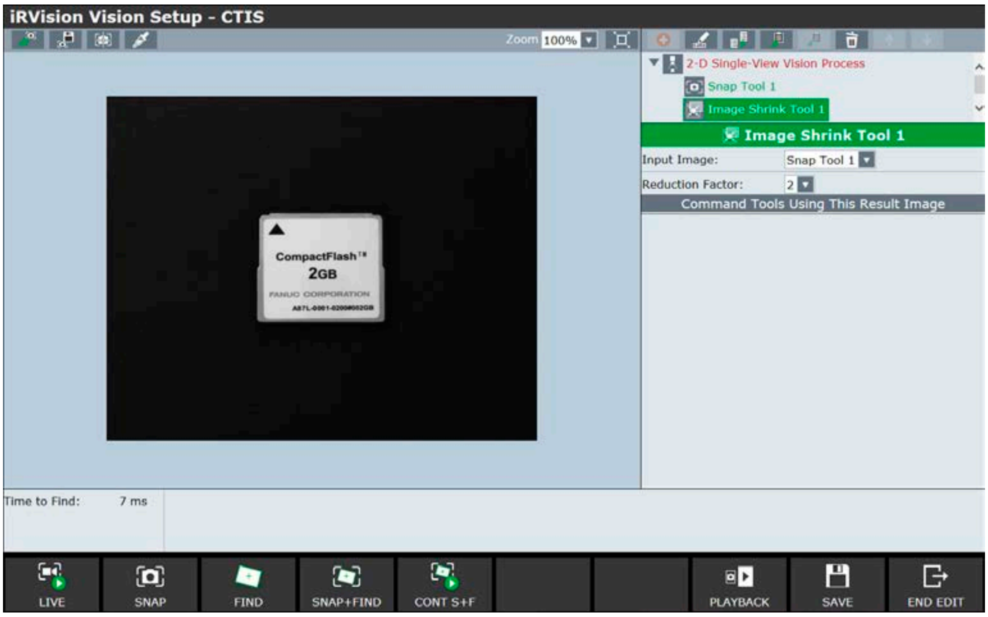
4.42.3 Overridable Parameters

This command tool has no parameters that can be overridden with Vision Override.

4.43 IMAGE SHRINK TOOL

Image Shrink Tool shrinks the image snapped with a snap tool.
It is allocated right under the snap tool. You can select shrunk images to be used for each command tool by snapping in original size with the snap tool and shrinking the size with the image shrink tool.

When you select [Image Shrink Tool] in the tree view of the vision process edit screen, the following screen will appear.



4.43.1 Setup Items

The Image Shrink Tool has the following parameters.

[Input Image]

Select an image to use for image shrinking from the drop-down box.
If there are multiple snap tools allocated, select the applicable snap tool name.

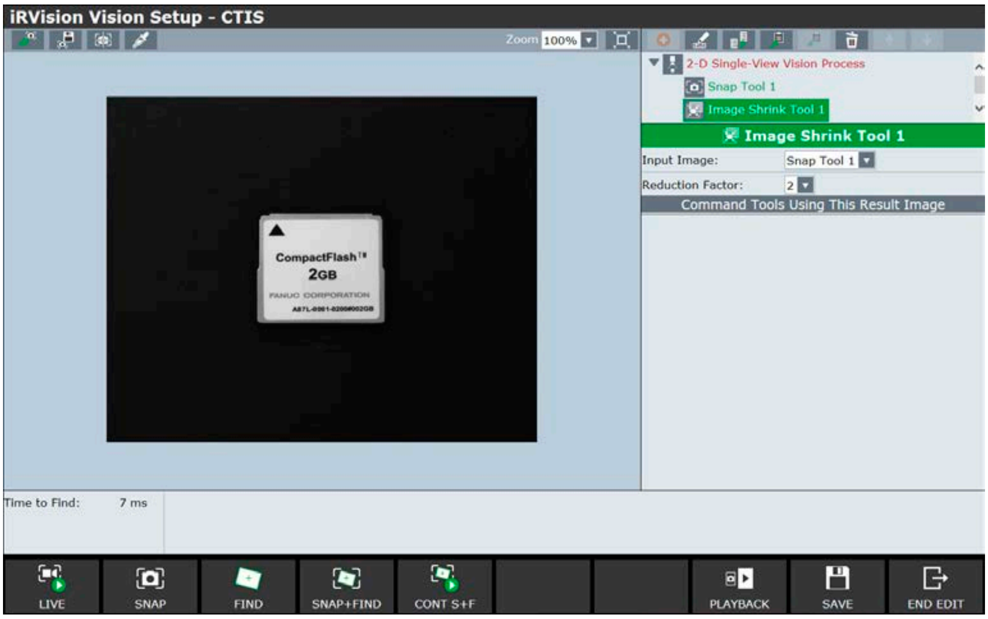
[Reduction Factor]

Select the image shrinkage factor. Select the factor between 2 and 4. The higher the factor value is, the higher the shrinkage ratio will be.

[Command Tools Using This Result Image]

The name of command tools which use the result image of this Image Shrink Tool as an input image is displayed. When this Image Shrink Tool is changed, verify that these command tools still operate as intended.

4.43.2 Running a Test



After executing a test, the following items are displayed in the result display area.

[Time to Find]

The processing time the Image Filter Tool took is displayed. The units are milliseconds.

4.43.3 Overridable Parameters

This command tool has no parameters that can be overridden with Vision Override.

5 APPLICATION DATA

This chapter describes how to set application data. Application data is one type of vision data. For the creation of application data, refer to "Setup: 1.3.1.1 Creating New Vision Data". There are the following two types of application data.

- Vision Override
- Offset Limit

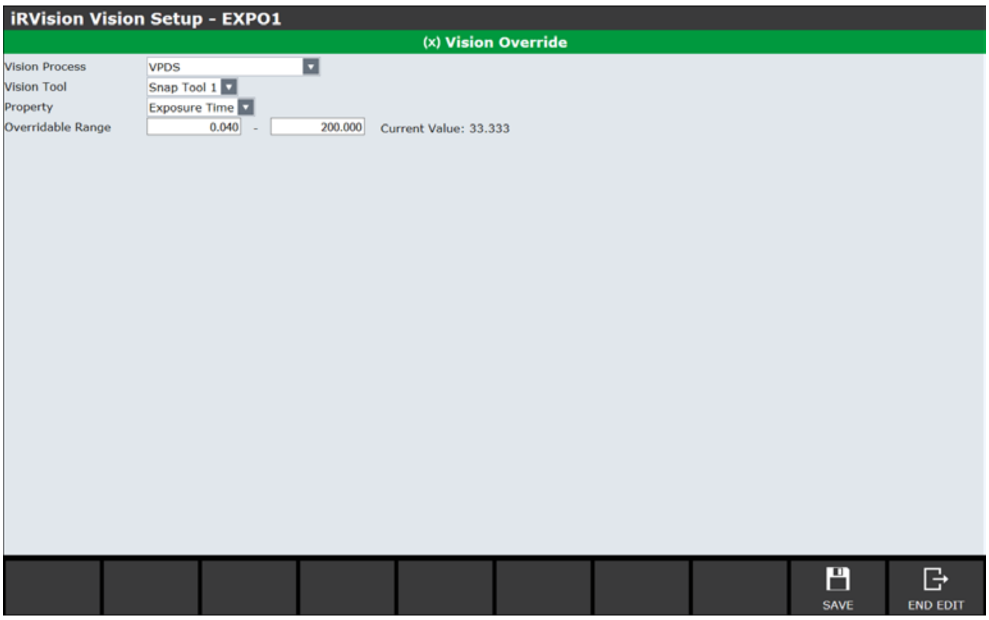
If you select [Vision Override] or [Limit Check Tool] for the types of data when creating vision data, the application data will be created.

5.1 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 “Snap Tool 1” of the vision process “VPDS”. This is tantamount to assigning a short alias “EXPO1” to the “Exposure Time of Snap 1 of VPDS”. Defining a vision override enables you to temporarily change the associated property from a robot program by using the VISION OVERRIDE instruction.

Select the overridable parameters to edit and click [EDIT] on the vision data list screen. The vision override edit screen like the following will be displayed.



The setting items area has the following parameters.

[Vision Process]

Select a vision process to be associated from a drop-down box.

[Vision Tool]

Select a vision tool to be associated from a drop-down box.

[Property]

Select a property to be associated from a drop-down box.

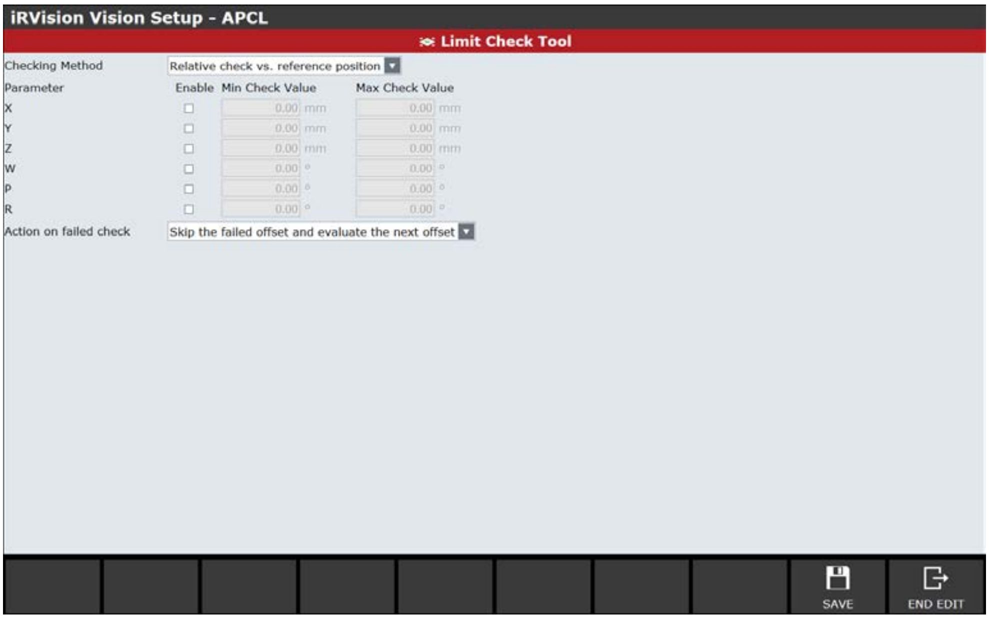
[Overridable Range]

Display maximum value, minimum value, and current value.
The overridable range for the selected parameter is set for minimum value and maximum value by default. By making the range of this value smaller, you can make the range of value that can be set by Vision Override Setting Instruction smaller.

5.2 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.

Select the offset limit check data to edit and click [EDIT] on the vision data list screen. The offset limit check edit screen like the following will be displayed.



The setting items area has the following parameters.

[Checking Method]

Select the offset limit checking method from a drop-down box.

[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 relative positions from the reference position.

[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 a drop-down box.:

[Cause the GET_OFFSET instruction to fail]

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.

6 STARTING FROM A ROBOT PROGRAM

This chapter describes how to start *i*RVision from a robot program.
There are two ways of how to use *i*RVision from a robot program as follows:

- Use program commands
- Use KAREL tools

6.1 PROGRAM COMMANDS

Program commands for *i*RVision are provided.

6.1.1 Vision Offset

This command offsets the robot position by using offset data stored in a vision register.

6.1.1.1 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 of offset data stored in the specified vision register 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 frame number.

> ⚠ **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 "Setup: 6.1.3.5 Offset data" 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 and VOFFSET

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.

MEMO
The VOFFSET CONDITION command needs to be specified in advance. For VOFFSET condition, refer to "Setup: 6.1.1.2 VOFFSET CONDITION".

```
L P[1] 500mm/sec FINE VOFFSET
```

6.1.1.2 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]
```

6.1.1.3 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 cannot be updated by vision. (The VISION GET_OFFSET instruction will fail).

6.1.1.4 UNLOCK VREG

This command unlocks vision registers.

```
UNLOCK VREG
```

6.1.2 Vision Execution

These commands instruct *i*RVision to perform processing.

The VISION RUN_FIND command is used to execute the vision process, and the following commands are used to obtain results.

- GET_OFFSET

- GET_NFOUND
- GET_PASSFAIL
- GET_READING

There are following commands other than above:

- SET_REFERENCE
- CAMERA_CALIB
- OVERRIDE

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.

6.1.2.1 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.

6.1.2.2 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.

The offset limit check is performed when the GET_OFFSET instruction is executed and an offset limit tool is selected in the vision process. The offset limit setup can be created / edited as application data (vision data). For details, refer to "Setup: 5.2 OFFSET LIMIT".

```
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.

> ✐**MEMO**
> 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 "Setup: 1.13 INTER-CONTROLLER COMMUNICATION" and “Ethernet Function OPERATOR’S MANUAL B-82974EN”.

> ⚠ **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.

6.1.2.3 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]
```

6.1.2.4 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

6.1.2.5 GET_READING

This command gets a result string of a reader vision process, then the command stores the string in a specified string register.
This 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.

> ⚠ **CAUTION**
> The length of the string indicates number of bytes. If the string is the multibyte character, the length of the string and number of characters do not match.

6.1.2.6 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_REFERENCE] 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.

6.1.2.7 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, refer to "Setup: 2.1.3 Robot-Generated Grid Calibration".
Visual Tracking Calibration	Not supported

6.1.2.8 OVERRIDE

This command sets a value for a vision override. The command is used immediately before the VISION RUN_FIND command.
The OVERRIDE command enables a vision process to run with part of its taught properties changed.
Each vision override is associated with a specific property of a vision process. For vision override, refer to "Setup: 5.1 VISION OVERRIDE".

```
VISION OVERRIDE (vision-override-name) a
```

Specify the value to be set in the "a" part. Numerical register can be used to indirectly specify the value.

```
VISION OVERRIDE (vision-override-name) R[n]
```

Values that can be directly specified are in the range from -1638.3 to 1638.3. When setting a value larger or smaller than the range, indirect specification using a register is used.

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.

6.1.3 Vision Registers

6

These commands assign the value of a vision register to a register or a position register.

6.1.3.1 Model ID

This command copies the model ID of the found workpiece from a vision register to a register.

```
R[a]=VR[b].MODELID
```

6.1.3.2 Measurement value

This command copies the measurement value of the found workpiece from a vision register to a register.

```
R[a]=VR[b].MES[c]
```

6.1.3.3 Encoder count

This command copies the encoder count of the found workpiece from a vision register to a register.
This command is used for visual tracking.

```
R[a]=VR[b].ENC
```

6.1.3.4 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.

> **MEMO**
> The position register format after assignment is XYZWPR.

6.1.3.5 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

> **MEMO**
> 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.

6.2 KAREL TOOLS

The KAREL programs below can be used.

- IRVSNAP, IRVFIND
- IRVTRAIN
- IRVBKLSH
- IRVHOMING
- IRVGETMSR, IRVGETMSL
- IRVOVRDANYVP
- SRWRTCSV, UPLDFIL, MAKEDIR
- SROUTSIG

> **MEMO**
> To call a KAREL program from a TP program, you must set the system variable $KAREL_ENB to TRUE.

For details on how to use the KAREL program, refer to KAREL program in the "R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR'S MANUAL(Basic Operation)."

6.2.1 IRVSNAP, IRVFIND

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.

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

For an application in which the workpieces have been put into a container mixed up so that some are showing their front and some their back and there are vision processes for both the front and the back, the following is an example of a program that executes a RUN_FIND for the back using the same image if the workpiece is not found by the RUN_FIND for the front.

```
CALL IRVSNAP(FRONT, 1, 1)
CALL IRVFIND(FRONT, 1, 1)
VISION GET_OFFSET FRONT VR[1] JUMP,LBL[10]
JMP,LBL[20]

LBL[10]
CALL IRVFIND(BACK, 1, 1)
VISION GET_OFFSET BACK VR[1] JUMP,LBL[99]

 LBL[20]
 J P[5] 500mm/sec FINE VOFFSET, VR[1]
```

6.2.2 ACQVAMAP, CLRVAMAP

ACQVAMAP and CLRVAMAP are functions to control 3D Area Sensor.

ACQVAMAP

This KAREL program acquires a 3D map of the specified 3D Area Sensor. Acquired 3D map is kept until a new 3D map for the same 3D Area Sensor is acquired, the 3D map is explicitly cleared by CLRVAMAP or the robot controller is turned off.

The following two arguments need to be passed.

Argument 1: 3D Area Sensor Name

Specify the vision data name of the 3D Area Sensor.

Argument 2: Merge Flag

When this argument is set to 1, the newly acquired 3D map is merged to the existing 3D map. When it is set to 0 or isn't specified, merging 3D maps does not occur. Usually you don't need to specify it.

CLRVAMAP

This KAREL program clears a 3D map of the specified 3D Area Sensor. Usually you don't have to clear a 3D map explicitly, but you can use this KAREL program when you do want to clear a 3D map for some reasons.

The following one argument needs to be passed.

Argument 1: 3D Area Sensor Name

Specify the vision data name of the 3D Area Sensor.

Program Example

Shown below is an example that acquires a 3D map of a specified 3D Area Sensor, finds workpieces in the acquired 3D map, and gets a vision offset for it.

```
CALL ACQVAMAP('SENSOR1')
VISION RUN_FIND 'VISION1'
VISION GET_OFFSET 'VISION1' VR[1] JMP,LBL[99]
```

Functions for acquiring a 3D map and finding workpieces are independently prepared, so you can retry finding workpieces in a same 3D map with different parameters. Shown below is an example of retrying.

```
CALL ACQVAMAP('SENSOR1')

VISION RUN_FIND ‘VISION1’
VISION GET_OFFSET ‘VISION1’ VR[1] JMP,LBL[1]
JMP,LBL[2]

LBL[1]
VISION RUN_FIND ‘VISION2’
VISION GET_OFFSET ‘VISION2’ VR[1] JMP,LBL[99]

LBL[2]
```

Managing 3D map

The number of 3D maps that can be kept in a robot controller is limited. By default, it is one.
You can change the number by changing the system variable $VAREA_CFG.$NUM_BUFFERS.
When this system variable is changed, the controller needs to be restarted. For details, refer to "Setup: 1.7 VISION CONFIG".

Because of the memory space issue, you may not be able to fully increase the number of 3D maps for 3D Area Sensors connected to the controller. When the number of 3D maps is smaller than the number of 3D Area Sensors, ACQVAMAP selects an area to store a new 3D map in the following manner:

1 Select an area that a 3D map of the specified 3D Area Sensor is stored in
2 Select an unused area that no 3D map is stored in
3 Select an area that the oldest 3D map is stored in

When you want to make sure to keep a certain 3D map for a while, you can control which area should be used to store a new 3D map by clearing an unnecessary 3D map by calling CLRVAMAP before calling ACQVAMAP.

For example, assume the number of 3D maps is two. When the following program is executed, ACQVAMAP(‘SENSOR3’) in the line 9 will overwrite the 3D map of SENSOR1, because it is the oldest one. Therefore, after the following program is executed, 3D maps of SENSOR2 and SENSOR3 remain in the controller.

```
 1:  CALL ACQVAMAP('SENSOR1')
 2:  VISION RUN_FIND ‘VISION1’
 3:  VISION GET_OFFSET ‘VISION1’ VR[1] JMP,LBL[99]
 4:
 5:  CALL ACQVAMAP('SENSOR2')
 6:  VISION RUN_FIND ‘VISION2’
 7:  VISION GET_OFFSET ‘VISION2’ VR[1] JMP,LBL[99]
 8:
 9:  CALL ACQVAMAP('SENSOR3')
10:  VISION RUN_FIND ‘VISION3’
11:  VISION GET_OFFSET ‘VISION3’ VR[1] JMP,LBL[99]
```

If you want to make sure to keep the 3D map of SENSOR1, you should call CLRVAMAP(‘SENSOR2’) before calling ACQVAMAP(‘SENSOR3’) as shown below.

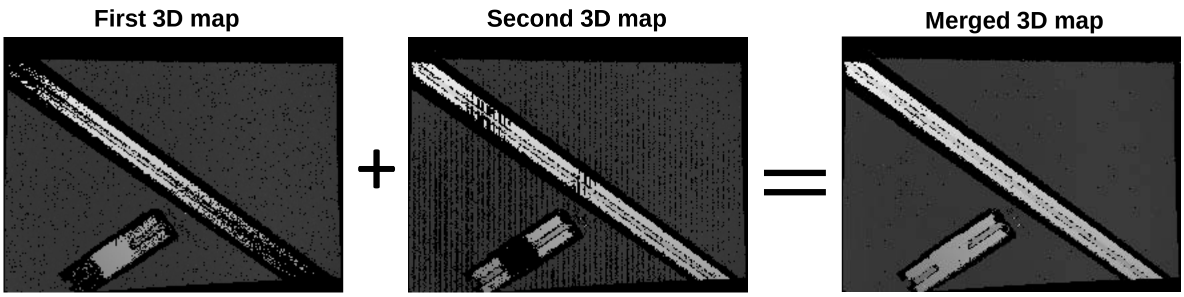
```
CALL ACQVAMAP('SENSOR1')
VISION RUN_FIND ‘VISION1’
VISION GET_OFFSET ‘VISION1’ VR[1] JMP,LBL[99]

CALL ACQVAMAP('SENSOR2')
VISION RUN_FIND ‘VISION2
VISION GET_OFFSET ‘VISION2 VR[1] JMP,LBL[99]

CALL CLRVAMAP('SENSOR2')

CALL ACQVAMAP('SENSOR3')
VISION RUN_FIND ‘VISION3’
VISION GET_OFFSET ‘VISION3’ VR[1] JMP,LBL[99]
```

Merging 3D maps

You can merge 3D maps acquired with different exposure times and/or different projector intensities.

This function is useful for the following cases.

- There are a bright part and a dark part on the workpiece surface and it is difficult to measure 3D points on the entire surface with a single exposure time.
- The entire surface cannot be measured because of the influence of unevenness of the projector light brightness.



Examples for merging 3D maps

> ⚠ **CAUTION**
> 1 The measurement time increases because it requires acquiring multiple 3D maps.
> 2 Only 3D maps acquired by the same 3D Area Sensor can be merged.
> 3 Merging 3D maps is only available from ACQVAMAP called from a TP program. In other words, it is not available on Vision Setup.

> ✐ **MEMO**
> You can check the merged 3D map on Vision Runtime and Vision Setup screens.

In the following example, the line 1 acquires the first 3D map, the second line overrides the exposure time, and the line 3 acquires the second 3D map and then merges it to the first 3D map.

```
1:    CALL ACQVAMAP('SENSOR1')
2:    VISION OVERRIDE ‘EXPO’ 40.0
3:    CALL ACQVAMAP('SENSOR1',1)
```

6.2.3 IRVTRAIN

IRVTRAIN is a function to train the model pattern of a GPM locator tool from a TP program.

The function to train the model pattern by executing IRVTRAIN from a TP program is called “External Model Train.” The details of the model pattern to be trained are specified in an XML-format text file. This text file is called a “model train file.”
In a model train file, search parameters of the GPM locator tool can be specified in addition to the shape of the model pattern to be trained.

External Model Train function has two training modes. The mode is selected by specifying it in the model train file.

Use Graphics
The shape of the model pattern to be trained is specified using circles, rectangles, lines, and arcs. The locations and dimensions of these graphics are specified in millimeters.

Use an Image
A model pattern is trained with a specified area within a specified image. Either a captured image or a saved image file can be used to train a model pattern.

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When the model pattern of a GPM locator tool is trained with External Model Train, the changes are saved in the executed vision data just as if the model pattern were trained from the GPM locator tool setup page.

External Model Train has the following effects in comparison to the model pattern trained from the GPM locator tool setup page.

- The model pattern can be trained free of contamination from image noise and part variance, because the model pattern can be specified with geometric shapes.
- Workers unfamiliar with *i*RVision can effortlessly change or add the parts to be handled, because the *i*RVision setup page operation is not required in the process.
- The downtime in changing or adding parts can be minimized, because the text file can be created off-line without the actual part or a camera.
- A single text file can train model patterns for similar parts with varying measurements, by specifying the measurements with numerical registers in the file.
- Problems of FROM capacity and complex TP programs can be moderated, because the number of vision processes with respect to the parts can be reduced.

The following two arguments need to be passed to this program.

Argument 1: Vision Process Name
Specify the name of a vision process with a GPM locator tool to train the model pattern for, as a character string. A string register can be specified instead.

Argument 2: Model Train File Name
Specify the name of a text file containing information about the model, as a character string. A string register can be specified instead.

Sample TP Program

```
1:    CALL IRVTRAIN (Vision Process Name, Model Train File Name)
```

> ⚠ **CAUTION**
> The setup page of the vision process intended for running the External Model Train must be closed before executing the TP program.

6.2.3.1 Model train file

The details of the model pattern to be trained are specified in a model train file.

The following information is described in a model train file.

- GPM locator tool name
- Training mode (Use graphics or use an image)
- If graphics are used, the location and dimensions of the graphics
- If an image is used, whether the image is captured or loaded from a file

The dimensions of the graphics described in the model train file can be indirectly specified using numerical registers. In the case of indirectly specifying the values using numerical registers, the model pattern with various dimensions can be trained by specifying the values in the registers and executing IRVTRAIN, even without changing the content of the model train file.
However, the model pattern is trained using the values in the numerical registers at the time IRVTRAIN is executed, thus simply changing the register values will not retrain the model pattern.

Furthermore, the following parameters can be modified with the training of the model pattern.
For instance, the orientation search can be disabled with the model train file if the model pattern to be trained is a circle.

- Model ID
- Score Threshold
- Contrast Threshold
- Area Overlap
- Elasticity
- EA Score Threshold
- Allow Floating EA
- Ignore Polarity
- DOF - Orientation
- DOF - Scale
- DOF - Aspect

Model Train File Location

External Model Train function operates by referencing a model train file and optionally an image file stored in the specified directory (MC:¥VISION¥TRAIN¥ by default).
Create this directory in a memory card, and store the files in the directory before executing External Model Train.

Model Train File Format

The model train file is written in an XML format.
If any discrepancies exist with the format, the line number of the first inadequacy is posted with an alarm message.

MEMO
The XML format can be verified using a viewer such as Microsoft Internet Explorer®. We recommend that you check the text file format with such a viewer prior to running External Model Train.

Sample model train file for training a model pattern with a rectangular shape:

```
<?xml version=“1.0” encoding=“UTF-8” ?>
    <visiontrain>
      <gpmtool name=“GPM Locator Tool 1”>
        <gpmmodel>
          <shape type=“rect”>
            <size>R[1] R[2]</size>
          </shape>
        </gpmmodel>
      </gpmtool>
    </visiontrain>
```


Sample model train file for training more complicated model pattern with multiple shapes:

```
<?xml version=“1.0” encoding=“UTF-8” ?>
    <visiontrain>
      <gpmtool name=“GPM Locator Tool 1”>
        <gpmmodel model-id=“1” train-height=“20”>
          <shape type=“polyline” closed=“true”>
            <point>12.0 12.0</point>
            <point>0.0 12.0</point>
            <point>0.0 0.0</point>
            <point>10.0 0.0</point>
            <point type=“arc-to” radius=“2”>12.0 2.0</point>
          </shape>
          <shape type=“circle” extra-care=“true”>
            <point>3.5 3.5</point>
            <value name=“radius”>R[1]</value>
          </shape>
        </gpmmodel>
        <gpmrunparams>
          <value name=“score-thresh”>70</value>
          <value name=“contrast-thresh”>50</value>
        </gpmrunparams>
      </gpmtool>
    </visiontrain>
```

Sample model train file for training a model pattern with a captured image

```
<?xml version="1.0" encoding="UTF-8" ?>
    <visiontrain>
      <gpmtool name="GPM Locator Tool 1">
        <gpmmodel model-id="1">
          <image>snap</image>
          <trainroi>
            <point>100 100</point>
            <size>140 240</size>
          </trainroi>
        </gpmmodel>
        <gpmrunparams>
          <value name="score-thresh">80</value>
          <value name="contrast-thresh">30</value>
        </gpmrunparams>
      </gpmtool>
    </visiontrain>
```

Sample model train file for training a model pattern with an image file:

```
<?xml version="1.0" encoding="UTF-8" ?>
    <visiontrain>
      <gpmtool name="GPM Locator Tool 1">
        <gpmmodel>
          <image center-origin="true">square1.png</image>
          <trainroi>
            <point>100 100</point>
            <size>140 240</size>
          </trainroi>
        </gpmmodel>
        <gpmrunparams>
          <value name="score-thresh">80</value>
          <value name="contrast-thresh">30</value>
        </gpmrunparams>
      </gpmtool>
    </visiontrain>
```

Values of elements and attributes can be indirectly specified using registers.
The samples above show examples of the usage.

The following registers can be specified.

R[ ]
Numerical register can be used to indirectly specify a numerical value. Enter "R[Register number]"

SR[ ]
String register can be used to indirectly specify a text. Enter "SR[Register number]".

The elements of the model train file are as follows:

<VISIONTRAIN>

This is the root element of the model train file. This element indicates that the text file is a model train file for *i*RVision External Model Train function.

```
<visiontrain>...</visiontrain>
```

<gpmtool> element must be inserted as a child element. No attributes can be specified.

<GPMTOOL>

This is the element for specifying the intended GPM locator tool.

```
<gpmtool name="gpm_tool_name">...</gpmtool>
```

This element is inserted for each GPM locator tool to be trained, as a child element of the <visiontrain> element. Multiple <gpmtool> elements are inserted when model patterns for multiple GPM locator tools are to be trained simultaneously with one model train file. The element can have one <gpmmodel> element and one <gpmrunparams> element as its child elements.

The following attribute can be specified:

name

The name of the intended GPM locator tool is specified. This attribute must be specified. The text can be indirectly specified with a string register. Texts with capitalization and spaces are distinguished.

<GPMMODEL>

This is the element for describing the model information.

```
<gpmmodel model-id="val1" train-height="val2">...</gpmmodel>
```

This element is inserted as a child element of the <gpmtool> element. Only one <gpmmodel> element can be inserted as a child tool of each <gpmtool> element.
The element can have the following elemnets as its child.

- <shape>
- <image>
- <trainarea>
- <trainroi>

Writing the <shape> element or the <image> element determines whether graphics or an image is used to train the model pattern. An alarm is posted if both <shape> element and <image> element are present.

The following attributes can be specified:

model-id

The model ID of the intended GPM locator tool is specified. A value between -2147483647 and 2147483646 can be specified. This attribute is optional. If omitted, the model ID specified in the GPM locator tool is used.
The value can be indirectly specified with a numerical register.

train-height

The application Z height in the offset frame is specified in millimeters when training a model pattern with graphics. This attribute is optional. If omitted, the application Z value specified in the vision process is used.
The value can be indirectly specified with a numerical register.

MEMO

The value of the train-height attribute dictates the height of a plane that the graphics are considered to be on, when the model is trained. Specifying this value in the model train file does not modify the application Z height in the vision process setup page.

<SHAPE>

This is the element for describing a model pattern graphic.

```
<shape type="text" closed="bool" light-inside="bool" light-left="bool" extra-care="bool">...</shape>
```

This element is inserted as a child element of the <gpmmodel> element. Each<shape> element signifies a rectangle, a circle, or sequential lines, and a complex shape can be specified by inserting multiple <shape> elements in the model train file.

The following attributes can be specified:

type

The type of the graphic is specified. This attribute must be specified. Select from the followings:

rect	A rectangle
circle	A circle
polyline	A polygonal line formed with straight lines and arcs

closed

The attribute specifies whether the polygonal line is closed or not, when the type attribute is "polyline". The last point and the first point are connected with a straight line if TRUE. This attribute is optional. The value will be FALSE if the attribute is omitted.

light-inside

The attribute specifies the polarity of the graphic when the type attribute is "rect" or "circle." The graphic will be light against a dark background if TRUE, and dark against a light background if FALSE. This attribute is optional. The value will be FALSE if the attribute is omitted.

light-left

The attribute specifies the polarity of the graphic when the type attribute is "polyline." The left side of a line drawn from the start point to the end point will be light if TRUE, and dark if FALSE. This attribute is optional. The value will be FALSE if the attribute is omitted.

extra-care

The attribute specifies whether the graphic is an emphasis area or not. The graphic will be an emphasis area if TRUE. This attribute is optional. The value will be FALSE if the attribute is omitted.

When "rect" is specified as the graphic type, the location, the size, and the orientation of the rectangle should be specified by inserting <point>, <size>, and <value> elements as the child elements of the <shape> element.

```
<shape type="rect" light-inside="bool" extra-care="bool">
  <point type="text">x y</point>
  <size>dx dy</size>
  <value name="angle">a</value>
</shape>
```

The child elements are specified as follows:

<point>

The location of the rectangle is specified in millimeters. This element is optional. The center of the rectangle will be positioned at (0, 0) if the element is omitted.

The "type" attribute can be optionally specified. Either "upper-left" or "center" can be specified. When "upper-left" is specified, the element values will be the coordinate of the upper-left corner of the rectangle. When "center" is specified, the element values will be the coordinate of the center of the rectangle. This attribute is optional, and omitting the attribute would be the same as specifying "center."

<size>
The size of the rectangle is specified in millimeters. This element must be specified.

<value>
The orientation of the rectangle is specified in degrees. The "name" attribute must be specified, and "angle" is specified as the attribute value. The center of rotation is the point specified with the <point> element. This element is optional. The orientation will be 0 if the element is omitted.

MEMO
A square can be trained by specifying the same value in the <size> element values.

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When "circle" is specified as the graphic type, the center and the radius should be specified by inserting <point> and <value> elements as the child elements of the <shape> element.

```
<shape type="circle" light-inside="bool" extra-care="bool">
  <point>x y</point>
  <value name="radius">r</value>
</shape>
```

The child elements are specified as follows:

<point>
The center of the circle is specified in millimeters. No attributes are specified. This element is optional. The center of the circle will be positioned at (0, 0) if the element is omitted.

<value>
The radius of the circle is specified in millimeters. This element must be specified. The "name" attribute must be specified, and "radius" is specified as the attribute value.

When "polyline" is specified as the graphic type, the coordinates of vertices should be specified by inserting multiple <point> elements as the child elements of the <shape> element.

```
<shape type="polyline" closed="bool" light-left="bool" extra-care="bool">
  <point>x1 y2</point>
  <point>x2 y2</point>
  ...
</shape>
```

The child element is specified as follows:

<point>
The coordinate of a vertex is specified in millimeters. This element must be specified. Each <point> element indicate a vertex in the polygonal line, thus at least two <point> elements are required.

By default, the vertices are connected by a straight line. An arc can be formed between the specified vertex and the previous vertex by specifying the "type" attribute with "arc-to" value. The dimensions of the arc are specified with "radius", "clockwise", and "roundabout" attributes. Refer to the <point> element description for detail.

<TRAINAREA>

This is the element for specifying the model train area, when training the model pattern with graphics.

```
<trainarea>
  <point>...</point>
  <size>...</size>
</trainarea>
```

When training the model pattern with graphics, the model train area is automatically calculated to circumscribe the specified graphics. Therefore, it is generally not necessary to specify this element. If a train area should be explicitly specified, then the <trainarea> can be inserted as the child element of the <gpmmodel> element. No attributes are specified. The location and the size of the area should be specified by inserting <point> and <size> elements as its child elements.

The child elements are specified as follows:

<point>

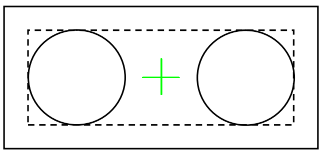
The upper-left coordinate of the train area is specified in millimeters. This element must be specified. No attributes are specified.

<size>

The size of the train area is specified in millimeters. This element must be specified. No attributes are specified.

MEMO

If the <trainarea> element is omitted is shown below, a rectangle shown in dotted lines circumscribing the model origin (0, 0) and the graphics specified with <shape> elements are expanded by 10 pixels in all directions to form a rectangular train area (shown in solid lines).



Train area

<IMAGE>

This is the element for specifying the image to be used.

```
<image center-origin=”bool”>val</image>
```

This element is inserted as a child element of the <gpmmodel> element to specify the image to be used for training a model pattern. The element does not have any child elements.

To use the captured image as the image for training a model pattern, specify “snap” as the element value. To use an image file as the image for training a model pattern, specify the name of the file as the element value. Image files with the extension BMP and PNG are supported. A string register can be used to indirectly specify the value.

The following attribute can be specified:

center-origin

Whether or not to set the model origin at the center of rotation is specified. The rotational center is calculated and set as the model origin if TRUE. If FALSE, the model origin will be set to a location such that the found result would coincide with the result of the previous model. This attribute is optional. The value will be FALSE if the attribute is omitted.

> ⚠ **CAUTION**
> External Model Train needs to be operated such that the reference data and robot positions are not required to be modified after training the model pattern. Refer to "Setup: 6.2.3.2 Operation Methods" for detail.

<TRAINROI>

This is the element for specifying the model train area, when training the model pattern with an image.

```
<trainroi>
  <point>x y</point>
  <size>dx dy</size>
</trainroi>
```

This element is inserted as a child element of the <gpmmodel> element to specify the position and the size of a train area when training a model pattern with an image. This element must be inserted if an image is used with External Model Train. No attributes are specified. The element should have <point> and <size> element as its child elements to specify the position and the size of the train area.

The child elements are specified as follows:

<point>
The upper-left coordinate of the train area within the image is specified in pixels. This element must be specified. No attributes are specified.

<size>
The size of the train area within the image is specified in pixels. This element must be specified. No attributes are specified.

<SIZE>

This is the element for specifying the size of a rectangle.

```
<size>dx dy</size>
```

This element is inserted as a child element of <shape>, <trainarea>, and <trainroi> elements to specify the size of a rectangle. The two numerical values must be separated by a space. If the unit of the values are in millimeters, the values are entered in the order of x and y, and if the unit of the values are in pixels, the values are entered in the order of vt and hz. Numerical registers can be used to indirectly specify the values. No attributes can be specified. The element does not have any child elements.

<POINT>

This is the element for specifying the coordinate of a point.

```
<point type=”text” radius=”r” clockwise=”bool” roundabout=”bool”>x y</point>
```

This element is inserted as a child element of <shape>, <trainarea>, and <trainroi> elements to specify the coordinate of a point. The two numerical values must be separated by a space. If the unit of the values are in millimeters, the values are entered in the order of x and y, and if the unit of the values are in pixels, the values are entered in the order of vt and hz. Numerical registers can be used to indirectly specify the values.
The element does not have any child elements.

The following attributes can be specified:

type

The type of a point is specified from the followings:

center	Used to specify the center of a rectangle
upper-left	Used to specify the upper-left corner of a rectangle
arc-to	Used to add an arc in the polygonal line

radius

The attribute specifies the radius of an arc when the point type is “arc-to”. The attribute must be specified.

clockwise

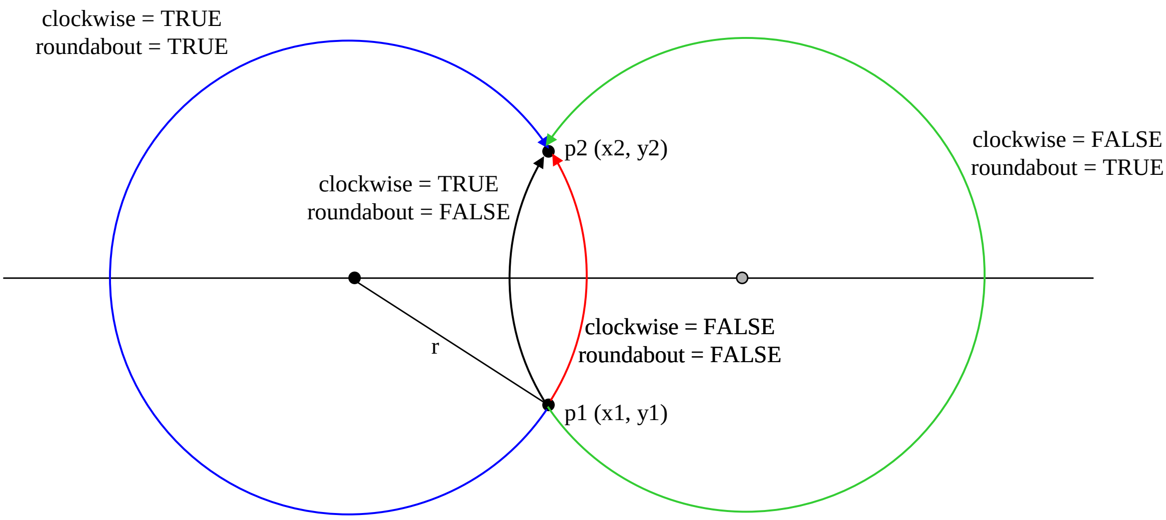
The attribute specifies the direction of the arc when the point type is “arc-to”. The arc is drawn clockwise if TRUE, and counter-clockwise if FALSE. The attribute is optional. The value will be FALSE if the attribute is omitted.

roundabout

The attribute specifies the route of the arc when the point type is “arc-to”. The arc is drawn with a roundabout route if TRUE, and with a shortest route if FALSE. The attribute is optional. The value will be FALSE if the attribute is omitted.

An example of the use of arc related attributes are shown below.

```
<point>x1 y1</point>
<point type="arc-to" radius="r" clockwise="bool1" roundabout="bool2>x2 y2</point>
```



Example of the use of an arc

<GPMRUNPARAMS>

This is the element for specifying the search parameters.

```
<gpmrunparams>...</gpmrunparams>
```

This element is inserted as a child element of the <gpmtool> element, and contains search parameter information.
No attributes can be specified.
The element has <value> elements as its child elements to specify the values of search parameters.

<VALUE>

This is the element for specifying a value.

```
<value name="text">...</value>
```

This element is inserted as a child element of <shape> and <gpmrunparams> elements.
The element does not have any child elements.

The following attribute can be specified:

name

The name of a search parameter is specified. This attribute must be specified. The parameters from the following list can be specified as the attribute value.

Parameters	Descriptions
radius	Specify the radius of a circle. A numerical register can be used to indirectly specify the value.
angle	Specify the orientation of a rectangle. A numerical register can be used to indirectly specify the value.
score-thresh	Specify the score threshold between 10.0 and 100.0. A numerical register can be used to indirectly specify the value.
contrast-thresh	Specify the contrast threshold between 1 and 200. A numerical register can be used to indirectly specify the value.
overlap-thresh	Specify the area overlap ratio between 0.0 and 100.0. A numerical register can be used to indirectly specify the value.
fit-err-thresh	Specify the elasticity between 0.1 and 5.0. A numerical register can be used to indirectly specify the value.
extra-care-thresh	Specify the emphasis area threshold between 10.0 and 100.0. A numerical register can be used to indirectly specify the value.
extra-care-float	Specify if emphasis area deviation is allowed. TRUE to allow deviation.
ignore-polarity	Specify if polarity is ignored. TRUE to ignore model pattern polarity.
angle-enabled	Specify whether or not to enable orientation search. TRUE to enable orientation search.
angle-nom	Specify the nominal orientation search angle between -180.0 and 180.0. A numerical register can be used to indirectly specify the value.
angle-min	Specify the minimum orientation search angle between -180.0 and 180.0. A numerical register can be used to indirectly specify the value.
angle-max	Specify the maximum orientation search angle between -180.0 and 180.0. A numerical register can be used to indirectly specify the value.
scale-enabled	Specify whether or not to enable scale search. TRUE to enable scale search.
scale-nom	Specify the nominal scale search range between 25.0 and 400.0. A numerical register can be used to indirectly specify the value.
scale-min	Specify the minimum scale search range between 25.0 and 400.0. A numerical register can be used to indirectly specify the value.
scale-max	Specify the maximum scale search range between 25.0 and 400.0. A numerical register can be used to indirectly specify the value.
aspect-enabled	Specify whether or not to enable aspect search. TRUE to enable aspect search.
aspect-nom	Specify the nominal aspect search range between 50.0 and 100.0. A numerical register can be used to indirectly specify the value.
aspect-min	Specify the minimum aspect search range between 50.0 and 100.0. A numerical register can be used to indirectly specify the value.

Parameters	Descriptions
aspect-max	Specify the maximum aspect search range between 50.0 and 100.0. A numerical register can be used to indirectly specify the value.

The <value> elements provided for the child elements on the <gpmrunparams> element overwrite parameters independently of one another.
For example, it is possible to set a value in angle-nom when angle-enabled is set to TRUE. In this case, the angle-nom value that is set is not used during detection, but the parameter itself is rewritten.

It is not necessary to specify angle-min and angle-max simply because angle-enabled is changed to TRUE.

MEMO

It is not necessary to insert the <value> elements for all parameters when the parent element is <gpmrunparams>. Unspecified parameters are simply not modified. The IRVTRAIN ends normally.

6.2.3.2 Operation methods

A conventional robot compensation process involves training a model pattern for the GPM locator tool first, setting a reference data by detecting a reference part placed at a reference position next, and creating and teaching robot positions in a TP program to handle the part at the end.

The same procedure is required for training the initial model pattern with External Model Train. However, for training subsequent model patterns, reference data and robot positions are not retrained—the robot is compensated using the same reference data and robot positions. In other words, the order of training the model pattern, reference data, and robot positions is altered. There are some critical points for the robot to properly compensate the offset without re-setting the reference data or re-teaching robot positions after re-training the model pattern. In this section, operation methods for training a model pattern with graphics and with an image are explained.

⚠ CAUTION

Interchanging the model pattern training methods for the same GPM locator tool will incapacitate the robot from properly compensating the offset without retraining the reference data and robot positions. If a model pattern was trained using graphics, then subsequent model patterns should be trained using graphics; if a model pattern was trained using an image, then subsequent model patterns should be trained using an image.

Training with Graphics

The following steps describe the initial model pattern training for training with graphics.

1 Create and train a camera calibration.
2 Create and train a vision process.
Setup the vision process (i.e., selecting a camera calibration, the offset mode, and the offset frame). However, do not train the GPM locator tool model pattern or set the reference data.
3 Create and store a model train file in a designated directory.
4 Move the robot to the search position, if the camera is mounted on the robot.
5 Run IRVTRAIN.
6 Place a reference part at a reference position.
7 Run vision execution (Run VISION RUN_FIND).
8 Set the reference data (Run VISION SET_REFERENCE).
9 Train robot picking motion.

Note that reference data and robot positions are not altered.
The data and positions trained with the initial model pattern training are used.

The following steps describe the subsequent model pattern training for training with graphics.

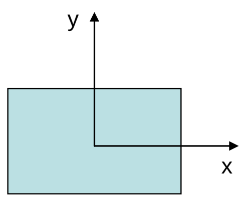
1 Create and store a model train file in a designated directory.
2 Move the robot to the search position, if the camera is mounted on the robot.
3 Run IRVTRAIN.

Graphic Projection

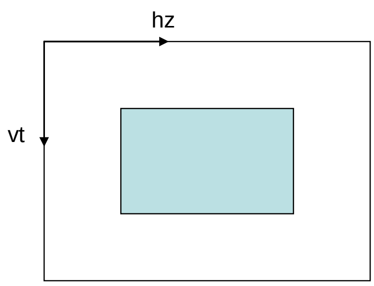
When training a model pattern with graphics, the locations and dimensions of the graphics are specified in millimeters. These graphics are projected onto the camera using a camera calibration; therefore a camera calibration must be trained before running IRVTRAIN.

6

Points on the graphics are specified as 2-dimensional data, described in a Cartesian coordinate (x, y) as shown in the left diagram below. When the graphics are projected onto the camera, the x-coordinate becomes the horizontal component in the image as shown in the right diagram below, such that the orientation of the graphics remains the same.



Specified shape



Projected shape

The size with which the graphics are projected onto a camera depends on the distance between the camera and the plane where the graphics are considered to be placed on.
In general, the part Z height specified in the vision process setup page represents the height of this plane.
If you prefer to train the model pattern with the graphics on another height, the height of this plane can be explicitly specified with the train-height attribute of the <gpmmodel> element.

MEMO
The value of the train-height attribute dictates the height of a plane that the graphics are considered to be on, when the model is trained. Specifying this value in the model train file does not modify the application Z height in the vision process setup page.

The graphics specified in the model train file are considered to be placed squared with the camera. Therefore, even if the camera were mounted at an angle with respect to the offset frame, a circle specified in the model train file would be a circle instead of an oval.

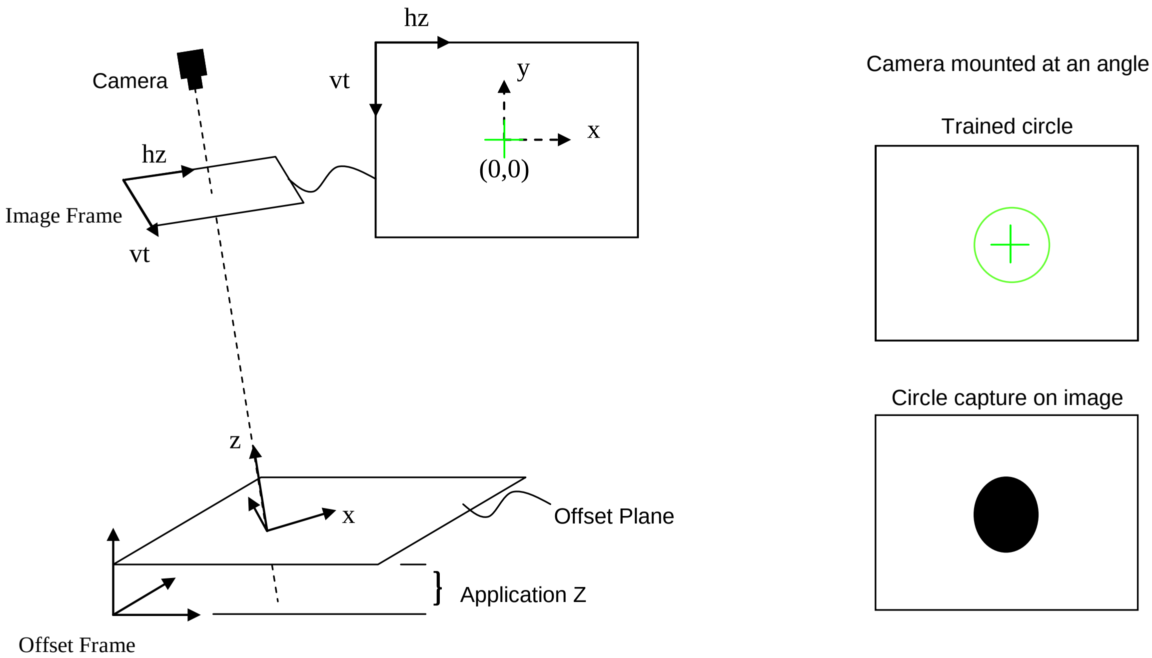
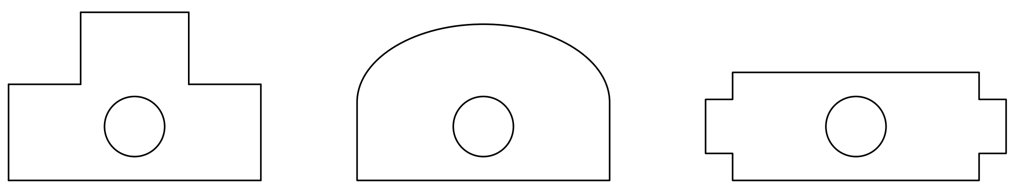


Image of graphic projection

> ✐**MEMO**
> If the camera is mounted at an angle, enabling the aspect search in the GPM locator tool setup page would help with the detection.

Model Origin

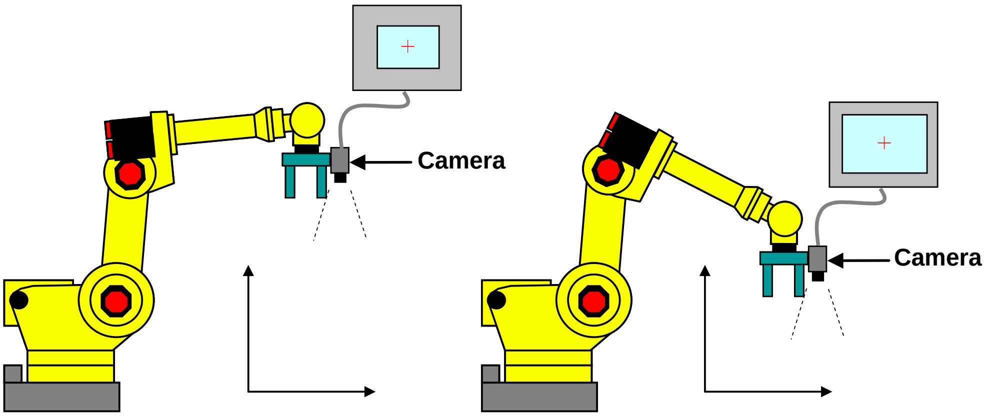
When training a model pattern with graphics, the model origin would always be set at (0, 0).
In order for the robot compensation to be correct without retraining the reference position and the robot positions, the model origin must remain the same with respect to the robot gripper when picking the part.
For instance, to be able to handle the three parts shown below by inserting a gripper in the hole, each graphic is specified such that the center of the circle is located at (0, 0).



Model origin of the center of the hole

Robot-mounted Camera

When training a model pattern with graphics, the graphics specified in the model train file are projected onto the camera as described above. Since the projected size varies according to the position of the camera, External Model Train should be executed with the robot at the detection position when the camera is mounted on the robot.



Example of external model train using a robot-mounted camera

6

Training with an Image

The following steps describe the initial model pattern training for training with an image.

1 Create and train a camera calibration.
2 Create and train a vision process.
Setup the vision process (i.e., selecting a camera calibration, the offset mode, and the offset frame). However, do not train the GPM locator tool model pattern or set the reference data.
3 Create and store a model train file in a designated directory.
4 Place a reference part at a reference position.
5 Move the robot to the search position, if the camera is mounted on the robot.
6 Run IRVTRAIN.
7 Run vision execution (Run VISION RUN_FIND).
8 Set the reference data (Run VISION SET_REFERENCE).
9 Train robot picking motion.

Note that reference data and robot positions are not altered.
The data and positions trained with the initial model pattern training are used.

The following steps describe the subsequent model pattern training for training with an image.

1 Create and store a model train file in a designated directory.
2 Place a reference part at a reference position (Only when training with a captured image).
3 Move the robot to the search position, if the camera is mounted on the robot.
4 Run IRVTRAIN.

When the model pattern is retrained with an image, in order for the robot compensation to be correct without retraining the reference data and the robot positions, the detection result of the new model pattern must coincide with the previous model pattern.

In order to ensure this, an image with the part placed at a position where the robot can handle it without an offset must be used with External Model Train. To keep the model origin identical to the previous model pattern, specify FALSE as the center-origin attribute value of the <image> element. (Omitting the center-origin attribute will set the value as FALSE.)

If the part is rotationally symmetric, by specifying the center-origin attribute of the <image> element as TRUE would set the model origin at the center of rotation. In the case where all the parts that are to be detected with a specific vision process are rotationally symmetric, and if the model origin were to be set at the rotational center of all parts, specifying the center-origin attribute to TRUE would ensure that the found result would be identical with respect to the handling position. However, the orientation of the detected part is relative to the orientation of the part in the image, with the trained model pattern being 0 degrees. Thus, unless the orientation of the part can be ignored such as with a circle, an image captured with the part placed at a position where the robot can handle it without an offset must be used.

> ⚠ **CAUTION**
> The model origin would be modified if the center-origin attribute of the <image> element is specified as TRUE in the model train file.
> To ensure that the robot position is offset correctly, set the center-origin attribute to FALSE and place the part at a position where the robot can handle it without an offset, before executing External Model Train with an image.

> **MEMO**
> External Model Train function is meant to automate model pattern training. Therefore it is undesirable to have to edit a model mask on the setup page after executing IRVTRAIN.
> Note the following points when capturing the image for training the model pattern, to get an appropriate model without editing mask.
> - Lighting is controlled.
> - A clean background
> - Enough contrast on edges of workpiece
> - Low noise
>
> Thus, preparing a designated model pattern training station is recommended.

In a system where multiple parts are interchanged at certain interval, the same set of images ought to be used to retrain the model pattern for consistency. In such a case, by keeping the images as image files, External Model Train can train model patterns using image files. This is also beneficial since an actual reference part is not required to train the model pattern. However, the image to be saved as an image file must be captured with the conditions specified in this section.

6.2.3.3 Precautions

This section describes restrictions and limitations for External Model Train.

Power Interruption

> ⚠ **CAUTION**
> Do not turn off the robot controller while running External Model Train.
> Doing so may corrupt the FROM module memory and may interfere with normal robot operation.

Supported Vision Processes

External Model Train is supported with the following vision processes.

- 2D Single-view Vision Process
- Depalletizing Vision Process

2D Single-view Vision Process cannot calculate the correct offset if the application Z height of the reference part and the detected part are not identical. When retraining model pattern for parts with different heights using External Model Train, use Depalletizing Vision Process with the application Z mode set to “Use Register Value” and set an appropriate value for the measurement plane corresponding to the part.

Supported Command Tool

External Model Train is supported only with GPM locator tool. In addition, the model pattern of a GPM locator tool with its search window set to shift dynamically cannot be trained with External Model Train.

Daily Execution Limit

When the robot is in production (TP is disabled and the controller is in AUTO mode), the number of times External Model Train can be executed is limited to five a day.
This limitation does not apply when the robot is not in production (i.e., executing IRVTRAIN from TP).

MEMO

Vision data are stored in the robot controller FROM module by default. There is a limit to the number of times the data on the flash memory of the FROM can be changed, and by executing External Model Train frequently, the limit may be reached unexpectedly and may interfere with normal robot operation. The daily execution limit is provided to avoid such trouble.

Model Pattern Mask and Emphasis Area

By executing External Model Train, previously set model mask and emphasis area are deleted, just as they are deleted when a new model pattern is trained from the setup page.

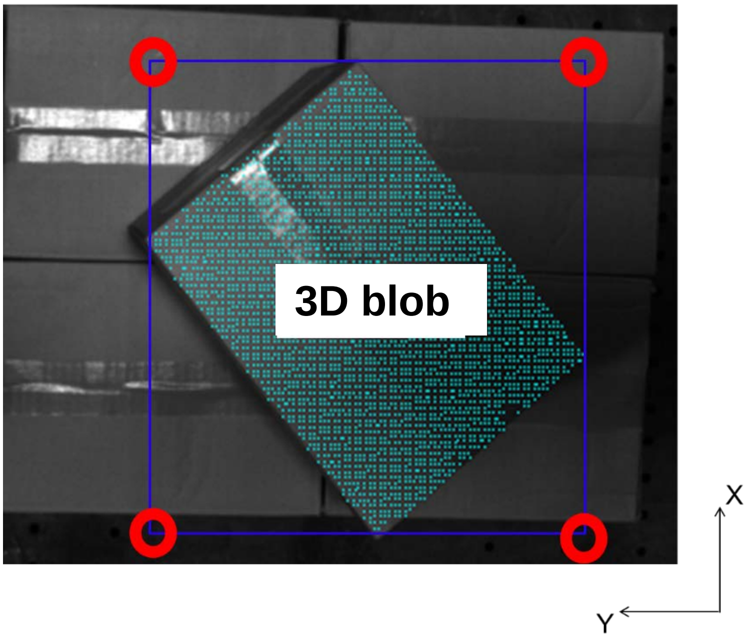
When the model pattern is trained with graphics, a model mask cannot be set from the GPM locator tool setup page. The graphics in the model train file should only contain features that are pertinent to the model pattern. On the other hand, an emphasis area can be set to the selected sections of the model pattern trained with graphics, from the GPM locator tool setup page.

6.2.4 BPGETAABB, BPGETOBB

BPGETAABB and BPGETOBB outputs the corner positions of 3D blob found by the Area Sensor Blob Locator Tool.

BPGETAABB

This KAREL program outputs the corner positions of Axis Aligned Bounding Box of 3D blob.



AABB (Axis Aligned Bounding Box)

The following arguments can be passed:

Argument 1: Vision register number
Specify the index number of vision register storing 3D blob data.

Argument 2: Measurement value number
Specify the index number of measurement value storing Min. X of 3D blob.

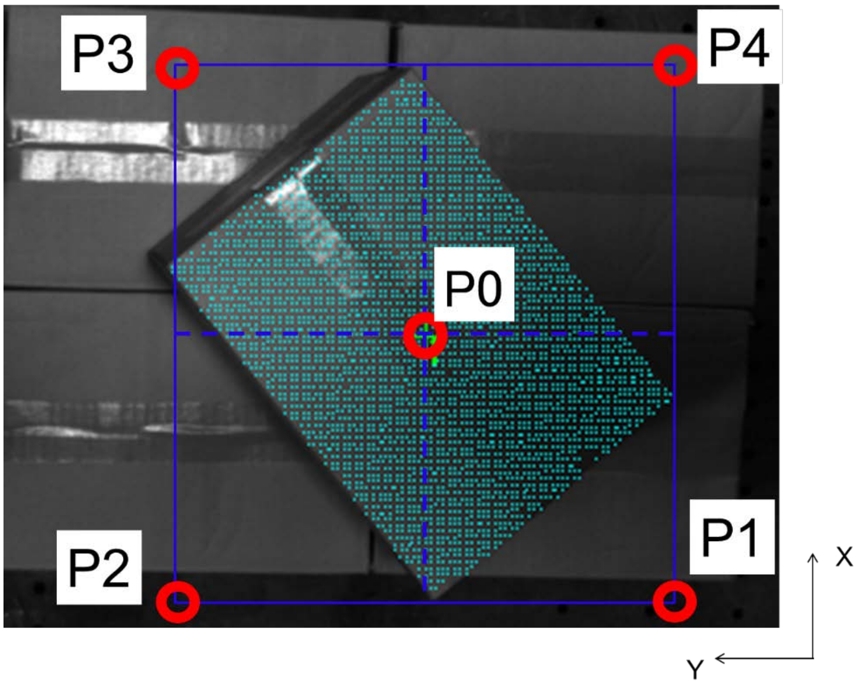
Argument 3: Measurement value number
Specify the index number of measurement value storing Max. X of 3D blob.

Argument 4: Measurement value number
Specify the index number of measurement value storing Min. Y of 3D blob.

Argument 5: Measurement value number
Specify the index number of measurement value storing Max. Y of 3D blob.

Argument 6: Position register number
Specify the index number of position register storing robot configuration data as reference.
Position info output through the position register of Arg9 is provided with this configuration data.

Argument 7: Index number to indicate the corner position.
Specify one of the corner positions to be output.
0: P0 in the figure shown below
1: P1 in the figure shown below
2: P2 in the figure shown below
3: P3 in the figure shown below
4: P4 in the figure shown below



Corner positions of an axis aligned bounding box

Argument 8: Register number (Output)

Specify index number of register to output the status information of this KAREL program.

In the register, one of the values shown below will be set depending on the error that occurs:
0: The program ended normally.
900: The vision register specified by Arg1 is not set 3D blob data.
901: The type of position register specified by Arg6 is not supported.
902: The type of position register specified by Arg9 is not supported.

Argument 9: Position register number (Output)

Specify index number of register to output the corner position.

Program Example

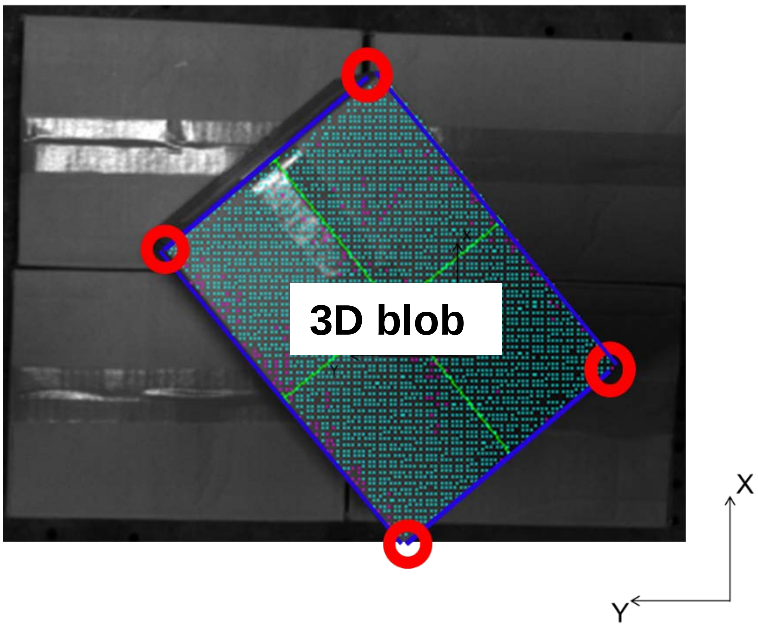
Shown below is an example that outputs the corner position P1 of 3D blob to the PR[11] and moves the robot to the PR[11].

```
1:    CALL ACQVAMAP('SENSOR')
2:    VISION RUN_FIND 'VISION'
3:    VISION GET_OFFSET 'VISION1' VR[1] JMP,LBL[10]
4:    CALL BPGETAABB (1,1,2,3,4,10,1,1,11)
5:    IF R[1]<>0, JMP LBL[10]
6:L PR[11] 100mm/sec FINE
7:    LBL[10]
```

BPGETOBB

This KAREL program outputs the corner positions of Oriented Bounding Box of 3D blob.

> ⚠ **CAUTION**
> Please specify the [Minimum Rectangle Center] as the [Found Position] in the Area Sensor Blob Locator tool when this KARE program is used.



OBB (Oriented Bounding Box)

The following arguments can be passed:

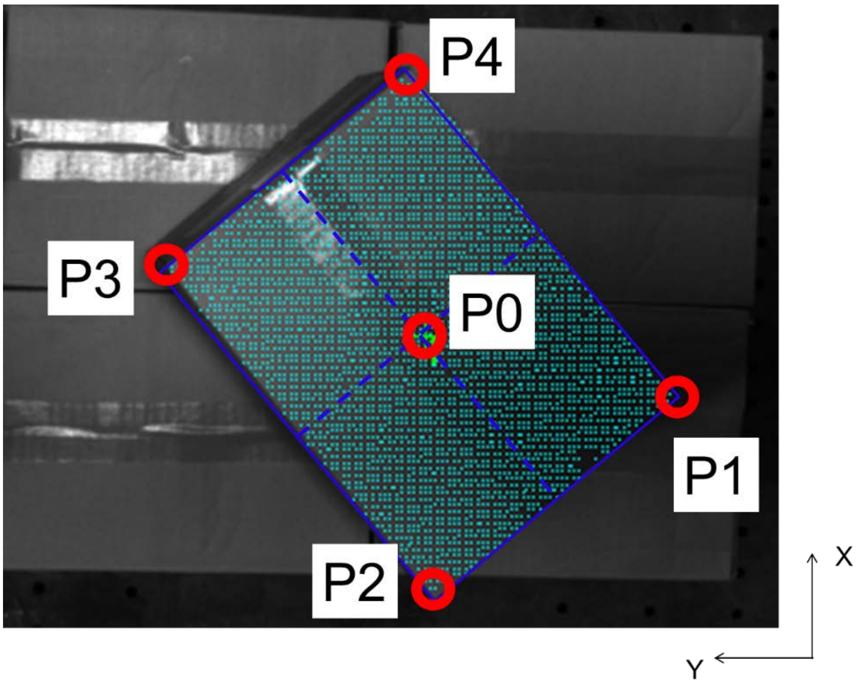
Argument 1: Vision register number
Specify the index number of vision register storing 3D blob data.

Argument 2: Measurement value number
Specify the index number of measurement value storing Length of 3D blob.

Argument 3: Measurement value number
Specify the index number of measurement value storing Width of 3D blob.

Argument 4: Position register number
Specify the index number of position register storing robot configuration data as reference.
Position info output through the position register of Arg7 is provided with this configuration data.

Argument 5: Index number to indicate the corner position.
Specify one of the corner positions to be output.
0: P0 in the figure shown below
1: P1 in the figure shown below
2: P2 in the figure shown below
3: P3 in the figure shown below
4: P4 in the figure shown below



Corner positions of an oriented bounding box

Argument 6: Register number (Output)

Specify index number of register to output the status information of this KAREL program.

In the register, one of the values shown below will be set depending on the error that occurs:

0: The program ended normally.
900: The vision register specified by Arg1 is not set 3D blob data.
901: The type of position register specified by Arg4 is not supported.
902: The type of position register specified by Arg7 is not supported.

Argument 7: Position register number (Output)

Specify index number of register to output the corner position.

Program Example

Shown below is an example that outputs the corner position P1 of 3D blob to the PR[11] and moves the robot to the PR[11].

```
1:    CALL ACQVAMAP('SENSOR')
2:    VISION RUN_FIND 'VISION'
3:    VISION GET_OFFSET 'VISION1' VR[1] JMP,LBL[10]
4:    CALL BPGETOBB (1,1,2,10,1,1,11)
5:    IF R[1]<>0, JMP LBL[10]
6:L PR[11] 100mm/sec FINE
7:    LBL[10]
```

6.2.5 IRVBKLSH

IRBKLSH is the KAREL program that the robot performs an operation intended to cancel the backlash effect at its current position.

The following arguments can be passed:

Argument 1: motion group number

Specify the motion group number of the robot that performs the backlash canceling operation.

Program Example

Shown below is an example that the robot of the motion group number 1 performs the backlash canceling operation before performing the CAMERA_CALIB instruction.

```
1:L P[1] 500mm/sec FINE
2:    CALL IRVBKLSH(1)
3:    VISION CAMERA CALIB 'CALIB1' REQUEST=1
```

6.2.6 IRVHOMING

IRVHOMING is a KAREL program for executing an unconventional type of vision processes that do not require a camera calibration. Henceforth, this type of vision process will be addressed as a "Calibration-free vision process."

When executing a calibration-free vision process, calling IRVHOMING is equivalent to executing RUN_FIND for a conventional vision process. By executing a calibration-free vision process with IRVHOMING, the robot automatically moves to match the found pose of a part on the image with the destination pose trained at setup. Offset data is obtained by calling GET_OFFSET after IRVHOMING, but for calibration-free vision processes, offset data is calculated as the difference between the robot position where the destination pose was trained, and the final robot position after homing in on the target part.

The following arguments can be passed:

Argument 1: vision process name

Specify the vision process name to execute. SR[] can be used to indirectly specify the name.

Argument 2: motion speed

Specify an integer value for the motion speed of the robot, in mm/sec. R[] can be used to indirectly specify the value.

Program Example

Shown below is an example for executing a calibration-free vision process, and offsetting the robot motion.

```
1:    VISION RUN_FIND 'READ_QR'
2:    VISION GET_READING 'READ_QR' SR[1] R[1] JMP,LBL[99]
3:    SR[2] = 'MC:DATA.CSV'
4:    CALL SRWRTCSV(1, 2)
```

6.2.7 IRVGETMSR, IRVGETMSL

IRVGETMSR and IRVGETMSL are functions to output measurement values used with the Single-view Inspection vision process to numeric registers. These commands are used after RUN_FIND.

IRVGETMSR

This KAREL program outputs measurement values designated by "Variable 1" to "Variable 10" in the last Evaluation Tool on the tree view.

The following four arguments need to be passed:

Argument 1: Vision Process Name
Specify the Single-view Inspection vision process name.

Argument 2: First Register Number for Measurement Values
Specify the first register number for storing the measurement values.
By default, 10 measurement values designated by “Variable 1” to “Variable 10” in Evaluation Tool are stored in 10 consecutive numeric registers, starting from the register number specified by this argument.

Argument 3: First Measurement Number
Specify the first measurement number in Evaluation Tool to be output.
This argument is optional. If not specified, the default value of 1 is used.

Argument 4: The Number of Measurement Values
Specify the number of measurement values in Evaluation Tool to be output.
This argument is optional. If not specified, the default value of “11 minus Argument 3” is used.

IRVGETMSL

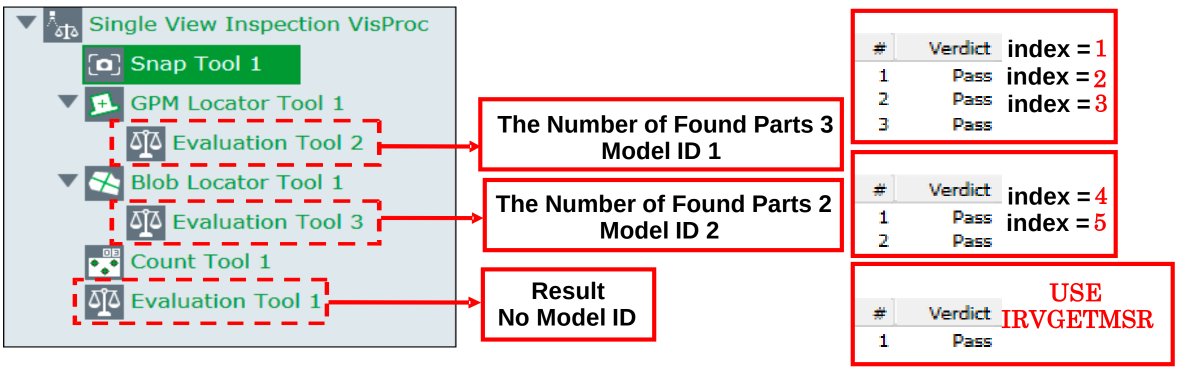
This KAREL program outputs measurement values designated by “Variable 1” to “Variable 10” in the child Evaluation Tool of each locator tool.

The following seven arguments need to be passed:

Argument 1: Vision Process Name
Specify the Single-view Inspection vision process name.

Argument 2: Found Part Index
Specify the index number of the found part to be output.

When there are multiple locator tools in the vision process, as shown in the following image, the index number is the cumulative number of the found parts from the top of the tree (The following image shows an example where GPM Locator Tool 1 detects three parts and Blob Locator Tool 1 detects two parts).



The number of found parts

Argument 3: Register Number for PASS/FAIL Result
Specify the register number for storing PASS/FAIL result of the found part designated by Argument 2.
The following value is set in the numeric register: “FAIL” = 0, “PASS” = 1, “Could not be determined” = 2.

Argument 4: Register Number for Model ID

Specify the register number for storing Model ID of the found part designated by Argument 2. As shown in the image above, when there are multiple locator tools in the vision process, measurement values to be output are different for each locator tool.
In this case, the users should set different Model ID to each locator tool so that the measurement values can be distinguished by the TP program.

Argument 5: First Register Number for Measurement Values

Specify the first register number for storing the measurement values.
By default, 10 measurement values designated by “Variable 1” to “Variable 10” in Evaluation Tool are stored in 10 consecutive numeric registers starting from the register number specified by this argument.

Argument 6: First Measurement Number

Specify the first measurement number in Evaluation Tool to be output.
This argument is optional. If not specified, the default value of 1 is used.

Argument 7: The Number of Measurement Values

Specify the number of measurement values in Evaluation Tool to be output.
This argument is optional. If not specified, the default value of “11 minus Argument 6” is used.

Sample Program 1

Shown below is an example of outputting measurement values in the last Evaluation Tool on the tree view.

```
1:    VISION RUN_FIND 'VISION1'
2:    VISION GET_PASSFAIL 'VISION1' R[1]
3:    CALL IRVGETMSR('VISION1', 2, 1, 5)
```

In this example, the PASS/FAIL result is stored in register [1] by GET_PASSFAIL. Then, the measurement values designated by “Variable 1” to “Variable 5” in the last Evaluation Tool on the tree view are stored in register [2] to [6] by IRVGETMSR.

Sample Program 2

Shown below is an example of outputting measurement values in the child Evaluation Tool of each locator tool.

```
1:    VISION RUN_FIND 'VISION1'
2:    VISION GET_NFOUND 'VISION1' R[1]
3:    FOR R[2]=1 TO R[1]
4:    CALL IRVGETMSL('VISION1', R[2], 3, 4, 5)
5:    …
6:    END FOR
```

In this example, the number of found parts is stored in register [1] by GET_NFOUND. Then, the data of each found part is output by IRVGETMSL. Specifically, the PASS/FAIL result is stored in register [3], the Model ID is stored in register [4], and the measurement values designated by “Variable 1” to “Variable 10” in the child Evaluation Tool of each locator tool are stored in register [5] to [14].

6.2.8 IRVOVRDANYVP

IRVOVRDANYVP is the KAREL program to set a value for a vision override. Its basic behavior is the same as VISION OVERRIDE instruction, but it is different in the point that it can be used not only for the vision process selected in the vision override but also for other vision processes.

The following two arguments need to be passed:

Argument 1: Vision Override name
Specify the vision override name.

Argument 2: Value to set
Specify a numerical value to override.

Program Example

Shown below is an example that a vision override “EXPO” created for a vision process “TEST1” is applied to another vision process “TEST2”.

```
1:    CALL IRVOVRDANYVP('EXPO', 100)
2:    VISION RUN_FIND 'TEST2'
3:    VISION GET_OFFSET 'TEST2' VR[1] JMP LBL[999]
```


> ⚠ **CAUTION**
> 1 The vision process to be applied with IRVOVRDANYVP must have the same vision tool and the property.
> 2 It might unexpectedly override a property of a vision process by mistake because it can handle that of any vision process.

6.2.9 SRWRTCSV, UPLDFIL, MAKEDIR

SRWRTCSV, UPLDFIL and MAKEDIR are the KAREL programs that output content of a string register by writing the content to a CSV file and uploading the CSV file to an external device.

SRWRTCSV

SRWRTCSV is the KAREL program that writes content of a string register to a CSV file.

The following two arguments need to be passed.

Argument 1: String register number to be written
Specify the string register number which stores a string to be written.

Argument 2: String register number of the CSV file name to write to
Specify the string register number which stores the CSV file name to write to.
The following device can be specified as the external device for the CSV file: MC, UT and UD.
The CSV file name needs to contain the file path.
The specified CSV file does not exist, the file will be created.
The data are written at the end of the CSV File.

This KAREL program outputs an error in the following cases:

- When a specified string register number is out of the range of 1 to the maximum register number
- When no string is stored in the specified string register
- When the extension of the file name specified with the argument 2 is not CSV
- When the file specified with the argument 2 is write-protected

Program Example

The following is an example to copy the string in the string register to DATA.CSV in the memory card (MC).

```
1:    VISION RUN_FIND 'READ_QR'
2:    VISION GET_READING 'READ_QR' SR[1] R[1] JMP,LBL[99]
3:    SR[2] = 'MC:DATA.CSV'
4:    CALL SRWRTCSV(1, 2)
```

UPLDFIL

UPLDFIL is the KAREL program to upload a specified file.

The following five arguments need to be passed.

Argument 1: Register number of the source file name

Specify the string register number which stores the source file name to be uploaded.
The source file name needs to contain the file path.
Multiple files can be uploaded by specifying '*' as the wildcard.

Argument 2: Register number of the destination path

Specify the string register number which stores the destination path to upload to.

Argument 3: Register number of the upload status

Specify the register number to return the upload status.
The upload status is returned as '0' if the source file is uploaded successfully. Any other value indicates a failure at uploading.

Argument 4: File deleting flag (option)

Specify whether the source file should be deleted or not from the source location when it is uploaded successfully. This can be omitted.
1: The source file will be deleted.
0: The source file will not be deleted.
When this argument is omitted, the source file will not be deleted.

Argument 5: Register number of the destination file name (option)

When you want to change the destination file name, specify the string register number which stores the destination file name. This can be omitted.
When this argument is omitted or the specified string register does not store any string, the same file name as the source file is used.
When a file with the specified file name already exists in the destination path, it will be overwritten without a warning.
When the wildcard '*' is used in the source file name, this argument is not effective.
The destination path needs to be specified in the argument 2, not in this argument.

This KAREL program outputs an error in the following cases:

- When a specified string register number is out of the range of 1 to the maximum register number
- When a specified register number is out of the range of 1 to the maximum register number
- When no string is stored in the specified string register
- When the flag specified on the argument 4 is neither 0 nor 1
- When the file to upload from subject to deletion by the argument 4 is deletion prohibited
- In cases of failure to communicate

✐MEMO

When communicating with the data server PC, use FTP communication. No error checks of files to upload from shall be performed.

Sample Program 1

The following is an example to upload 'DATA.CSV' in the memory card (MC:) to the '201607' folder in the client PC (C1:).
The source file is not deleted.

```
1:    SR[2] = 'MC:DATA.CSV'
2:    SR[3] = 'C1:¥201607'
3:    CALL UPLDCSV(2, 3, 10)
```

Sample Program 2

The following is an example to upload all CSV files of which names start from 'DATA' in the memory card (MC:) to the '201607' folder in the client PC (C1:).
The source files are deleted from the memory card.

```
1:    SR[2] = 'MC:DATA*.CSV'
2:    SR[3] = 'C1:¥201607'
3:    CALL UPLDCSV(2, 3, 10, 1)
```


Sample Program 3

The following is an example to upload 'DATA.CSV' in the memory card (MC:) to the '201607' folder in the client PC (C1:) with renaming to 'DATA2016017.CSV'.
The source file is kept in the memory card.

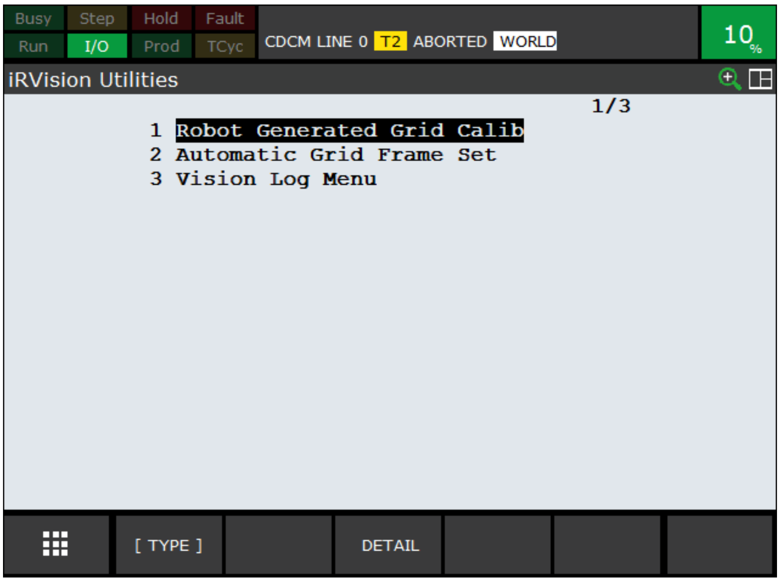
```
1:   SR[2] = 'MC:DATA.CSV'
2:   SR[3] = 'C1:¥201607'
3:   SR[4] = 'DATA201607.CSV'
4:   CALL UPLDCSV(2, 3, 10, 0, 4)
```

7 UTILITY MENU

'*i*RVision utility' is the function to be operated on the [iRVision Utilities] screen on the teach pendant, and this function supports the use of *i*RVision.

To display the [iRVision utilities] menu, perform the following steps:

1 On the teach pendant, after selecting the [MENU] key – [iRVision], place the cursor over [Vision Utilities] and press the [ENTER] key.
The [iRVision Utilities] screen appears. A screen like the one shown below appears here.



[Robot Generated Grid Calib]

By pressing the [ENTER] key, the robot-generated grid calibration setup screen will appear. For details, refer to "Setup: 7.1 ROBOT-GENERATED GRID CALIBRATION".

[Automatic Grid Frame Set]

By pressing the [ENTER] key, the "Automatic Grid Frame Set" screen will appear. For details, refer to "Setup: 7.2 AUTOMATIC GRID FRAME SETTING".

[Vision Log Menu]

By pressing the [ENTER] key, the "Vision Log Menu" screen will appear. For details, refer to "Setup: 7.3 VISION LOG MENU".

7.1 ROBOT-GENERATED GRID CALIBRATION

'Robot-Generated Grid Calibration' is a type of general-purpose camera calibration function that can be done without calibration grid. The function moves the target, mounted on the robot end of arm tooling, in the camera field of view to generate a virtual grid pattern for camera calibration. For details, refer to "Setup: 2.1.3 Robot-Generated Grid Calibration".

7.2 GRID FRAME SETTING

The grid frame setting function sets the robot frame by 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. Also, it is usable with 6-axis robots with an additional axis.
> The function cannot be used with 4-axis robots and 5-axis robots.

> **MEMO**
> If preparing another camera for the grid frame setting, an USB camera (BASLER acA640-20um) may also be used connected to the teach pendant instead of an *i*RVision camera.

The below explains the grid frame setting.

Frame to set in the grid frame setting

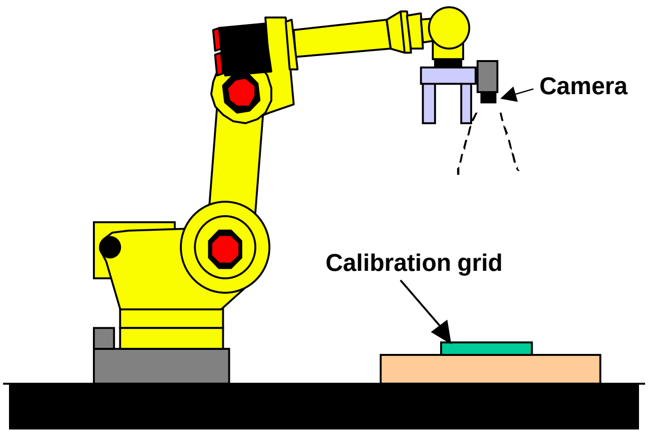
The measurement methods in the grid frame setting vary like below in the case of setting a user frame and the case of setting a tool frame.

Setting a user frame

When the calibration grid is secured to fixed surface, the camera mounted on the robot end of arm tooling is used to set the user frame to the position of calibration grid.

When applying the grid frame setting, the function identifies the position of the calibration grid on the robot world frame and writes the results in the user defined user frame.

When a robot-mounted camera is available, that camera may perform the grid frame setting. When only a fixed camera is available, prepare a different camera that is attached to the temporary position on the robot end of arm tooling, and perform the grid frame setting function.



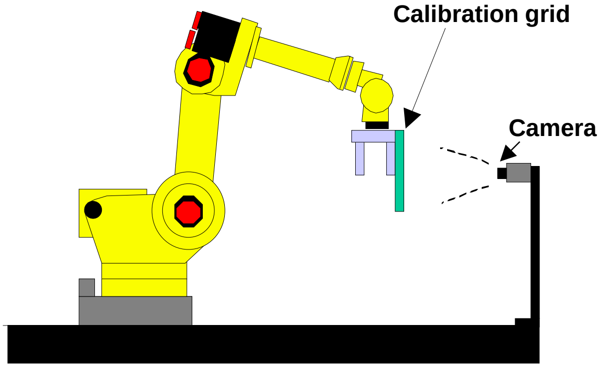
Measure a fixed calibration grid with a robot-held camera

Setting a tool frame

A tool frame is set on the position of the robot-held calibration grid, by measuring the calibration grid with a camera fixed on a mount and so on.

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.

When a fixed camera is available, that camera may perform the grid frame setting. When there is not enough space for the robot to move around the fixed camera field of view, or when a fixed camera is not available, prepare a different camera that is fixed on the temporary position, and perform the grid frame setting function.



Measure a robot-held calibration grid with a fixed camera

Process of grid frame setting

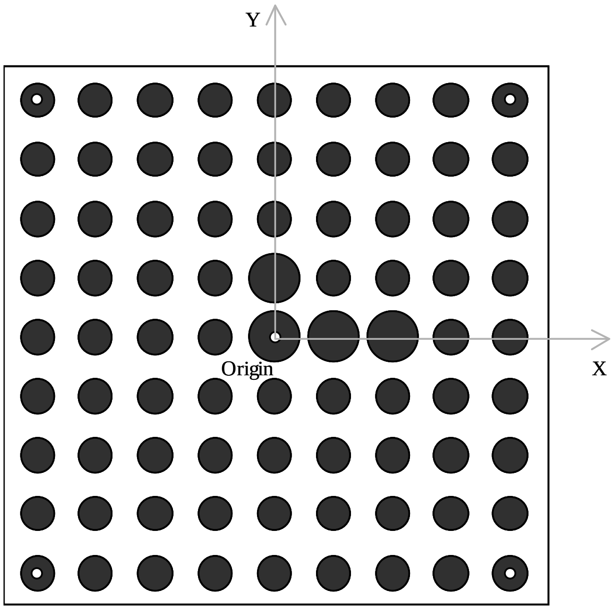
The process of grid frame setting is as follows.

1 Install a calibration grid.
When setting a user frame, fix the calibration grid on a table and so on.
When setting a tool frame, 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.

> **MEMO**
> 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.

2 Display the [Automatic Grid Frame Set] screen of the utilities screen on the teach pendant.
3 Set the parameter and teach the start position.
For the procedure to set procedures, refer to "Setup: 7.2.1 Setting the Parameters".
4 Run the measurement.
For executing measurement, refer to "Setup: 7.2.3 Run Measurement".

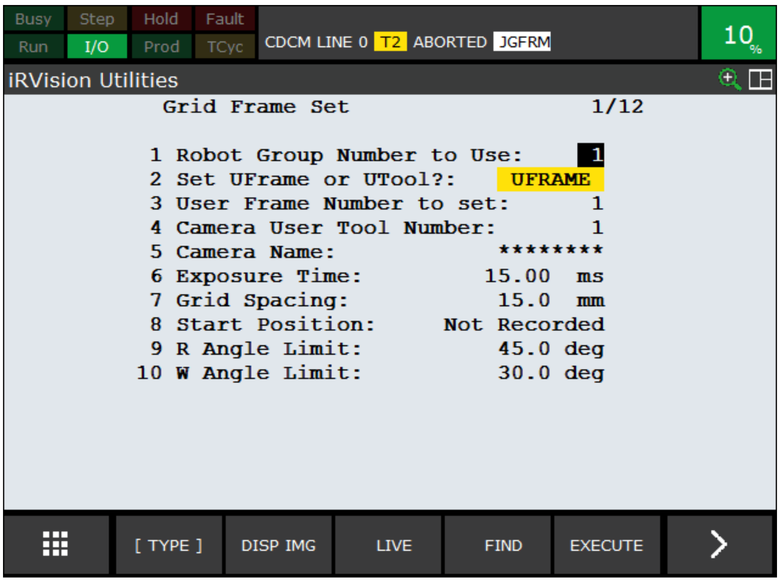
The robot holding the camera or the robot holding calibration grid automatically moves to change relative position and orientation between the camera and the calibration grid, and find the grid pattern repeatedly.
Finally, identify the position of the grid frame on the robot world frame or the position of the grid frame on the robot mechanical interface frame (robot face plate)
When the grid frame setting function is executed, a frame is set on the calibration grid, as shown in the following figure.



Example of a frame using a calibration grid

7.2.1 Setting the Parameters

Place the cursor over [Automatic Frame Grid Set] on [iRVision Utilities] of the teach pendant and press the [ENTER] key, the [Grid Frame Set] screen like below will appear.



> **NOTE**
> The [Grid Frame Set] screen cannot be opened in more than one window at a time.

The following items are displayed on the [Grid Frame Set] screen.

[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]

This parameter is used only when [UFRAME] is selected for [Set UFrame or UTool?]. Specify the number of the user frame to be set. The range of specifiable user frame numbers is 1 to 9.

[Tool Frame Number to set]

This parameter is used only when [UTOOL] is selected for [Set UFrame or UTool?]. Specify the number of the user tool to be set. The range of specifiable user tool numbers is 1 to 10.

[Camera User Tool Number]

This parameter is used only when [UFRAME] is selected for [Set UFrame or UTool?].
Specify the number of the user tool for the work space to be used during measurement. The range of specifiable user tool numbers is 1 to 10. The user tool you specify here will be rewritten during the measurement for grid frame setting.

[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] to display camera list. Specify the camera to be used for measurement by selecting from the list.

[Exposure Time]

Specify the exposure time, or shutter speed, for the camera to capture an image. If you increase this value, the snapped image will be brighter.
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. If the position has been taught already, [Recorded] will be displayed. If it hasn't been, [Not Recorded] will be displayed.
In the case of "Not Recorded," measurement cannot be executed. Be sure you always teach the start position before measurement.
For the procedure to teach the start position, refer to "Setup: 7.2.2 Teach the Start position".

[R Angle Limit], [W Angle Limit], [P Angle Limit], [Z Move Dist. Limit]

Set the operation space for the robot when executing measurement.
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

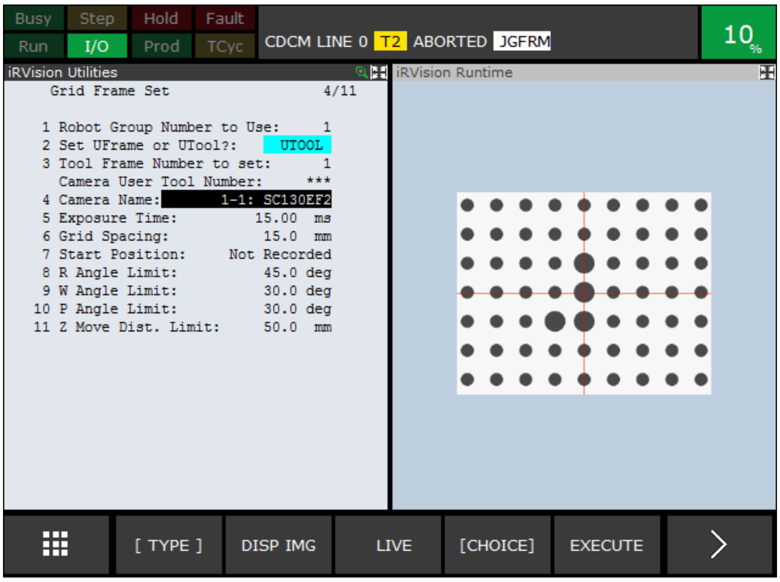
If the operation range defined by the default settings cannot be secured, you can make the operation range smaller by changing the parameters. Note, however, that the precision of grid frame setting depends on the amount of motion at the time of measurement. A smaller operation range can lead to lower measurement precision. It is therefore recommended that measurements be made using a range as close to the default operation range as possible.

Function key

The following function keys will be displayed on the [Grid Frame Set] screen as common functions.

Key number	Item Name	Function
F2	DISP IMG	The grid frame screen and the vision runtime display are displayed.
F3	LIVE	The live image of the selected camera is displayed on the vision runtime display. The F3 label changes to [STOPLIVE] during the display of the live image and if you press F3 [STOPLIVE], the display of the live image is stopped.
F4	FIND	Pressing F4 [FIND] detect the calibration grid for a trial. The found result is displayed on the vision runtime display.
F7	DEFAULT	If you press F7 [DEFAULT], the set values are initialized. [Camera Name] and [Start Position] will be changed to their initial statuses, so please set them again.

Pressing F2 [DISP IMG] displays the grid frame screen and the vision runtime display, as shown below.



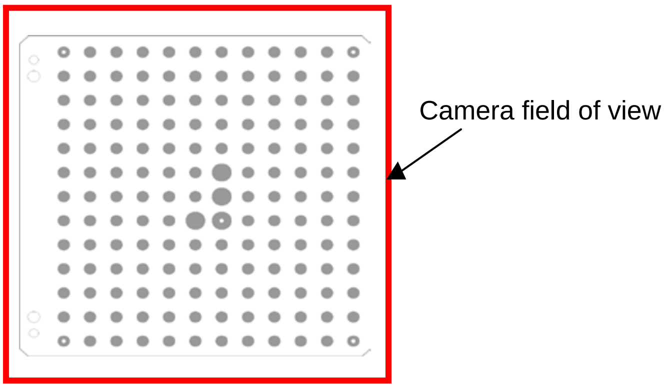
7.2.2 Teaching the measurement start position

To teach the start position, take the following steps:

1 If Vision Runtime is not displayed, press F2 [DISP IMG].

MEMO

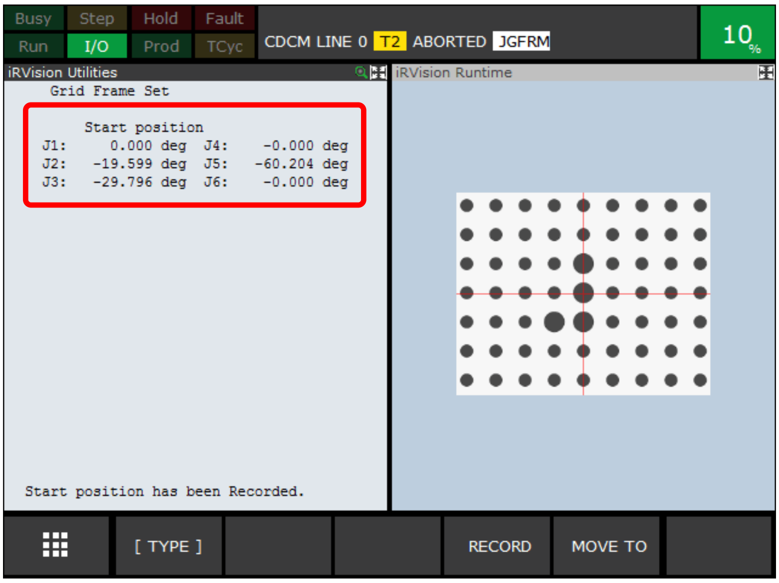
Grid Frame Setting measures the calibration grid with moving the robot on which the camera or the calibration grid is mounted. So be sure to set the camera field of view somewhat larger than the calibration grid so the four large circles of the calibration grid do not protrude out of the camera field of view.



Camera field of view

2 Pressing the [SHIFT] key on the teach pendant and F4 [RECORD] at the same time will record the start position, and [Start Position] will change 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].

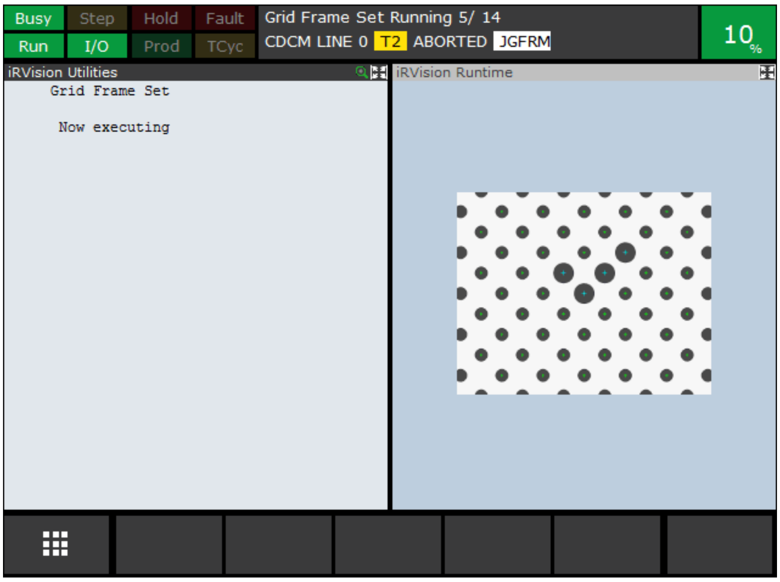


To move the robot to the start position, press [SHIFT] and F5 [MOVE TO] at the same time.

7.2.3 Run Measurement

Perform measurement as follows, using the taught start position as a reference.

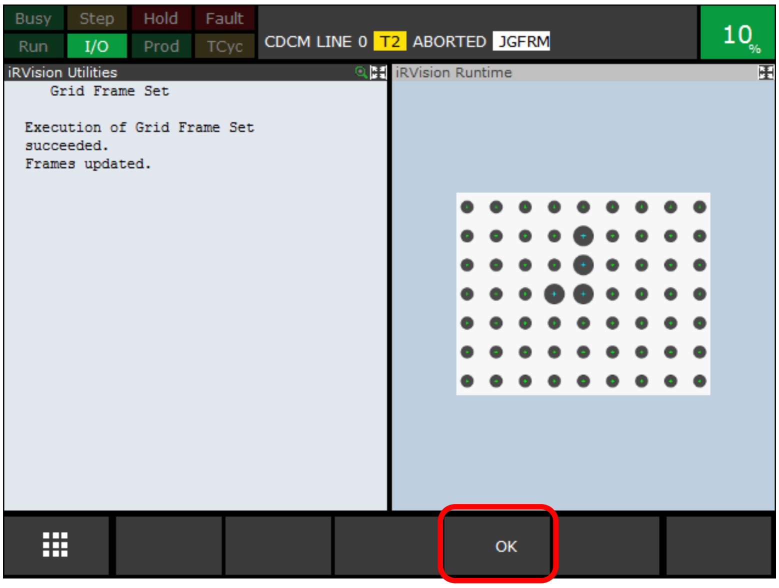
1 If Vision Runtime is not displayed, press F2 [DISP IMG].
2 Check the parameter setup on the [Grid Frame Set] screen.
3 Check that the robot is at the start position.
4 Pressing the [SHIFT] key and F5 [EXECUTE] at the same time starts measurement, causing the robot to start moving.
A message saying 'Now executing' will appear during the operation.



⚠ CAUTION

1 Releasing [SHIFT] while measurement is in progress stops the measurement. In that case, perform the measurement again. You can resume the measurement from where stopped.
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. You can resume the measurement from where stopped.
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 doing the measurement, 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.



5 If F4 "OK" is pressed, the screen will return to the setup screen.

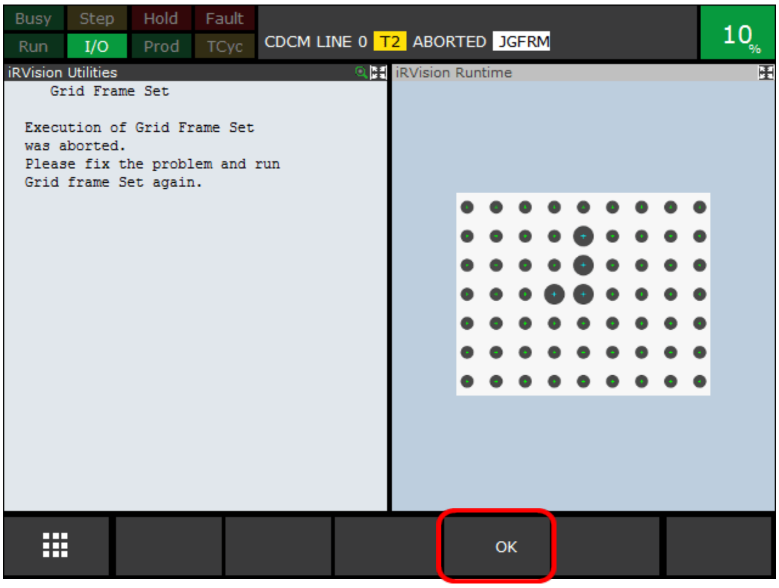
Measurement check

The grid frame will be set depending on the measurement. You can confirm that the frame is set accurately with the following procedures.

1 Change the manual-feed coordinate system to the frame set with Grid Frame Setting.
When you have set a user tool, change the manual-feed coordinate system to the user tool.
When you have set a user frame, change the manual-feed coordinate system to the user frame, and then select the user tool selected in [Camera User Tool Number].
2 By pressing F3 [LIVE], 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.

In the event of failure to measure

If the measurement fails, a menu like the one shown below appears.



Press F4 [OK] to return to the previous menu.

After changing the parameters, pressing [SHIFT] and F5 [EXECUTE] at the same time starts the measurement again from the beginning.

7.3 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.

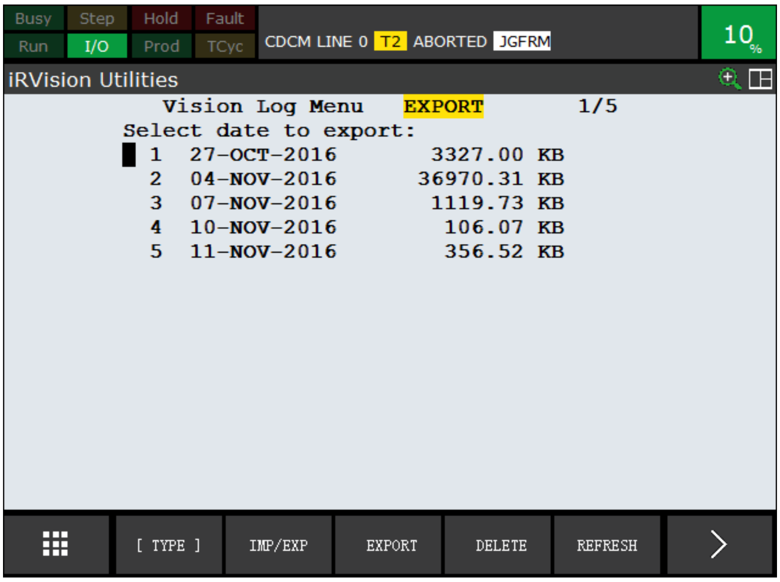
Import

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 [iRVision Utilities] menu in TP and press [ENTER], a menu like the one shown below appears.
The vision logs of the selected vision data recorded on the selected date are displayed on the screen.



7.3.1 Setting the Device

Before exporting the vision log data, set the export destination as necessary.
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 – Export], press F9 [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.

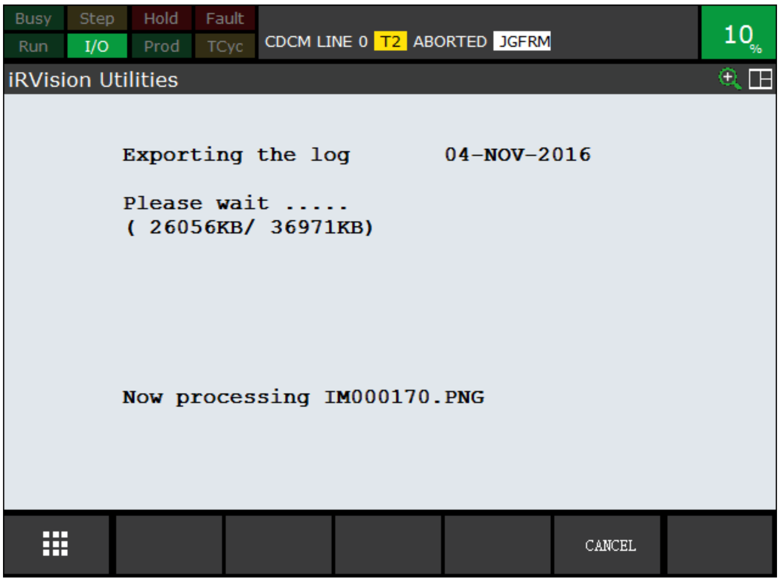
⚠ **CAUTION**
1 An external device that you can specify is a memory card, USB memory device of the robot controller, or PC share client.
2 Set up a necessary device as appropriate for the export device setting. Under the default setting, for example, you need to insert a USB memory device into the robot controller.

7.3.2 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 In the vision logs displayed on the [Vision Log Menu – Export] screen, place the cursor on the date of the vision log you want to export.

2 Press F3 [EXPORT].
The export of the vision log starts. 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 [Log <log file name> 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]. The prompt [Operation will be cancelled, OK?] appears. If you press F4 [Yes], the export is canceled. If you press F5 [No], the export is continued.

7.3.3 Exporting Vision Logs of All Dates

To export all vision log data stored in the robot controller to external device, take the following steps:

1 Pressing F7 [ALL EXP] on the [Vision Log Menu – Export] starts the export.
2 When the export completes, the message [All log export succeeded.] appears on the screen.

If the external device contains any vision log of the same date, the message [Log <log file name> 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]. The prompt [Operation will be cancelled, OK?] appears. If you press F4 [Yes], the export is canceled. If you press F5 [No], the export is continued.

7.3.4 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 In the vision logs displayed on the [Vision Log Menu – Export] screen, place the cursor on the date of the vision log you want to export.
2 Press F4 [DELETE]. The prompt [Log <log file name> will be deleted, OK ?] appears.
3 If you press F4 [Yes], the vision log of the selected date is deleted.
If you press F5 [No], the deletion operation is canceled.

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.

7.3.5 Deleting Vision Logs of All Dates

To delete all vision logs stored in the robot controller, take the following steps:

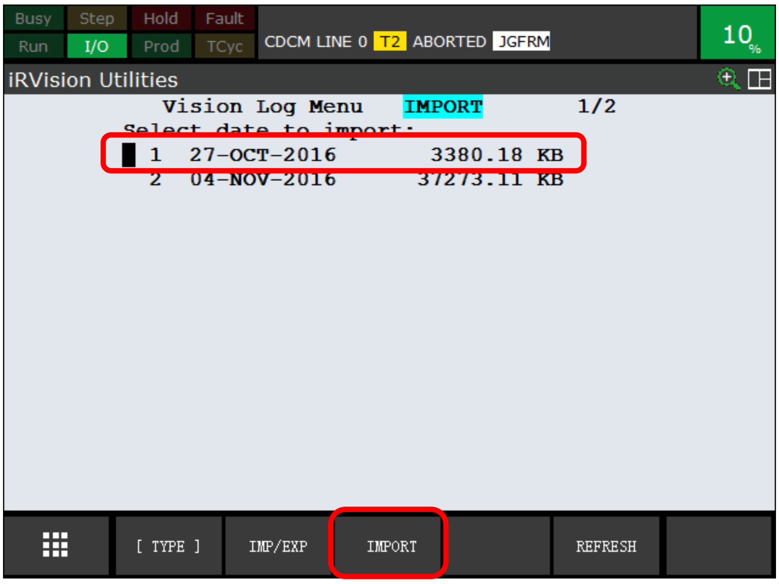
1 Press F8 [ALL DEL] on the [Vision Log Menu – Export].
The message [All logs will be deleted, OK?] appears.
2 If you press F4 [YES], the deleting all vision logs is stared.
If you press F5 [NO], the deletion operation is canceled.
When [ALL DEL] is complete, the message [All log deletion succeeded.] 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.

7.3.6 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] on the [Vision Log Menu – Export]. The [Vision Log Menu – Import] appears as shown below.



> ⚠ **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.
When the import is complete, the message [Log import succeeded.] appears.

If the robot controller contains any vision log of the same date, the message [Log <log file name> will be overwritten, OK?] appears. If you press F4 [Yes], the vision log of that date stored in the robot 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.

7.3.7 Refreshing the Display

On the [Vision Log Menu] screen, press F5 [REFRESH] refreshes the list of vision logs so as to show the latest information.

7.3.8 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¥Y16OCT27 …Vision log for October 27, 2016

A sub-folder is created under the folder of each day, and files with the following extensions are saved in the sub-folder.

```
UD1:
 |-VISION
    |-EXLOG
        |-Y16OCT27 (Date folder)
           |-SUBxxxxx (Sub-foloder)
              |-LOGxxxxx.XML (Vision log file)
              |-IMxxxxx.PNG (Logged image file)
```

⚠ 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. When you copy or move an exported vision log or logged image, do not change the directory structure or file name.

8 OTHER OPTIONS

This chapter describes other software options, which occasionally used with *i*RVision.

- Vision Support Tools
- Data Transfer Between Robots
- 4D Graphics
- Zero Down Time

8.1 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, STVS1, GETCROSS and VSFIT2D2

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

- 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.

8.1.1 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.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following eight arguments need to be passed:

Argument 1:Register number (Input)

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 (Input)

Specify the number of the position register storing the found position of the first camera.

Argument 3:Position register number (Input)

Specify the number of the position register storing the found position of the second camera.

Argument 4:Position register number (Input/Output)

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 (Output)

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 (Output)

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 (Output)

Specify the number of the position register to store the calculated tool offset data.

Argument 8:Register number (Output)

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: L P[1] 1000mm/sec FINE TOOL_OFFSET,PR[P7]
```

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: L P[1] 1000mm/sec FINE TOOL_OFFSET,PR[P7]
```

8.1.2 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.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following four arguments need to be passed:

Argument 1:Position register number (Input)

Specify the number of the position register storing input matrix A.

Argument 2:Position register number (Input)

Specify the number of the position register storing input matrix B.

Argument 3:Position register number (Output)

Specify the number of the position register storing input matrix C.

Argument 4:Register number (Output)

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].

8.1.3 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 $B=A^{-1}$.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following three arguments need to be passed:

Argument 1:Position register number (Input)

Specify the number of the position register storing input matrix A.

Argument 2:Position register number (Output)

Specify the number of the position register storing output matrix B.

Argument 3:Register number (Output)

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)
```

8.1.4 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.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following seven arguments need to be passed:

Argument 1:Position register number (Input)

Specify the number of the position register storing 3D measurement results.

Argument 2:Position register number (Input)

Specify the number of the position register storing 3D measurement results.

Argument 3:Position register number (Input)

Specify the number of the position register storing 3D measurement results.

Argument 4:Position register number (Input)

Specify the number of the position register storing 3D measurement results.

Argument 5:Position register number (Output)

Specify the number of the position register to store generated 3D position data.

Argument 6:Register number (Input)

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 (Output)

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.

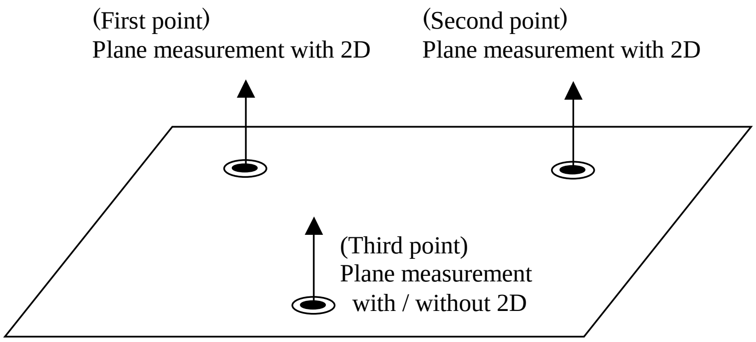
When the first point is measured as a 3D position and the second point is measured as a 3D gaze line (see usage example 3 below), the second point must normally be on the same plane (same height) as point 1. Otherwise, specify a register number in argument 6 and set the height difference between points 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.



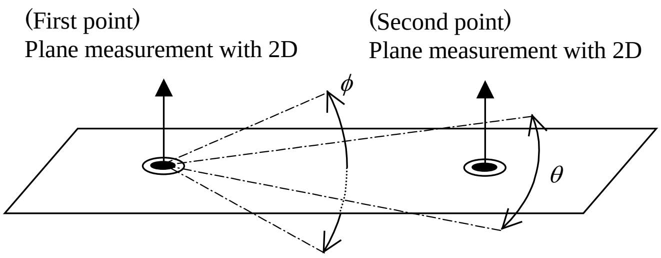
Designating three 3D positions

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.



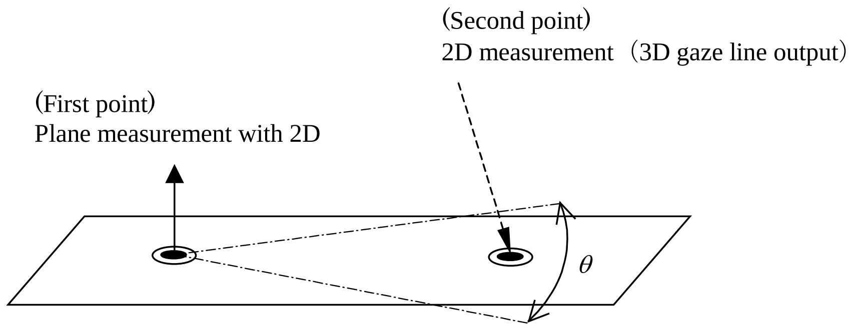
Two-point 3D posture

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.



3D posture + 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.

8.1.5 LOADNOM,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.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

SAVENOM

This program saves position register data.

The following four arguments need to be passed:

Argument 1: Table number (Input)

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 (Input)

Specify the number of position registers to save. The specifiable value range is 1 to 30.

Argument 3:Position register number (Input)

Specify the number of the first position register to save.

Argument 4:Register number (Output)

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.

The following four arguments need to be passed:

Argument 1: Table number (Input)

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 (Input)

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 (Input)

Specify the number of the first position register to which to restore saved data.

Argument 4:Register number (Output)

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.

8.1.6 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 used to set 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.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1 when the position register is specified as the type of the register storing offset data.

The following five arguments need to be passed:

Argument 1: Type of the register storing offset data (Input)

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 (Input)

Specify the number of the vision register or position register storing offset data.

Argument 3: Position register number (Input)

Specify the number of the position register storing the amount of adjustment.

Argument 4: Vision register or position register number (Output)

Specify the number of the vision register or position register to store adjusted offset data.

Argument 5: Register number (Output)

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.
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.
112: The specified vision register cannot be read.
113: Data cannot be written to the specified vision register.

Usage example 1

his 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.

MEMO
Specify the amount of adjustment relative to the offset frame.

8.1.7 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.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following eight arguments need to be passed:

Argument 1: Sorting method (Input)

Specify the sorting method. The specifiable value range is 1 to 4, 11 to 18, and 21.

Argument 2: Register number (Input)

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 (Input)

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 (Input)

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 (Input)

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 (Input)

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: Flag (Input)

Specify the flag that indicates whether to sort a register. If you set 1 in the flag 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. If you set the number except 0 or 1, Illegal parameter input alarm is generated.

Argument 8: Register number (Output)

Specify the number of the position register to store the error number. This argument can be omitted.

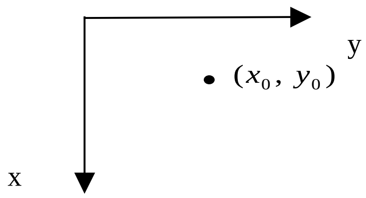
In the register to store the error number, one of the values shown below will be set depending on the error that occurs:

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.

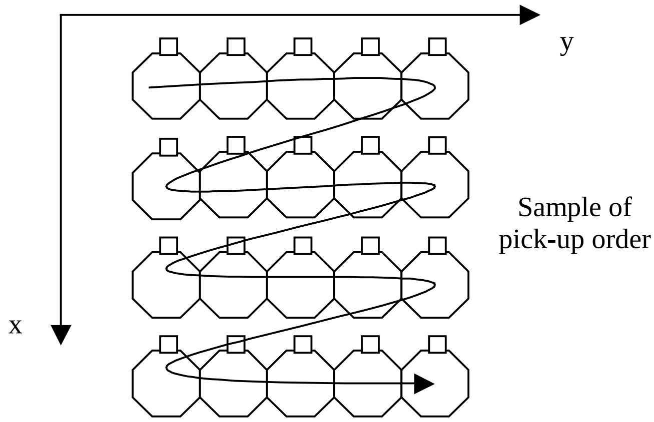
In argument 1, specify one of the values shown below that corresponds to the desired sorting method.

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.



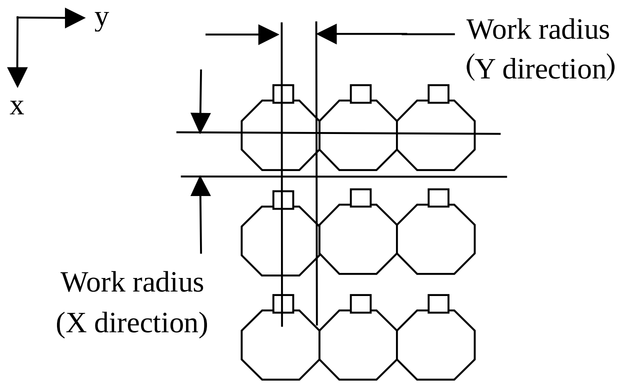
XY value

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.



Orderly aligned workpieces

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.



Workpiece by specified radius

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.

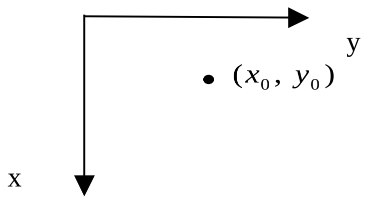
15 Workpieces are sorted in the ascending order of the Y value on a column-by-column basis. Workpieces on the same column are sorted in the ascending order of the X value. The value specified in argument 5 is used as the Y-direction radius (half the width) of the workpiece.

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.

21 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.



Square of the distance from the specified point

8.1.8 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.

The following seven arguments need to be passed:

Argument 1: Group number (Input)

Specify the motion group number of the robot.

Argument 2: User frame number of the position data (Input)

Specify the user frame number of the position data you want to check.

Argument 3: Tool frame number of the position data (Input)

Specify the tool frame number of the position data you want to check.

Argument 4: Position register number (Input)

Specify the number of the position register storing the position data you want to check.

Argument 5: Position register number (Input)

Specify the number of the position register storing the fixed frame offset data.

Argument 6: Position register number (Input)

Specify the number of the position register storing the tool offset data.

Argument 7: Register number (Output)

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 “OPERATOR’S MANUAL (Alarm Code List) B-83284EN-1”.

Usage example 1

```
11: J P[1] 100% FINE
12:     PR[1]=P[2]
13:     PR[2]= VOFFSET,VR [1].OFFSET
14:     CALL CHK_POS(1,0,1,1,2,0,1)
15:     IF R[1]<>0 JUMP,LBL [99]
16: L P[2] 2000mm/sec FINE OFFSET,PR [2]
17:     LBL[99]
```

Line 12 The taught position (pre-offset position) is copied to the position register.
Line 13 The offset data is copied to from vision register to position register.
Line 14 The group number is 1, the user frame number is 0, and the tool frame number is 1.
Line 15 If the robot cannot move to the offset position, the program jumps to label [99].
Line 16 If the robot can move to the offset position, the program lets it do so.

> ⚠ **CAUTION**
> 1 The robot position and the offset data stored in the specified position registers need to be indicated on the same user frame.
> 2 The joint representation cannot be used for the positions set as the arguments of CHK_POS.

8.1.9 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 calibration data for both of these cameras, the same user frame needs to be set as [Application Frame].

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following five arguments need to be passed:

Argument 1: Position register number (Input)

Specify the number of the position register storing the found position of camera A.

Argument 2: Position register number (Input)

Specify the number of the position register storing the found position of camera B.

Argument 3: Register number (Input)

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 (Output)

Specify the number of the position register storing the calculated 3D position.

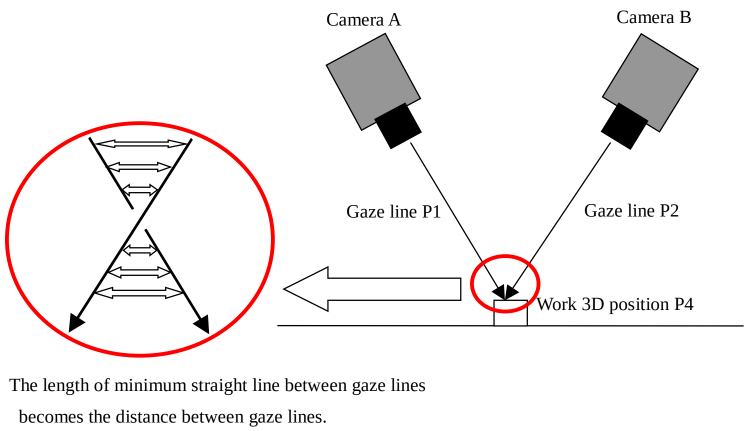
Argument 5: Register number (Output)

Specify the number of the 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.
1412: The error limit of the distance between the two gaze lines is negative.

Usage example 1



Distance between gaze lines

```
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]
```

8.1.10 GETCROSS

This program calculates the intersection of a plane and a straight line.

> ⚠ **CAUTION**
> This KAREL program supports only the motion group 1.

The following four arguments need to be passed:

Argument 1: Position register number (Input)

Specify the number of the position register storing the plane information. The XY plane of the position is used for the calculation as the plane.

Argument 2: Position register number (Input)

Specify the number of the position register storing the straight line information. The Z-axis of the position is used for the calculation as the straight line.

Argument 3: Position register number (Output)

Specify the number of the position register to store the calculated intersection. The X, Y and Z of the position register indicate the intersection point. W, P and R are calculated so that the XY plane of the position is parallel to the XY plane of the argument 1.

Argument 4: Register number (Output)

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.
1501: A required argument is not specified.
1502: An invalid argument is specified.
1503: The format of the specified position register failed to be acquired.
1504: The format of the specified position register is invalid.
1505: The specified position register cannot be read.
1506: The specified position register has not been initialized.
1507: The XY plane and the straight line is parallel.
1508: Data cannot be written to the specified position register.
1509: Data cannot be written to the specified register.

```
11:   CALL GETCROSS(P1,P2,P3,P4)
12:   IF R[P4]<>0 JUMP,LBL [999]
```

8.1.11 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 "Setup: 7.3 VISION LOG MENU". Refer to "Setup: 7.3 VISION LOG MENU" about setting the external device to export to.

The following two arguments need to be passed:

Argument 1: Register Number (Output)

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 (Input)

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
```

8.1.12 VSFIT2D2

This KAREL program calculates the 3D position of a large workpiece (such as a car body) based on the found result of three gauge holes and the distances between the gauge holes.

The following nine arguments need to be passed:

Argument 1: Register number (Input)

Specify the register number storing the distance between the first and second gauge holes.

Argument 2: Register number (Input)

Specify the register number storing the distance of the second and third gauge holes.

Argument 3: Register number (Input)

Specify the register number storing the distance of the third and first gauge holes.

Argument 4: Position register number (Input)

Specify the position register number storing the found position of the first gauge hole.

Argument 5: Position register number (Input)

Specify the position register number storing the found position of the second gauge hole.

Argument 6: Position register number (Input)

Specify the position register number storing the found position of the third gauge hole.

Argument7: Register number (Output)

Specify the position register number to store the calculation status.
0 will be stored when the calculation succeeds, otherwise 1 will be stored.

Argument8: Position register number (Output)

Specify the position register number to store the calculated 3D position of the workpiece.

Argument9: Register number (Output)

Specify 1 not to display messages on the USER menu. This argument is optional.

8.2 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/R-30*i*B Mate CONTROLLER Optional Function OPERATOR’S MANUAL”

> ⚠ **CAUTION**
> Data Transfer Between Robots function is different from ROS Interface Packet over Ethernet (RIPE) function, which is introduced in the "Introduction: 1.13 INTER-CONTROLLER COMMUNICATION". Dedicated setting for this function is required separately.

8.2.1 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 four arguments need to be passed:

Argument 1: Destination Robot (Input)

Specify the name of the destination robot controller.

Argument 2: Destination Register Number (Input)

Specify the numeric register number on the destination robot controller.

Argument 3: Source Register Number (Input)

Specify the numeric register number on this robot controller.

Argument 4: Mode (Input)

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 two arguments need to be passed:

Argument 1: Destination Robot (Input)

Specify the name of the destination robot controller.

Argument 2: Destination Position Register Number (Input)

Specify the position register number on the destination robot controller.

Argument 3: Destination Group Number (Input)

Specify the motion group number on the destination robot controller.

Argument 4: Source Position Register Number (Input)

Specify the position register number on this robot controller.

Argument 5: Source Group Number (Input)

Specify the motion group number on this robot controller.

Argument 6: Mode (Input)

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.

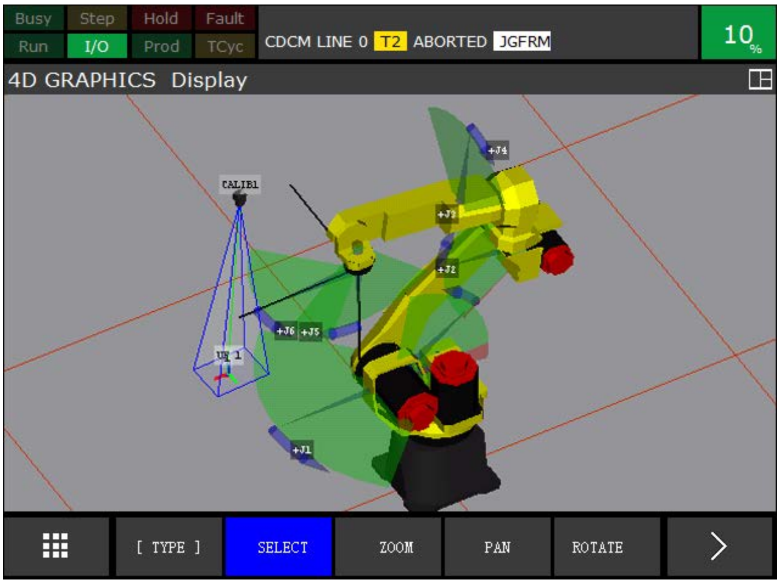
```
1:  VISION RUN_FIND 'FIND1'
2:  VISION GET_OFFSET 'FIND1' VR[1] JUMP,LBL[99]
3:  PR[10]=VR[1].OFFSET
4:  CALL RSETPREG(ROBOT2,20,1,10,1,1)
5:  DO[1]=ON
```

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.

8

8.3 4D GRAPHICS

4D Graphics function is a software option that enables you to visually view various internal data such as positions taught in a program or a tool center point visually along together the robot. This helps you to understand a system spatially and visually. Regarding *i*RVision, if the 4D Graphics option is installed, you can check the position of cameras and found results visually. This section introduces the 4D Graphics function related to *i*RVision. For details of 4D Graphics function, refer to “R-30*i*B/R-30*i*B Mate CONTROLLER Optional Function OPERATOR’S MANUAL”.



The following operations on the 4D Graphics menu make the *i*RVision related 4D graphics data visible:

- Select [4D *i*RVision] from F1 [TYPE].
- Select [4D *i*RVision] from F8 [VISIBLE] and press F10 [SHOW].

The following operations cause *i*RVision to generate 4D graphics data:

- Opening the setup page of a camera calibration tool.
  When the camera is calibrated, the camera, its field of view, the found calibration points, and the related frames are displayed. When the camera calibration is performed, the 4D graphics data is updated.
- Opening the setup page of a vision process tool.
  When the calibration tools are selected, they are all displayed at the same time as described above, except for the found calibration points. When a Find is executed, the found results are also displayed.
- Opening the setup page of a 3D area sensor tool.
  When the calibration tools are selected, they are both displayed at the same time as described above, except for the found calibration points. When a 3D Map is acquired, it is displayed as a point cloud additionally.
- Calling RUN_FIND from an application program.
  The calibration data and found results are both displayed.
- Calling CAMERA_CALIB from an application program.
  The calibration data is displayed.
- Calling IRVDISPLAY4D() from an application program.
  For a camera calibration tool or a 3D area sensor tool, the same graphics data as its setup page are displayed. For a vision process, its calibration tools are displayed and if the results are still available from the last RUN_FIND call, they are also displayed. Refer to "Setup: 8.3.1 IRVDISPLAY4D".

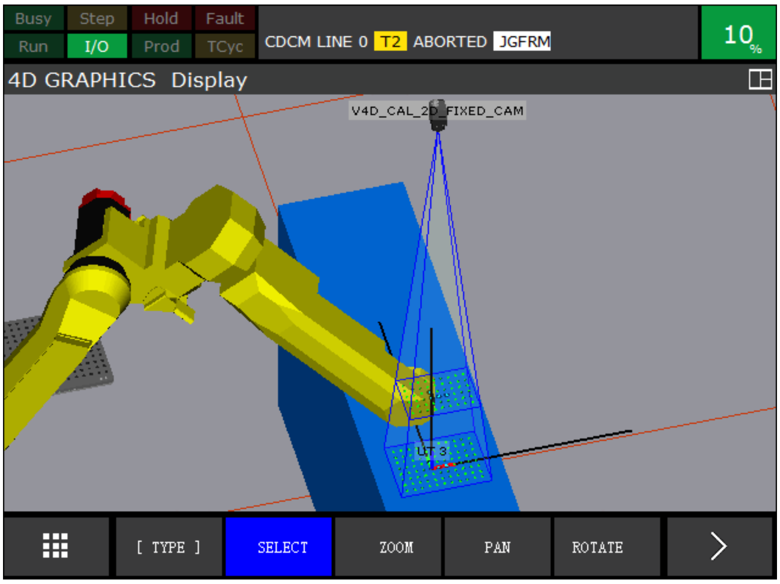
> ⚠ **CAUTION**
> There are some vision processes that do not support 4D graphics yet.

> **MEMO**
> Displaying 4D graphics at calling RUN_FIND from an application program is disabled by default because it can affect cycle time. Enable it by checking "Plot 4D Graphics During RUN_FIND" on the Vision Config page accordingly.

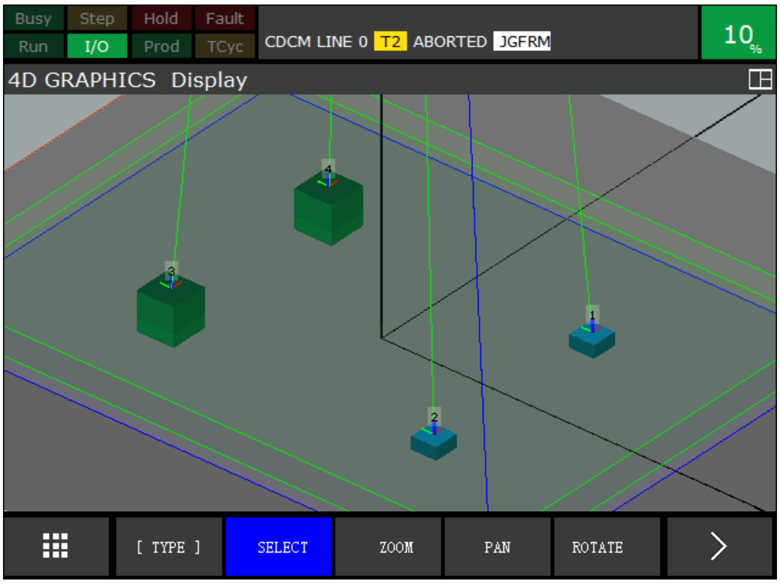
Examples of 4D Graphics

Here is the display example of 4D Graphics function.

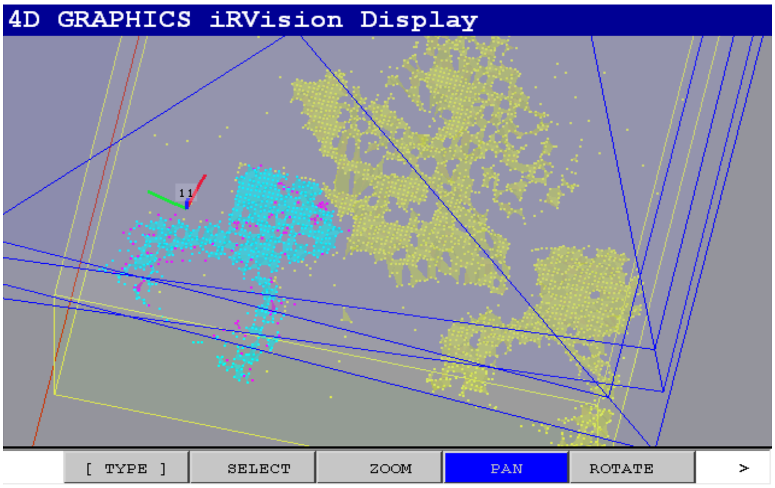
- Grid pattern calibration of a fixed camera with a robot-held calibration grid.



- Close-up of 2D single view vision process results display showing 2 Z heights



- 3D area sensor vision process results highlighting a found area sensor plane tool result



8.3.1 IRVDISPLAY4D

This KAREL program displays 4D graphics data of the specified vision data. Use this program when you want to refresh 4D graphics data without opening the setup page or calling RUN_FIND or CAMERA_CALIB.

The following arguments can be passed:

The following argument needs to be passed:

Argument 1: Vision Data Name (Input)

Specify the name of a camera calibration tool or a vision process tool.

Program Example

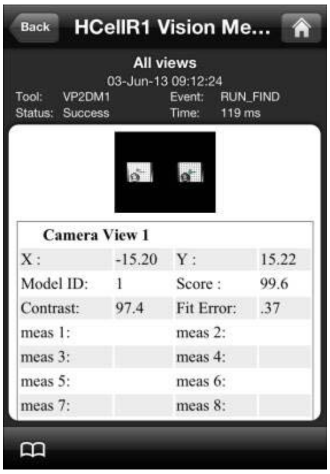
The following example calls RUN_FIND for vision processes VP1 and VP2, and then calls IRVDISPLAY4D to display 4D graphics data of the vision process VP1 (Note that RUN_FIND does not generated 4D graphics data by default).

MEMO
RUN_FIND does not display the 4D graphics by default.

```
1:    VISION RUN_FIND 'VP1'
2:    VISION RUN_FIND 'VP2'
3:    CALL IRVDISPLAY4D('VP1')
```

8.4 ZERO DOWN TIME

'Zero Down Time is a function to send the status of the robot and events to the ZDT server through network. *i*RVision can send images used to find and the found results. This section describes *i*RVision related part of the zero down time function.
For details of the zero down time function, refer to "Ethernet Function OPERATOR's MANUAL B-82974EN".



Examples of mobile device displays

8.4.1 IRVIZDT

This KAREL program sends the most recent *i*RVision results to ZDT server by using the zero downtime function. By configuring your TP program to call IRVICONN after RUN_FIND, you can send the same information that you see on Vision Runtime, i.e. the image, number of found and found positions, to ZDT server.

> **MEMO**
> An alarm can be posted if too many workpieces are found. To restrict the alarm, set a larger value to $RCMCFG.$SIZE_THROT.

The following two arguments need to be passed:

Argument 1: Description string (Input)
Specify a text string you wish to associate with the vision result data. The specified text is displayed on the user interface of ZDT as it is along with the vision result data.

Argument 2: Priority (Input)
Specify an integer 0 ~ 3 which is the priority level of the vision result data. The sent result data are highlighted in different colors on the user interface of ZDT based on the associated priority level.
0: Specify when sending data purely informational. The data is not highlighted on the ZDT UI.
1: Specify when sending data purely informational. The data is highlighted in green on the ZDT UI.
2: Specify when sending a potential problem or a warning. The data is highlighted in yellow on the ZDT UI.
3: Specify when sending a serious issue. The data is highlighted in red on the ZDT UI.

Program Example

The following is an example of sending *i*RVision result data to ZDT server. This example sends the data in the following cases:

- When parts are not found:
  When no part is found, GET_OFFSET in the line 2 fails. In this case, it jumps to LBL[998], the event "part not found "is sent to ZDT server. This is the most typical usage of this function.

- When the found score is low:
  The found score is checked in the line 4. If the score is lower than the specified value, the event "score is low" is sent to ZDT server (It is assumed that the vision process is configured to output the score as the measurement value 1 by using the measurement output tool). Although the score was low, the program continues to pick the part, because the part was found. This is an example to notify as a precaution.

- When pick fails:
  The program checks whether the part is picked properly or not in the line 7. When the pick fails, it jumps to LBL[999], and the event "pick failed" is sent to ZDT server in the line 16.
  You can check whether the cause of the pick failure was vision detection or not by looking the image sent to ZDT server.

```
 1:  VISION RUN_FIND 'VP1'
 2:  VISION GET_OFFSET 'VP1' VR[1] JMP,LBL[998]
 3:  R[1]=VR[1].MEAS[1]
 4:  IF R[1:score]<60 CALL IRVIZDT ('Score is low',2)
 5:  CALL PICK
 6:
 7:  IF RI[1:SENSOR]=OFF JMP,LBL[999]
 8:  CALL DROP
 9:  END
10:
11:  LBL[998]
12:  CALL IRVIZDT ('Part not found',3)
13:  END
14:
15:  LBL[999]
16:  CALL IRVIZDT ('Pick failed',3)
17:  END
```

Maintenance

1 TEACH PENDANT FIRMWARE UPDATE

When [Vision Setup] or [Vision Log] is selected on teach pendant, a message may prompt the users to update the teach pendant firmware and they cannot get into *i*RVision menus. In this case, updating teach pendant firmware is required to get into *i*RVision related menus on teach pendant.
This chapter describes how to update teach pendant firmware.

Verify Firmware Versions

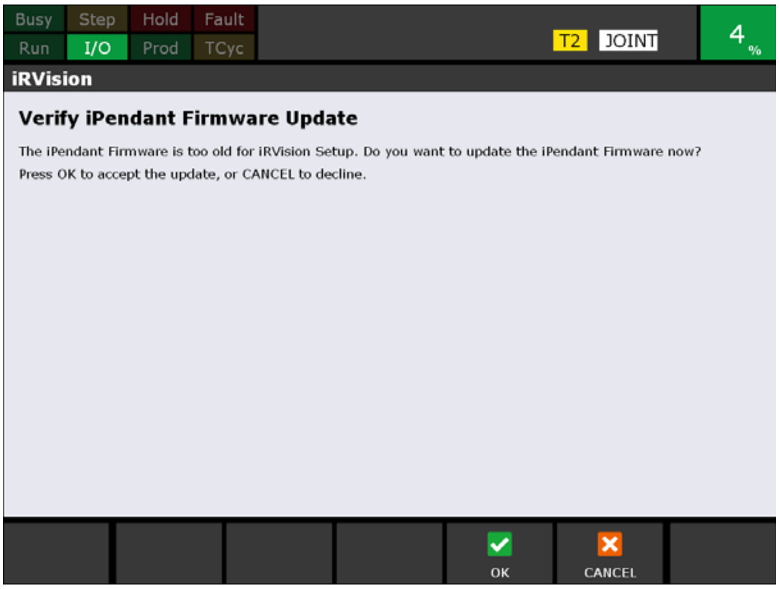
Verify the teach pendant firmware version with the following procedure:

1 Press [MENU] on the teach pendant of the robot controller.
2 Select [NEXT], and then select [STATUS], [Version ID].
3 You can verify the teach pendant firmware versions in [TP Core Firmware] line on the [STATUS Version ID] screen.

Update procedure

You can update the teach pendant firmware with the following procedure without re-booting the robot controller.

1 For safety, make sure that the E-stop button is pressed down.
2 Press [MENU] to select [iRVision], and then [Vision Setup]. The following screen is displayed.



3 Make sure either the robot controller is in T1/T2 mode or the teach pendant is enabled. And then press F4 [OK].
Updating the firmware starts. While updating, the following screen is displayed.

⚠ CAUTION
Updating the firmware takes several minutes. Never power off the robot controller while updating!!!

When it finishes, the teach pendant becomes operable.

2 FREQUENTLY ASKED QUESTIONS

When you have problems using *i*RVision, refer to this section.

2.1 PROBLEMS ABOUT CAMERA INSTALLATION AND CAMERA IMAGE DISPLAY

A camera is connected but the robot controller does not recognize the camera.

Cause 1: A camera cable may be broken or almost broken.

Measure 1: Replace the camera cable and check whether an image is correctly displayed.

Cause 2: A camera cable connector may be loosely connected.

Measure 2: Check whether the camera cable is properly inserted.

Cause 3: Surrounding noise may affect the connection.

Measure 3:

1 Check the following.
- Whether the robot controller is grounded
- Whether there is a device that is not grounded
- Whether grounding in a plant is established properly

2 If you cannot find a noise source, the following methods can be used to reduce the effect of noise.
- Separate the grounding for the device that you think is the noise source and the grounding for the robot controller, and ground them at points that are apart from each other
- Ground a camera stand to the robot controller case, etc.
- Shorten a camera cable
- Attach a ferrite core to a camera cable
- Wrap a camera cable with zipper tubing and thicken the shield
- If a camera package is not used, isolate a camera from a camera stand
- Turn off the power of the robot controller and turn it on again

Camera images are not displayed

Cause 1: Possibly because of communication problems between a teaching PC and the robot controller, images that are captured by the camera is not displayed.

Measure 1: Refer to "Setup: 1.1 CONNECTING A SETUP PC", and check that the PC is set correctly.

Cause 2: A camera cable may be broken or almost broken.

Measure 2: Replace the camera cable and check whether an image is correctly displayed.

> ✐**MEMO**
> If you move the position or direction of a camera, or the aperture or focus of a lens, you have to calibrate camera again. Be careful not to move them by mistake during work.

Cause 3: The camera may be broken.

Measure 3: Replace the camera and check whether an image is displayed correctly.

Images of the camera is dark or white, so the contrast in the images is weak

Cause 1: The focus of the lens may be inappropriate.

Measure 1: Check that it is adjusted appropriately.

> ✐**MEMO**
> If you move the position or direction of a camera, or the aperture or focus of a lens, you have to calibrate camera again. Be careful not to move them by mistake during work.

Cause 2: The setup of exposure time may be inappropriate.

Measure 2: Check that it is set appropriately.

Cause 3: Lighting or a lighting cover may be dusty.

Measure 3: Clean it as necessary.

Cause 4: A Lens or protective window may be dusty.

Measure 4: Clean it as necessary.

Cause 5: The MAIN board of the robot controller may be broken.

Measure 5: Replace it and check whether an image is displayed correctly.

Cause 6: The camera may be broken.

Measure 6: Replace the camera and check whether an image is displayed correctly.

Camera images get bright or dark

Cause 1: If you use lighting that flickers at a low cycle, such as a fluorescent light or mercury light, images may get bright or dark when you specify shorter exposure time than the flickering cycle of lighting.

Measure 1: Set longer exposure time than the flickering cycle of lighting (For example, in the case of 50Hz, 1000 msec ÷ 50 Hz = 20 msec or more), or replace lighting with one with a short flickering cycle, such as an LED or a high-frequency fluorescent light.

Cause 2: If camera images get bright or dark when you increase the excitation of the servo, the video signal of the camera may contain electrical noise.

Measure 2: Check that the shield of the camera cable is grounded without any problem (fixed on a ground plate) in the robot controller.

Camera mounting has become invalid

Measure:

1 If the camera mounting position has become invalid, you need to calibrate the camera again. Move the camera back to the original position, fix it in place firmly, and calibrate the camera again. For most cases, you do not have to set a reference position again or reteach a robot position. For work procedures of recalibration of the camera, refer to "Setup: 2 CAMERA DATA".

2 If the vision process is depalletizing vision process, you may have to redo association of found size and Z height again.

I want to widen the camera field of view

Measure: You can widen the field of view using the following methods.

1 Separate the distance between the camera and a workpiece
- The longer the distance between the camera and a workpiece is, the wider the camera field of view will be.

2 Use a lens with short focal distance
- When you do not change the distance between camera and workpiece and widen the camera field of view, use a lens with short focal distance.
- The lens with the shortest focal distance that is officially supported is 8 mm. If you need wider field of view, you can use a commercial C mount lens.
- The shorter the focal distance is, the more distorted the lens will be, so use a lens with small distortion. The following lenses have been used before.

  6 mm lens LM6NC1M made by Kowa Optical Products
  5 mm lens LM5JC1M made by Kowa Optical Products
  3.5 mm lens LM3NC1M made by Kowa Optical Products

* Any of the lenses cannot be stored in the camera package because the sizes are too large.

2.2 PROBLEMS ABOUT THE BEHAVIOR AND OPERATION OF THE ROBOT CONTROLLER

We will introduce the problems by dividing them into problems about vision detection, problems about vision UIF controls, problems about dot pattern coordinate system settings, and other problems.

2.2.1 Problems about Vision Detection

When I execute vision detection, the robot controller freezes.

Cause 1: Some commercial memory cards cannot properly perform reading or writing in the robot controller. If you use such memory cards, data in memory cards may be corrupted when the robot controller writes data to memory cards. If the vision log function of *i*RVision is enabled, a memory card is accessed during the execution of vision detection. If data in a memory card is corrupted at that time, the robot controller may freeze depending on the corruption status.

Measure 1: Perform the following measures.

- Replace the memory card with the one which has been verified.
- Remove the memory card and disable the *i*RVision vision log function.
- Change the *i*RVision system setting and disable the vision log function.

Vision detection takes a very long time

Cause 1: The *i*RVision vision log function is set to delete old histories in order to secure space, and save new histories when there is not enough space in a memory card. Finding and deleting old histories take time.

Measure 1: Delete old histories from a memory card. You can export vision logs to a USB and PC or delete them on the teach pendant. For details, refer to "Setup: 7.3 VISION LOG MENU". Furthermore, you can execute the 'Export vision logs' function above from the robot program. For details, refer to "Setup: 8.1.11 VL_EXPORT".

Cause 2: Depending on the way TP programs are created, almost all CPU capacity is used to execute the programs and the process of *i*RVision may not be performed. This includes the example when you program a loop that uses a upward jump, and a operation statement of zero movement distance exists in the loop. For example, if there is an 'operation statement for moving to a waiting position,' then the movement distance of the operation statement will be 0 (zero) starting from the second run of the loop.

Measure 2: You can check whether the TP program has the such logic or not by changing the value of the system variable $PG_CFG.$JMPWAIT_UPR to 16 (the default is -16). If you change this system variable value and the problem is resolved, that is the cause. Changing a system variable is a measures.

MEMO

Changing the a system variable will put the system into the same state as if a WAIT of 16 ms had been entered in all the upward jumps. If there is a problem with application as a result of this change, analyze the TP program to identify the loop that is causing the problem, and enter a WAIT command in that loop (set the system variable back to the default).

Results are found in the Vision Setup screen of GPM Locator Tool, but are not found in the Vision Setup screen of the Vision Process.

Cause 1: The value set for [Found] may be too small in the Vision Setup screen of the Vision Process. When you execute test in Vision Setup screen of the GPM Locator Tool, it displays all results that have been found by the GMP Locator Tool. On the other hand, if you execute test in the Vision Setup screen of the Vision Process, it displays only the [Found] portion that were specified by the Vision Process. If the number of items that has been found by the GPM Locator Tool are more than the number of [Found] that is set in the Vision Setup screen of the Vision Process, some workpieces that have been found by the GPM Locator Tool will not be displayed.

Measure 1: Set larger [Found] value.

Cause 2: Using the Conditional Execution Tool, it is possible that you treat found items as items that are not found. When you execute test in Vision Setup screen of the GPM Locator Tool, the Conditional Execution Tool that is located under the GPM Locator Tool is not executed, so it displays all results that have been found by the GMP Locator Tool. On the other hand, if you execute test in the Vision Setup screen of the Vision Process, all tools are executed. Therefore, if 'Treat as not found when conditions are met' are specified in the Conditional Execution Tool, the results that have met conditions are treated as not found and will not be displayed.

Measure 2: Change the setup of the Conditional Execution Tool as necessary.

Cause 3: Two found positions may be too close. In order not to find a workpiece twice, the Vision Process automatically deletes found result with lower scores when two found positions are close. By default, if the distance between two found positions are 20 pixels or less, one of these will be deleted and will not be displayed.

Measure 3: Change the overlap tolerance of pixels using the Vision Process as necessary.

2.2.2 Problems about Vision UIF Controls

Vision UIF Control Cannot be Installed

Cause 1: The '*i*RVision UIF Control' option may not be installed in the robot controller.

Measure 1: Check that the “*i*RVision UIF Controls” option is ordered. If the option is not ordered, contact your FANUC technical representative.

When I try to install the Vision UIF Control, 'No file available' is issued

Cause 1: Internet Explorer might be set incorrectly.

Measure 1: Set it as described in "Setup: 1.1.4 Modifying Settings of Internet Explorer".

Installing Vision UIF Controls is required even after it has been installed

Cause 1: If there is a module whole installer is not replaced because it was in use, etc. this may occur.

Measure 1: Reboot the PC.

Cause 2: If the setting of Trusted Sites in Internet Explorer is incorrect, you may not be able to install the Vision UIF Controls.

Measure 2: Refer to "Setup: 1.1.4 Modifying Settings of Internet Explorer", and make sure that of the robot IP address is in Trusted Sites.

Cause 3: If the Vision UIF Controls is disabled in [Manage add-ons] of Internet Explorer, the problem can occur.

Measure 3: You can verify whether it is disabled or not with the following procedures:

1 Open the robot homepage on Internet Explorer.
2 Open [Tools] - [Manage add-ons].
3 Select [Toolbars and Extensions] and then select [FRImageDisplay Control] in the list.
4 If its status is [Disabled], click the [Enable] button at the bottom right of the window.
5 Click [Close]. Close all Internet Explorer windows, then restart IE.

Cause 4: If the AcitveX Filtering is enabled in Internet Explorer, the problem can occur.

Measure 4: Open [Tool] – [Safety], and make sure that the [ActiveX Filtering] box is unchecked.

Cause 5: If the automatic crash recovery function is enabled in Internet Explorer, the Vision UIF Control cannot be installed properly.

Measure 5: Disable the automatic crash recovery function using the following procedure.

1 Open [Internet Options] from the control panel.
2 Select the [Advanced] tab and uncheck [Enable automatic crash recovery].
3 Click the [OK] button to close the window, and reboot the PC.

2.2.3 Problems during Grid Frame Setting

[CVIS-020 Big circles cannot be distinguished] is issued

Cause: During the measurement of grid patterns, detection of large black circles failed because of an improper exposure time, or an object other than a grid point was detected. As a result, when the found amount of black circles with large calibration grids are not 4, the alarm occurs.

Measure: 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

Cause: This alarm is posted when the number of grid points of the calibration grid detected during measurement is less than 4. This alarm is posted also if a measurement is made when the camera is disabled for hardware trouble.

Measure: Check whether the hardware is broken. 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.

The program was terminated abnormally with an error

Cause: If an error occurs, the program is terminated forcibly.

Measure: Modify the setting to enable correct measurement then execute the program from the beginning.

2.2.4 Other Problems

After the replacement of the MAIN board of the robot controller, the PC cannot recognize the robot controller

Cause: After you replace the MAIN board of the robot controller and set the same IP address as before, your PC may not recognize the robot controller in some cases. This problem occurs because the MAC address of the robot controller is changed.

Measure: Issue PING from the robot controller to a router.

The Runtime Image screen is not updated

Cause: If you use Internet Explorer 9, memory leak may occur in your PC. In screens that are displayed for a long time, such as the Runtime Image, memory leak may be accumulated and subsequently the screen may not be updated.

Measure: When you close the Internet Explorer window and open it again, leaked memory will be cleared. In order not to repeat the same problem again, use Windows Update and upgrade to Internet Explorer 10 or later.

2.3 PROBLEMS ABOUT SCREEN OPERATION AND DISPLAY

We will introduce problems in two parts: problems about the screen display on the Setup PC and problems about the use of ROBOGUIDE.

2.3.1 Problems about the Screen Display on the Setup PC

In the TP program edit screen, VOFFSET is not displayed in the command choices

Cause: There is a restriction where up to 27 choices can be displayed on the pop-up list of the motion statement options. If you specify many software options, 28th or later commands do not appear on the pop-up list, and commands cannot be added to the program.

Measure: Reduce the number of specified software options.

The display in the screen of *i*RVision gets garbled

Cause 1: If the vision data that were created and taught using the Japanese robot controller are loaded to the English robot controller, or if you select Japanese for the language of the robot controller and create and teach vision data then change the language of the robot controller to a language that is not Japanese, character strings that are entered in Japanese, such as a Vision Tool name, will gets garbled.

Measure 1: Input character strings again in English.

Cause 2: Depending on PC setup, some display may get garbled.

Measure 2: Check the setup using the following procedure.

1. Open [Regional and Language Options] from the control panel.
2. Check that the language is [Japanese] and the region is [Japan].
3. Click the [Management] tab.
4. Check that [Language for non-Unicode programs] is [Japanese].

The tool bar buttons in the "Editing a mask" screen are hidden and not operatable.

Cause 1: If the setting of Trusted Sites in Internet Explorer is incorrect, you may not be able to install the Vision UIF Controls.

Measure 1: Refer to "Setup: 1.1.4 Modifying Settings of Internet Explorer", and make sure that of the robot IP address is in Trusted Sites.

Cause 2: If the address bar or the status bar is shown on the Vision Setup window, the mask setting buttons are hidden and you may not be able to operate them.

Measure 2: Refer to "Setup: 1.1.4 Modifying Settings of Internet Explorer", and make sure that the settings of ［Require server verification (https) for all sites in this zone］ are correct.

In the Vision Setup screen of Vision Data, an image appears on a deviated place, and buttons and setting items are being hidden

Cause: If the address bar or the status bar is shown on the Vision Setup window, the mask setting buttons are hidden and you may not be able to operate them.。

Measure: In accordance with "Setup: 1.1.4 Modifying Settings of Internet Explorer", register the robot controller in the Internet Explorer Trusted Sites, and uncheck [Require server verification (https) for all sites in this zone].

The robot home page cannot be opened

Cause: 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.

Measure: Set it as described in "Setup: 1.1.4 Modifying Settings of Internet Explorer".

When you click *i*RVision [Vision Setup], the message “Failed to login Vision Setup” appears.

Cause: The Windows firewall might be set incorrectly.

Measure: Set it as described in "Setup: 1.1.5 Modifying Setting of Windows Firewall".

When you open the *i*RVision Vision Setup, the message “Please enable pop-up windows in Internet Explorer” appears

Cause: Internet Explorer might be set incorrectly.

Measure: Set it as described in "Setup: 1.1.4 Modifying Settings of Internet Explorer".

When you create a new vision data file, a runtime error occurs

Cause: Internet Explorer might be set incorrectly.

Measure: Set it as described in "Setup: 1.1.4 Modifying Settings of Internet Explorer".

Clicking *i*RVision [Vision Setup] displays the alarm [70: Cannot write].

Cause: Internet Explorer might be set incorrectly.

Measure: Set it as described in "Setup: 1.1.4 Modifying Settings of Internet Explorer".

No window opens even though *i*RVision [Vision Setup] is clicked

Cause 1: The Windows firewall might be set incorrectly.

Measure 1: Set it as described in "Setup: 1.1.5 Modifying Setting of Windows Firewall".

Cause 2: If security software is installed in your PC, communication might be blocked by the security software.

Measure 2: Disabled the security software.

The alarm [PMON-001 Failed to notify PC Monitor] is displayed on the teach pendant of the robot

Cause 1: The Windows firewall might be set incorrectly.

Measure 1: Set it as described in "Setup: 1.1.5 Modifying Setting of Windows Firewall".

Cause 2: If security software is installed in your PC, communication might be blocked by the security software.

Measure 2: Disabled the security software.

Clicking *i*RVision [Vision Setup] displays [A problem occurred] and closes Internet Explorer

Cause: Communication with the robot controller may not be performed normally due to the influence of the add-on software of Internet Explorer.

Measure: 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.

No image is displayed on the *i*RVision teach screen

Cause 1: When you log in to your PC as a user without the Administrator password, the PC might not normally communicate with the robot.

Measure 1: Log in to your PC as a user with the Administrator password.

Cause 2: 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.

Measure 2: Disable the Worldwide Web Publishing Service.

Cause 3: If you use a single PC to open Vision Setup on multiple robot controllers, the same IP address are used for the controllers, and different versions of robot software are installed to them, various problems, for example Vision Setup cannot be displayed or operated properly, may occur. This is because a setup page file from a controller is cashed by IE, and the caches page file is used for Vision Setup of another controller.

Measure 3: Delete temporary internet files by opening the [Delete Browsing History] dialog box from [Internet Options] – [General] – [Delete] and clicking [Delete] button. The problem can occur also when the controller software is updated.

MEMO

1. The [Delete Browsing History] dialog box has the check box [Preserve favorite website data] in recent versions of Internet Explorer. If it is checked, the [Delete] button does not delete the browsing history of the favorite website. It means the cached page files from a controller are not deleted if you added the robot homepage to the favorite website list. Un-checking it before clicking the [Delete] button.
2. If you reboot your PC, images may appear. Reboot your PC and open the screen of *i*RVision again.

When you try to load an image file, [Runtime error '0'] occurs

Cause: When Internet Information Services (IIS) is enabled, communication with the robot controller may not be performed correctly.

Measure: Choose Control Panel then open [Add or Remove Program]. Next, uncheck [Internet Information Services (IIS)] on the list of [Windows Components].

Buttons to edit mask are hidden, and not operatable

Cause 1: If the setting of trusted sites in Internet Explorer is incorrect, the mask setting buttons are hidden and you may not be able to operate them.

Measure 1: Refer to "Setup: 1.1.4 Modifying Settings of Internet Explorer", and make sure that of the robot IP address is in Trusted Sites.

Cause 2: If the address bar or the status bar is shown on the [Vision Setup] window, the mask setting buttons are hidden and you may not be able to operate them.

Measure 2: Refer to "Setup: 1.1.4 Modifying Settings of Internet Explorer", and make sure that the [Allow websites to open windows without address or status bars] box is checked.

The address bar is displayed on the Vision Setup page

Cause: If the setting of trusted sites in Internet Explorer is incorrectly, the address bar is displayed on the [Vision Setup] screen and you may not be able to operate it.

Measure: Refer to "Setup: 1.1.4 Modifying Settings of Internet Explorer", and make sure that of the robot IP address is in Trusted Sites.

When you try to finish editing masks, the [CVIS-005 File access is denied] alarm is issued.

Cause: When Internet Information Services (IIS) is enabled, communication with the robot controller may not be performed correctly.

Measure: Choose Control Panel then open [Add or Remove Program]. Next, uncheck [Internet Information Services (IIS)] on the list of [Windows Components].

2.3.2 Problems about the Use of ROBOGUIDE

On ROBOGUIDE, vision data cannot be newly created

Cause: The [Vision Setup] screen of *i*RVision cannot be displayed using the browser that is built into ROBOGUIDE.

Measure: 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

Cause: The [Vision Setup] screen of *i*RVision cannot be displayed using the browser that is built into ROBOGUIDE.

Measure: 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

Cause: The [Vision Setup] screen of *i*RVision cannot be displayed using the browser that is built into ROBOGUIDE.

Measure: 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”/>

2.4 HINTS FOR OPERATION

To Create More Vision Data

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

1 Disable automatic backup
By default, the R-30*i*B Plus controller is configured to make the backup automatically. By default, automatic backups are stored on the FROM 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 "OPERATOR'S MANUAL (Basic Operation) B-83284EN."

2 Change the automatic backup destination to MC:
By default, automatic backups are stored on FROM and the most recent two sets are preserved.
By changing the automatic backup destination device from FRA: (FROM) to MC: vision data about three times larger can be created on FROM. For the procedure for modifying the setting of the automatic backup function, refer to "OPERATOR'S MANUAL (Basic Operation) B-83284EN."

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

I want to know the number of found results in one execution by a vision process

Measure: With 'GET_NFOUND' command, you can obtain the number of found results to the register. Execute it in accordance with "Setup: 6.1.2.3 GET_NFOUND".

I want to change exposure time and retry the Vision Process

Measure: If you use 'OVERRIDE' command, you can change exposure time and retry the same vision process. Refer to "Setup: 5.1 VISION OVERRIDE" and "Setup: 6.1.2.8 OVERRIDE".

Can I use the same user frame for an application user frame and cal. grid frame for a grid pattern calibration?

Measure: We recommend that you use user frames with different numbers. If you use user frames with the same number, in the event of camera replacement due to camera failure, you cannot perform recovery only by the recalibration of the camera, so you need to reteach robot positions. It is OK to use user frames when you set the same frame data in user frame area with different numbers.

INDEX

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REVISION RECORD

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