FANUC Robot series

R-30*i*B/R-30*i*B Mate CONTROLLER

*i*RVision Bin Picking Application

OPERATOR'S MANUAL

B-83304EN-5/04

• **Original Instructions**

Before using the Robot, be sure to read the "FANUC Robot Safety Manual (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 have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

SAFETY PRECAUTIONS

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

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

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

1 WORKING PERSON

The personnel can be classified as follows.

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

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

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

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

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

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

2 DEFINITION OF WARNING, CAUTION AND NOTE

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

⚠**WARNING**
Applied when there is a danger of death or injury to the working person and the equipment being damaged, if the approved procedure is not observed.

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

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

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

3 WORKING PERSON SAFETY

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

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

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

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

The controller is designed to receive this interlocking signal of the door switch. When the gate is opened and this signal received, the controller stops the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). For connection, see Fig.3 (a) and Fig.3 (b).

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).
(5) Try to install the peripheral devices outside the work area.

(6) Draw an outline on the floor, clearly indicating the range of the robot motion, including the tools such as a hand.
(7) Install a mat switch or photoelectric switch on the floor with an interlock to a visual or aural alarm that stops the robot when a working person enters the work area.
(8) If necessary, install a safety lock so that no one except the working person in charge can turn on the power of the robot.

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

(9) When adjusting each peripheral device independently, be sure to turn off the power of the robot.
(10) Operators should be ungloved while manipulating the operator's panel or teach pendant. Operation with gloved fingers could cause an operation error.
(11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident.
(12) The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
(13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
(14) Before the robot is started, it should be checked that no one is in the area of the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.
(15) When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
- Avoid using the robot in a flammable environment.
- Avoid using the robot in an explosive environment.
- Avoid using the robot in an environment full of radiation.
- Avoid using the robot under water or at high humidity.
- Avoid using the robot to carry a person or animal.
- Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)
(16) When connecting the peripheral devices related to stop(safety fence etc.) and each signal (external emergency , fence etc.) of robot. be sure to confirm the stop movement and do not take the wrong connection.
(17) When preparing trestle, please consider security for installation and maintenance work in high place according to Fig.3 (c). Please consider footstep and safety bolt mounting position.

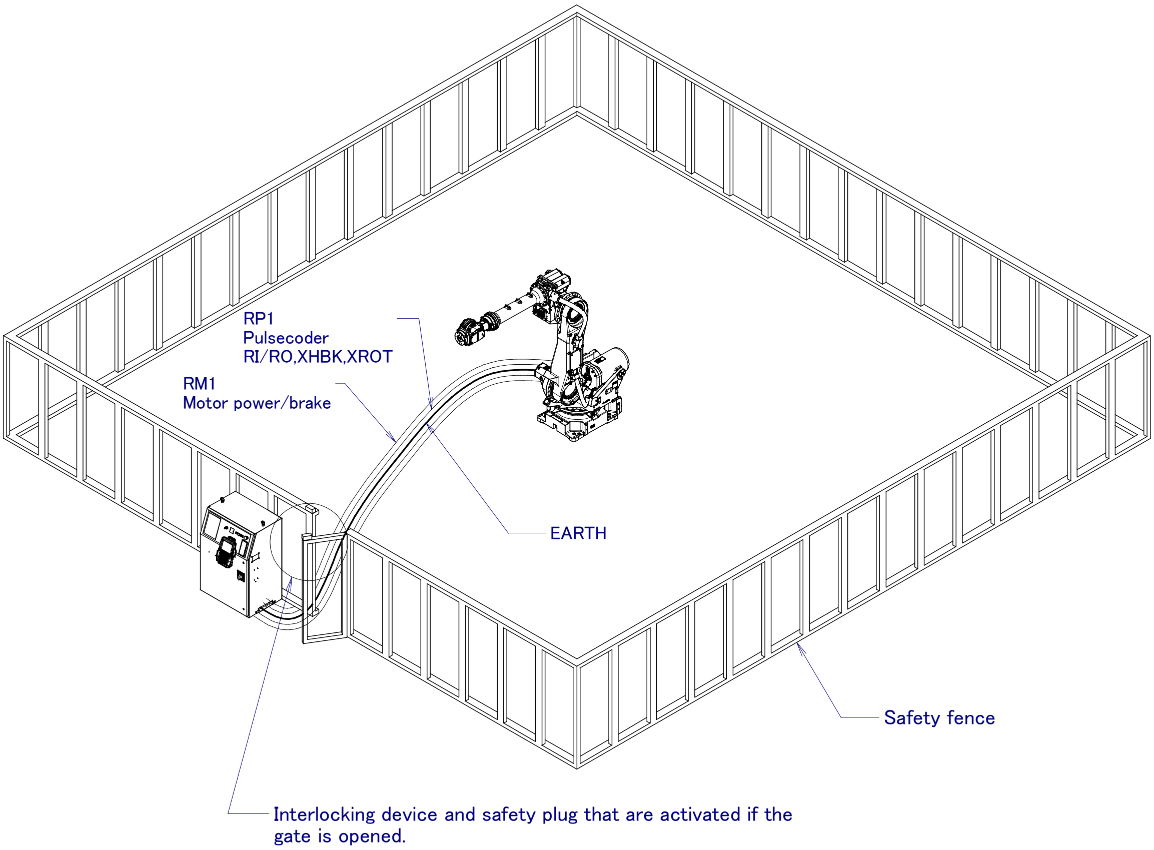
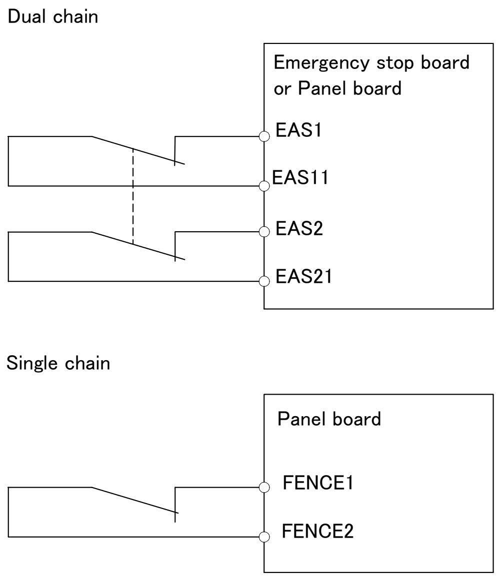


Fig. 3 (a) Safety fence and safety gate



(Note)

For the R-30*i*B, the R-30*i*B Mate
Terminals EAS1,EAS11,EAS2,EAS21 are provided on the emergency stop board.

For the R-30*i*A
Terminals EAS1,EAS11,EAS2,EAS21 are provided on the emergency stop board or connector panel

For the R-30*i*A Mate
Terminals EAS1,EAS11,EAS2,EAS21 or FENCE1,FENCE2 are provided on the emergency stop board or in the connector panel of CRM65 (Open air type).

Refer to the ELECTRICAL CONNCETIONS Chapter of CONNECTION of controller maintenance manual for details.

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

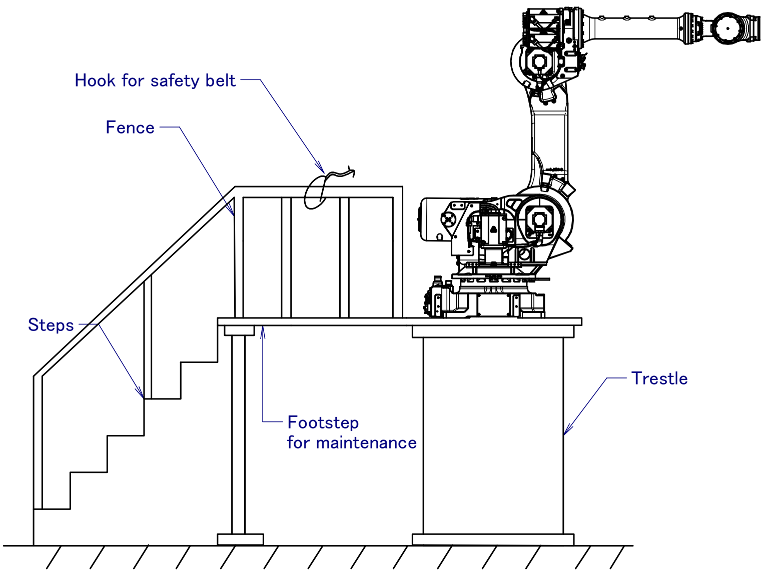


Fig.3 (c) Footstep for maintenance

3.1 OPERATOR SAFETY

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

(1) If you do not have to operate the robot, turn off the power of the robot controller or press the EMERGENCY STOP button, and then proceed with necessary work.
(2) Operate the robot system at a location outside of the safety fence
(3) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the work area unexpectedly and to prevent the worker from entering a dangerous area.
(4) Install an EMERGENCY STOP button within the operator's reach.

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

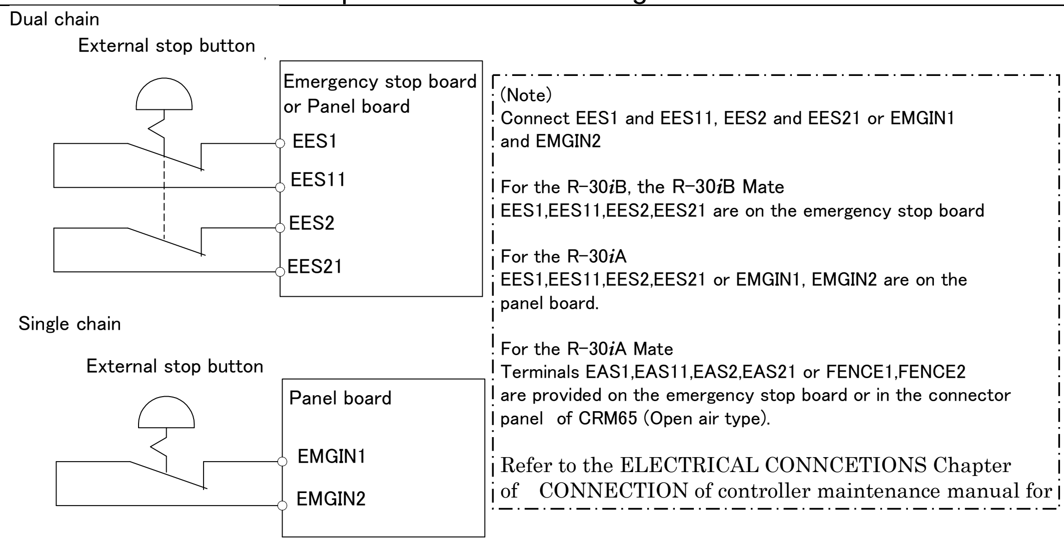


Fig.3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

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

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

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation mode set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence. (For the R-30*i*A Mate Controller standard specification, there is no mode switch. The automatic operation mode and the teach mode is selected by teach pendant enable switch.)

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) Disable: The DEADMAN switch is disabled.
   (b) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
   Note) The DEADMAN switch is provided to stop the robot when the operator releases the teach pendant or presses the pendant strongly in case of emergency. The R-30*i*B/R-30*i*B Mate/R-30*i*A/ R-30*i*A Mate 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 programmer’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 programmer 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 device interface send each robot start signal. However the validity of each signal changes as follows depending on the mode switch and the DEADMAN switch of the operator panel, the teach pendant enable switch and the remote condition on the software.

For the R-30*i*B/R-30*i*B Mate/R-30*i*A Controller or CE or RIA specification of the R-30*i*A Mate Controller

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

T1,T2 mode: DEADMAN switch is effective.

For the standard specification of R-30*i*A Mate Controller

Teach pendant enable switch	Software remote condition	Teach pendant	Peripheral device
On	Ignored	Allowed to start	Not allowed
Off	Local	Not allowed	Not allowed
	Remote	Not allowed	Allowed to start

(6) (Only when R-30*i*B/R-30*i*B Mate /R-30*i*A Controller or CE or RIA specification of R-30*i*A Mate controller is selected.) To start the system using the operator's panel, make certain that nobody is the robot work area and that there are no abnormal conditions in the robot work area.

(7) When a program is completed, be sure to carry out a test operation according to the procedure below.

- (a) Run the program for at least one operation cycle in the single step mode at low speed.
- (b) Run the program for at least one operation cycle in the continuous operation mode at low speed.
- (c) Run the program for one operation cycle in the continuous operation mode at the intermediate speed and check that no abnormalities occur due to a delay in timing.
- (d) Run the program for one operation cycle in the continuous operation mode at the normal operating speed and check that the system operates automatically without trouble.
- (e) After checking the completeness of the program through the test operation above, execute it in the automatic operation mode.

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

3.3 SAFETY OF THE MAINTENANCE ENGINEER

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

(1) During operation, never enter the robot work area.

(2) A hazardous situation may arise when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system should be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed.

(3) If it becomes necessary to enter the robot operation range while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the range. The

maintenance personnel must indicate that maintenance work is in progress and be careful not to allow other people to operate the robot carelessly.

(4) When entering the area enclosed by the safety fence, the maintenance worker must check the entire system in order to make sure no dangerous situations exist. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and entire system status must be carefully monitored.

(5) Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.

(6) Before the start of teaching, check that the robot and its peripheral devices are all in the normal operating condition.

(7) Do not operate the robot in the automatic mode while anybody is in the robot work area.

(8) When you maintain the robot alongside a wall or instrument, or when multiple workers are working nearby, make certain that their escape path is not obstructed.

(9) When a tool is mounted on the robot, or when any moving device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.

(10) If necessary, have a worker who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the worker should be ready to press the EMERGENCY STOP button at any time.

(11) When replacing a part, please contact FANUC service center. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the worker.

(12) When replacing or reinstalling components, take care to prevent foreign 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 work area and that the robot and the peripheral devices are not abnormal.

(16) When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.

(17) Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.

(18) The following parts are heated. If a maintenance worker needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.

- Servo motor
- Inside the controller
- 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 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 operation should be given for the robot according to a predetermined method. (See TESTING section of “Controller operator’s manual”.) During the test operation, the maintenance staff should work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL DEVICES

4.1 PRECAUTIONS IN PROGRAMMING

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

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

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

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

4.2 PRECAUTIONS FOR MECHANISM

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

(2) Only use approved cuttings fluids and cleaning fluids.

(3) Use a limit switch or mechanical stopper to limit the robot motion to prevent the robot from collisions against peripheral devices or tools.

(4) Observe the following precautions about the mechanical unit cables. Failure to follow these precautions may cause mechanical problems.
- Use mechanical unit cable that meet user interface requirement.
- Don not route additional cables or hoses inside the mechanical unit.
- Do not obstruct the movement of the mechanical unit cables when additional cables are touted external to the mechanical unit.
- For models that have exposed cables, do not modify the cable bundle construction (such as by adding on protective covers, tying on additional cables) that could change the behavior of the cable motion.
- When installing user peripheral equipment on the robot mechanical unit, please pay attention that equipment 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 execute power-off stop after reducing the speed of the robot and stopping it by hold stop or cycle stop when it is not urgent. (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type.)
(Bad case example)

- Whenever poor product is generated, a line stops by emergency stop and power-off of the robot is executed.
- When alteration was necessary, safety switch is operated by opening safety fence and power-off stop is executed for the robot during operation.
- An operator pushes the emergency stop button frequently, and a line stops.
- An area sensor or a mat switch connected to safety signal operate routinely and power-off stop is executed for the robot.

(6) Robot stops urgently when collision detection alarm (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 MECHANISM

5.1 PRECAUTIONS IN OPERATION

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

5.2 PRECAUTIONS IN PROGRAMMING

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

5.3 PRECAUTIONS FOR MECHANISMS

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

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

For emergency or abnormal situations (e.g. persons trapped in or 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

The following three robot stop types exist:

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

Servo power is turned off and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.
The following processing is performed at Power-Off stop.

- An alarm is generated and servo power is turned off.
- The robot operation is stopped immediately. Execution of the program is paused.

Frequent Power-Off stop of the robot during operation can cause mechanical problems of the robot.
Avoid system designs that require routine or frequent Power-Off stop conditions.

Controlled stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
The following processing is performed at Controlled stop.

- The alarm "SRVO-199 Controlled stop" occurs along with a decelerated stop. Execution of the program is paused.
- An alarm is generated and servo power is turned off.

Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.
The following processing is performed at Hold.

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

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

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

There are the following 3 Stop patterns.

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

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

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

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

(*) R-30*i*B/R-30*i*B Mate does not have servo disconnect. R-30*i*B Mate does not have SVOFF input.

Option	R-30*i*A				R-30*i*A Mate		
	Standard (Single)	Standard (Dual)	RIA type	CE type	Standard	RIA type	CE type
Standard	B (*)	A	A	A	A (**)	A	A
Stop type set (Stop pattern C) (A05B-2500-J570)	N/A	N/A	C	C	N/A	C	C

(*) R-30*i*A standard (single) does not have servo disconnect.
(**) R-30*i*A Mate Standard does not have servo disconnect, and the stop type of SVOFF input is Power-Off stop.

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

"Controlled stop by E-Stop" option

When "Controlled stop by E-Stop" (A05B-2600-J570) option (For the R-30*i*A/R-30*i*A Mate, it is Stop type set (Stop pattern C) (A05B-2500-J570)) is specified, the stop type of the following alarms becomes Controlled stop but only in AUTO mode. In T1 or T2 mode, the stop type is Power-Off stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*A/R-30*i*B/R-30*i*B Mate controller)
SRVO-194 Servo disconnect	Servo disconnect input (SD4-SD41, SD5-SD51) is open. (R-30*i*A controller)
SRVO-218 Ext.E-stop/Servo Disconnect	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*A Mate controller)
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

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

- In Controlled stop, the robot is stopped on the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Controlled stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and stopping time of Controlled stop is longer than the stopping distance and stopping time of Power-Off stop, depending on the robot model and axis. Please refer to the operator's manual of a particular robot model for the data of stopping distance and stopping time.

For the R-30*i*A or R-30*i*A Mate, this function is available only in CE or RIA type hardware.

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

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

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

140730

TABLE OF CONTENTS

1 PREFACE

This chapter describes an overview of this manual and safety precautions regarding the FANUC 3D Laser Vision Sensor, which should be noted before operating the *i*RVision function.

1.1 OVERVIEW OF THE MANUAL

This manual describes how to operate the *i*RVision function controlled by the R-30*i*B/R-30*i*B Mate controller. In this manual, only the operation and the technique of programming for the dedicated sensor functions are explained, if the installation and the setup of the robot are completed. Refer to the "HANDLING TOOL Operations Manual" about other operations of FANUC Robots.
This manual is directed to users who have taken the *i*RVision 3D Laser Vision Sensor course, the *i*RVision 2D Vision Sensor course and *i*RVision 3D Area Sensor at the FANUC Training Center. For details of each setup parameter, refer to the online help information or the "R-30*i*B/R-30*i*B Mate *i*RVision OPERATOR'S MANUAL (Reference)".

> ⚠ **CAUTION**
> This manual is based on the R-30*i*B system software version V8.30P/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.

Contents of this manual

Chapter 1	How to use this manual
Chapter 2	Overview of Bin Picking system
Chapter 3	Basic Bin Picking system configuration and features
Chapter 4	Basic setup procedures of Bin Picking system
Chapter 5	Reference of Frame Setup
Chapter 6	Reference of Camera Calibration
Chapter 7	Reference of 3D Area Sensor
Chapter 8	Reference of Interference Avoidance function
Chapter 9	Reference of Parts List Manager function
Chapter 10	Bin Picking configuration function
Chapter 11	Description of customization of Bin Picking system
Chapter 12	Trouble shooting related Bin Picking system

1.2 RELATED MANUALS

This section introduces related manuals.

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

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

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

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

R-30*i*B CONTROLLER MAINTENANCE MANUAL B-83195EN

This manual describes the maintenance and connection of R-30*i*B Controller.

R-30*i*B Mate CONTROLLER MAINTENANCE MANUAL B-83525EN

This manual describes the maintenance and connection of R-30*i*B Mate Controller.

R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR'S MANUAL (Alarm Code List) B-83284EN-1

This manual describes the error code listings, causes, and remedies of R-30*i*B/R-30*i*B Mate Controller.

R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL B-83434EN

This manual describes the connection between sensors which is a camera or 3D Laser Sensor and R-30*i*B/R-30*i*B Mate Controller, and maintenance of sensors.

R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference) B-83304EN

This manual is the reference manual for *i*RVision on the R-30*i*B controller. This manual describes each function which is provided by *i*RVision. This manual describes the meanings (e.g. the items on *i*RVision setup screen, the arguments of the instruction, and so on.

R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision 2D Vision Application OPERATOR'S MANUAL B-83304EN-1

This manual is desired to first refer to when you start up systems of *i*RVision 2D Compensation and 2.5D Compensation. This manual describes startup procedures of *i*RVision 2D Compensation and 2.5D Compensation system, creating programs, caution, technical know-how, response to several cases, and so on.

R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision 3D Laser Vision Sensor Application OPERATOR'S MANUAL B-83304EN-2

This manual is desired to first refer to when you start up systems of *i*RVision 3D Laser Sensor Compensation. This manual describes startup procedures of *i*RVision 3D Laser Sensor Compensation, creating programs, caution, technical know-how, response to several cases, and so on.

1.3 PRECAUTIONS FOR 3D LASER VISION SENSOR

This section describes precautions to be taken for the 3D Laser Vision Sensor before using it.

1.3.1 Safety of Laser Sensor

A 3D Laser Vision Sensor is a visual sensor, which detects the position and posture of an object using semiconductor lasers.

> ⚠ **CAUTION**
> Observe user's safety and fire precautions in accordance with the safety standards and the regulations, which the country and the region provide when you use this sensor. Moreover, when the safety standards and regulations are changed or newly enacted, please follow them.

The laser classification used in the sensor
Semiconductor lasers → Class IIIa Laser (cf. FDA 1040.10)
Class 3R Laser (cf. IEC Pub.60825 / JIS C6802)

1.3.2 Laser Beam

The semiconductor laser beam is a visible optical laser with a wave length of 650 nm. It is necessary to pay attention to its operation though the maximum output power is at most 4.5mW x 2. Do not irradiate the output beam from the sensor directly to your eyes. Moreover, do not look straight at the scattered light for a long time.

1.3.3 Warning Label

The warning labels which inform the danger of the laser beam irradiation are affixed on this laser sensor. Moreover, the warning labels in accordance with United States FDA standard are prepared as an option. Fig. 1.3.3 (a) and Fig. 1.3.3 (b) show the warning labels used.

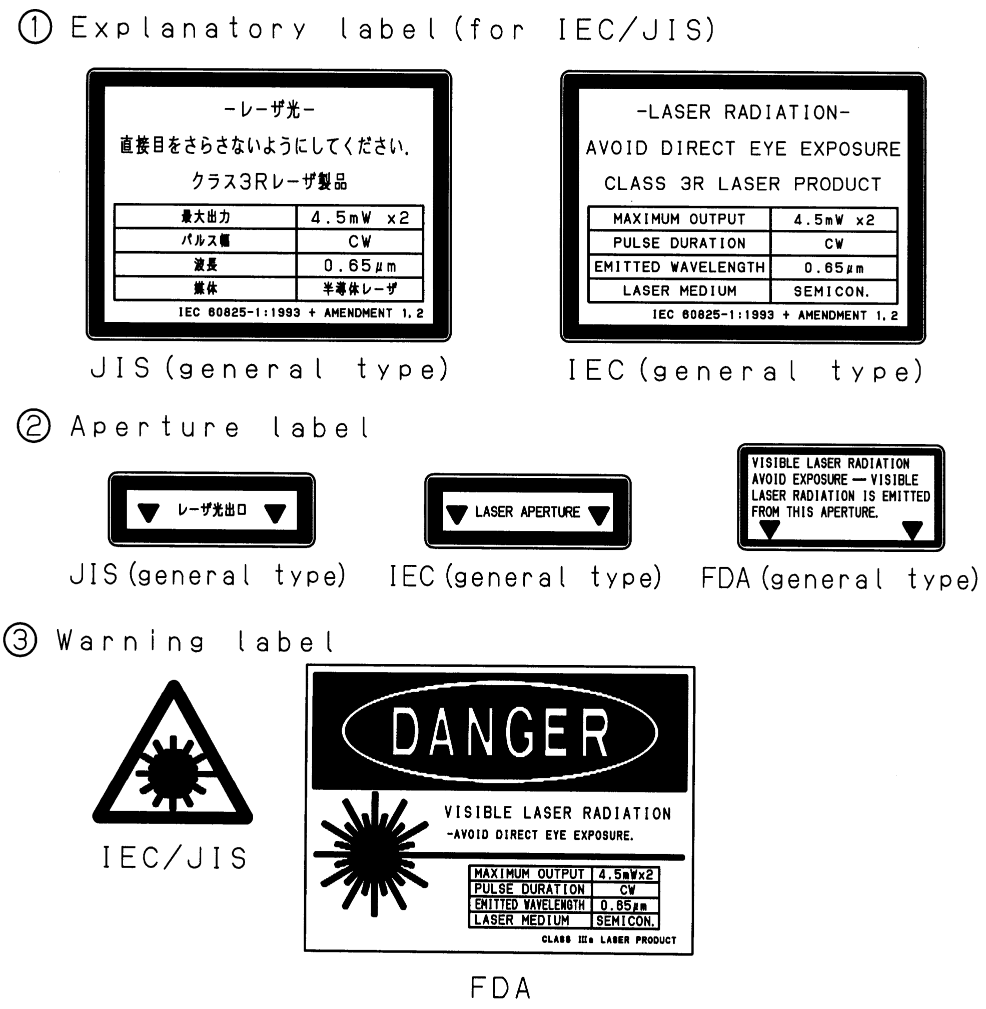


Fig. 1.3.3 (a) Warning labels (1)

④ Address label (for FDA)

3580, Shibokusa Aza-Komanba.
Oshino-mura, Minamitsuru-gun,
Yamanashi Prefecture, Japan

⑤ Access panel label

注意 ―ここを開くとクラス3Rレーザ光が
出ます.
直接目をさらさないようにしてください.

JIS

CAUTION ― CLASS 3R LASER
RADIATION WHEN OPEN.
AVOID DIRECT EYE EXPOSURE.

IEC

DANGER
VISIBLE LASER RADIATION
WHEN OPEN.
AVOID DIRECT EYE EXPOSURE.

FDA

⑥ Certification label (for FDA)

- CERTIFICATION LABEL -
•This laser product complies
with 21 CFR 1040.10 and 1040.11.

Fig. 1.3.3 (b) Warning labels (2)

2 OVERVIEW

A bin picking system is an application that enables the vision system to recognize the position and posture of each of the parts, which are randomly placed inside a container, and the robot to pick up those parts one by one.

This manual sequentially describes the procedure to build a bin picking system. A bin picking system can be built by performing the operations described in Chapter 4 according to the specified procedure.

2.1 FUNCTIONS RELATED BIN PICKING

Whether the functions described in this manual can be used depends on the options installed in the robot controller. Please check whether the functions required for a bin picking system to be configured are installed with reference to the following table.

	*i*RVision Bin Picking	*i*RVision 3D Laser Vision Sensor
Bin Picking SEARCH vision process	✓	
Interference Avoidance function	✓	
Parts List Manager function	✓	
3D Area Sensor-related function (3D Area Sensor Vision Process, etc.)	✓	
3D Laser Sensor-related function (3DL Single-View Vision Process, etc)		✓
Robot-Generated Grid Cal. Tool	✓	
Image Processing related function (2-D Single-View Vision Process, etc.)	✓	
Search Area Restriction Tool	✓	

The functions not listed in this table can be basically used for any option.

2.2 KEY CONCEPT

This section describes terms used in this manual.

SEARCH

Indicates the detection of parts in a container using a camera or 3D Area Sensor installed above the container. SEARCH can also be performed using a hand camera installed in the wrist of a robot. SEARCH finds the approximate position of each part in the container. In SEARCH with 3D Area Sensor, the accurate 3D position and posture of each part can be obtained.

FINE

Indicates moving a robot to a predetermined position and performing 3D measurement with the 3D Laser Sensor attached to the wrist of the robot, based on the position of a part obtained by SEARCH. This enables the obtainment of the accurate 3D position and posture of each part, which cannot be measured by SEARCH with a fixed camera or hand camera. If there is no robot mounted sensor then FINE does not have to be setup.

Part Data

Indicates one data item including detection results of SEARCH and FINE for a specific part in the container. Part data is assigned a unique ID number (part data ID). Part data is identified by its part data ID.

Parts List

Indicates a list of the parts with their part data ID. A bin picking system needs to be designed so that the part data of parts in one container is managed by one parts list.

Push

Indicates that a part data is created on the basis of the result of detection by the SEARCH process and the created part data is added to the parts list.

Pop

Indicates the selection of part data that is picked up preferentially, from a parts list.

Black List

If the part data that was failed to be picked up is popped again, it is likely that same picking failure will occur again. To address such a failure, the part data that was failed to be picked up is put in a black list and managed differently.

3D Area Sensor

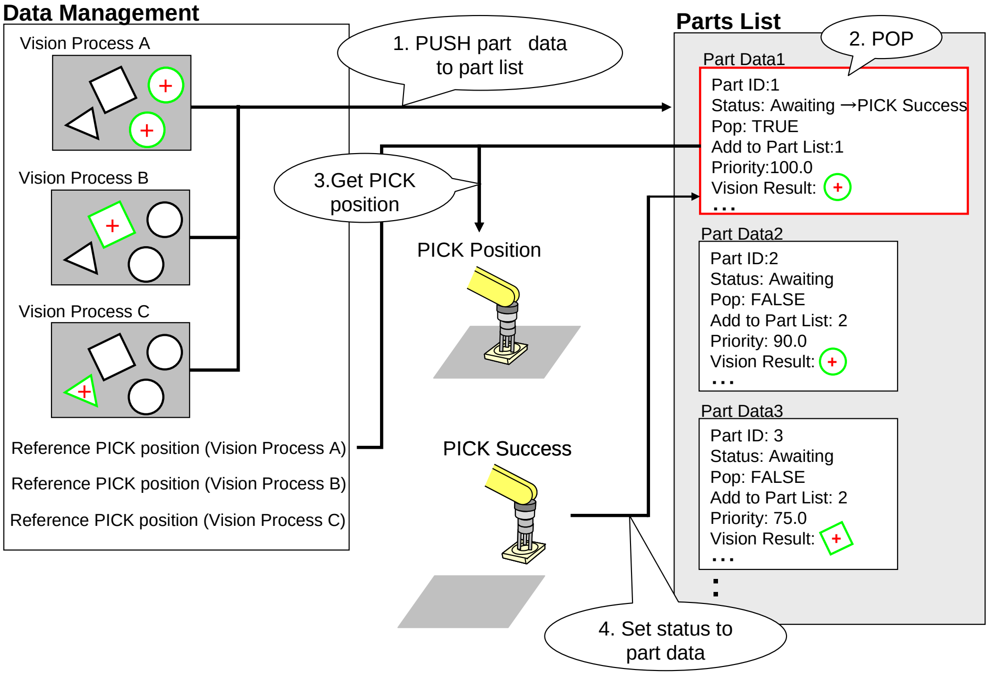
Indicates a 3D sensor that consists of two camera units and one projector unit. 3D Area Sensor obtains 3D information in the field of view by imaging multiple stripe patterns projected by the projector unit using the two camera units.

3D Map

Multiple 3D points obtained in one measurement by 3D Area Sensor are collectively called a 3D map.

2.3 OVERVIEW OF PARTS LIST MANAGER

This section describes the Parts List Manager, which is a basic function of bin picking. The Parts List Manager is a collection of functions required for bin picking. For example, the Parts List Manager creates part data based on the result of detection by a vision process executed as SEARCH and pushes the found part data to the parts list. Bin picking using the Parts List Manager is performed mainly in the four steps shown in the figure below.



Step 1 Pushing

Part data is created on the basis of the result of detection by the SEARCH vision process and the created part data is added to the parts list.

Step 2 Popping

A candidate for part data to be picked up is selected from part data included in the parts list. At this time, the part data with the highest priority included in the part data is selected. The priority of part data is set when the part data is pushed. The user-specified measurement value of 10 measurement values held in the result of detection by the vision process is set as the priority.

Step 3 Getting the pick position (getting the robot movement position)

The vision offset from the popped part data and the reference PICK position from the Parts List Manager are used to calculate the robot pick and approach positions. Since the part data including the found results by vision process A is popped in the above example, the pick position is calculated on the basis of the vision offset data stored in this part data and the reference pick position of vision process A saved by Parts List Manager and the calculated pick position is output to the position register.

Step 4 Setting the status

When any operation is performed on the part corresponding to popped part data, such as a success or failure of PICK, a success or failure of FINE, etc., the status indicating the state of the part is set for the part data. Setting the status for the part data makes the states of parts in the container identical to the states of part data in the parts list. If the state of the parts in the container is not identical to the states of the part data in the pat list, bin picking cannot be performed efficiently.

Parts List Manager has the following functions in order to facilitate bin picking in the above four steps.

Data management function

This function performs data management by setting a vision process and reference robot positions such as the reference PICK position in a list form. Since the vision process used and the reference robot positions can be set and displayed in a list form, the structure of a bin picking system can be easily understood.

Position get function

This function allows Parts List Manager to automatically calculate the robot positions (for example, the FINE position and PICK position) required for the next processing by using the reference robot position stored in the data management function and the vision offset data of popped part data and the calculated positions to the position register.

Reference position setting wizard function

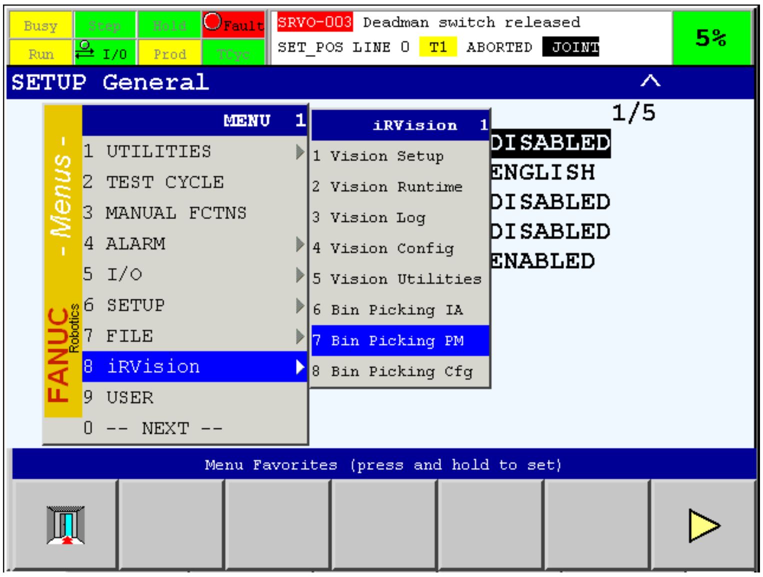
This function sets the reference data and its corresponding robot reference position related to the vision process set by the data management function, in a wizard form.

The parts list management function, data management function, position get function, and reference position setting wizard function as described above are combined in Parts List Manager.

> ⚠ **CAUTION**
> The Parts List Manager does not support for the following robot.
> The robot with additional axes.
> The robot whose motion group is not group 1.

2.3.1 Login to Parts List Manager Setup

To log in to the Parts List Manager Setup screen, press MENU on the *i*Pendant and select [7 Bin Pick PM] from [8 iRVision].



2.4 OVERVIEW OF INTERFERENCE AVOIDANCE

This section describes the interference avoidance function, which is a basic function of the bin picking. The interference avoidance function includes the following three functions.

Interference Check

This function checks interference between the end of arm tooling of the robot and peripheral objects.

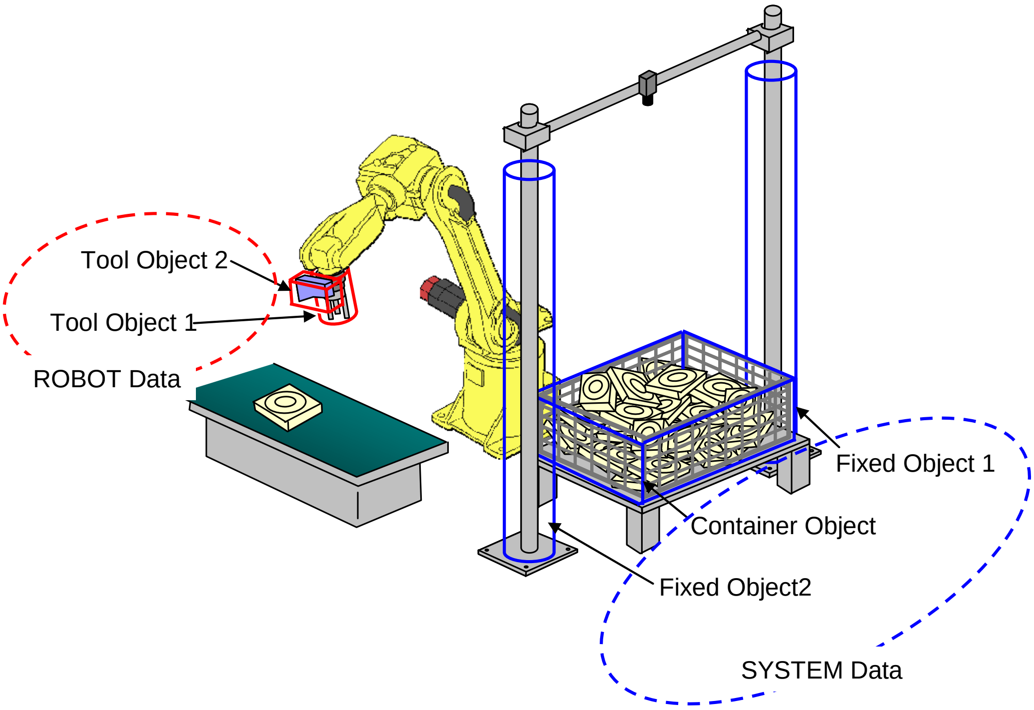
Interference Avoidance

In addition to the Interference Check, this function automatically generates the target position and posture in a specified range if interference occurs at the checked robot position.

Wall Avoidance

This function calculates the offset by which the end of arm tooling of the robot is retracted from the wall toward the center of the container. This function is used when the robot retracts from the wall of the container after the FINE or the PICK operation.

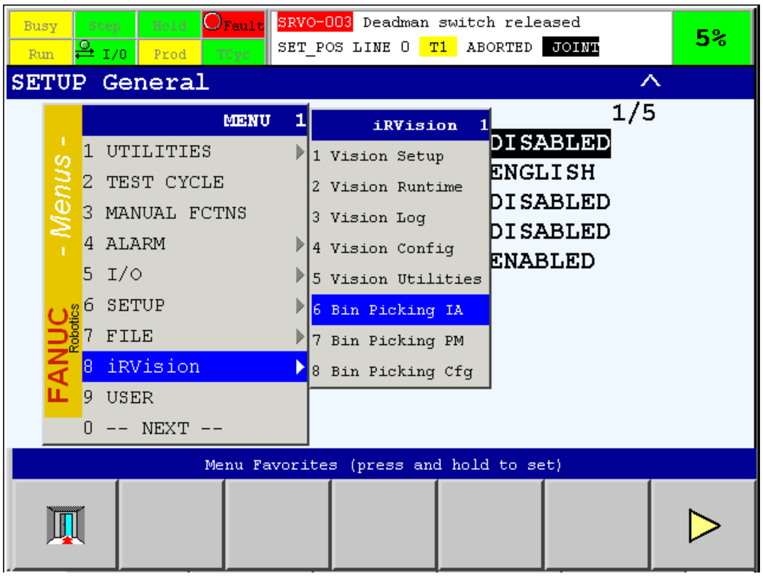
When using the above three functions, the position and size of an object for which interference is checked should be set in advance in the interference avoidance setup section. The position and size of an object for which interference is checked are set by combination of multiple fixed-shape objects (container, sphere, cylinder, and hexahedron) as shown in the figure below.



Peripheral objects such as the container and the columns of the camera stand are set as system data and objects other than the container are treated as fixed objects. Robot-equipped objects such as the gripper and the 3D Laser Vision Sensor, if used, are set as robot data and the set objects are treated as tool objects. Conditions when an interference check, interference avoidance, or wall avoidance is performed using the data of these objects are set as avoidance condition data.

2.4.1 Login to Interference Avoidance Setup

To log in to the Interference Avoidance Setup screen, press MENU on the *i*Pendant and select [6 Bin Pick IA] from [8 iRVision].



3 CONFIGURATION AND FEATURES

The *i*RVision mainly supports the following bin picking systems:

- Bin picking system with 3D Area Sensor
- Bin picking system with 2D camera
- Bin picking system with 3D Laser Vision Sensor

This document explains how to set up each bin picking system. In addition to the above three, it also explains how to set up a fixed frame offset system with 3D Area Sensor. Each system requires the software option(s) below.

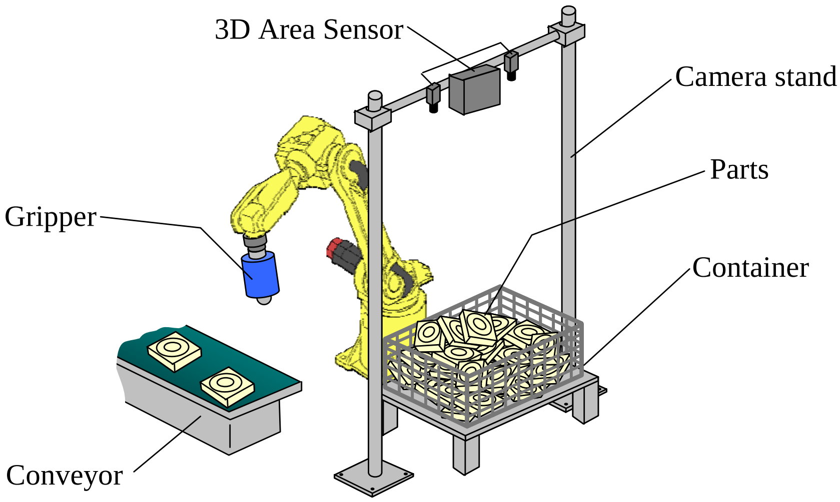
System configuration	Required software option
Bin picking system with 3D Area Sensor	*i*RVision bin picking
Bin picking system with 2D Camera	*i*RVision bin picking
Bin picking system with 3D Laser Vision Sensor	*i*RVision bin picking *i*RVision 3D Laser Vision Sensor
Fixed frame offset system with 3D Area Sensor	*i*RVision bin picking

This chapter explains the configurations and features of the four systems for which the set up procedures are explained in the next chapter.

3.1 BIN PICKING SYSTEM WITH 3D AREA SENSOR

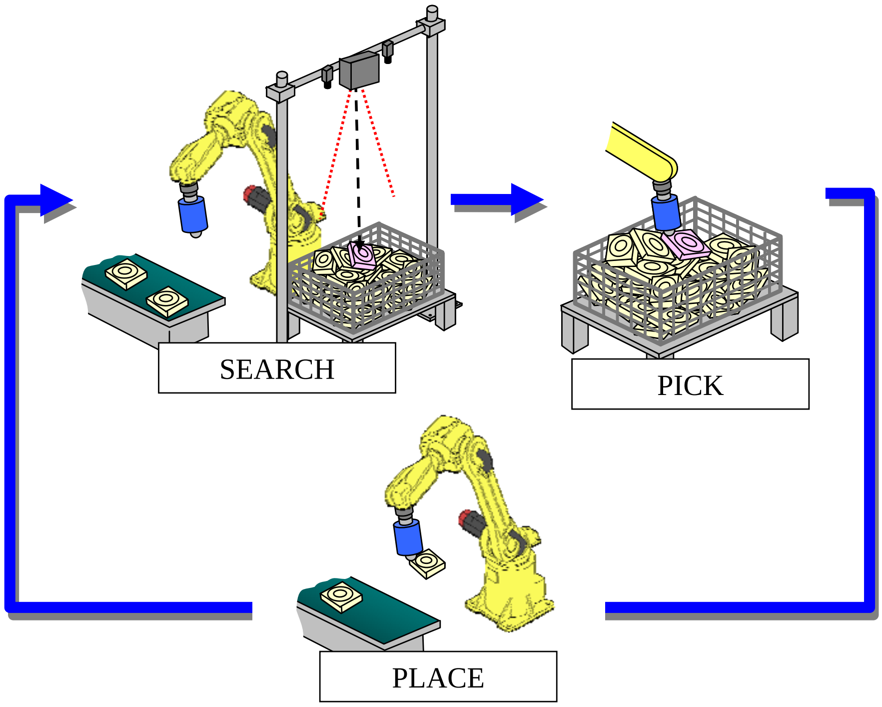
Configuration

This bin picking system has a configuration such as that shown in the figure below.



Process Flow

SEARCH is performed with the 3D Area Sensor mounted on the camera stand, and information about the 3D position and posture of a part is detected, and the part is picked.



Features

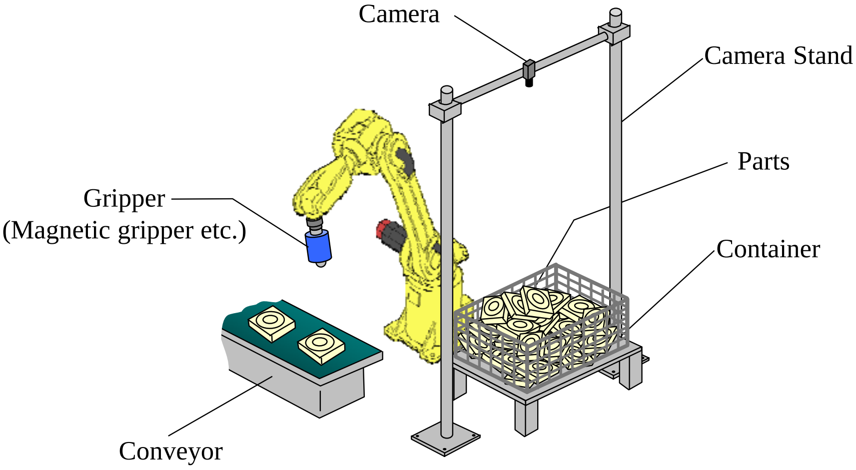
- The 3D Area Sensor provides a function for measuring the 3D position and posture of a part by using a 3D point near the part that is detected with a detection tool such as pattern match, as well as a function for detecting a mass of local peaks and 3D point groups higher than surrounding points on a 3D map acquired without using a detection tool such as pattern match. For details, see Chapter 7, "3D AREA SENSOR REFERENCE".
- In some cases a part can be picked in such a way that the direction of the gripper is matched with the orientation of the part by using the Area Sensor Plane Tool with a GPM locator. (This depends on the shape and characteristics of the part, so it is recommended to study the applicability.)
- In some cases it is possible to achieve bin picking that does not require re-teaching in the event of a product type change that will change the size and shape of the part, by using the Area Sensor Blob Locator Tool, or Area Sensor Peak Locator Tool (This depends on the shape and characteristics of the part, so it is recommended to study the applicability.)
- The 3D Area Sensor may be affected by ambient light such as ceiling lighting. If the ambient light is too strong in relation to the intensity of the light emitted from the projector unit to the part, the acquisition of a 3D map will be unstable, and the number of 3D points that can be acquired will be reduced.
- The 3D position and posture of a part can be detected without a FINE measurement, which is necessary for a bin picking system with 3D Laser Vision Sensor, so that the cycle time can be reduced.
- The Interference Avoidance function is used because it is necessary to avoid the interference between the gripper and the container.
- The Parts List Manager function is used to manage part data, thereby preventing the process of attempting to pick a part again that can be detected with SEARCH but is in a position where it cannot be picked.

For how to set up a bin picking system with 3D Area Sensor, see Section 4.1,"BIN PICKING SYSTEM WITH 3D AREA SENSOR".

3.2 BIN PICKING SYTEM WITH 2D CAMERA

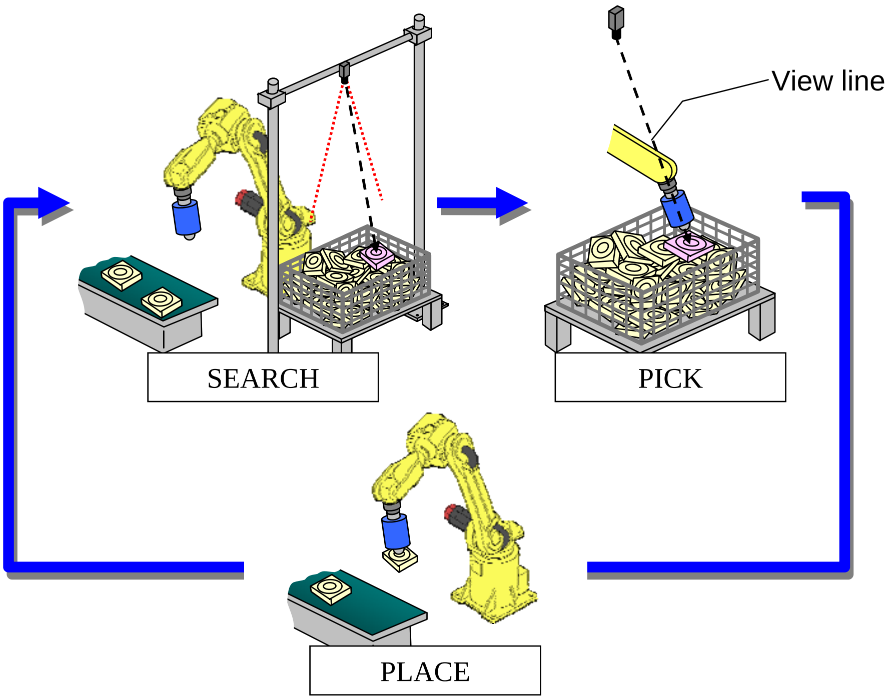
Configuration

This bin picking system has a configuration such as that shown in the figure below.



Process Flow

SEARCH is performed with the fixed camera mounted on the camera stand, and the robot approaches a detected part along the view line joining the part and the camera, and picks the part.



Features

- Part detection results output from SEARCH include information about the view line joining the camera and the part as posture information. This means that a part cannot be picked in such a way that the orientation of the part is matched with the direction of the gripper.
- For this reason, the gripper must be designed so that a part can be picked even if the orientation of the part is not consistent with the direction of the gripper. (For example, a magnetic gripper may be used.)

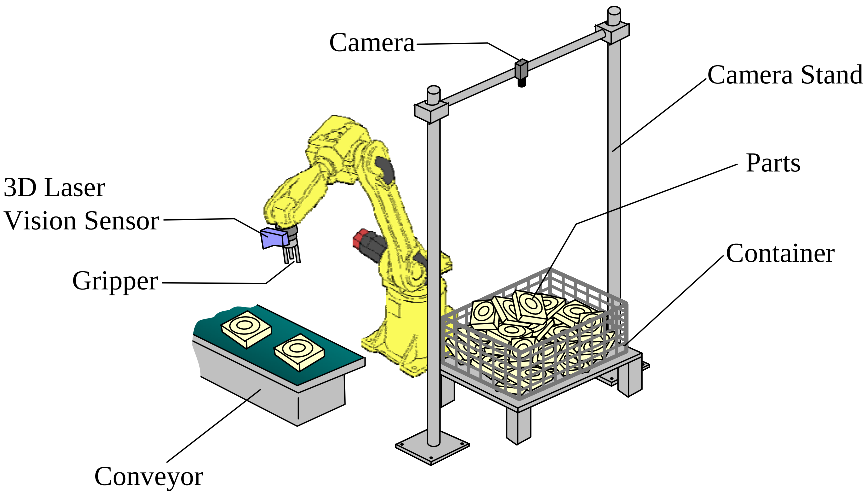
- Because the robot approaches the part along the view line, the robot is sure to come in contact with the part and, at the same time, the interference between the pallet and the robot can be minimized.
- SEARCH measures the apparent size as viewed from the camera, and from the measured size, the height of the part (Z coordinate value) is estimated. For the size to be measured accurately, a stable lighting environment is important.
- It is assumed that parts in bulk are to be picked. When in bulk, parts are at various angles, so their sizes may not always be measured accurately. It is important to study the gripper design and the robot operation beforehand so that parts can be picked even if there are errors in the part height direction. To prevent system faults, it is recommended that the gripper has compliance to accommodate inaccuracies in found height of the part. A method to determine part present on the gripper is important to help determine the required gripping height of the part while picking. For example, by using a lead switch for an air cylinder and the high-speed skip function in combination, it is possible to stop the robot immediately if the gripper comes in contact with a part.
- The Interference Avoidance function is used because it is necessary to avoid the interference between the gripper and the container.
- The Parts List Manager function is used to manage part data, thereby preventing the process of attempting to pick a part again that can be detected with SEARCH but is in a position where it cannot be picked.

For how to set up a bin picking system with 2D camera, see Section 4.2, "BIN PICKING SYSTEM WITH 2D CAMERA".

3.3 BIN PICKING SYSTEM WITH 3D LASER VISION SENSOR

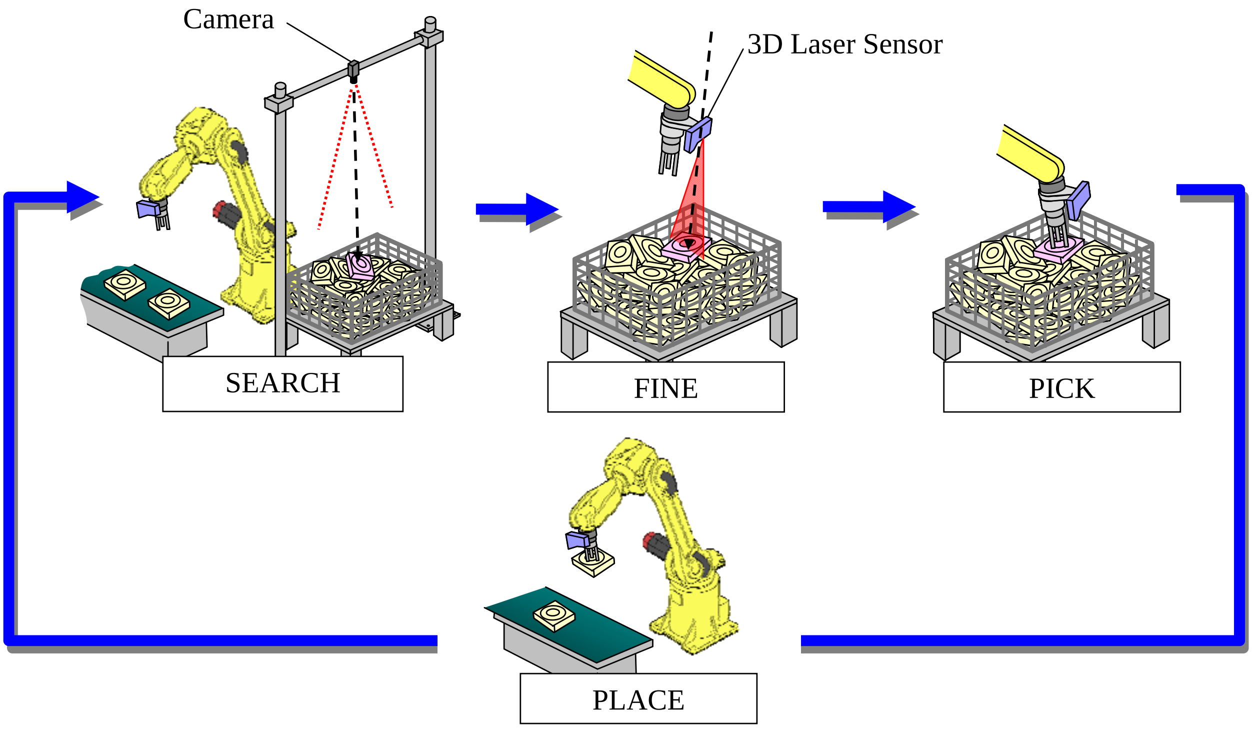
Configuration

This bin picking system has a configuration such as that shown in the figure below.



Process Flow

SEARCH is performed with the fixed camera mounted on the camera stand, and the robot approaches a detected part along the view line joining the part and the camera, and then measures the accurate position and posture of the part with the 3D Laser Vision Sensor mounted on the robot, and picks the part.



Features

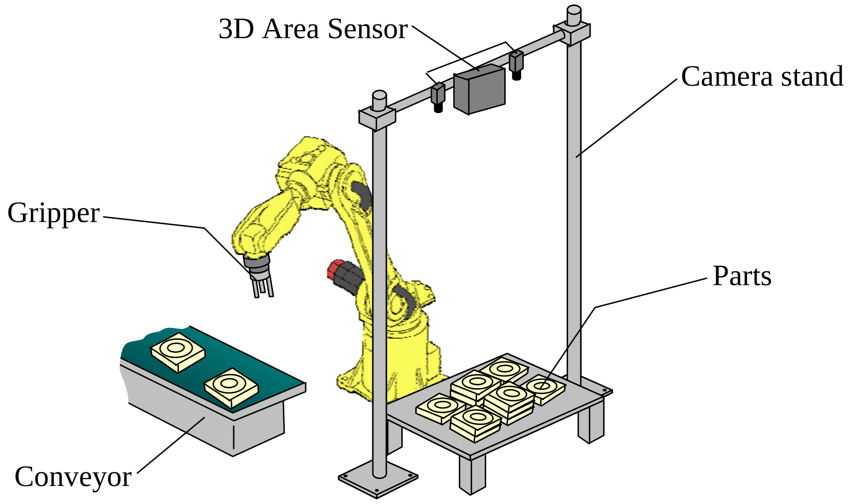
- By using a 3D Laser Vision Sensor, the 3D position and posture of a part can be measured, so that the part can be picked in such a way that the orientation of the part is matched with the direction of the gripper.
- For this reason, the gripper for use with a bin picking system with 3D Laser Vision Sensor need not be provided with compliance and a part present input, which are necessary for a bin picking system with 2D camera.
- SEARCH measures the apparent size as viewed from the camera, and from the measured size, the height of the part (Z coordinate value) is estimated. For the size to be measured accurately, a stable lighting environment is important.
- To perform fine measurement with the 3D Laser Vision Sensor, the robot must be temporarily stopped to position the 3D Laser sensor above the part detected with SEARCH. This causes the cycle time to be longer than in a bin picking system with 2D camera by about one to two seconds.
- The Interference Avoidance function is used because it is necessary to avoid the interference between the gripper and the container.
- The Parts List Manager function is used to manage part data, thereby preventing the process of attempting to pick a part again that can be detected with SEARCH and fine measurement but is in a position where it cannot be picked.

For how to set up a bin picking system with 3D Laser Vision Sensor, see Section 4.3, "BIN PICKING SYSTEM WITH 3D LASER VISION SENSOR".

3.4 FIXED FRAME OFFSET SYTEM WITH 3D AREA SENSOR

Configuration

This fixed frame offset system has a configuration such as that shown in the figure below.



Features

- The Interference Avoidance function is not used because in general, parts are lined up, and the robot will not tilt the gripper greatly during the part picking process of the robot and because the area that the robot picks up parts is free from any objects such as a container and a camera stand that would interfere with the gripper. Also, because it is a simple fixed frame offset system, the Parts List Manager function is not used, either.
- The 3D Area Sensor provides a function for measuring the 3D position and posture of a part by using a 3D point near the part that is detected with a detection tool such as pattern match, or a function for detecting a mass of local peaks and 3D point groups higher than surrounding points on a 3D map acquired without using a detection tool such as pattern match. For details, see Chapter 7, "3D AREA SENSOR REFERENCE".
- In some cases a part can be picked in such a way that the direction of the gripper is matched with the orientation of the part by using the Area Sensor Plane Tool with a GPM locator. (This depends on the shape and characteristics of the part, so it is recommended to study the applicability.)
- In some cases it is possible to achieve bin picking that does not require re-teaching in the event of a product type change that will change the size and shape of the part, by using the Area Sensor Blob Locator Tool, or Area Sensor Peak Locator Tool (This depends on the shape and characteristics of the part, so it is recommended to study the applicability.)
- The 3D Area Sensor may be affected by environmental light such as ceiling lighting. If the environmental light is too strong in relation to the intensity of the light emitted from the projector unit to the part, the acquisition of a 3D map will be unstable, and the number of 3D points that can be acquired will be reduced.

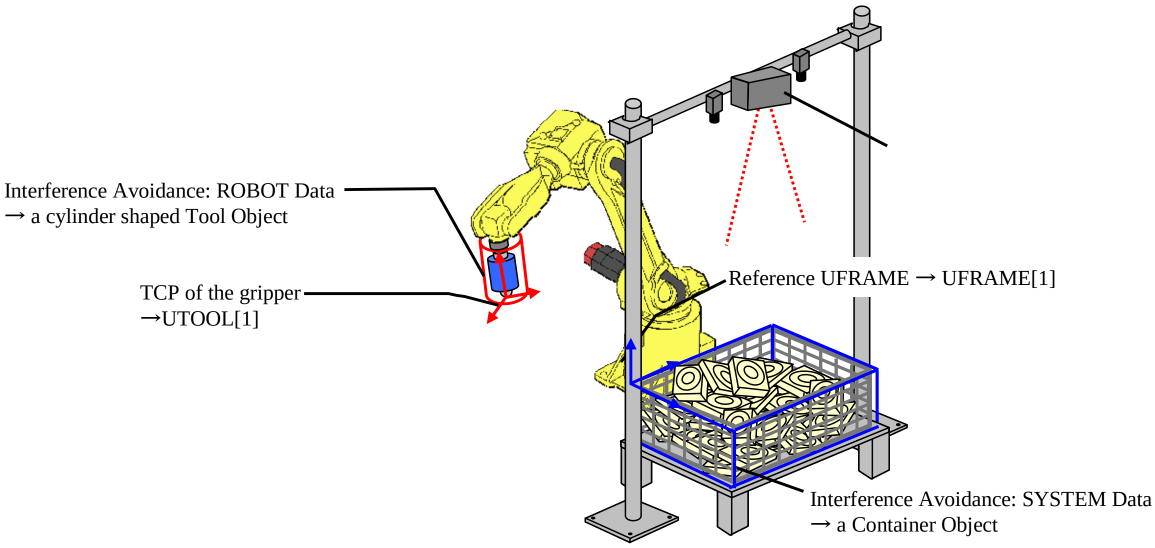
For how to set up a fixed frame offset system with 3D Area Sensor, see Section 4.4, "FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR".

4 BASIC SETUP PROCEDURES

This chapter describes some basic setup procedures of Bin Picking described in previous chapter.

4.1 BIN PICKING SYSTEM WITH 3D AREA SENSOR

Described below is the procedure of setting up a bin picking system with 3D Area Sensor.



> ⚠ **CAUTION**
> The position of the container is fixed and the container is not moved.

The setup procedures are as follows.

4.1.1 Installation and Connection of 3D Area Sensor

Installation of the 3D Area Sensor

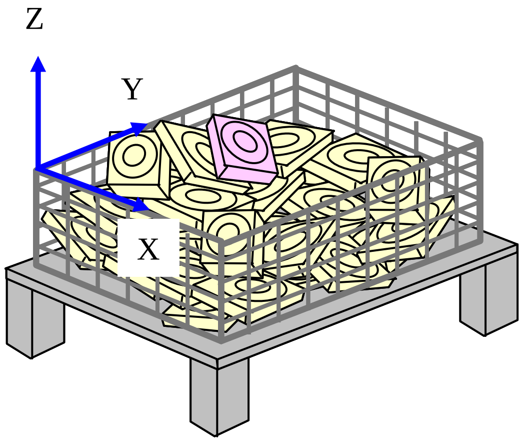
Install the 3D Area Sensor on the camera mount. See Chapter 7, "3D AREA SENSOR REFERENCE" to refer the layout of the 3D Area Sensor.

Connecting the 3D Area Sensor

Connect the 3D Area Sensor to a robot controller. For details, refer to Section 2.6 of the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL".

4.1.2 User Frame Setup

Set the user frame which is the reference frame of an offset data calculation or interference avoidance calculation. Set it on the upper opening of the container as shown below. For setup procedures of user frame, refer to Chapter 5 "FRAME SETUP REFERENCE".



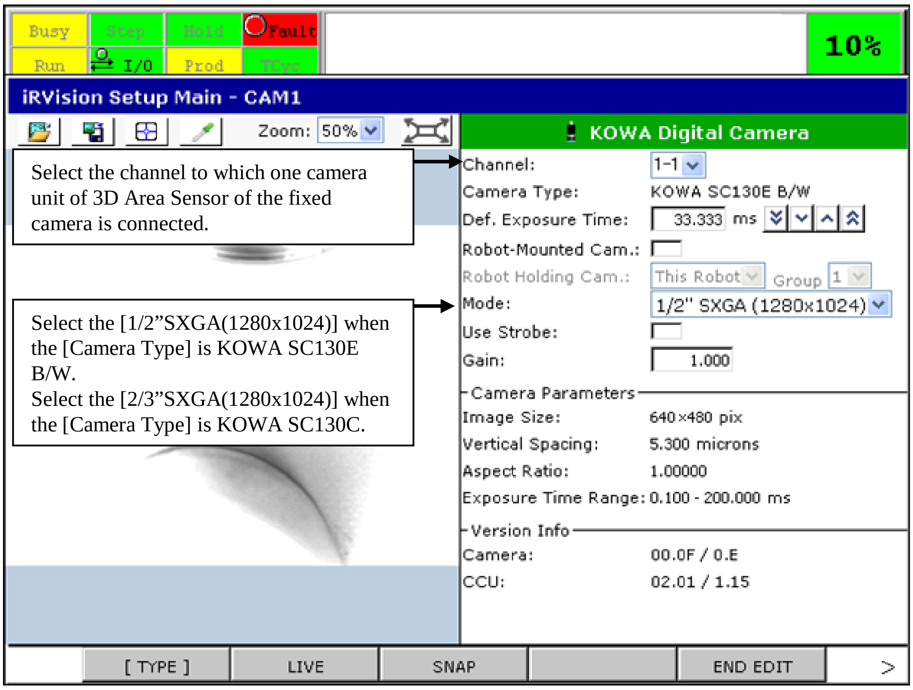
Here, set the user frame to UFRAME[1] as described in Section 4.1, "BIN PICKING SYSTEM WITH 3D AREA SENSOR".

4.1.3 3D Area Sensor Setup

Setup the 3D Area Sensor in the following procedures.

Creating two Camera Data

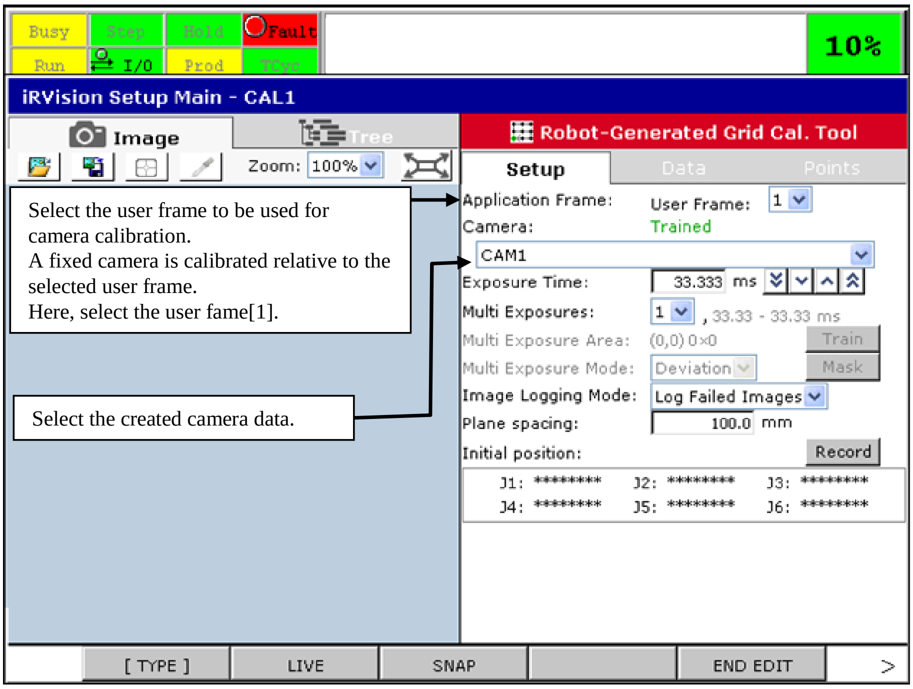
Create a KOWA Digital Camera data, and set the following parameters.



For the other camera of the 3D Area Sensor, do the above same procedures.

Creating two Calibration Data

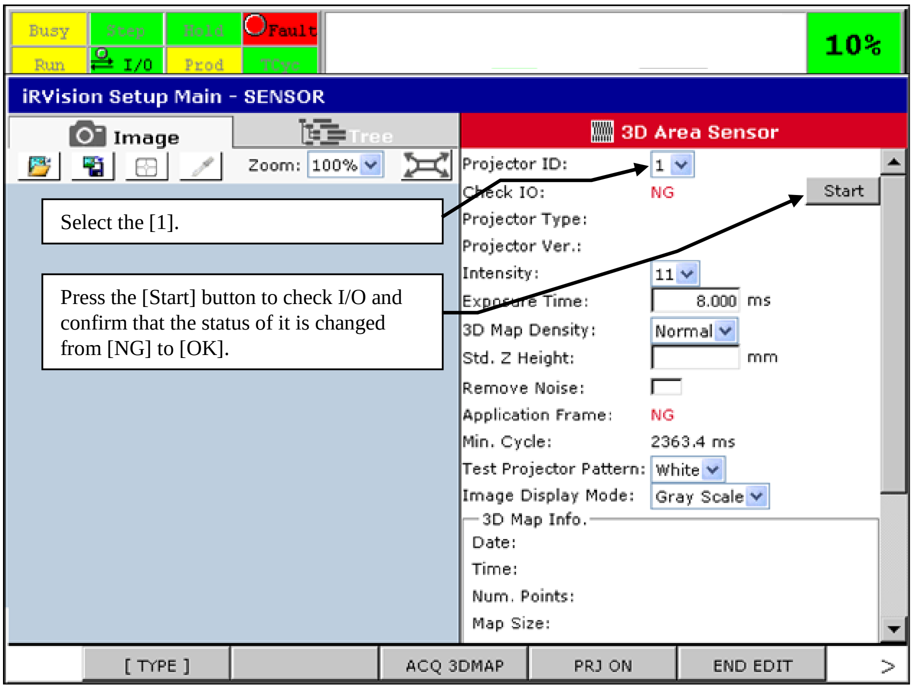
Create a Robot-Generated Grid Calibration data, and set the following parameters.

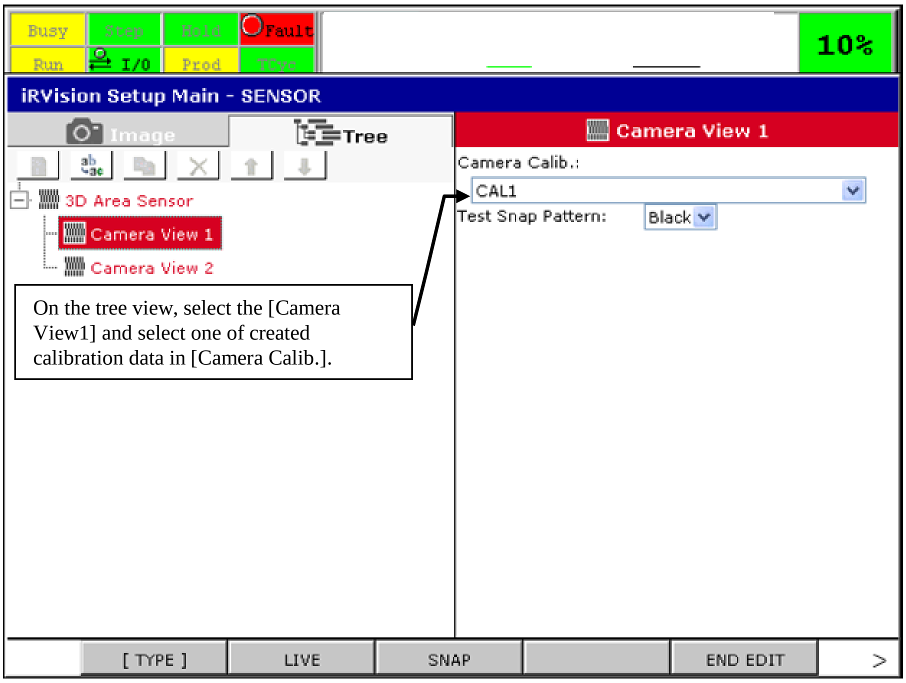


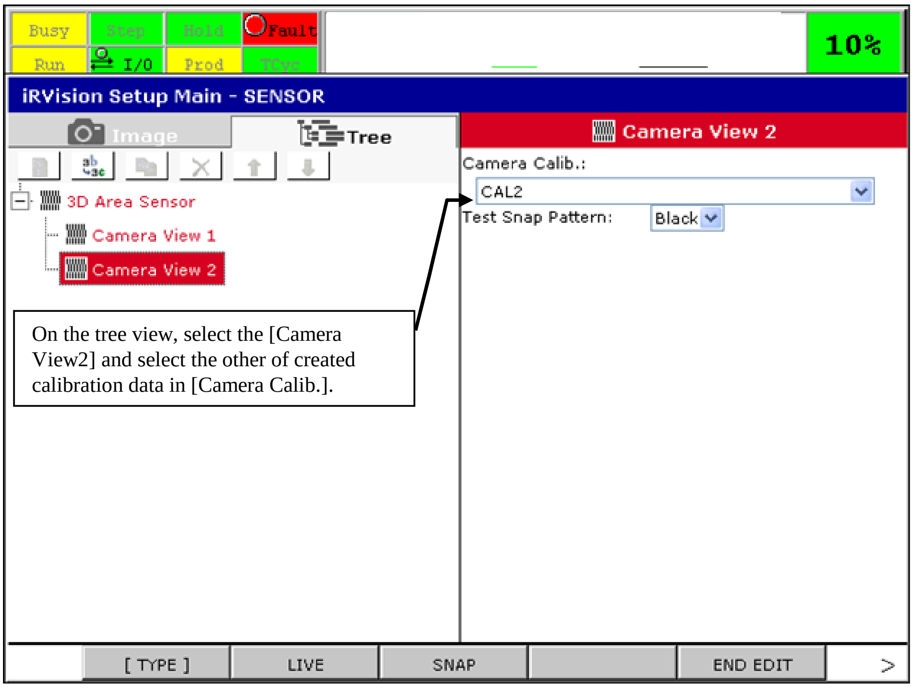
For the other camera of the 3D Area Sensor, do the above same procedures.

Creating a 3D Area Sensor Data

Create a 3D Area Sensor data, and set the following parameters.







Adjusting the Layout of the 3D Area Senor

Adjust the layout of the 3D Area Sensor. For detail, refer to Subsection 7.4.1 "Adjusting the Layout of 3D Area Sensor".

Adjusting the focus of the Projector Unit of the 3D Area Senor

Adjust the focus of the projector unit of the 3D Area Sensor. For detail, refer to Subsection 7.4.2 "Adjusting the Focus of the Projector Unit".

Adjusting the focus of the Camera Units of the 3D Area Senor

Adjust the focus of the camera units of the 3D Area Sensor. For detail, refer to Subsection 7.4.3 "Adjusting the Focus of the Camera Units".

Calibrating the Camera Units

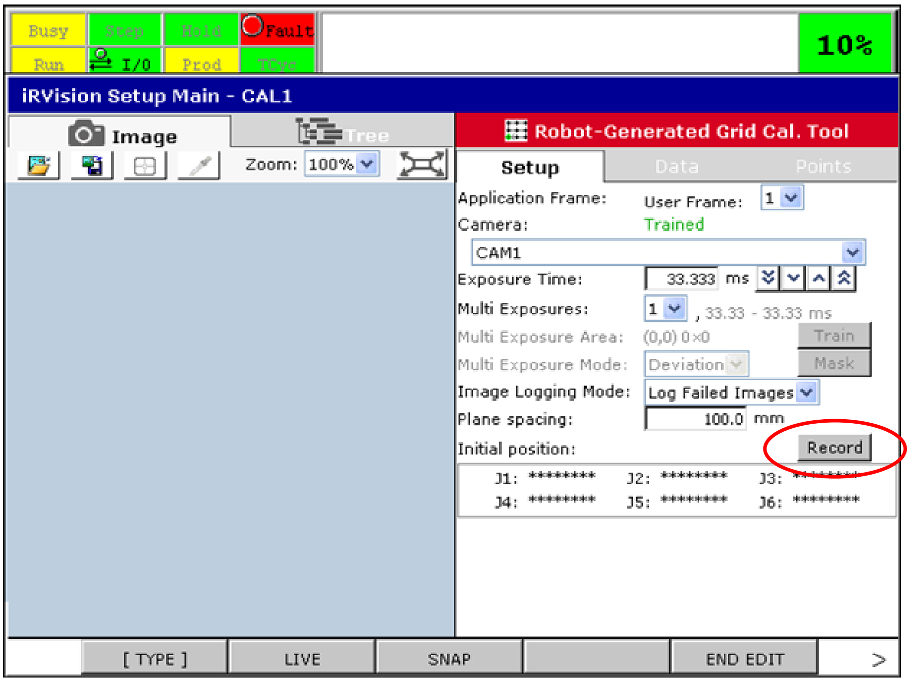
Calibrate the two camera units of the 3D Area Sensor in the following procedures. For detail of each procedure, refer to Section 6.1 "Robot-Generated Grid Calibration".

Mounting a Target

The function moves the target, mounted on the robot end of arm tooling, in the camera's field of view to generate a virtual grid pattern for camera calibration. Mount the target at the robot end of arm tooling. Make sure that the target does not get blocked by the robot arm or the tooling while the robot moves in the camera's field of view.

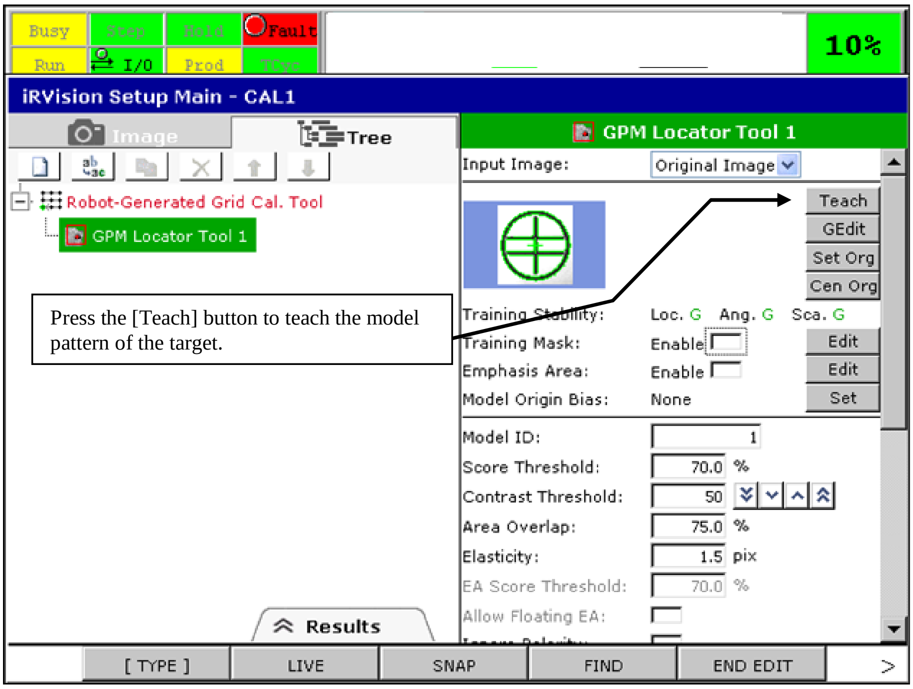
Teaching the Initial Position

Open one of calibration data. In the [Initial Position], set the current robot position as the starting position to measure the target position. The starting positions should be set as the robot gripper is about the center of FOV.



Teaching the GPM Locator Tool

With the target located at the starting position set in the [Initial Position], select the [GPM Locator Tool1] on the tree view and teach the model pattern of the target.

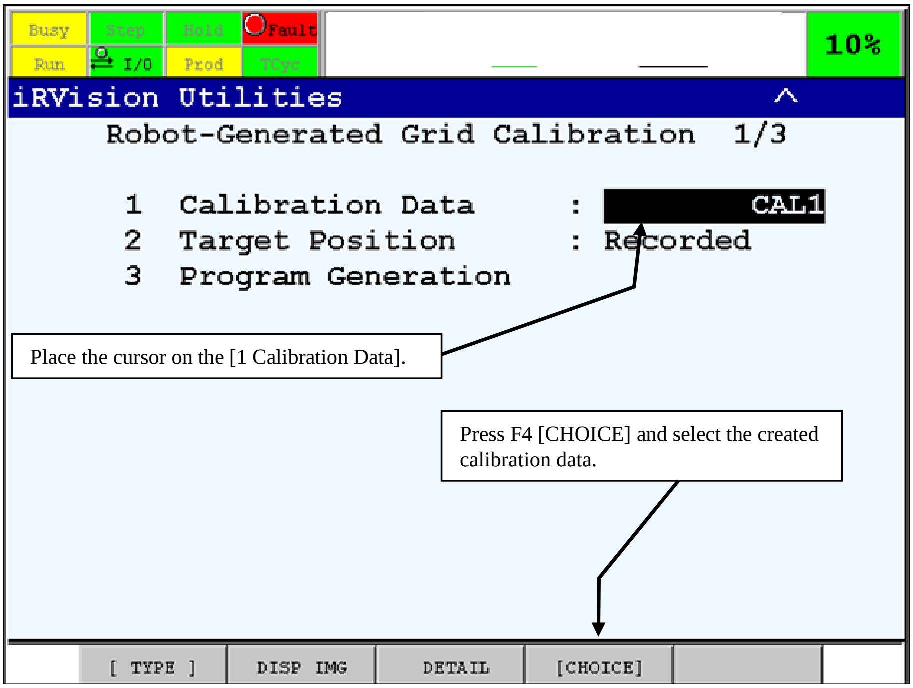


> ⚠ **CAUTION**
> After setting the calibration data, press F5 END EDIT to close the setup page. If the calibration setup page is opened, the Robot-Generated Grid Calibration fails to measure the target position.

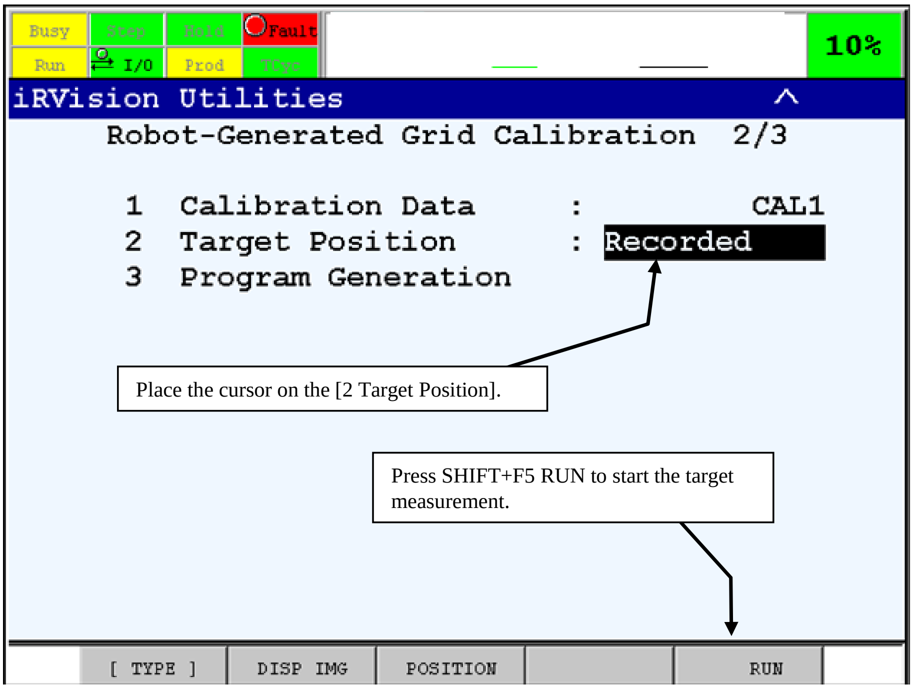
Measuring the Target Position

Visit the [Robot-Generated Grid Calibration] in the *i*RVision > Vision Utility Menu.

Select the calibration data in the following procedures.

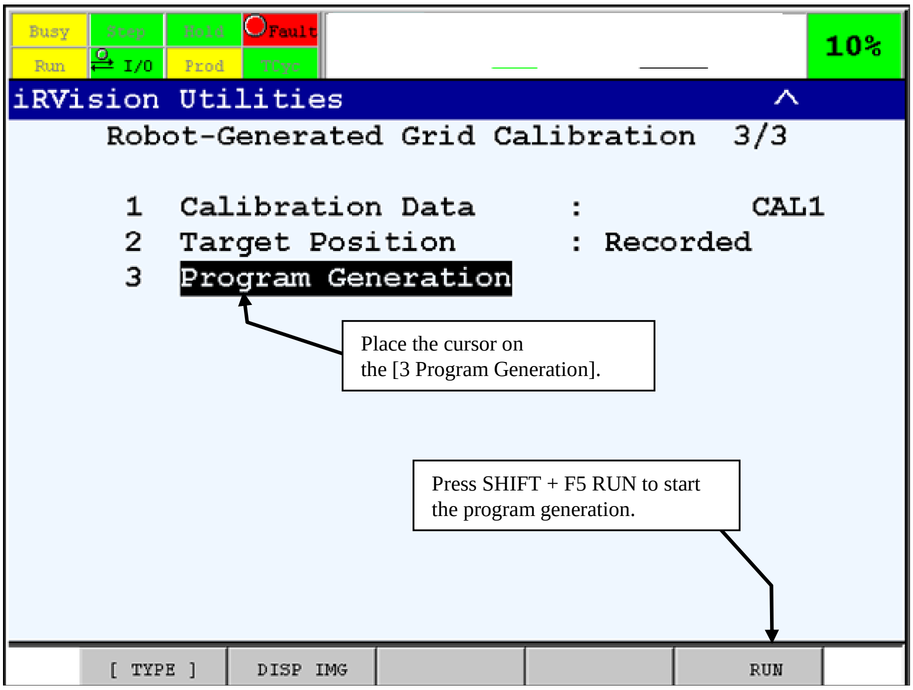


Measure the target position in the following procedures.



Generating a Calibration Program

Generate a calibration program in the following procedures.

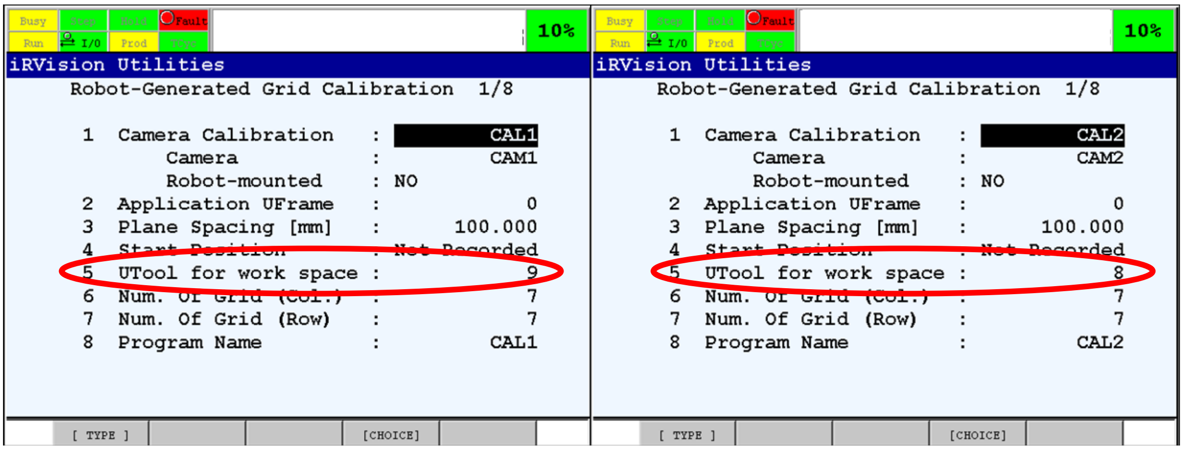


Executing the Calibration Program

Select the generated calibration program in the SELECT menu, and play it back from first line to calibrate camera.

Do the same procedure on the other calibration data. Then calibration of two camera unit is completed.

If the installation of the target has reproducibility, set the set different tool frame index for each calibration data as follows. As long as the position where the target is mounted remains unchanged, you can re-calibrate the camera by executing the generated calibration program.

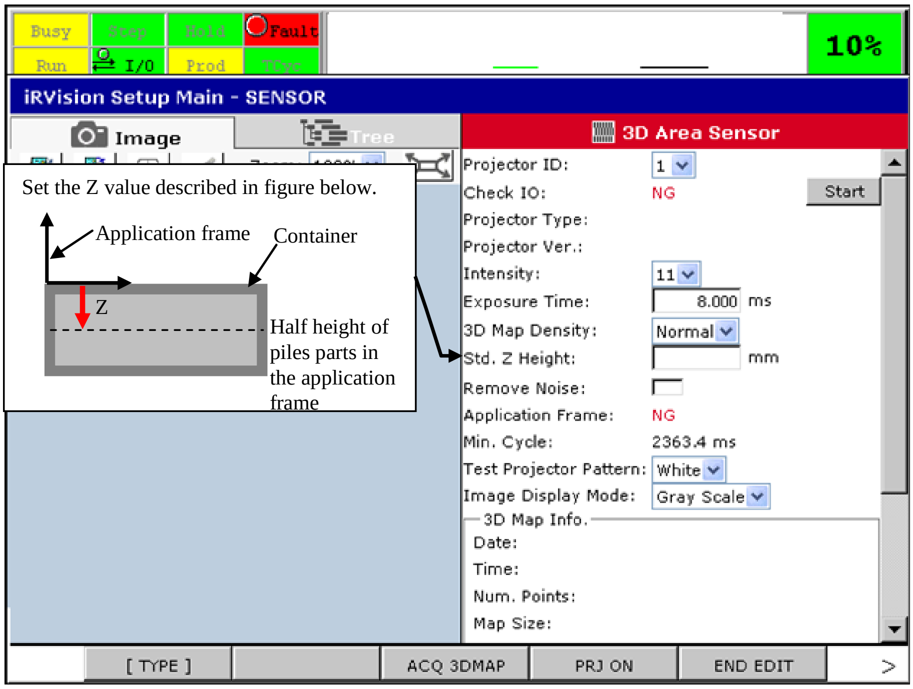


Checking the Calibration Data

Check that the calibration result is correct. To check the calibration data, refer to Subsection 6.1.6 "Camera Calibration Data Checking".

Teaching of condition of acquiring 3D Map

Open the 3D Area Sensor data and set the following parameter.



Confirm that a 3D map is acquired correctly by pressing F3 ACQ 3DMAP. If there is an area that 3D points are not acquired, adjust the [Exposure Time] and the [Intensity] by referring to Subsection 7.4.4 "Adjusting the Condition of Acquiring 3D Map".

4.1.4 Tool Frame Setup

TCP of the Gripper

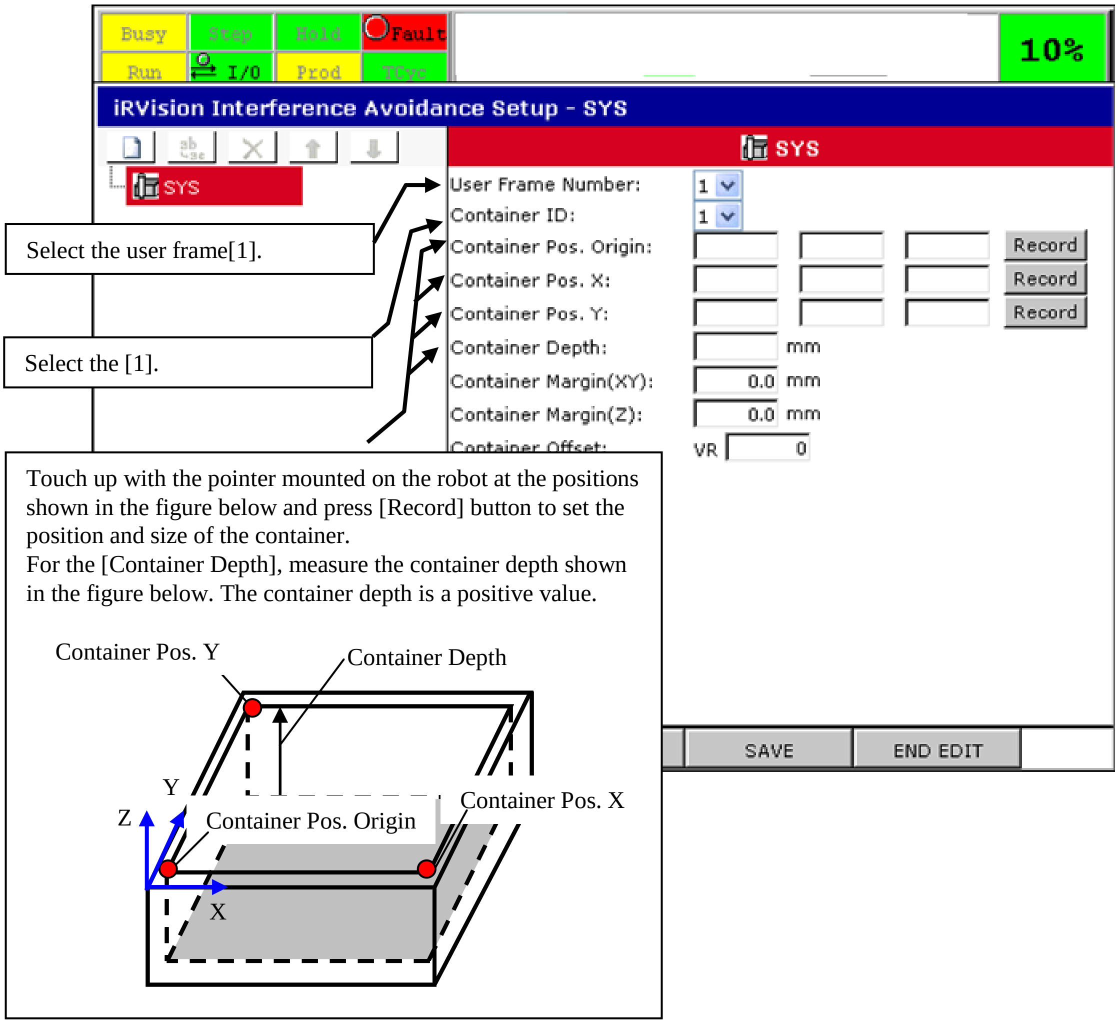
Set the tool frame on the TCP of the end of robot gripper. This frame is useful for ensuring that the TCP of the gripper is moved to the part pick position when fixed frame offset or interference avoidance is applied to the part pick position. The Z-axis of this frame should be set along the direction in which the robot proceeds and retreats as it picks up a part. For setup procedures of tool frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".

Here, set the tool frame to UTOOL [1] as described in Section 4.1, "BIN PICKING SYSTEM WITH 3D AREA SENSOR".

4.1.5 Setup of Interference Setup Data

Creating an Interference Setup (System) and Setting the Parameters

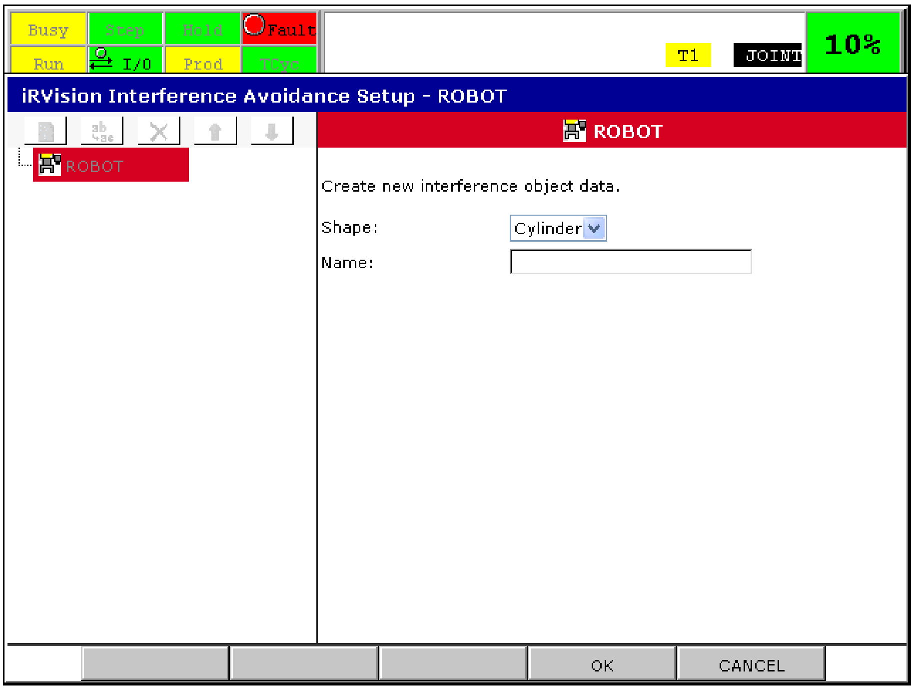
On the interference avoidance data setup screen, create an interference setup (system) for interference avoidance, and set the user frame and the container object to form the basis for interference avoidance position calculation in the following procedures.



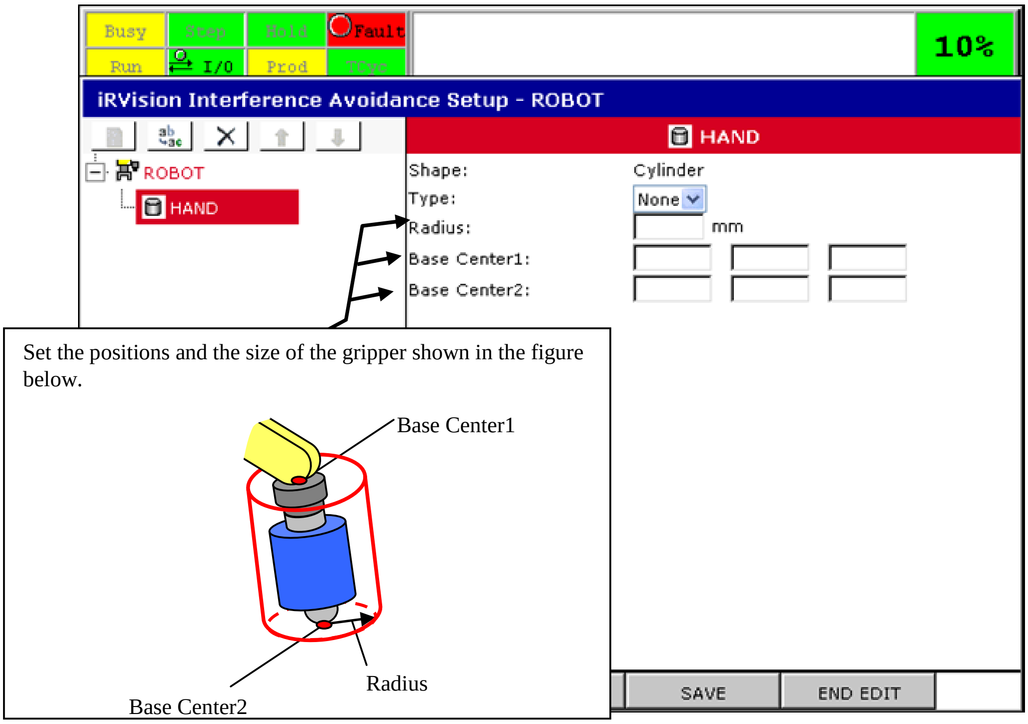
Creating the Interference Setup (Robot) and Setting the Parameters

On the interference avoidance data setup screen, create an interference setup (robot) for interference avoidance, and set a tool object.

In the tree view on the interference setup (robot) screen, press the button. On the new tool object creation screen, which appears, select [Cylinder] for [Shape] and [Hand] for [Name], and press F4 OK.

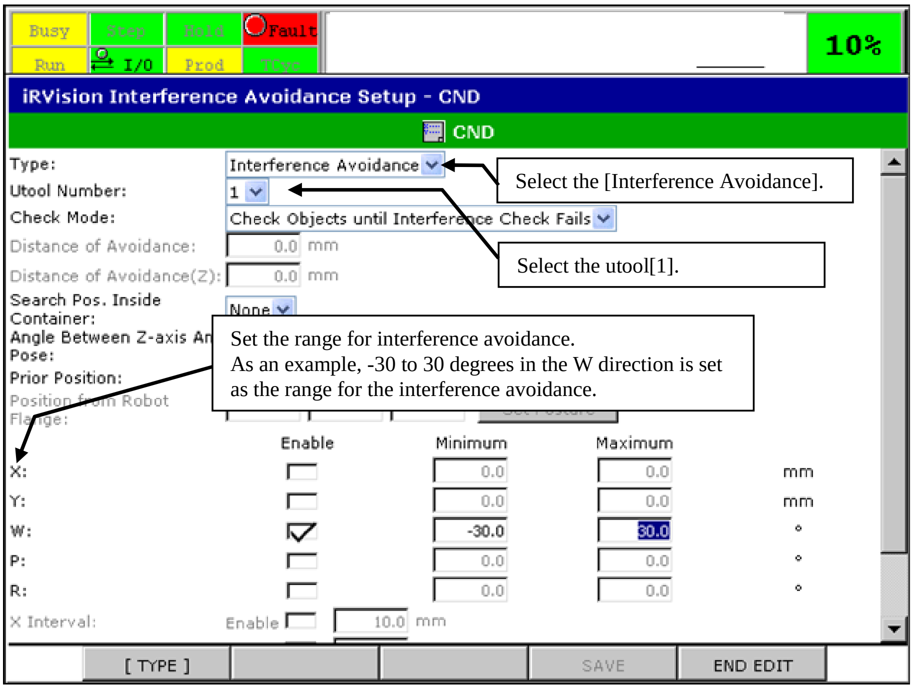


Set the created tool object in the following procedures.



Creating an Interference Setup (Condition) and Setting the Parameters

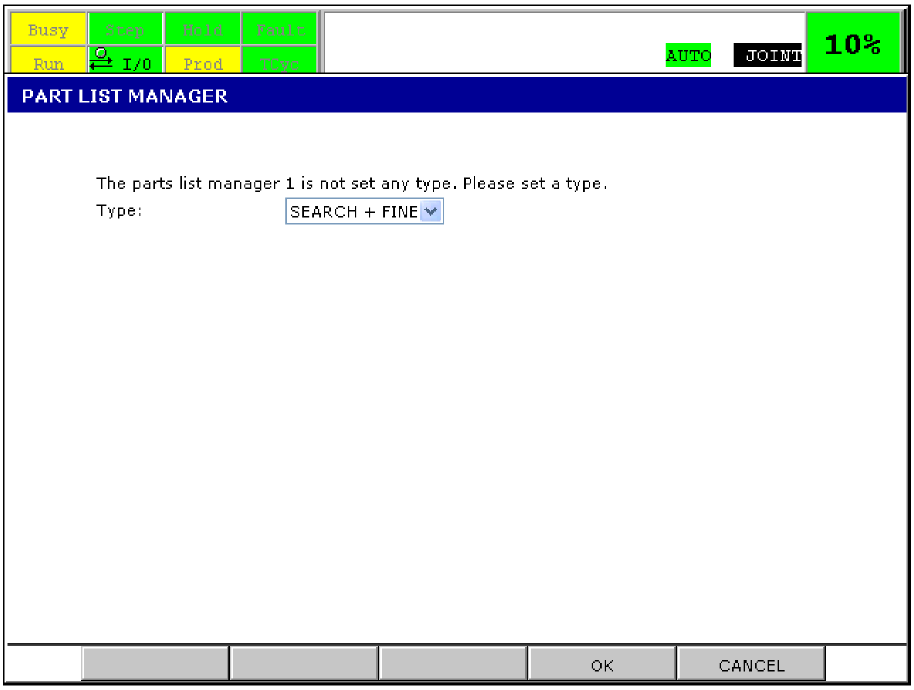
On the interference avoidance data setup screen, create an interference setup (condition) for interference avoidance and set it. Create interference setup (condition) used during part picking, and set the following parameters.



4.1.6 Setup of Parts List Manager

Setting the type of the Parts List Manager

In the data list screen of the Parts List Manager, select the Parts List Manager [1] and press F3 EDIT. If the type of the Parts List Manager [1] is not set, the following screen is displayed.



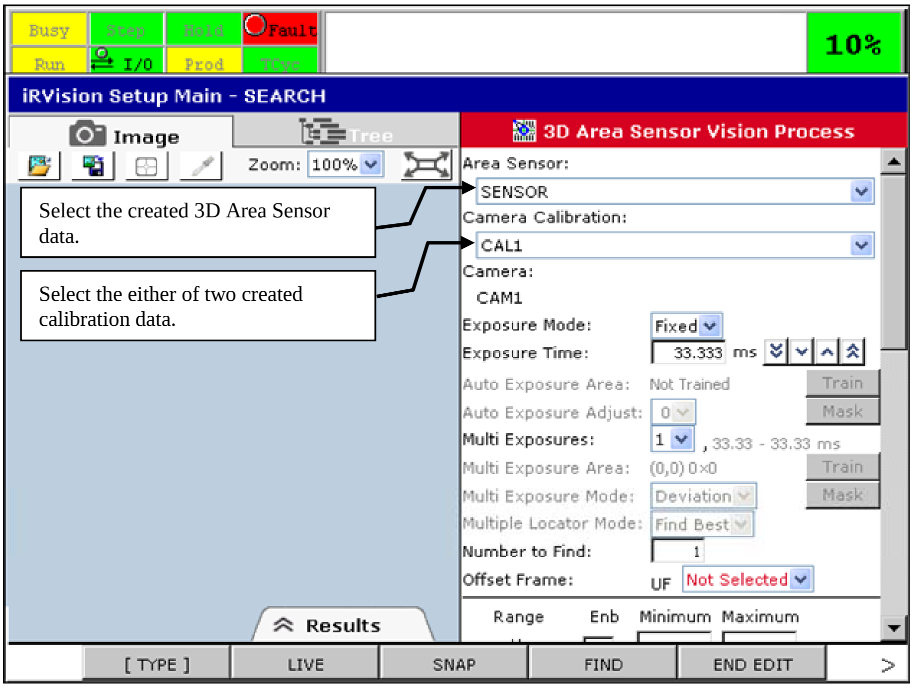
In the [Type], select the [SEARCH] and press F4 OK.

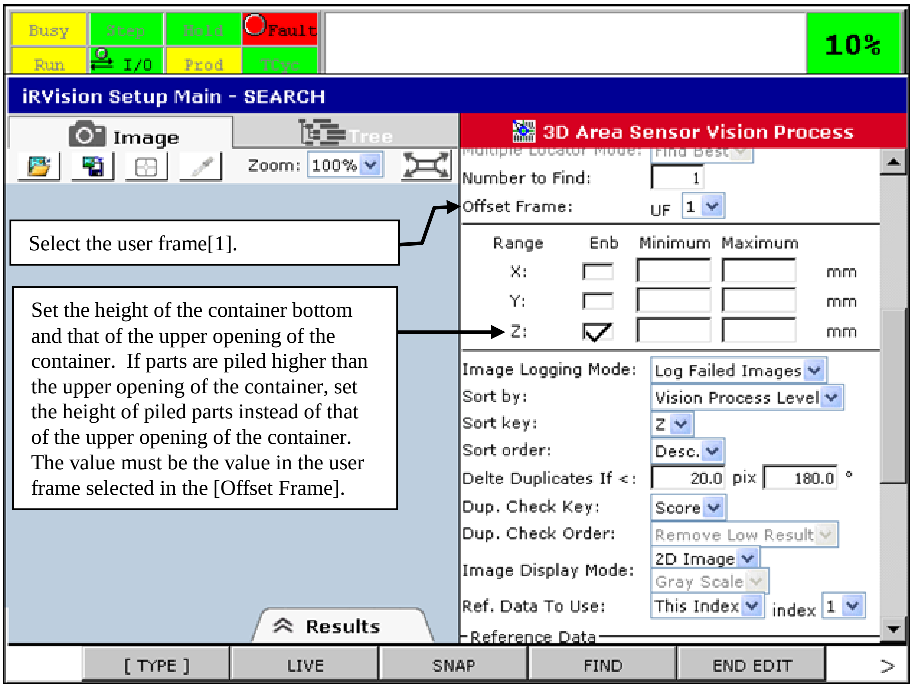
If the type of the Parts List Manager [1] is [SEARCH+FINE], change the type of the Parts List Manager [1] to [SEARCH]. For details of the operation procedures about the Parts List Manager, refer to Section 9.1 "BASIC OPERATIONS OF PARTS LIST MANAGER".

4.1.7 SEARCH Vision Process Setup

Creating a Vision Process and Setting the Parameters

Create a 3D Area Sensor Vision Process, and set the following parameters.





Teaching the Area Sensor Preprocess Tool

On the tree view of the 3D Area Sensor Vision Process, select the [Area Sensor Preprocess Tool 1] and teach it. For setup procedures of the Area Sensor Preprocess Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

Teaching the Area Sensor Peak Locator Tool

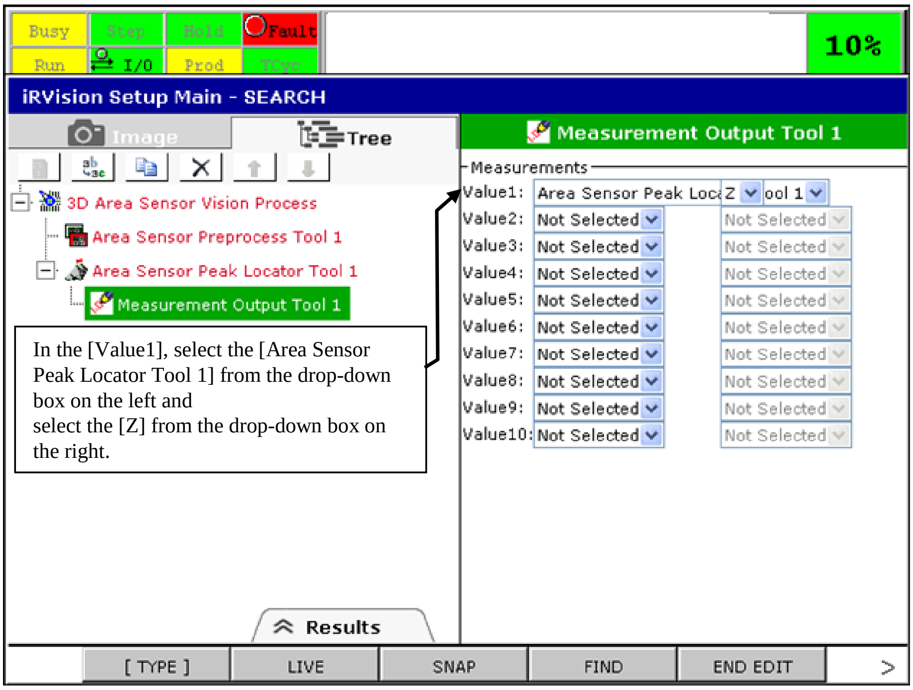
On the tree view of the 3D Area Sensor Vision Process, select the [Area Sensor Peak Locator Tool 1] and teach it. For setup procedures of the Area Sensor Peak Locator Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

Creating the Measurement Output Tool and Setting the Parameters

Create a Measurement Output Tool as a child tool of the Area Sensor Peak Locator Tool in the following procedures.

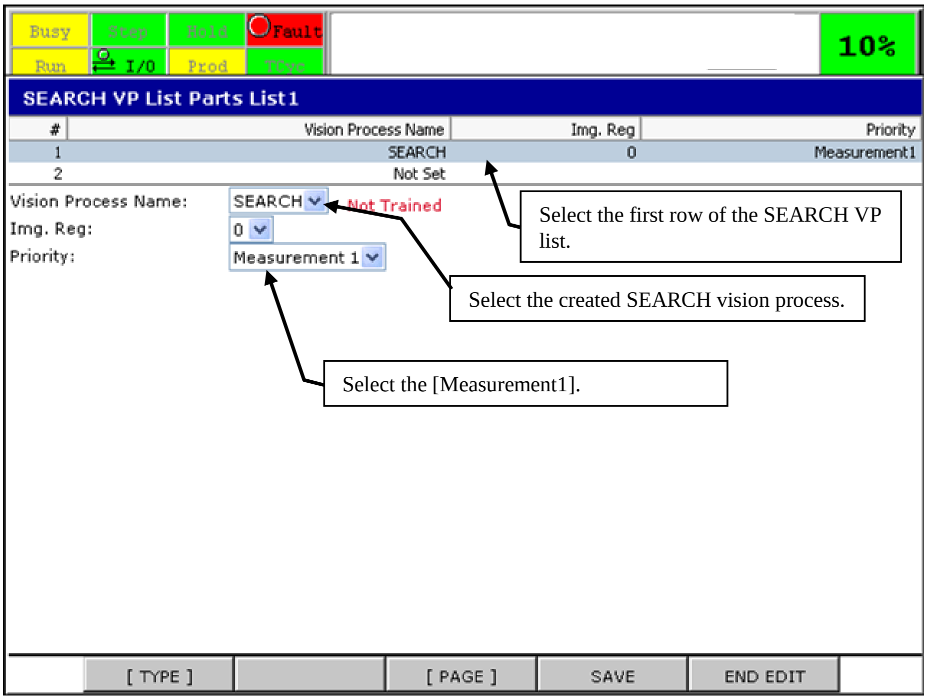
1 On the tree view of the 3D Area Sensor Vision Process, select the [Area Sensor Peak Locator Tool1].
2 Press the button to create a new vision tool.
3 On the setup screen to create a new vision tool, select the [Measurement Output Tool] for the [Type].
4 Press F4 OK.

On the [Measurement Output Too1] setup screen, set the following parameters. For setup procedures of the Measurement Output Tool, refer to Chapter 7 in the R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



Setting the SEARCH VP List

Set the created SEARCH vision process to a SEARCH VP list in the Parts List Manager. On the SEARCH VP List setup screen of the Parts List Manager of Part List[1], set the following parameters.

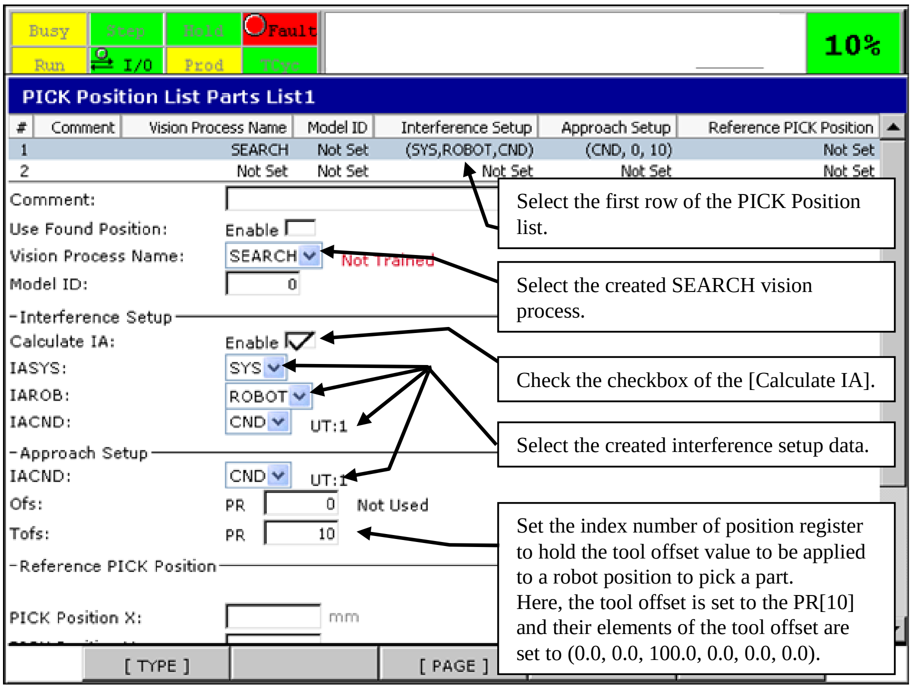


4.1.8 Reference PICK Position Setup

On the PICK Position List of the Parts List Manager of Part List[1], teach the reference position to pick the part. In this document, one reference position to pick a part is referred to as "reference PICK position".

Setting Parameters

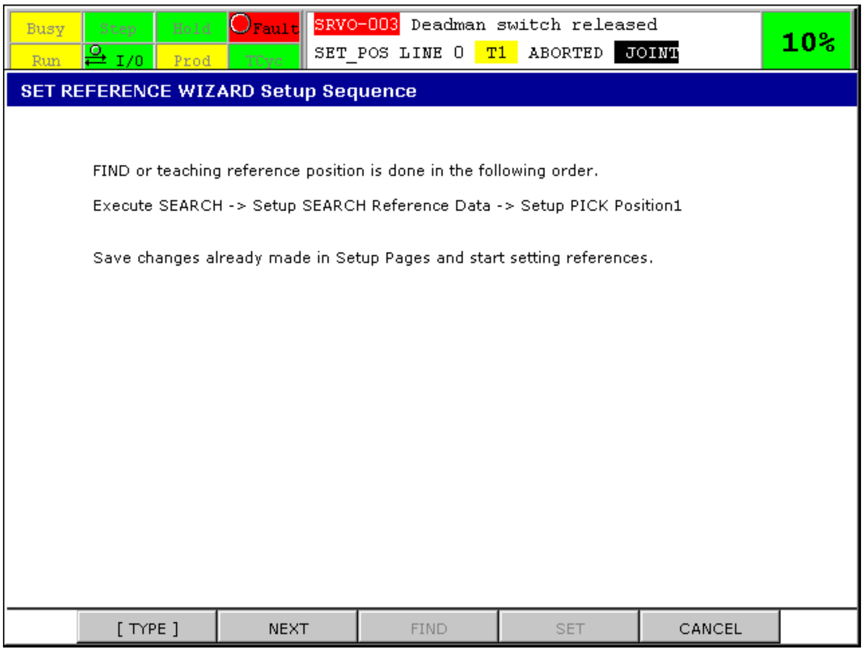
On the PICK Position List setup screen of the Part List Manager of Part List[1], set the following parameters.



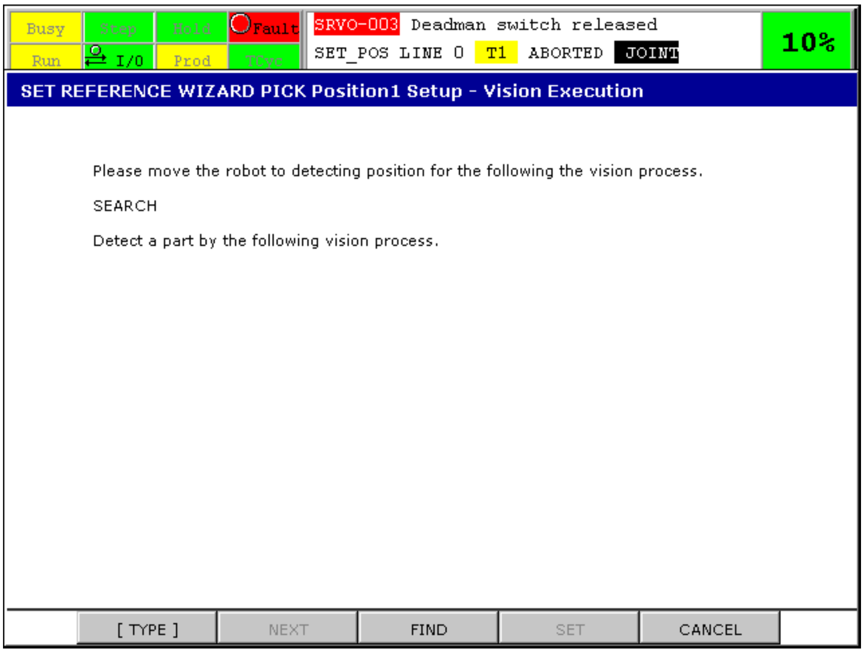
Teaching the Reference PICK position and Setting the Reference Data of the SEARCH VISON PROCESS

Teach the reference PICK position and Set the reference data of the SEARCH Vision Process by pressing the [Start Set Reference Wizard] button.

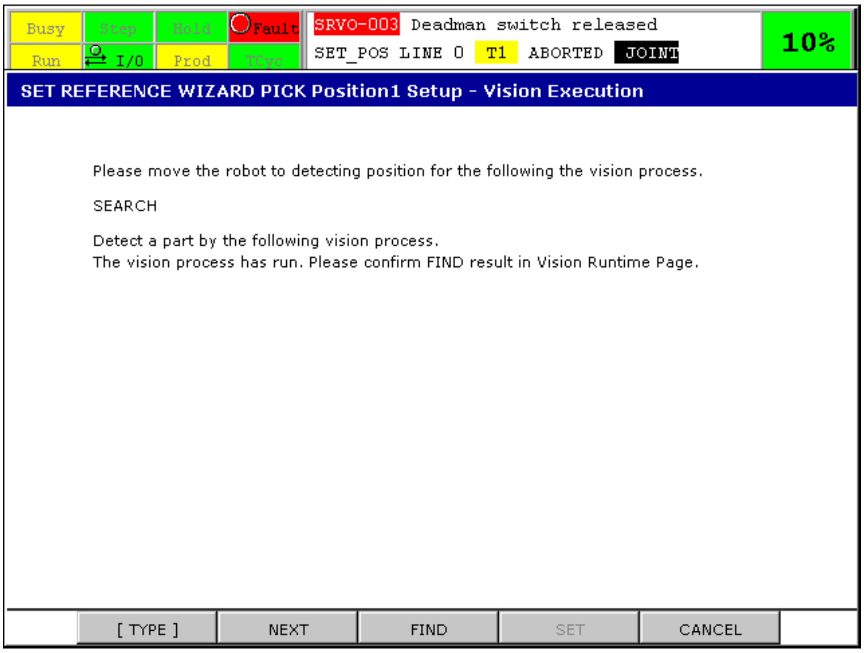
The following screen is displayed by pressing the [Start Set Reference Wizard]button. Then, press F2 NEXT to start the Set Reference Wizard after confirming the setup procedures.



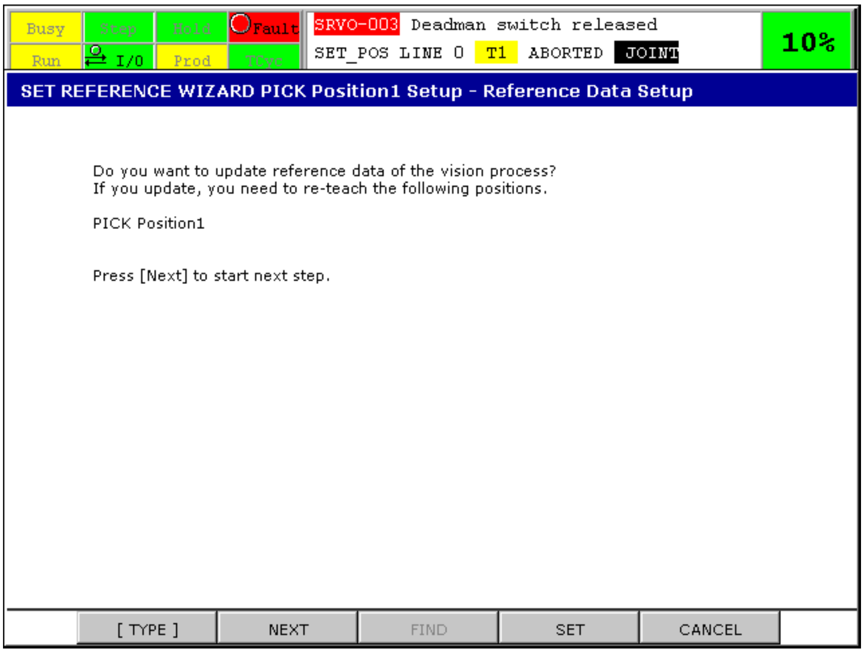
Then, the following screen to execute a vision process is displayed. Press F3 FIND after moving the robot outside of the container.



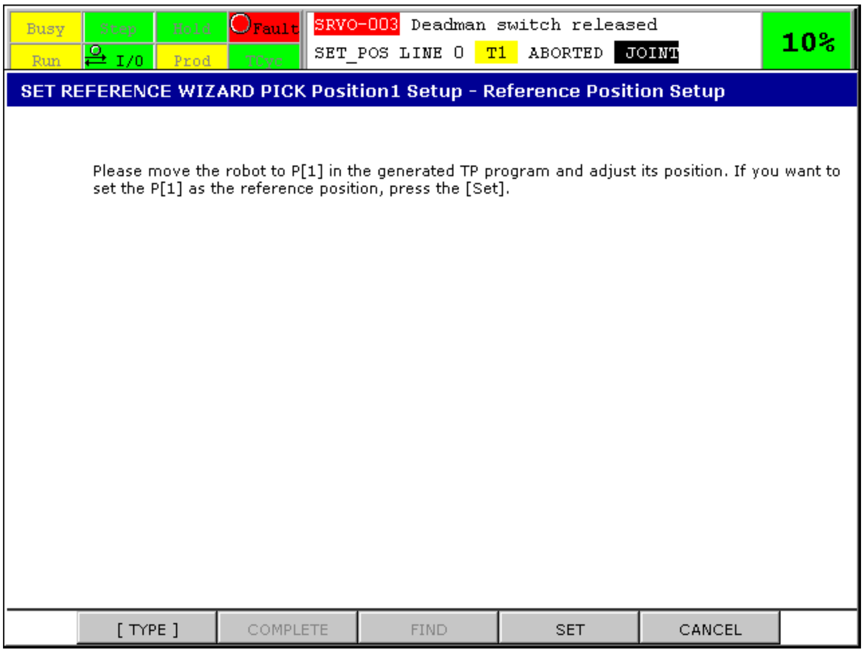
Then, the message "The vision process has run. Please confirm FIND result in Vision Runtime Page" is displayed as follows. Press F2 NEXT after confirming that the vision process finds part correctly.



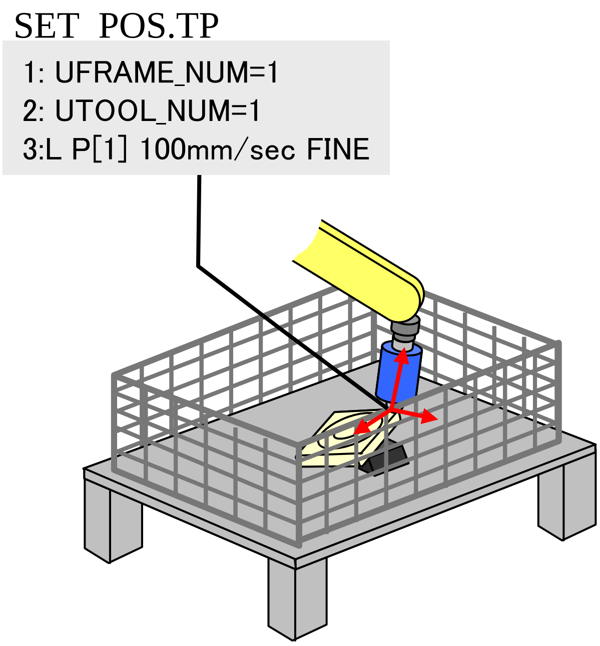
Then, the following screen to set the reference data of the Vision Process is displayed. Press F2 Next after pressing F4 SET to set the reference data of it.



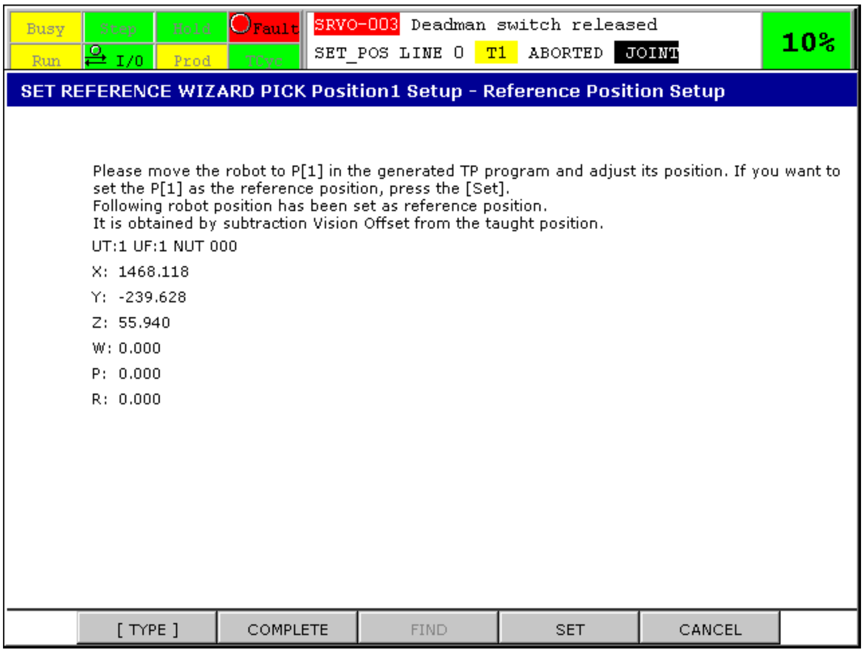
The following screen to set the reference PICK position is displayed.



And then, the following TP program, which is "SET_POS.TP", is automatically generated. Move the robot to the P[1] in the SET_POS.TP by executing the TP Program. The P[1] is automatically set to the found position of the vision process. Confirm that the found position is on a point of a part by moving the robot to the P[1].



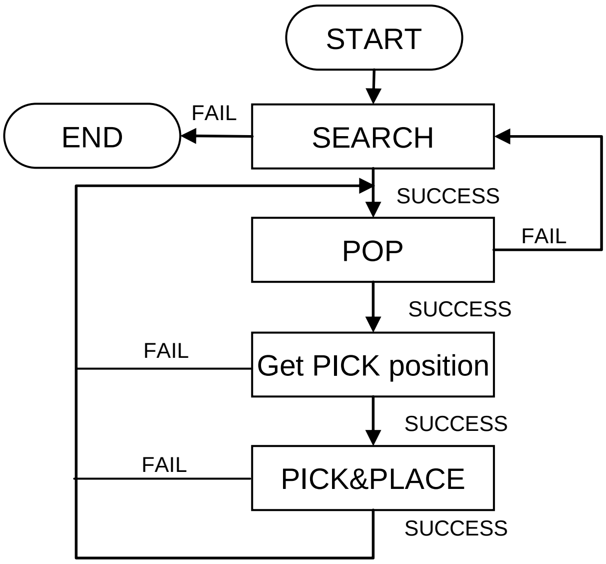
Press F4 SET to set the reference PICK position after confirming that the P[1] is an appropriate position to pick a part. If the P[1] is set to inappropriate position to pick a part, adjust the P[1] by moving the robot. The set reference PICK position is displayed as follows.



Press F2 COMPLETE after confirming that the set reference PICK position is correct.

4.1.9 Creating TP Program

Create a TP program for the Bin picking system with 3D Area Sensor. The flow chart of the TP program is as follows.



Then, the following TP programs use the following the registers, position registers, vision registers and tool frame and user frame.

Table of Registers

R[10]	The status of the SEARCH Vision process 0: SUCCESS (Some new part data are added to a Parts List) 1: FAIL (No Part Data is added to a Parts List)
R[11]	The status of POP 0: SUCCESS 1: FAIL (Any Part Data is not popped from a Parts List)
R[12]	The Model ID of the popped Part Data

R[14]	The status of the process to get a PICK position 0: SUCCESS 12: Failed to get a PICK position 13: Failed to get a position to approach a part (approach position)

Table of Position Register

PR[20]	Result of interference avoidance for part pick position (avoidance position)
PR[21]	Result of interference avoidance for the part pick position (tool offset value)
PR[22]	Result of interference avoidance for the approach position (avoidance position)

Table of Tool frame

UTOOL[1]	The TCP of the gripper

Table of User frame

UFRAME[1]	Application frame

BIN_PICKING.TP

The following TP program is a sample program for the Bin Picking System with 3D Area Sensor. For description of the macro programs such as BINPICK_CLEAR, refer to Chapter 9, "PARTS LIST MANAGER REFERENCE".

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  CALL BINPICK_CLEAR (1)
 4:
 5:  ! SEARCH
 6:  LBL[1]
 7:L P[1] 2000mm/sec FINE
 8:  CALL BINPICK_ACQUIRE3DMAP('SENSOR')
 9:  CALL BINPICK_SEARCH(1,1,10)
10:  IF R[10]<>0,JMP LBL[999]
11:
12:  ! POP
13:  LBL[2]
14:  CALL BINPICK_POP(1,11,12)
15:  IF R[11]<>0,JMP LBL[1]
16:
17:  ! Get PICK position
18:  CALL BINPICK_GETPICKPOS(1,1,14,20,21,22)
19:  IF R[14]=0,JMP LBL[3]
20:
21:  CALL BINPICK_SETSTAT(1,22)
22:  JMP LBL[2]
23:
24:  ! PICK
25:  LBL[3]
26:L P[2] 2000mm/sec CNT100
27:L PR[22] 2000mm/sec CNT50
28:L PR[20] 500mm/sec FINE
29:  ! Insert program instructions to grasp the part.
30:  CALL BINPICK_SETSTAT(1,20)
31:
32:  ! PLACE
33:L P[3] 2000mm/sec CNT100
34:L P[4] 2000mm/sec FINE
35:  ! Insert program instructions to place the part.
36:
37:  ! Continuous
38:  JMP LBL[2]
39:
40:  ! END
41:  LBL[999]
42:J P[5] 100% FINE
```

Specify the user frame set in Subsection 4.1.2, "User Frame Setup" (line 1)

Acquire 3D map. (line 8)

Execute a SEARCH vision process to find some parts. (line 9)

If any part can not be found, terminate the process. (line 10)

If any part data can not be popped from the parts list, go to the process to execute the SEARCH vision process. (line 15)

If the calculation of a position to pick up a part fails, go to the process to pop next part data. (line 21)

Execute the process to pick up a part. (line 29)

Execute a process to place a part. (line 35)

After placing a part, go to the process to pop next part data. (line 38)

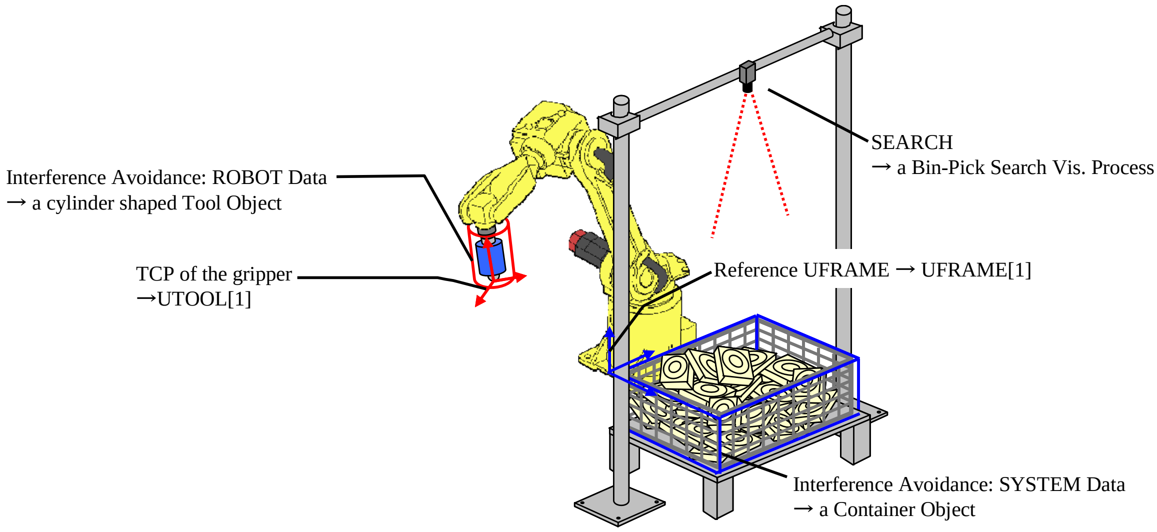
4.1.10 Robot Compensation Operation Check

Check that a part gripped by the robot can be detected and positioned precisely at a desired location.

- Place the part on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting.
- Move the part without rotation, find it and check the handling accuracy.
- Rotate the part, find it and check the handling accuracy.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

4.2 BIN PICKING SYSTEM WITH 2D CAMERA

Described below is the procedure of setting up a bin picking system with 2D camera.



> ⚠ **CAUTION**
> The position of the container is fixed and the container is not moved.

The setup procedures are as follows.

4.2.1 Fixed Camera Installation and Connection

Checking the Camera Setting

Change the setting on the back of camera to match *i*RVision. For details, refer to Chapter 6 in the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL".

Installing the Camera

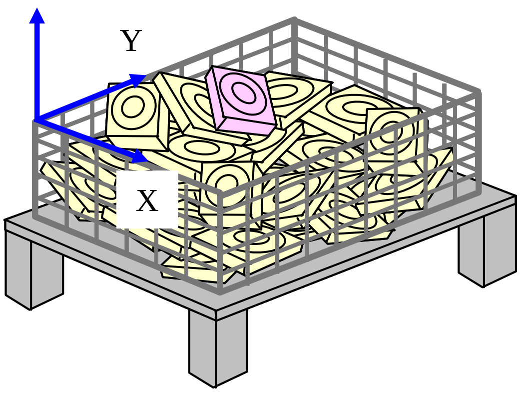
Attach the lens to the camera then install the camera over the container of parts. Install the camera so that the field of view of the camera includes the whole container.

Connecting the Camera

Connect the camera to the robot controller. For details, refer to the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL".

4.2.2 User Frame Setup

Set the user frame which is the reference frame of an offset data calculation or interference avoidance calculation. Set it on the upper opening of the container as shown below. For setup procedures of user frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".



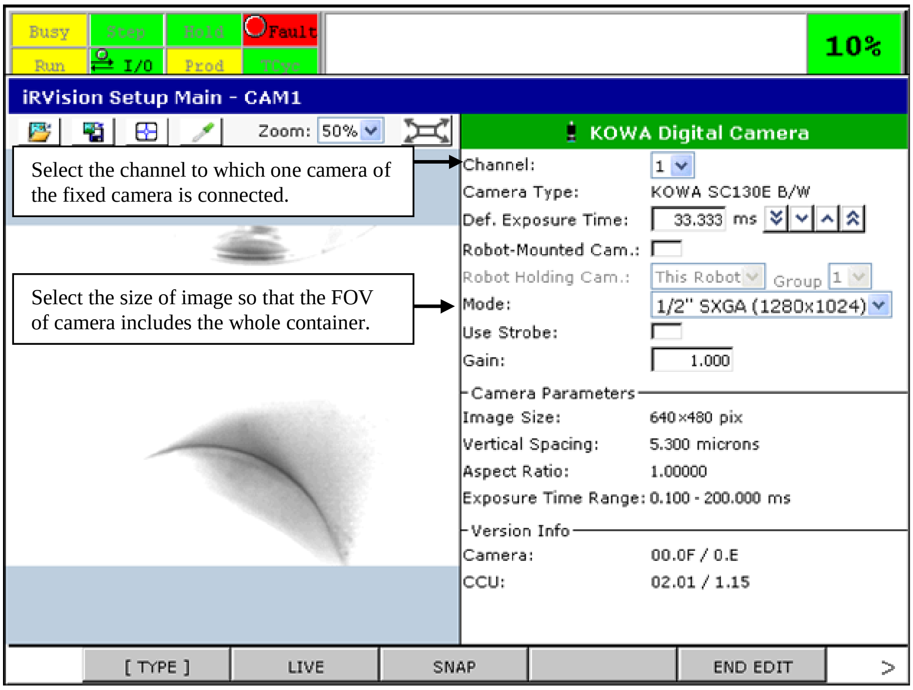
Here, set the user frame to UFRAME[1] as described in Section 4.1, "BIN PICKING SYSTEM WITH 2D CAMERA".

4.2.3 Camera Data Setup of Fixed Camera

Set the camera data of the fixed camera in the KOWA Digital Camera setup screen.

Creating a Camera Data and Setting the Parameters

Create a KOWA Digital Camera data, and set the following parameters.



4.2.4 Calibration of Fixed Camera

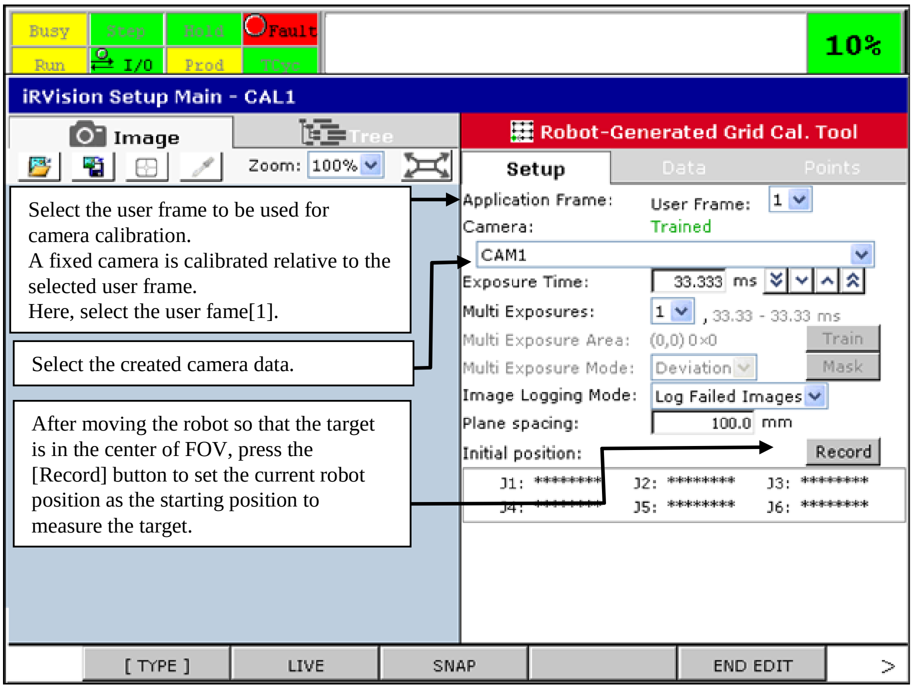
Calibrate the fixed camera with the Robot-generated grid calibration utility.

Mounting a Target

The function moves the target, mounted on the robot end of arm tooling, in the camera's field of view to generate a virtual grid pattern for camera calibration. Mount the target at the robot end of arm tooling. Make sure that the target does not get blocked by the robot arm or the tooling while the robot moves in the camera's field of view.

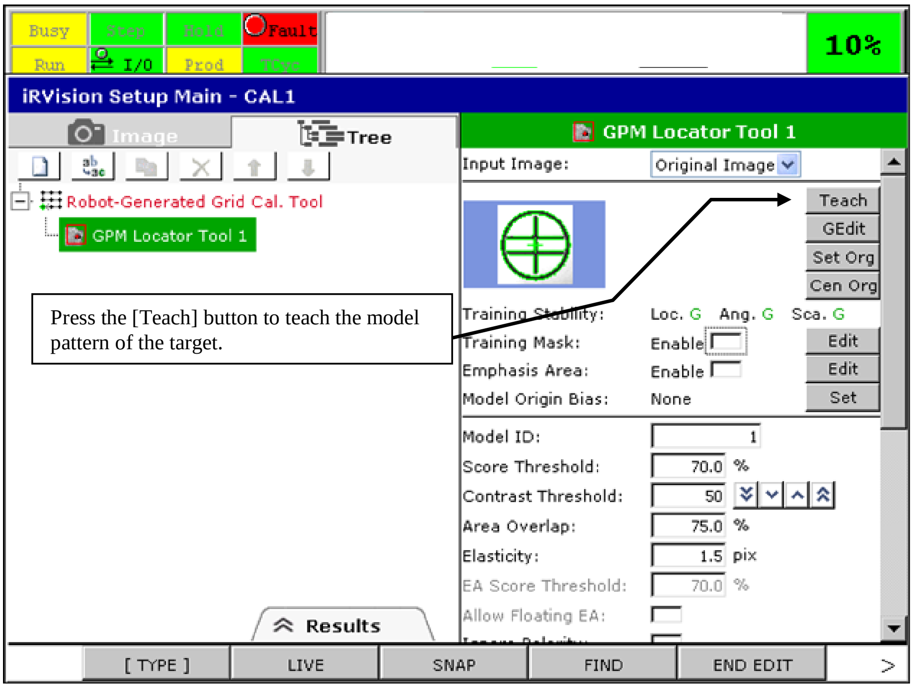
Creating a Calibration Data and Setting the Parameters

Create a Robot-Generated Grid Calibration data, and set the following parameters.



Teaching the GPM Locator Tool

With the target located at the starting position set in the [Initial Position], select the [GPM Locator Tool1] on the tree view and teach the model pattern of the target.

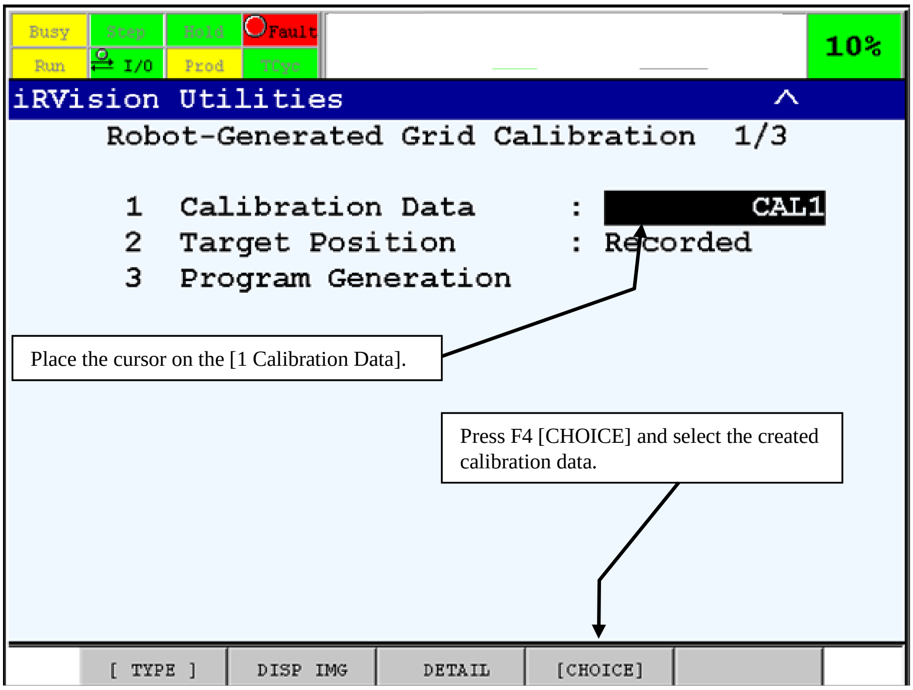


> ⚠ **CAUTION**
> After setting the calibration data, press F5 END EDIT to close the setup page. If the calibration setup page is opened, the Robot-Generated Grid Calibration fails to measure the target position.

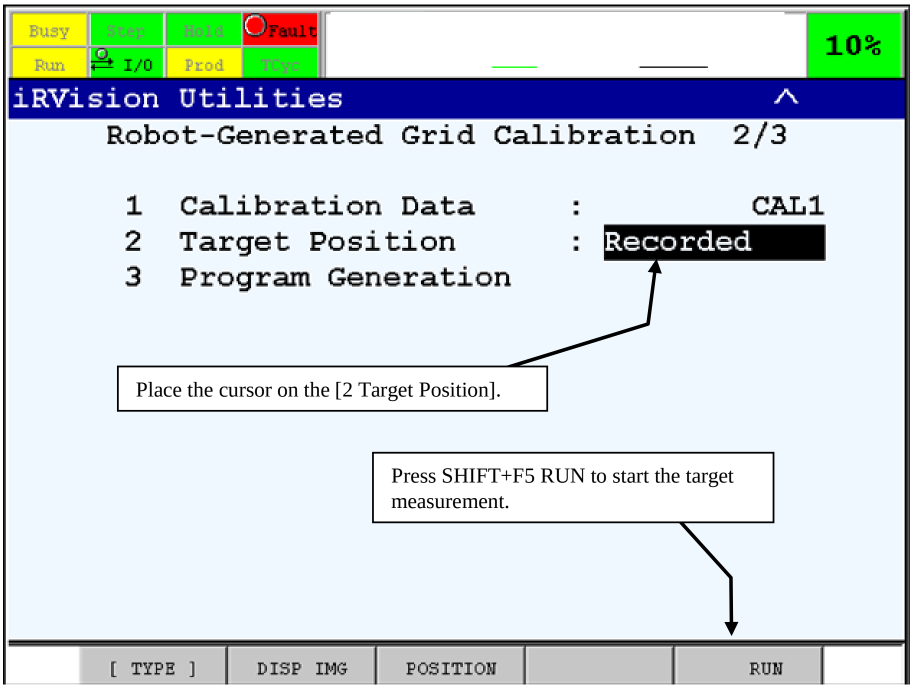
Measuring the Target Position

Visit [Robot-Generated Grid Calibration] in the *i*RVision > Vision Utility Menu.

Select the calibration data in the following procedures.

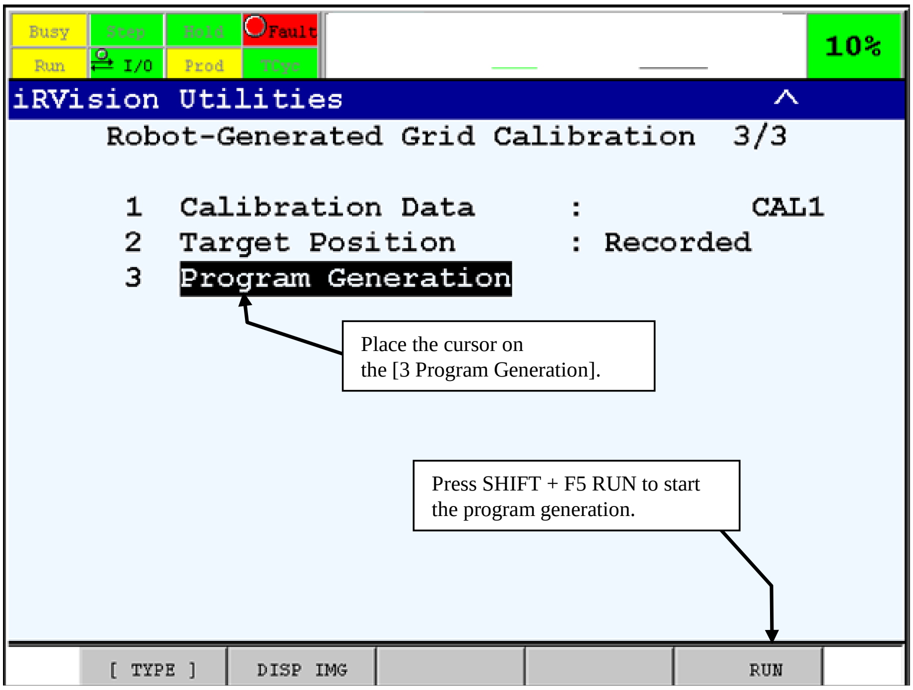


Measure the target position in the following procedures.



Generating a Calibration Program

Generate a calibration program for executing camera calibration in the following procedures.



Executing the Calibration Program

Select the generated calibration program in the SELECT menu, and play it back from first line to calibrate camera.

Checking the Calibration Data

Check that the calibration result is correct. To check the calibration data, refer to Subsection6.1.6 "Camera Calibration Checking".

4.2.5 Tool Frame Setup

TCP of the Gripper

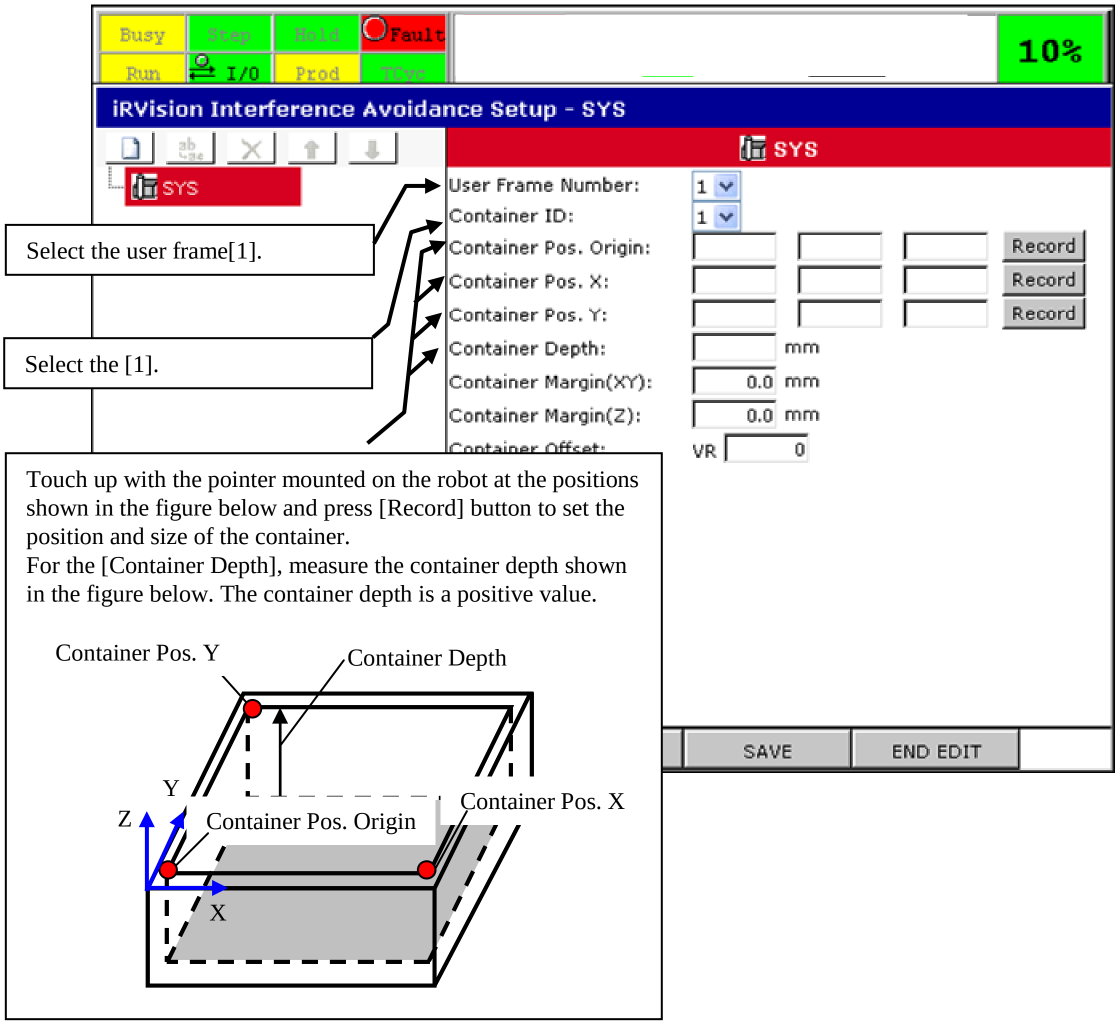
Set the tool frame on the TCP of the end of robot gripper. This frame is useful for ensuring that the TCP of the end of the gripper is moved to the part pick position when fixed frame offset or interference avoidance is applied to the part pick position. The Z-axis of this frame should be set along the direction in which the robot proceeds and retreats as it picks up a part. For setup procedures of tool frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".

Here, set the tool frame to UTOOL [1] as described in Section 4.2, "BIN PICKING SYSTEM WITH 2D CAMERA".

4.2.6 Setup of Interference Setup Data

Creating an Interference Setup (System) and Setting the Parameters

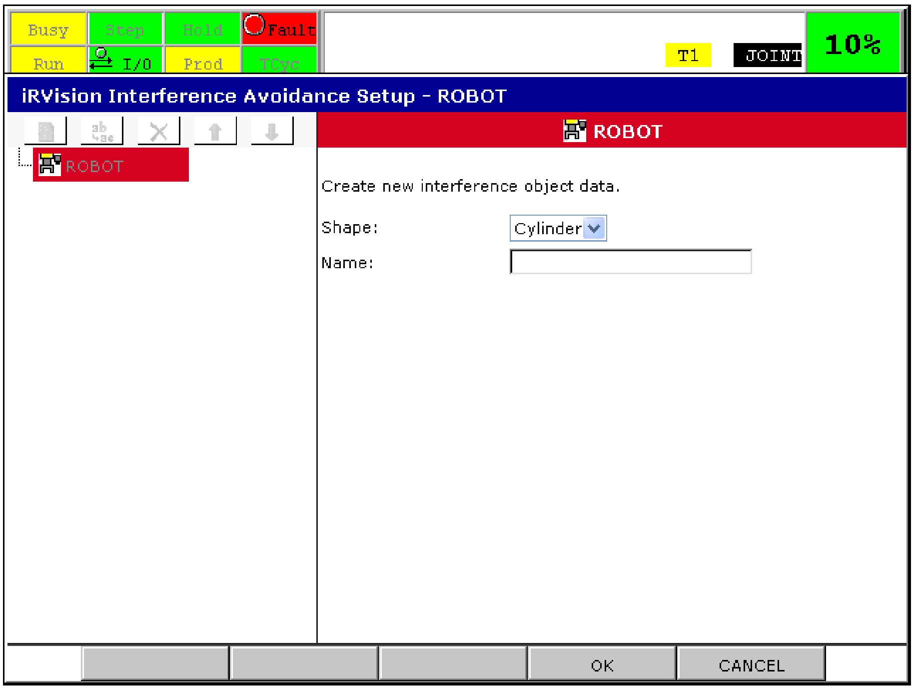
On the interference avoidance data setup screen, create an interference setup (system) for interference avoidance, and set the user frame and the container object to form the basis for interference avoidance position calculation in the following procedures.



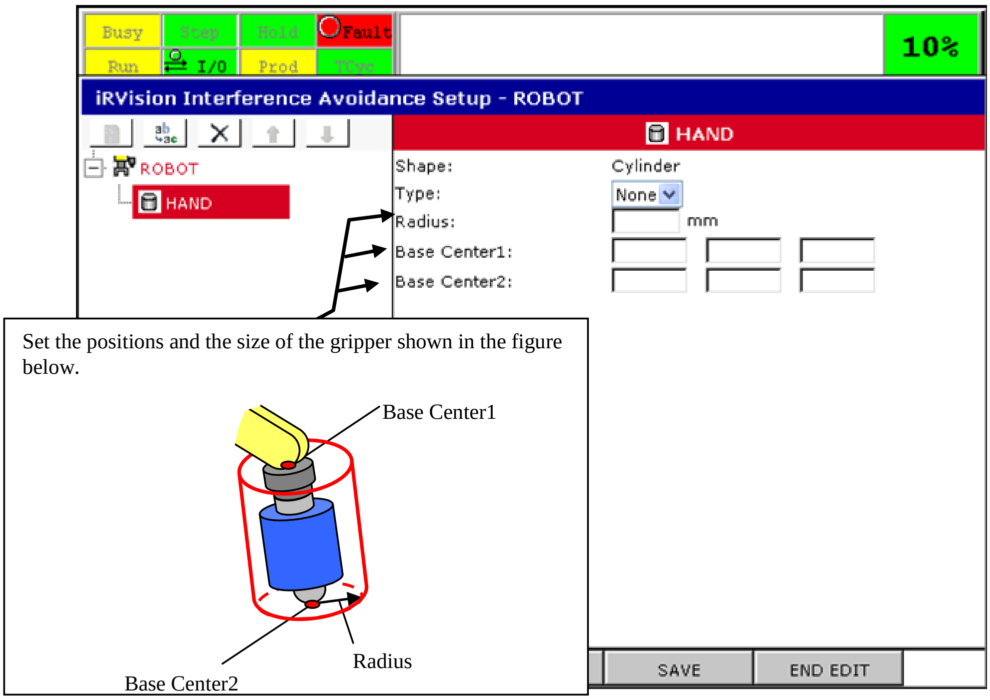
Creating an Interference Setup (Robot) and Setting the Parameters

On the interference avoidance data setup screen, create an interference setup (robot) for interference avoidance, and set a tool object.

In the tree view on the interference setup (robot) screen, press the button. On the new tool object creation screen, which appears, select [Cylinder] for [Shape] and [Hand] for [Name], and press F4 OK.

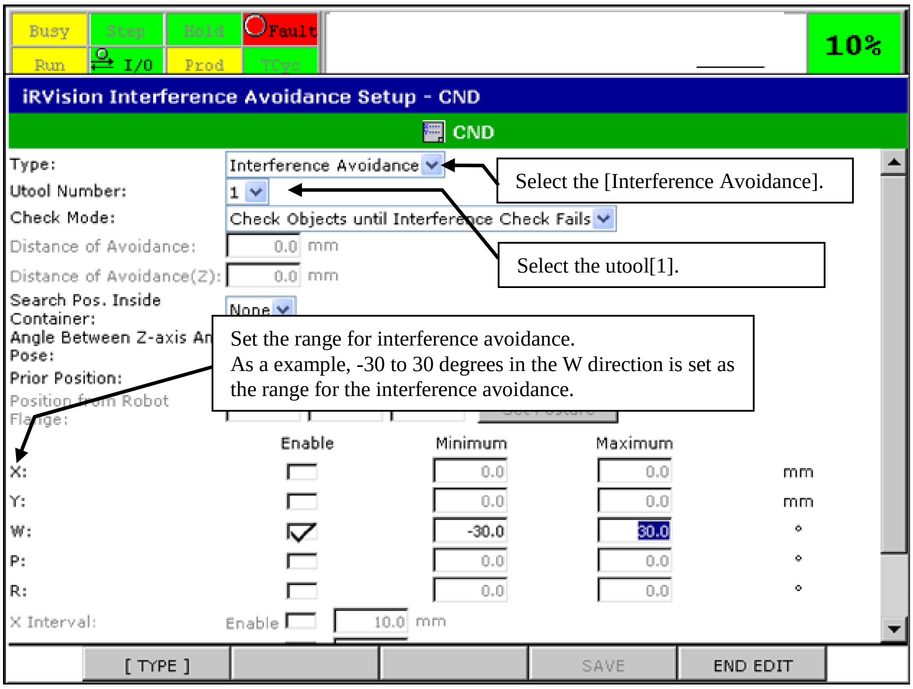


Set the created tool object in the following procedures.



Creating an Interference Setup (Condition) and Setting the Parameters

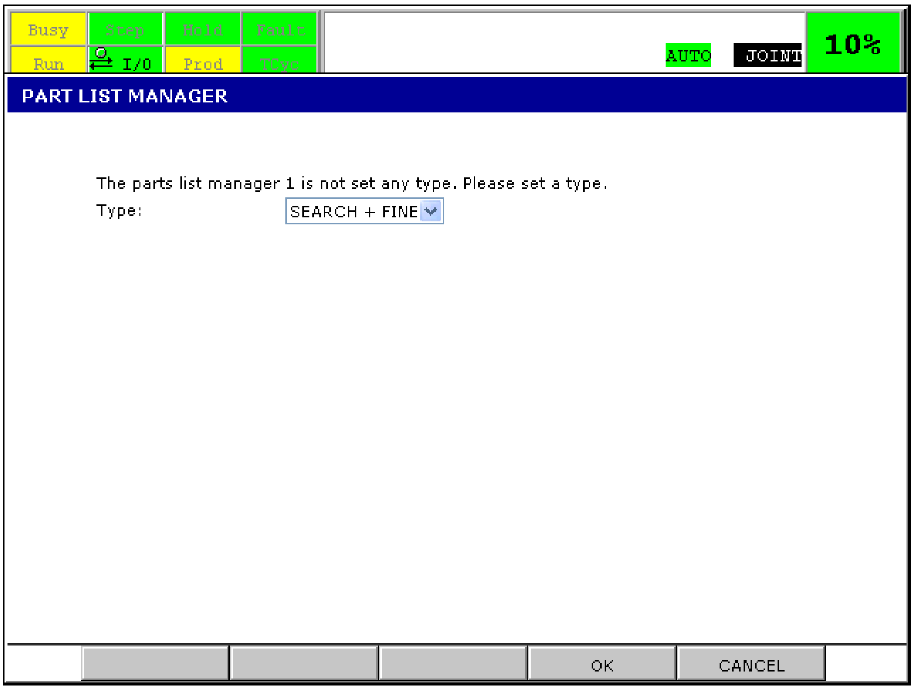
On the interference avoidance data setup screen, create an interference setup (condition) for interference avoidance and set it. Create interference setup (condition) used during part picking, and set the following parameters:



4.2.7 Setup of Parts List Manager

Setting the type of the Parts List Manager

In the data list screen of the Parts List Manager, select the Parts List Manager [1] and press F3 EDIT. If the type of the Parts List Manager [1] is not set, the following screen is displayed.



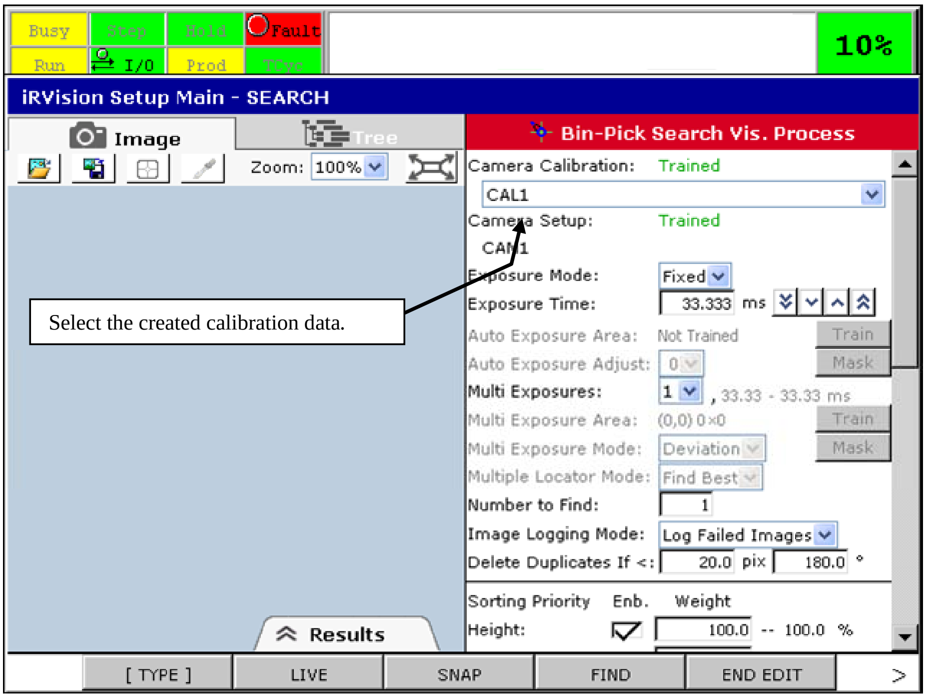
In the [Type], select the [SEARCH] and press F4 OK.

If the type of the Parts List Manager [1] is [SEARCH+FINE], change the type of the Parts List Manager [1] to [SEARCH]. For details of the operation procedures about the Parts List Manager, refer to Section 9.1 "BASIC OPERATIONS OF PARTS LIST MANAGER".

4.2.8 SEARCH Vision Process Setup

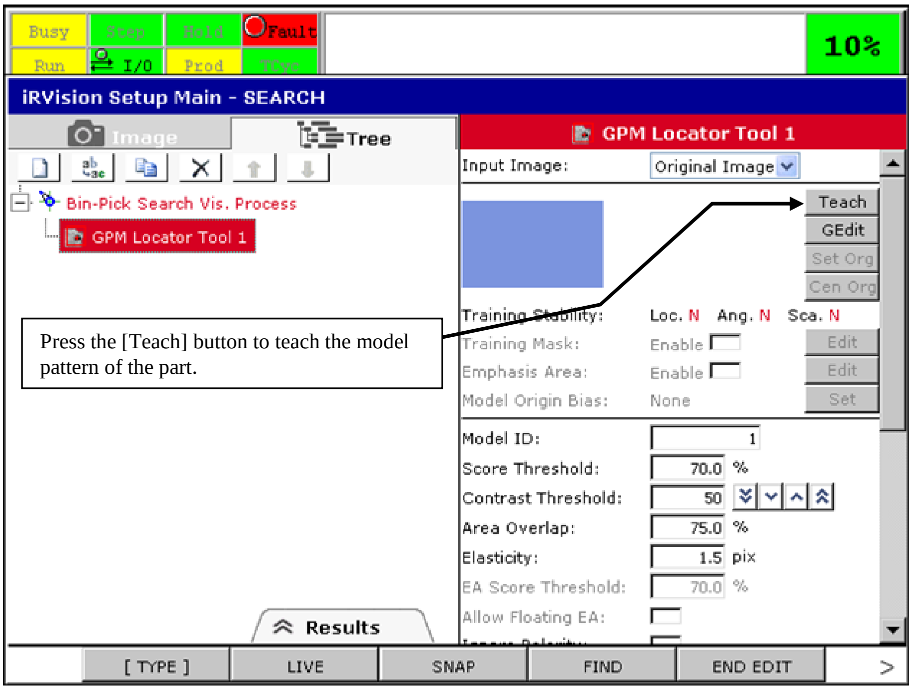
Creating a Vision Process and Setting the Parameters

Create a Bin-Pick Search Vis. Process, and set the following parameter.



Teaching the GPM Locator Tool

On the tree view of the Bin-Pick Search Vis. Process, select the [GPM Locator Tool 1] and teach it. Set [Model Origin] to the position at which the robot picks the part. For setup procedures of the GPM Locator Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

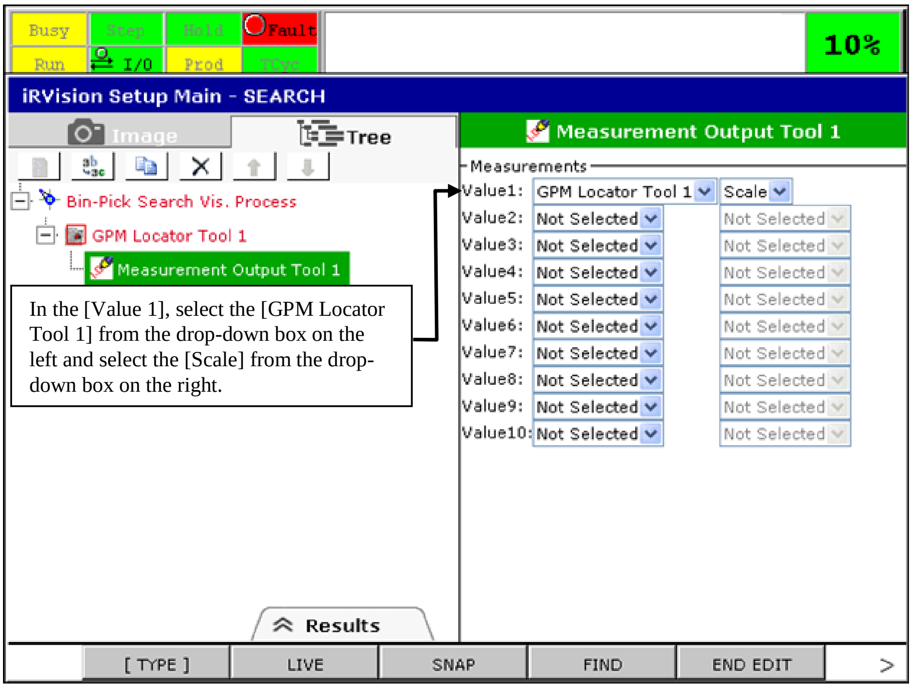


Creating the Measurement Output Tool and Setting the Parameters

Create a Measurement Output Tool as a child tool of the GPM Locator Tool in the following procedures.

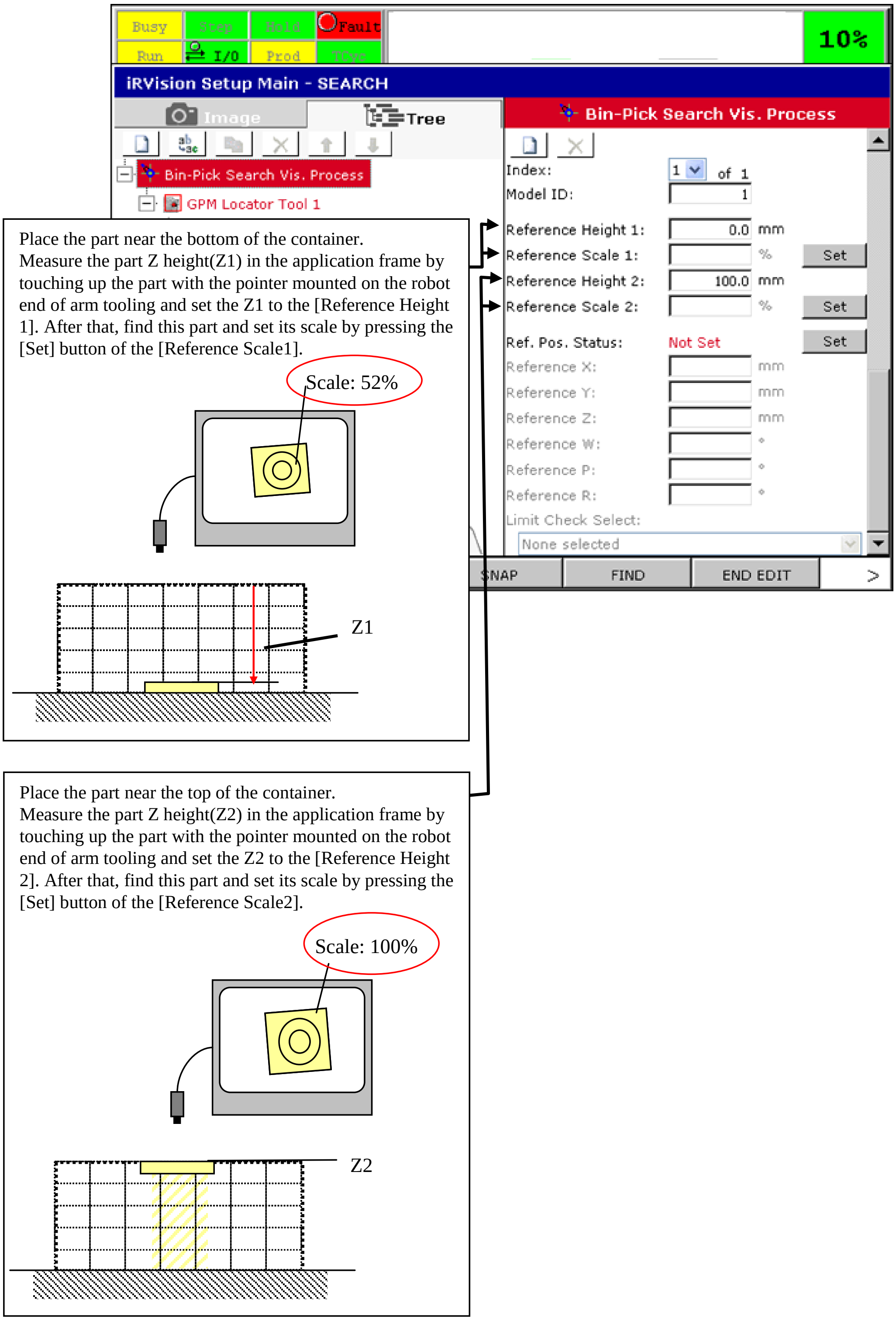
1. On the tree view of the 3D Area Sensor Vision Process, select the [GPM Locator Tool1].
2. Press the button to create a new vision tool.
3. On the setup screen to create a new vision tool, select the [Measurement Output Tool] for the [Type].
4. Press F4 OK.

On the [Measurement Output Too1] setup screen, set the following parameters. For setup procedures of the Measurement Output Tool, refer to Chapter 7 in the R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



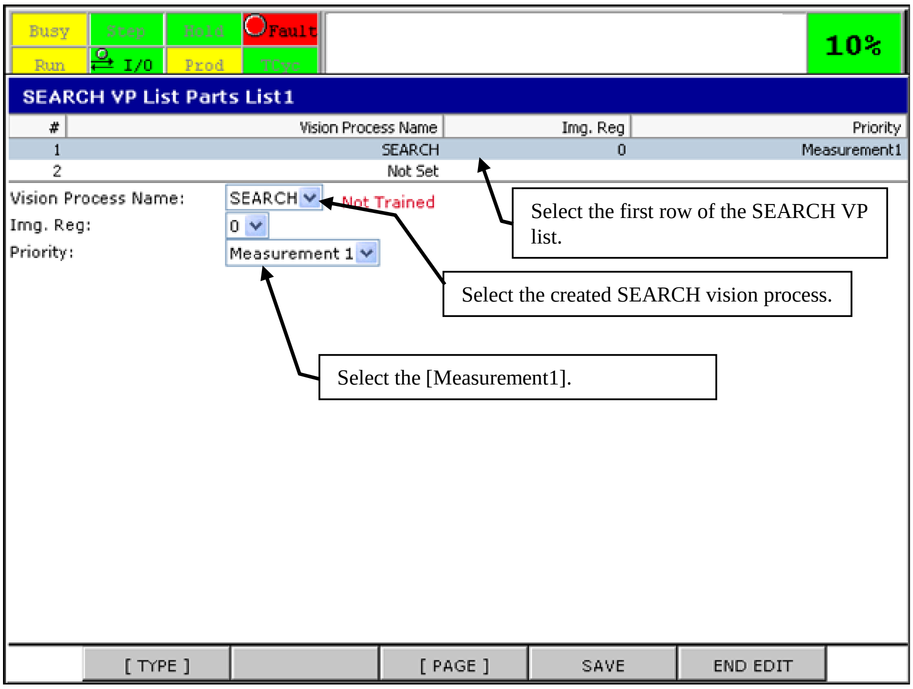
Setting Z Height

The Bin-Pick Search vision process calculates the part Z height, using the scale of the detected parts. It is therefore necessary to set the part Z height and apparent scale at two different heights.



Setting the SEARCH VP List

Set the created SEARCH vision process to a SEARCH VP list in the Parts List Manager. On the SEARCH VP List setup screen of the Parts List Manager of Part List[1], set the following parameters.

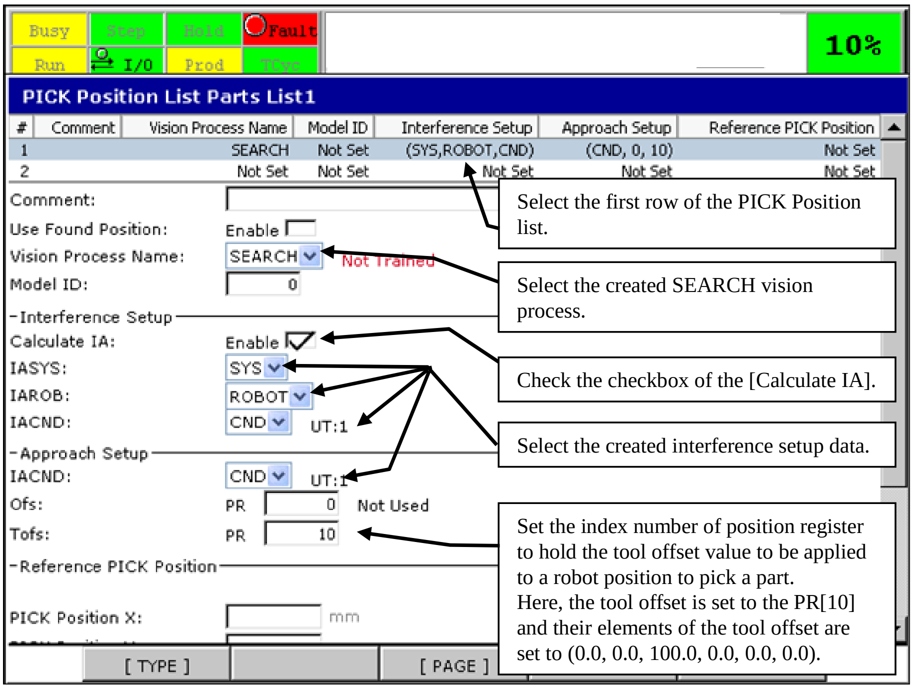


4.2.9 Reference PICK Position Setup

On the PICK Position List of the Parts List Manager of Part List[1], teach the reference position to pick the part.

Setting Parameters

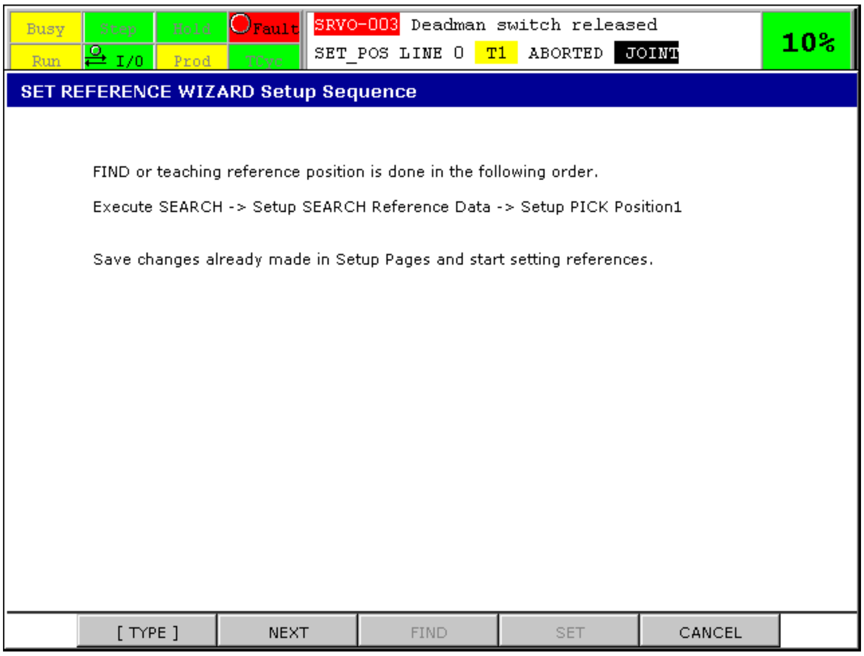
On the PICK Position List setup screen of the Part List Manager of Part List[1], set the following parameters.



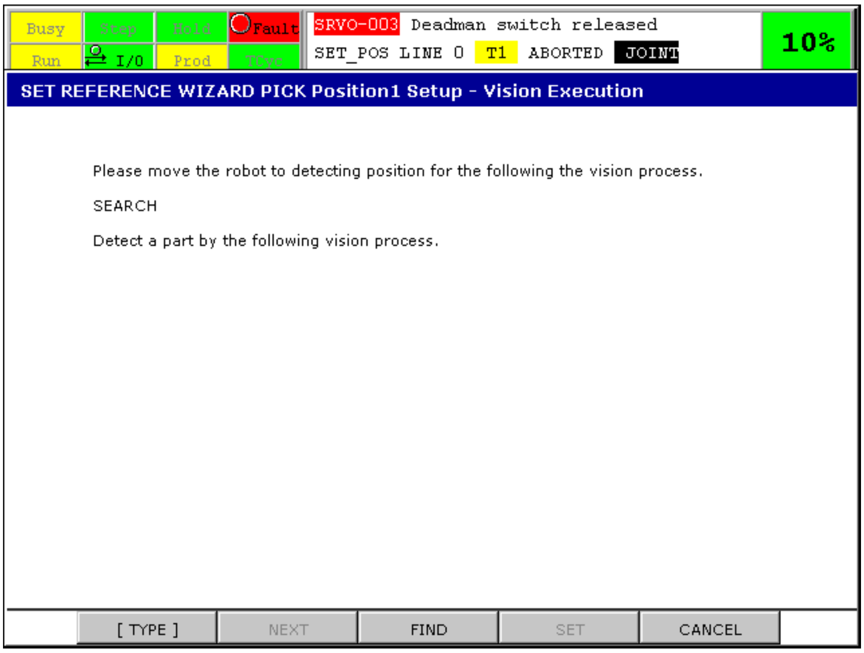
Teaching the Reference PICK position and Setting the Reference Data of the SEARCH VISON PROCESS

Teach the reference PICK position and Set the reference data of the SEARCH Vision Process by pressing the [Start Set Reference Wizard] button.

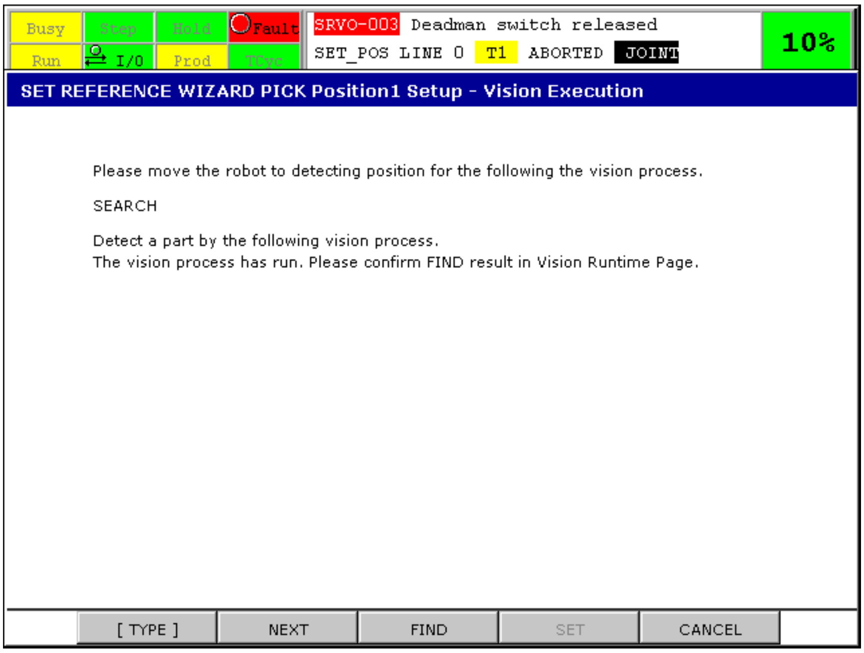
The following screen is displayed by pressing the [Start Set Reference Wizard] button. Then, press F2 NEXT to start the Set Reference Wizard after confirming the setup procedures.



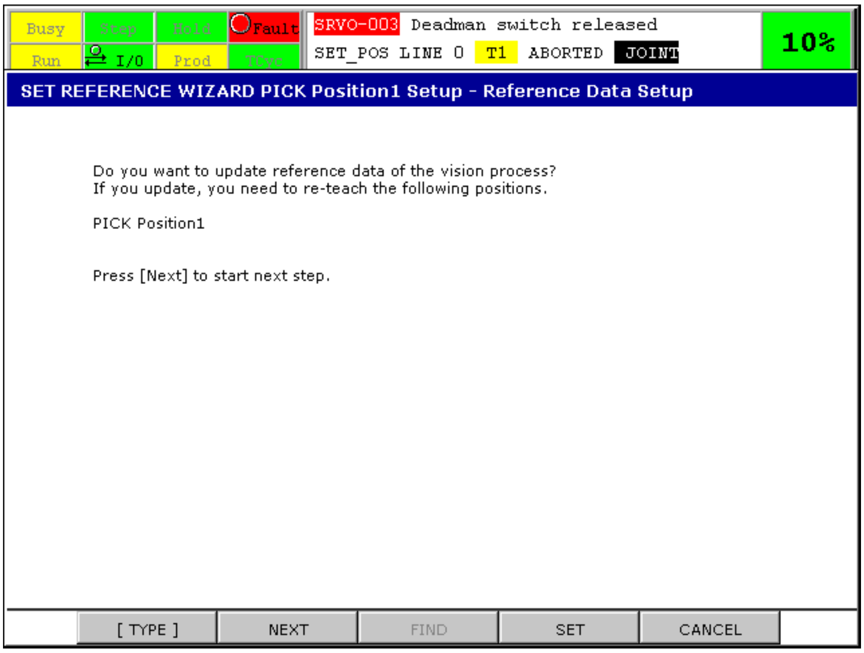
Then, the following screen to execute a vision process is displayed. Press F3 FIND after moving the robot outside of the container.



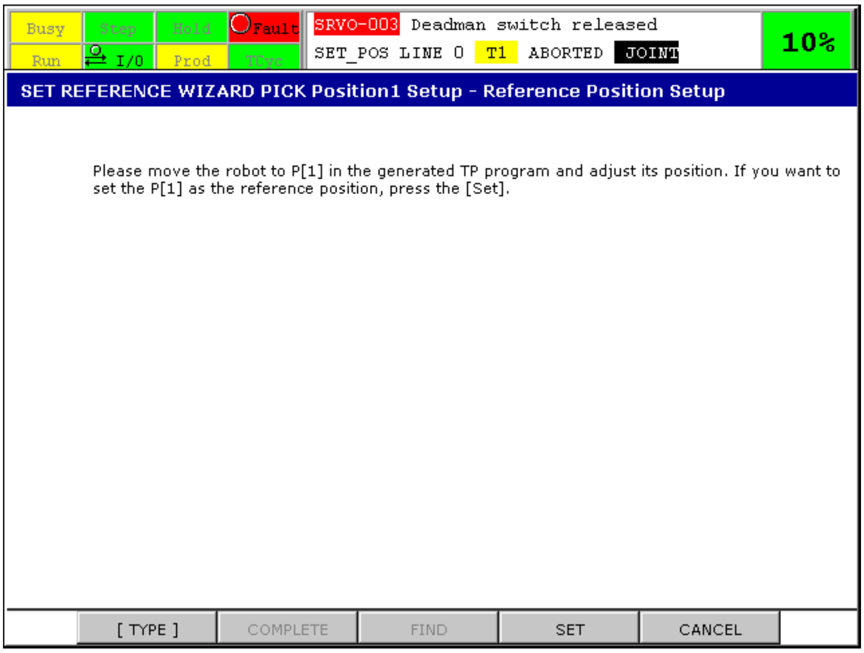
Then, the message "The vision process has run. Please confirm FIND result in Vision Runtime Page" is displayed as follows. Press F2 NEXT after confirming that the vision process finds part correctly.



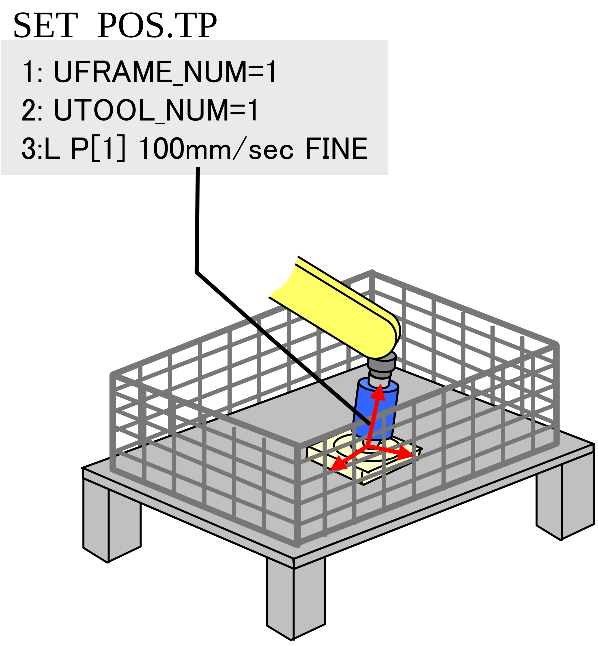
Then, the following screen to set the reference data of the Vision Process is displayed. Press F2 Next after pressing F4 SET to set the reference data of it.



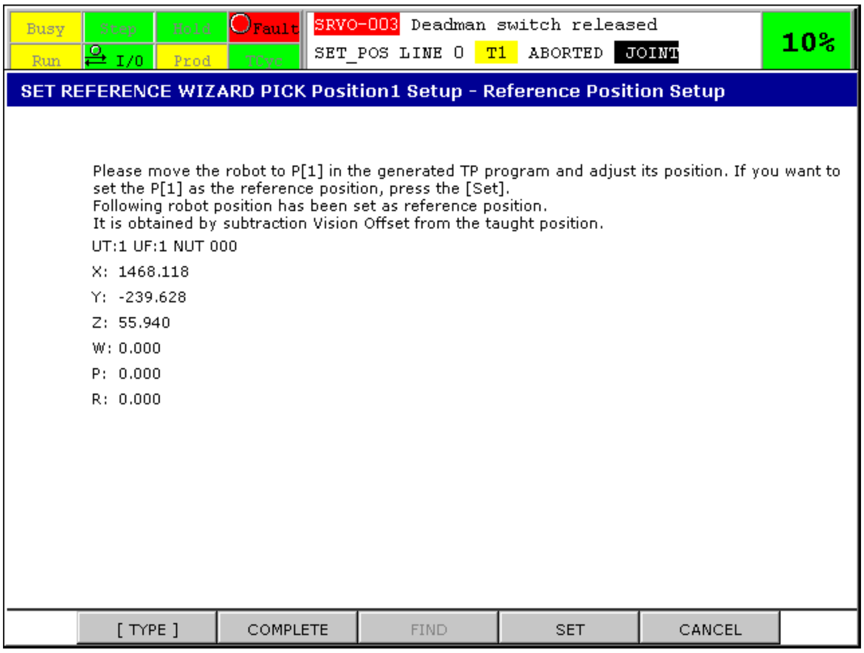
The following screen to set the reference PICK position is displayed.



And then, the following TP program, which is "SET_POS.TP", is automatically generated. Move the robot to the P[1] in the SET_POS.TP by executing the TP Program. The P[1] is automatically set to the found position of the vision process. Confirm that the found position is on a point of a part by moving the robot to the P[1].



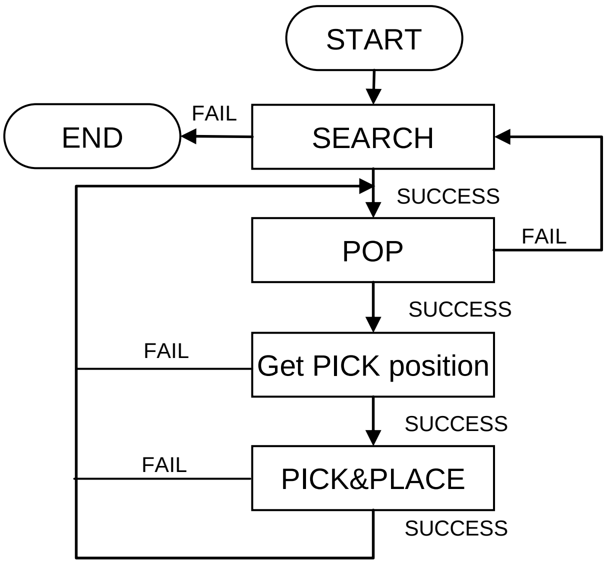
Press F4 SET to set the reference PICK position after confirming that the P[1] is an appropriate position to pick a part. If the P[1] is set to inappropriate position to pick a part, adjust the P[1] by moving the robot with the tool mode along or around the Z-axis. The set reference PICK position is displayed as follows.



Press F2 COMPLETE after confirming that the set reference PICK position is correct.

4.2.10 Creating TP Program

Create a TP program for the Bin picking system with 2D camera. The flow chart of the TP program is as follows.



Then, the following TP programs use the following the registers, position registers, vision registers and tool frame and user frame.

Table of Registers

R[10]	The status of the SEARCH Vision process 0: SUCCESS (Some new part data are added to a Parts List) 1: FAIL (No Part Data is added to a Parts List)
R[11]	The status of POP 0: SUCCESS 1: FAIL (Any Part Data is not popped from a Parts List)
R[12]	The Model ID of the popped Part Data

R[14]	The status of the process to get a PICK position 0: SUCCESS 12: Failed to get a PICK position 13: Failed to get a position to approach a part (approach position)

Table of Position Register

PR[20]	Result of interference avoidance for the part pick position (avoidance position)
PR[21]	Result of interference avoidance for the part pick position (tool offset value)
PR[22]	Result of interference avoidance for the approach position (avoidance position)

Table of Tool frame

UTOOL[1]	The TCP of the gripper

Table of User frame

UFRAME[1]	Application frame

BIN_PICKING.TP

The following TP program is a sample program for the Bin Picking System with 2D Camera. For description of the macro programs such as BINPICK_CLEAR, refer to Chapter 9, "PARTS LIST MANAGER REFERENCE".

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  CALL BINPICK_CLEAR (1)
 4:
 5:  ! SEARCH
 6:  LBL[1]
 7:L P[1] 2000mm/sec FINE
 8:  CALL BINPICK_SEARCH(1,1,10)
 9:  IF R[10]<>0,JMP LBL[999]
10:
11:  ! POP
12:  LBL[2]
13:  CALL BINPICK_POP(1,11,12)
14:  IF R[11]<>0,JMP LBL[1]
15:
16:  ! Get PICK position
17:  CALL BINPICK_GETPICKPOS(1,1,14,20,21,22)
18:  IF R[14]=0,JMP LBL[3]
19:
20:  CALL BINPICK_SETSTAT(1,22)
21:  JMP LBL[2]
22:
23:  ! PICK
24:  LBL[3]
25:L P[2] 2000mm/sec CNT100
26:L PR[22] 2000mm/sec CNT50
27:L PR[20] 500mm/sec FINE
28:  ! Insert program instructions to grasp the part.
29:  CALL BINPICK_SETSTAT(1,20)
30:
31:  ! PLACE
32:L P[3] 2000mm/sec CNT100
33:L P[4] 2000mm/sec FINE
34:  ! Insert program instructions to place the part.
35:
36:  ! Continuous
37:  JMP LBL[2]
38:
39:  ! END
40:  LBL[999]
41:J P[5] 100% FINE
```

Specify the user frame set in Subsection 4.2.2, "User Frame Setup" (line 1)

Execute a SEARCH vision process to find some parts. (line 8)

If any part can not be found, terminate the process. (line 9)

If any part data can not be popped from the parts list, go to the process to execute the SEARCH vision process. (line 14)

If the calculation of a position to pick up a part fails, go to the process to pop next part data. (line 21)

Execute the process to pick up a part. (line 28)

Execute a process to place a part. (line 34)

After placing a part, go to the process to pop next part data. (line 37)

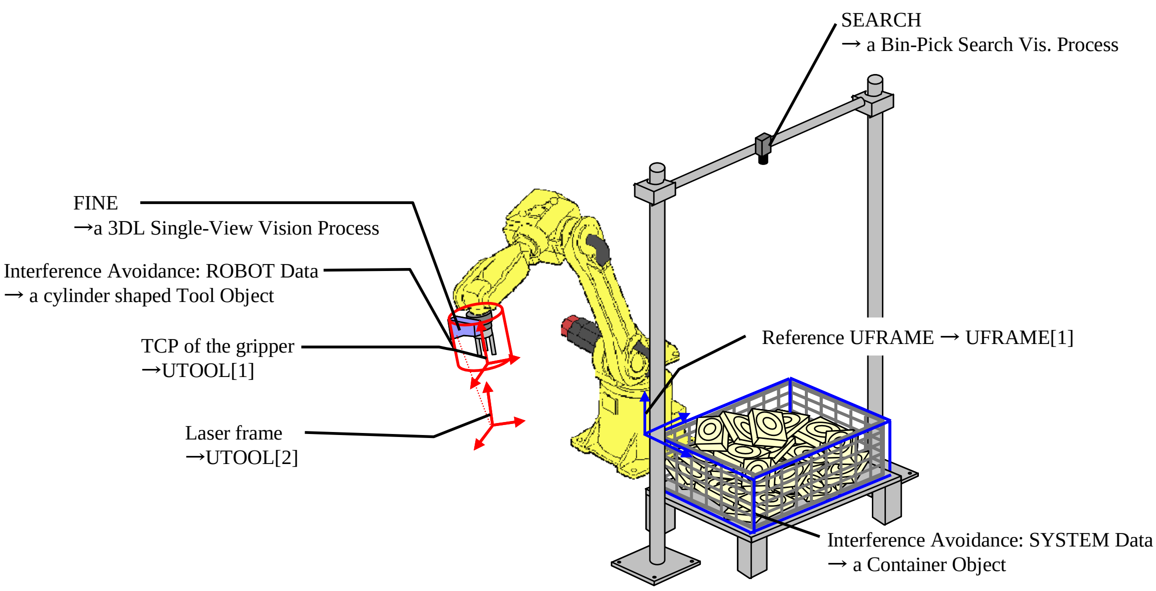
4.2.11 Robot Compensation Operation Check

Check that a part gripped by the robot can be detected and positioned precisely at a desired location.

- Place the part on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting.
- Move the part without rotation, find it and check the handling accuracy.
- Rotate the part, find it and check the handling accuracy.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

4.3 BIN PICKING SYSTEM WITH 3D LASER VISION SENSOR

Described below is the procedure of setting up a bin picking system with 3D Laser Vision Sensor.



> ⚠ **CAUTION**
> The position of the container is fixed and the container is not moved.

The setup procedures are as follows.

4.3.1 Fixed Camera Installation and Connection

Checking the Camera Setting

Change the settings on the back of the camera to match *i*RVision. For details, refer to Chapter 6 in the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR’S MANUAL".

Installing the Camera

Attach the lens to the camera then install the camera over the container of parts. Install the camera so that the field of view of the camera includes the whole container.

Connecting the Camera

Connect the camera to the robot controller. For details, refer to Section 2.6 of the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR’S MANUAL".

4.3.2 3D Laser Vision Sensor Installation and Connection

Installing the 3D Laser Vision Sensor

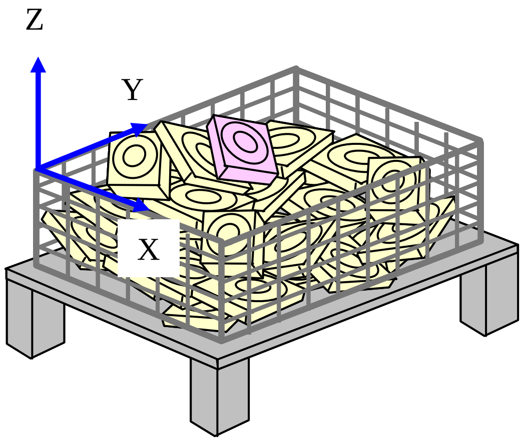
Install the 3D Laser Vision Sensor on the end of arm tooling.

Connecting the 3D Laser Vision Sensor

Connect the 3D Laser Vision Sensor to the robot controller. For details, refer to Section 2.6 the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL".

4.3.3 User Frame Setup

Set the user frame which is the reference frame of an offset data calculation or interference avoidance calculation. Set it on the upper opening of the container as shown below. For setup procedures of user frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".



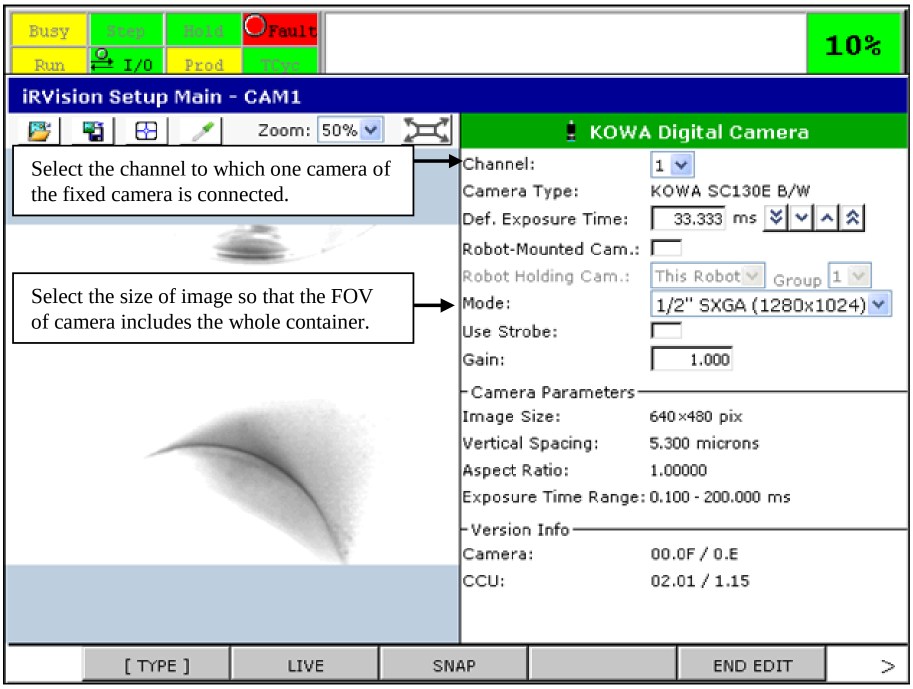
Here, set the user frame to UFRAME[1] as described in Section 4.3, "BIN PICKING SYSTEM WITH 3D LASER VISION SENSOR".

4.3.4 Camera Data Setup of Fixed Camera

Set the camera data of the fixed camera in the KOWA Digital Camera setup screen.

Creating a Camera Data and Setting the Parameters

Create a KOWA Digital Camera data, and set the following parameters.



4.3.5 Calibration of Fixed Camera

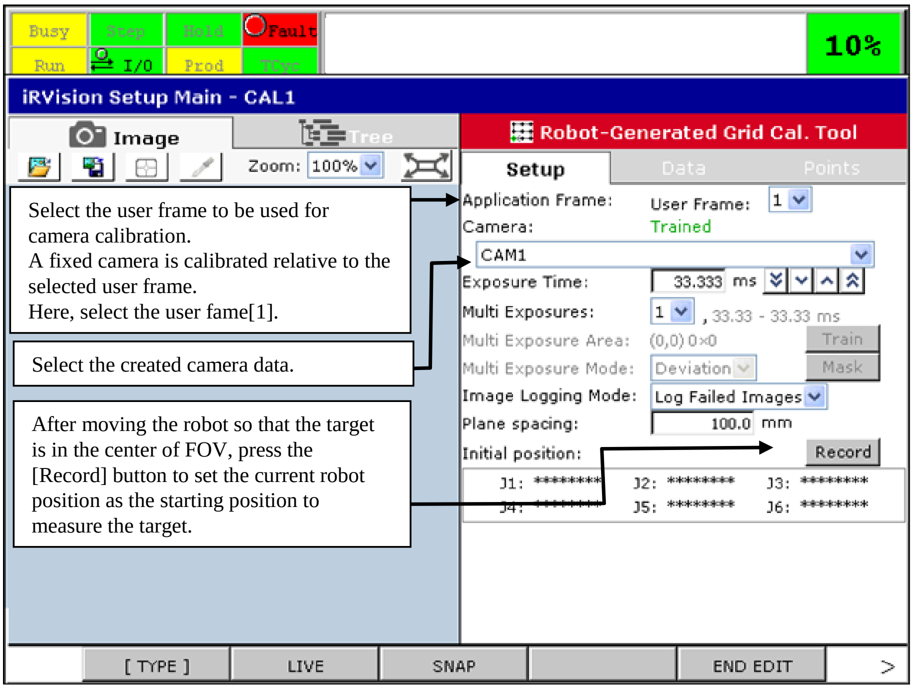
Calibrate the fixed camera with the Robot-generated grid calibration created.

Mounting a Target

The function moves the target, mounted on the robot end of arm tooling, in the camera's field of view to generate a virtual grid pattern for camera calibration. Mount the target at the robot end of arm tooling. Make sure that the target does not get blocked by the robot arm or the tooling while the robot moves in the camera's field of view.

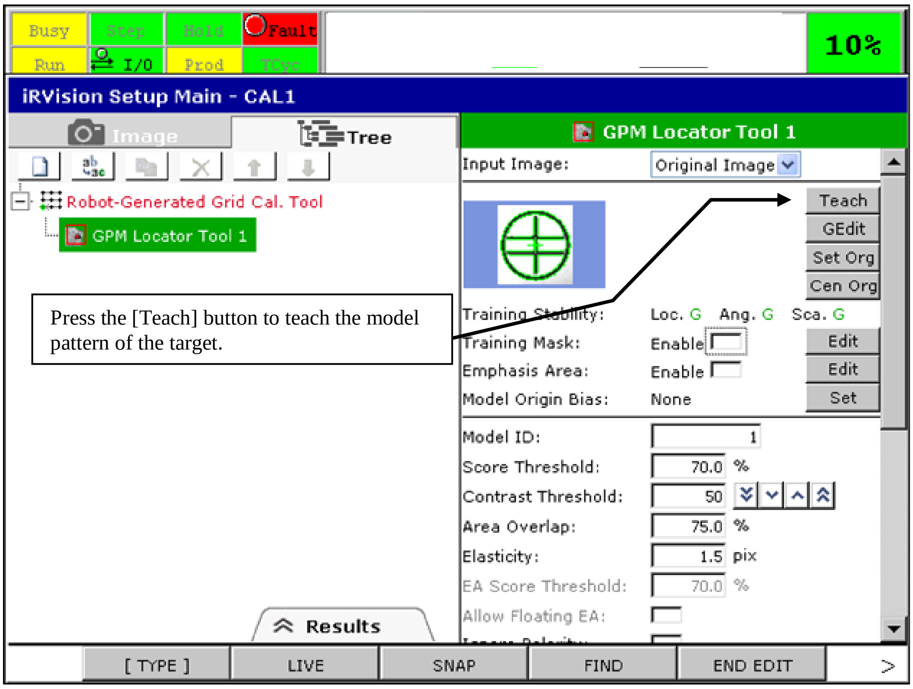
Creating a Calibration Data and Setting the Parameters

Create a Robot-Generated Grid Calibration data, and set the following parameters.



Teaching the GPM Locator Tool

With the target located at the starting position set in the [Initial Position], select the [GPM Locator Tool1] on the tree view and teach the model pattern of the target.

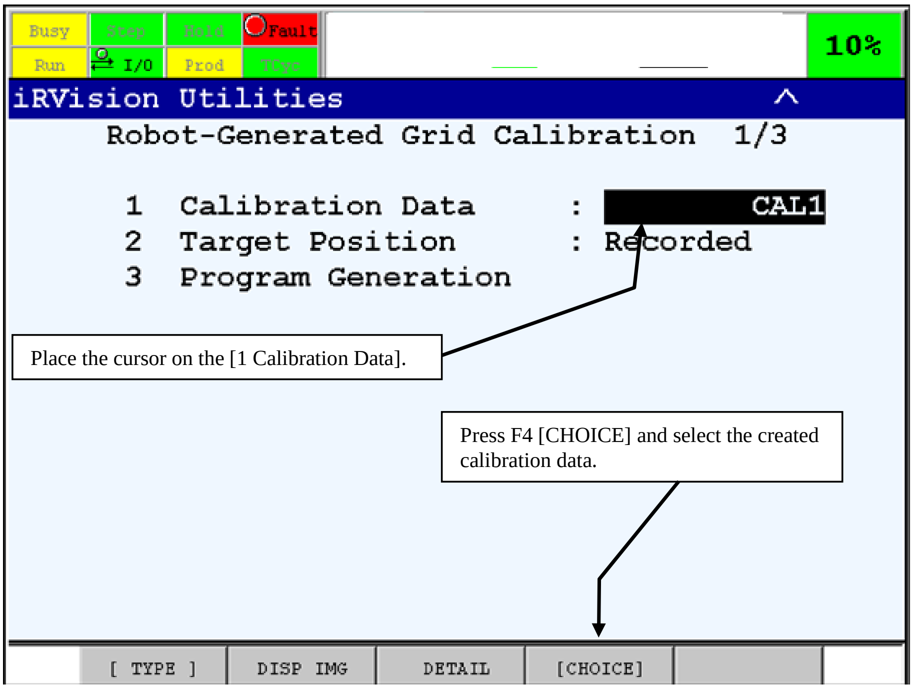


> ⚠ **CAUTION**
> After setting the calibration data, press F5 END EDIT to close the setup page. If the calibration setup page is opened, the Robot-Generated Grid Calibration fails to measure the target position.

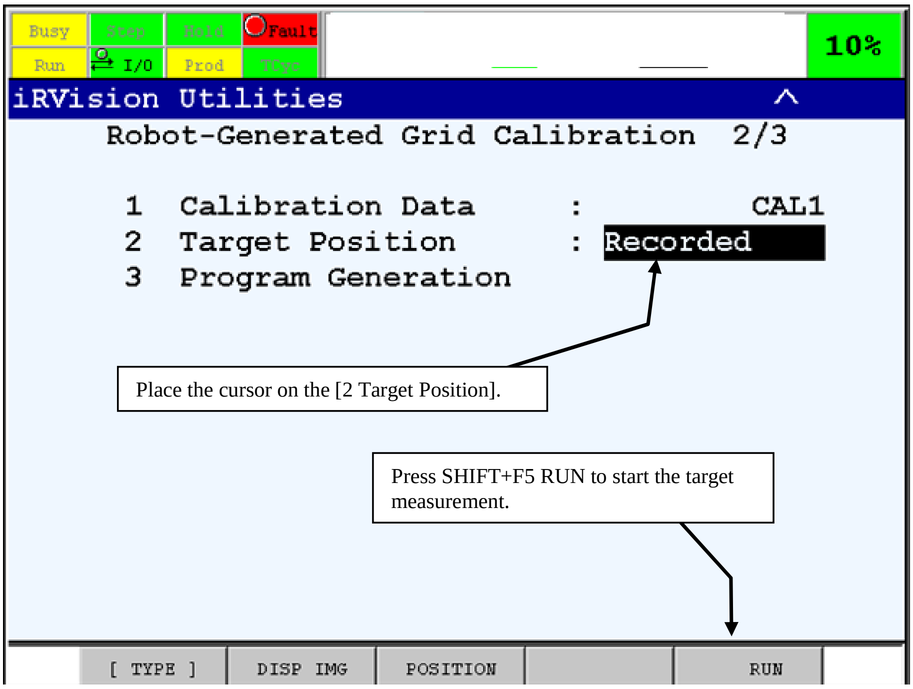
Measuring the Target Position

Visit the [Robot-Generated Grid Calibration] in the iRVision > Vision Utility Menu.

Select the calibration data in the following procedures.

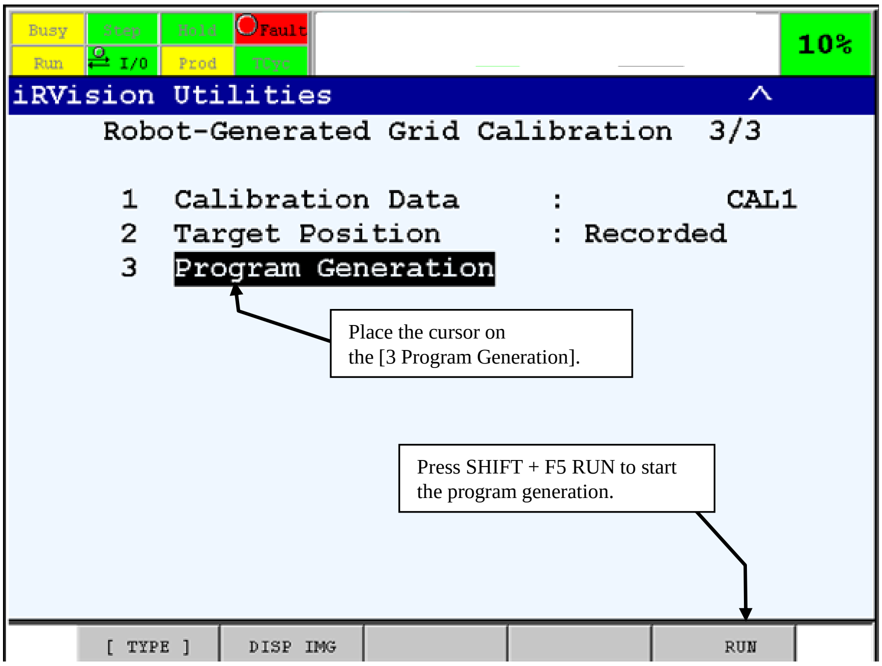


Measure the target position in the following procedures.



Generating a Calibration Program

Generate a calibration program for executing camera calibration in the following procedures.



Executing the Calibration Program

Select the generated calibration program in the SELECT menu, and play it back from first line to calibrate camera.

Checking the Calibration Data

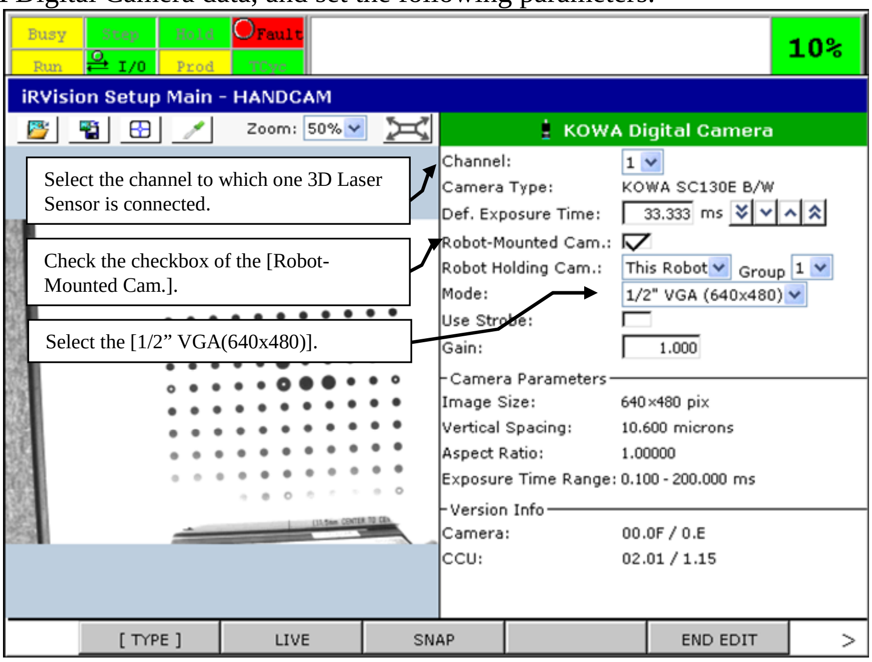
Check that the calibration result is correct. To check the calibration data, refer to Subsection 6.1.6 "Camera Calibration Data Checking".

4.3.6 Camera Data Setup of 3D Laser Vision Sensor

Set the camera data of the 3D Laser Vision Sensor in KOWA Digital Camera setup screen.

Creating a Camera Data and Setting the Parameters

Create a KOWA Digital Camera data, and set the following parameters.



4.3.7 Calibration of 3D Vision Laser Sensor

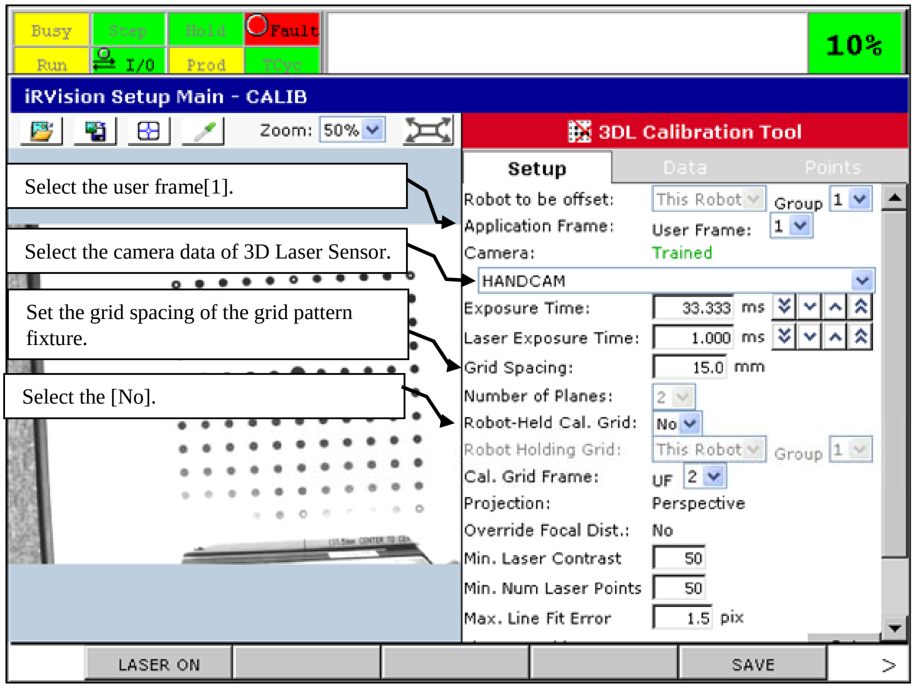
Create the calibration data for the 3DL Calibration Tool and calibrate the 3D Laser Vision Sensor. For the calibration of the 3D Laser Vision Sensor, install the calibration grid in a fixed manner and move up and down the 3D Laser Vision Sensor mounted on the robot, thereby achieving two-plane calibration.

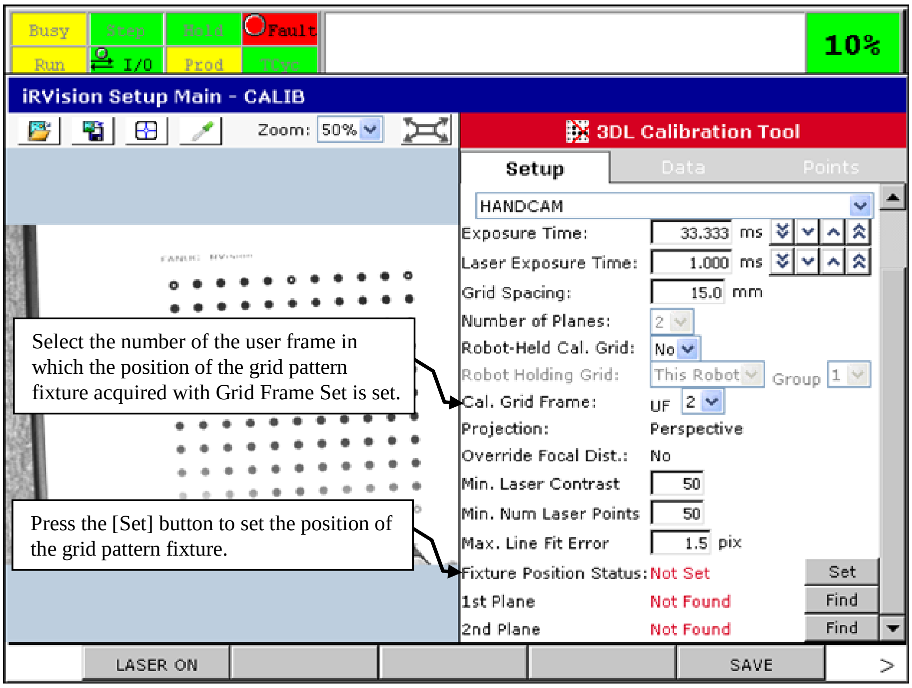
Acquiring the Calibration Grid Installation Information

Install the calibration grid in the operating range of the robot, and teach the grids location by teaching a user frame to the grid. To teach the calibration grid frame, use Automatic Grid Frame Set Automatic Grid Frame Set will automatically teach a user specified user frame to the calibration grid. For details of Grid Frame Set, refer to Section 5.2 " FRAME SETTING WITH THE AUTOMATIC GRID FRAME SET FUNCTION"Chapter 10 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

Calibration Data Creation and Parameter Setting

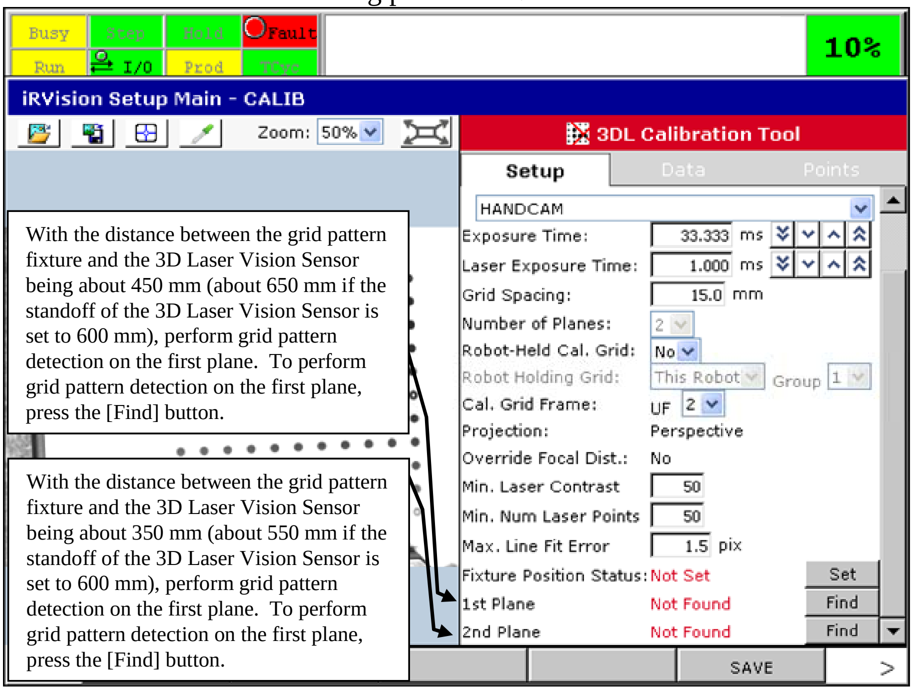
On the *i*RVision's main setup screen, create the calibration data for the 3DL Calibration Tool, and set the parameters necessary prior to the execution of calibration.





Detecting the Calibration Grid

Perform grid pattern detection in the following procedures.



4.3.8 Tool Frame Setup

TCP of the Gripper

Set the tool frame on the TCP of the end of robot gripper. This frame is useful for ensuring that the TCP of the end of the gripper is moved to the part pick position when fixed frame offset or interference avoidance is applied to the part pick position. The Z-axis of this frame should be set along the direction in which the robot proceeds and retreats as it picks up a part. For setup procedures of tool frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".

Here, set the user frame to UTOOL [1] as described in Section 4.3, "BIN PICKING SYSTEM WITH 3D LASER VISION SENSOR".

Laser Frame

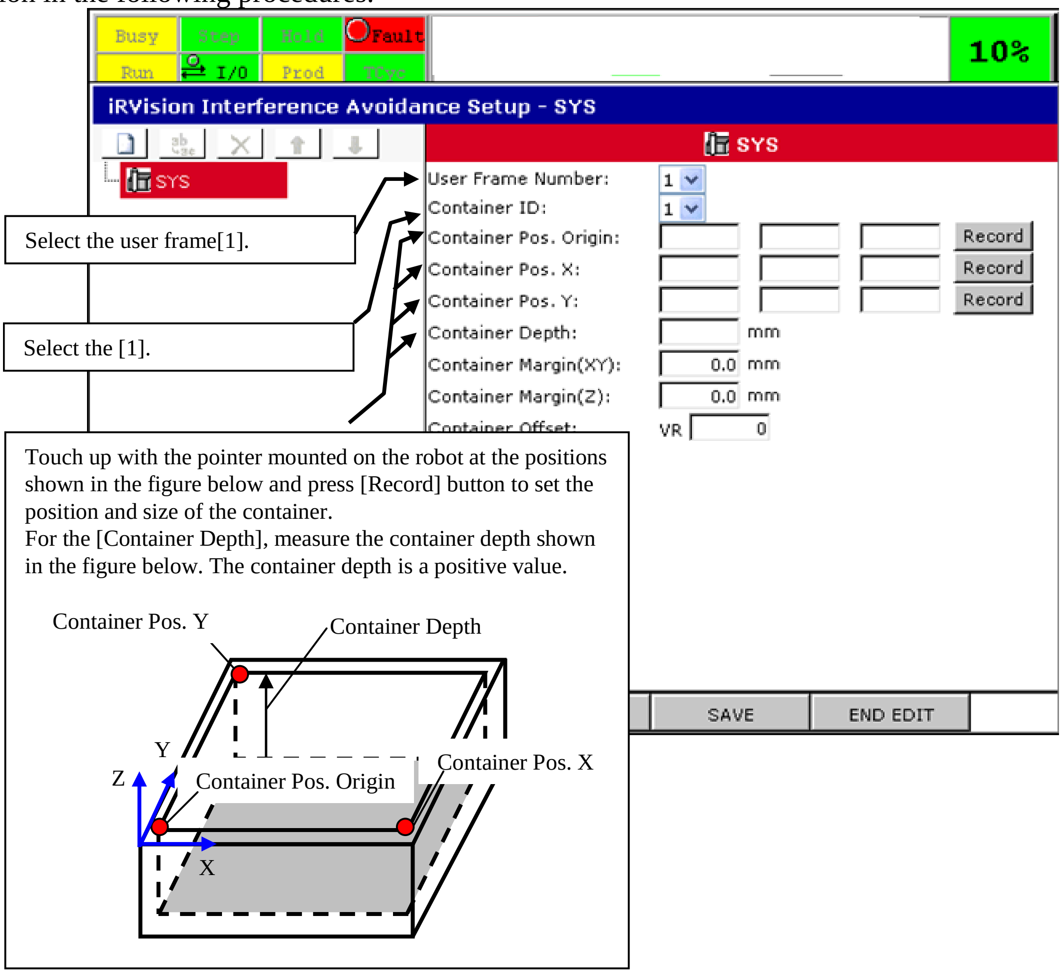
When the 3D Laser Vision Sensor is mounted on the robot end of arm tooling, the laser frame represents the laser emitting direction. It is defined so that the origin is on the line of intersection of two slit laser beams and about 400 mm apart from the center of the window plate of the light receiving unit (or about 600 mm; depending on the standoff of the 3D laser sensor) and that the Z axis is parallel to the line of intersection of two slit laser beams. The positive direction of the Z-axis is from the part side to the window plate of the laser project unit. The laser frame is useful for ensuring that the line of intersection of slit laser beams is moved above the part when fixed frame offset or interference avoidance is applied to the measurement position for the FINE. The laser frame is displayed in [Laser frame relative to the robot] when the data tab is selected on the calibration setup screen of the 3D Laser Vision Sensor. Set the displayed value as a tool frame.

Here, set the user frame to UTOOL [2] as described in Section 4.3, "BIN PICKING SYSTEM WITH 3D LASER VISION SENSOR".

4.3.9 Setup of Interference Setup Data

Creating an Interference Setup (System) and Setting the Parameters

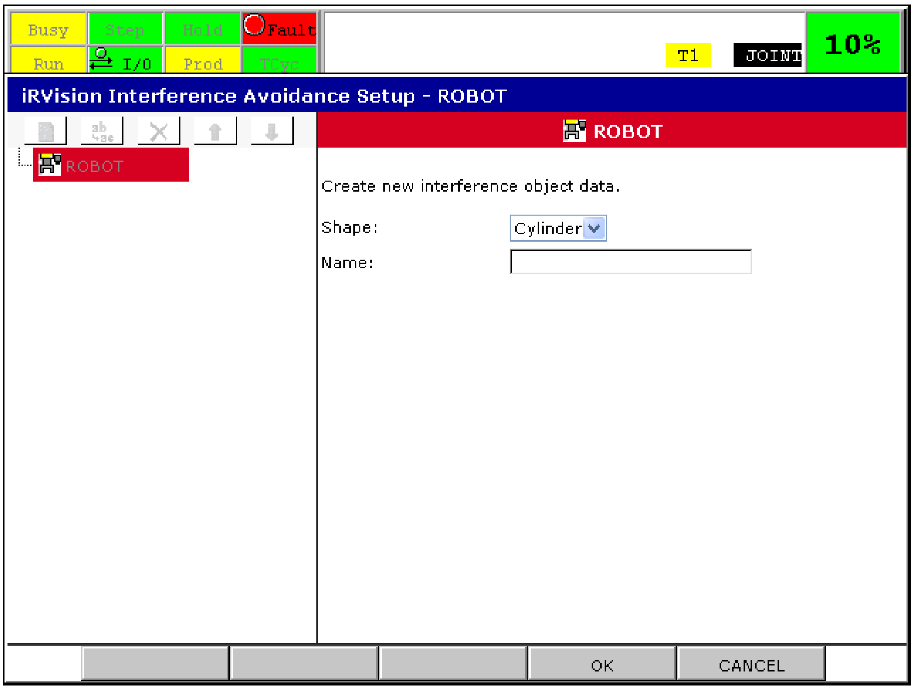
On the interference avoidance data setup, create an interference setup (system) for interference avoidance, and set the user frame and the container object to form the basis for interference avoidance position calculation in the following procedures.



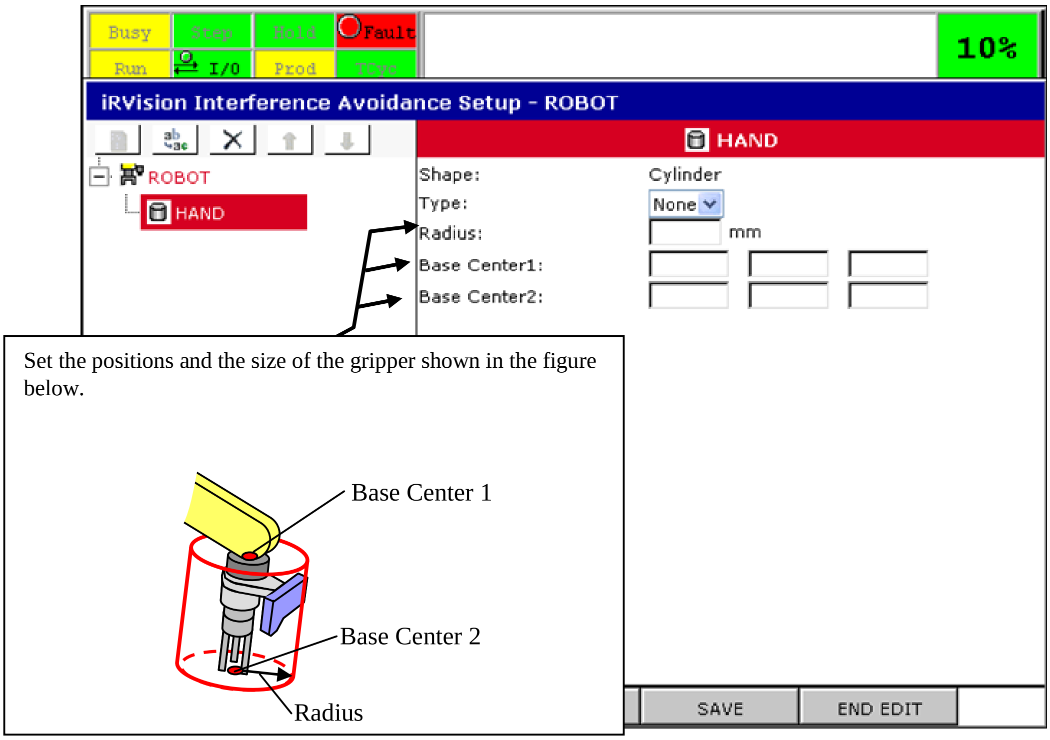
Creating an Interference Setup (Robot) and Setting up the Parameters

On the interference avoidance data setup screen, create an interference setup (robot) for interference avoidance, and set a tool object.

In the tree view on the interference setup (robot) screen, press the button. On the new tool object creation screen, which appears, select [Cylinder] for [Shape] and [Hand] for [Name], and press F4 OK.



Set the created tool object in the following procedures.

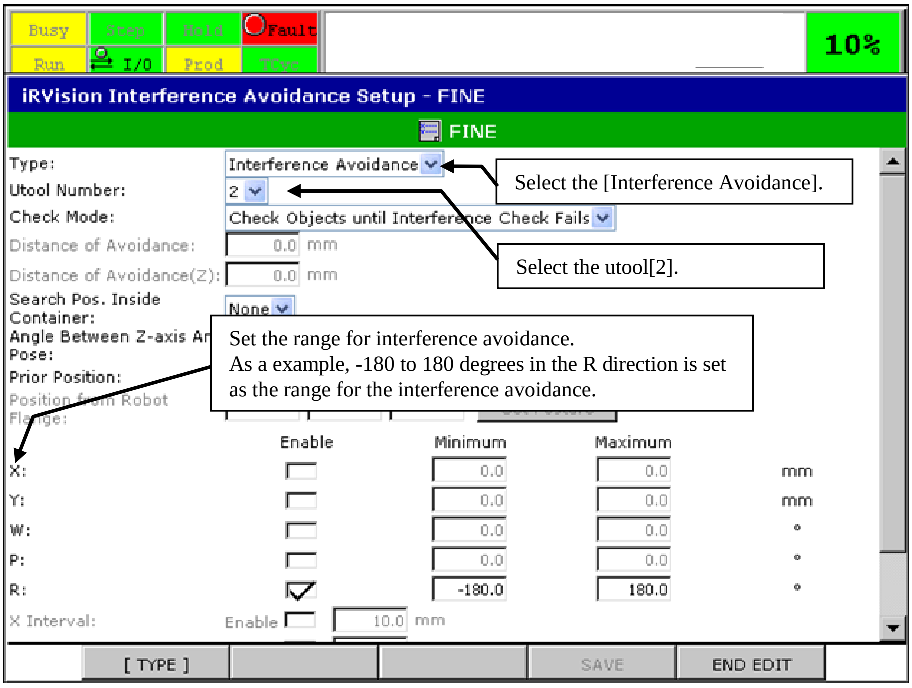


Creating an Interference Setup (Condition) and Setting the Parameters

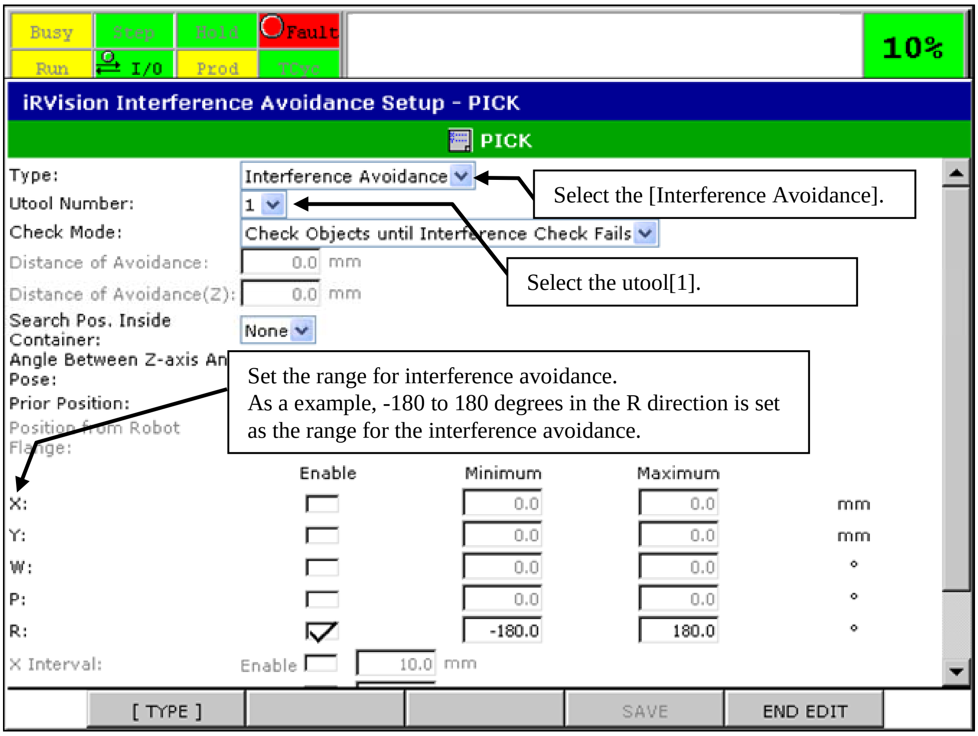
On the interference avoidance data setup screen, create an interference setup (condition) for interference avoidance and set it. Create two sets of interference setup (condition): interference setup (condition) used during fine measurement and interference setup (condition) used during part picking.

Create the interference setup (condition) used during fine measurement, and set the following parameters.

For [Type], select [Interference avoidance].



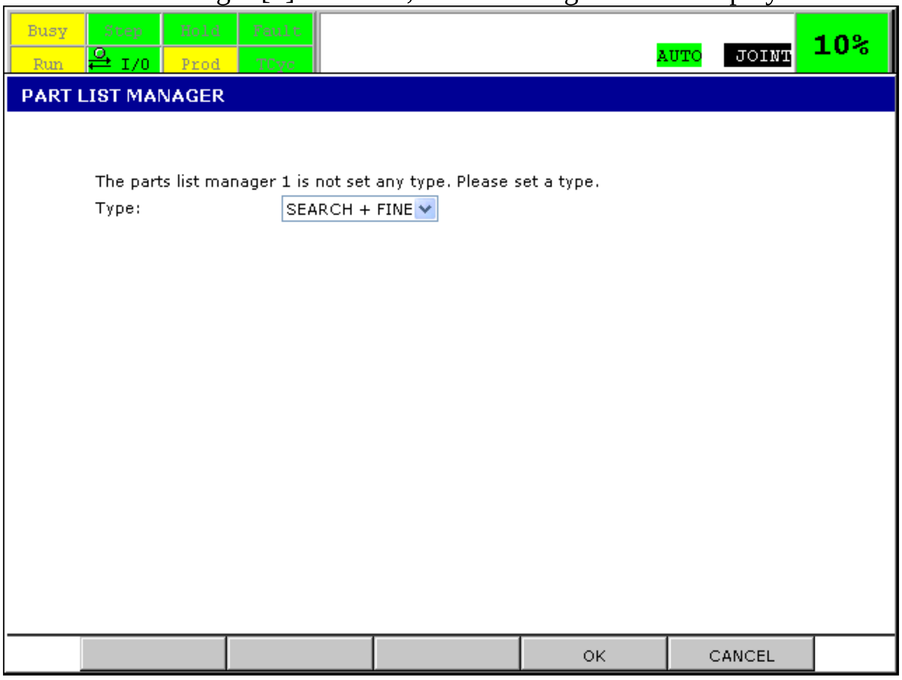
Create the interference setup (condition) used during part picking, and set the following parameters:



4.3.10 Setup of Parts List Manager

Setting the type of the Parts List Manager

In the data list screen of the Parts List Manager, select the Parts List Manager [1] and press F3 EDIT. If the type of the Parts List Manager [1] is not set, the following screen is displayed.



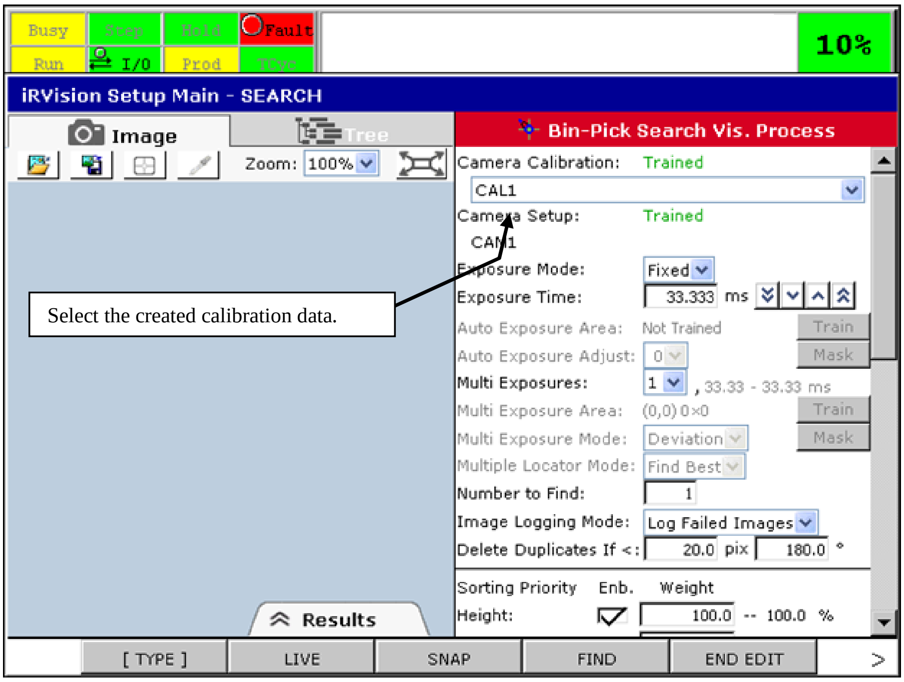
In the [Type], select the [SEARCH+FINE] and press F4 OK.

If the type of the Parts List Manager [1] is [SEARCH], change the type of the Parts List Manager [1] to [SEARCH+FINE]. For details of the operation procedures about the Parts List Manager, refer to Section 7.1 "BASIC OPERATIONS OF PARTS LIST MANAGER".

4.3.11 SEARCH Vision Process Setup

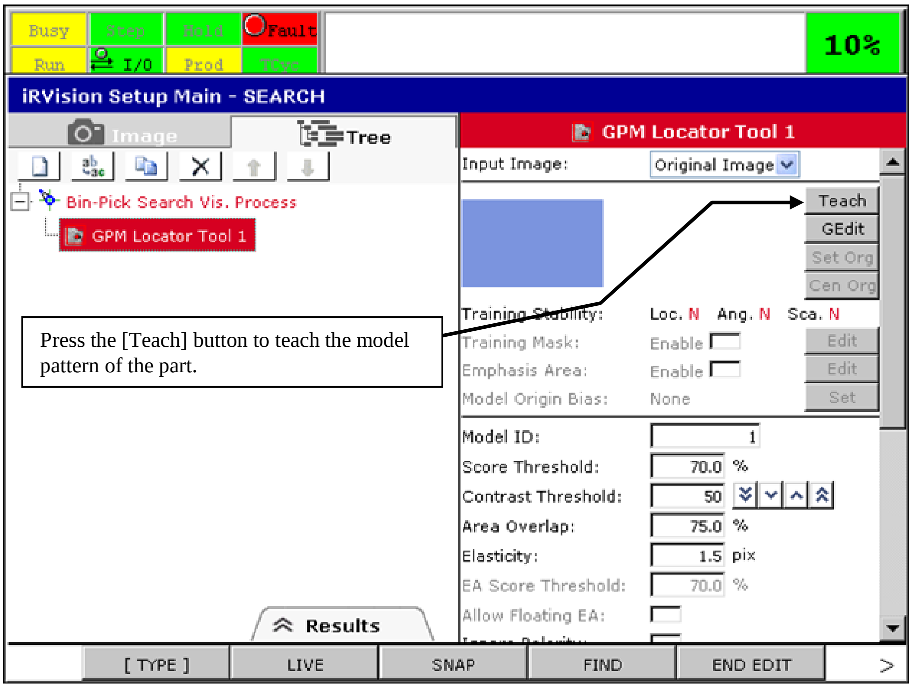
Creating a Vision Process and Setting Parameters

Create a Bin-Pick Search Vis. Process, and set the following parameter.



Teaching the GPM Locator Tool

On the tree view of the Bin-Pick Search Vis. Process, select the [GPM Locator Tool 1] and teach it. Set [Model Origin] to the position where you want the laser beam intersection to come in FINE. For setup procedures of the GPM Locator Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



Creating the Measurement Output Tool and Setting the Parameters

Create a Measurement Output Tool as a child tool of the GPM Locator Tool in the following procedures.

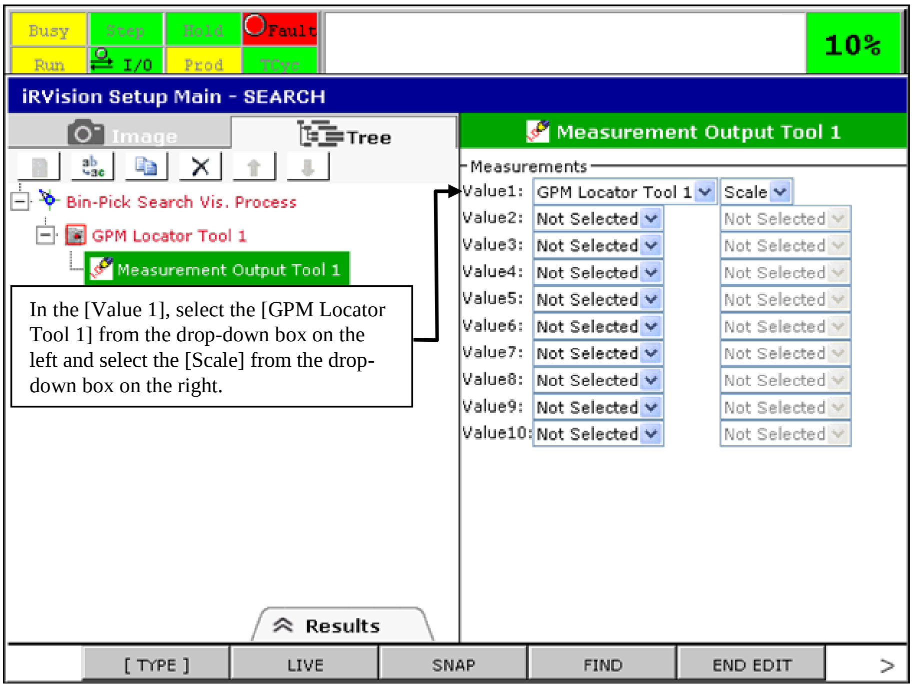
1 On the tree view of the 3D Area Sensor Vision Process, select the [GPM Locator Tool1].

2 Press the button to create a new vision tool.

3 On the setup screen to create a new vision tool, select the [Measurement Output Tool] for the [Type].

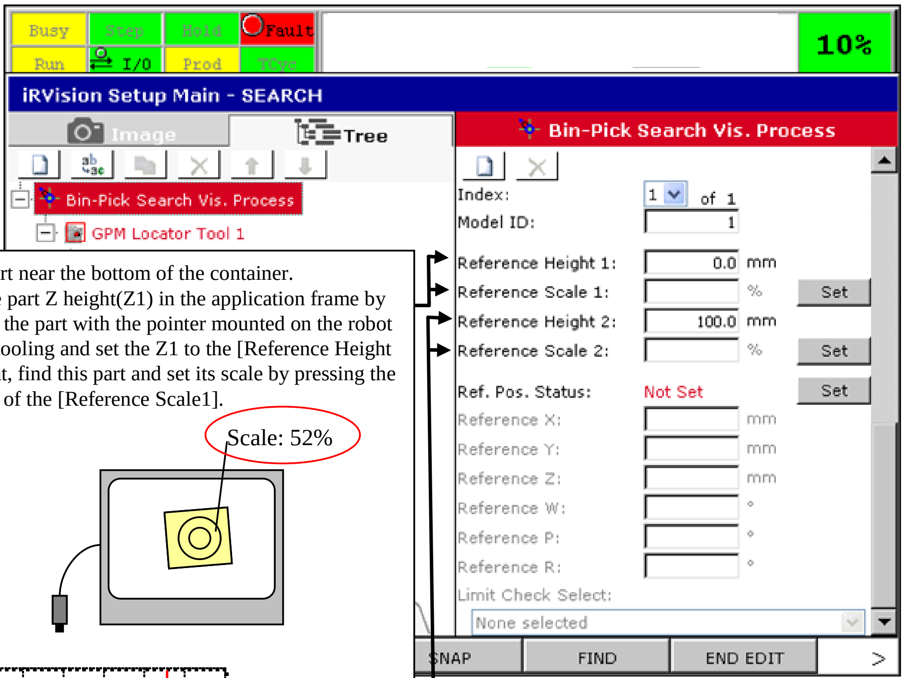
4 Press F4 OK.

On the [Measurement Output Too1] setup screen, set the following parameters. For setup procedures of the Measurement Output Tool, refer to Chapter 7 in the R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

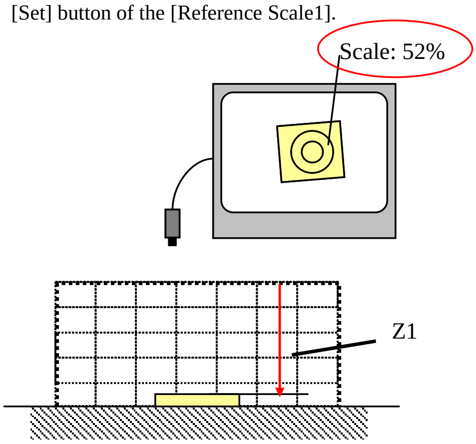


Setting Z Height

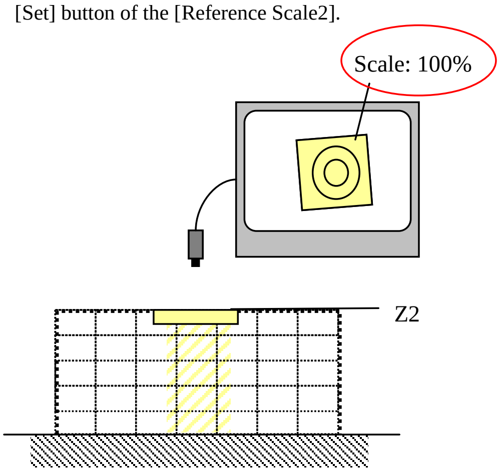
The Bin-Pick Search vision process calculates the part Z height, using the scale of the detected parts. It is therefore necessary to set the part Z height and apparent scale at two different heights.



Place the part near the bottom of the container.
Measure the part Z height(Z1) in the application frame by touching up the part with the pointer mounted on the robot end of arm tooling and set the Z1 to the [Reference Height 1]. After that, find this part and set its scale by pressing the [Set] button of the [Reference Scale1].

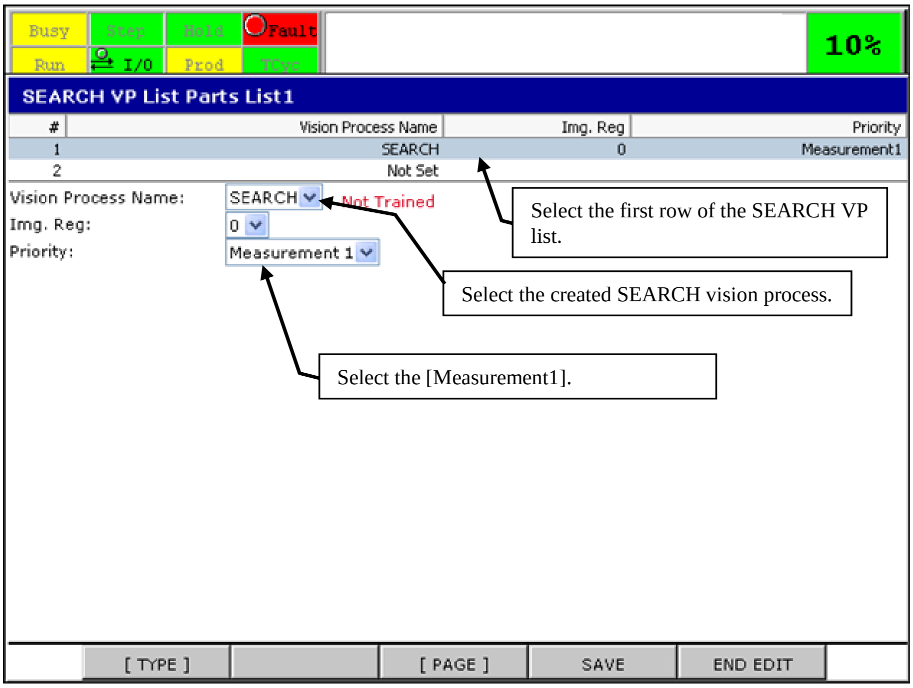


Place the part near the top of the container.
Measure the part Z height(Z2) in the application frame by touching up the part with the pointer mounted on the robot end of arm tooling and set the Z2 to the [Reference Height 2]. After that, find this part and set its scale by pressing the [Set] button of the [Reference Scale2].



Setting the SEARCH VP List

Set the created SEARCH vision process to a SEARCH VP list in the Parts List Manager. On the SEARCH VP List setup screen of the Parts List Manager of Part List[1], set the following parameters.

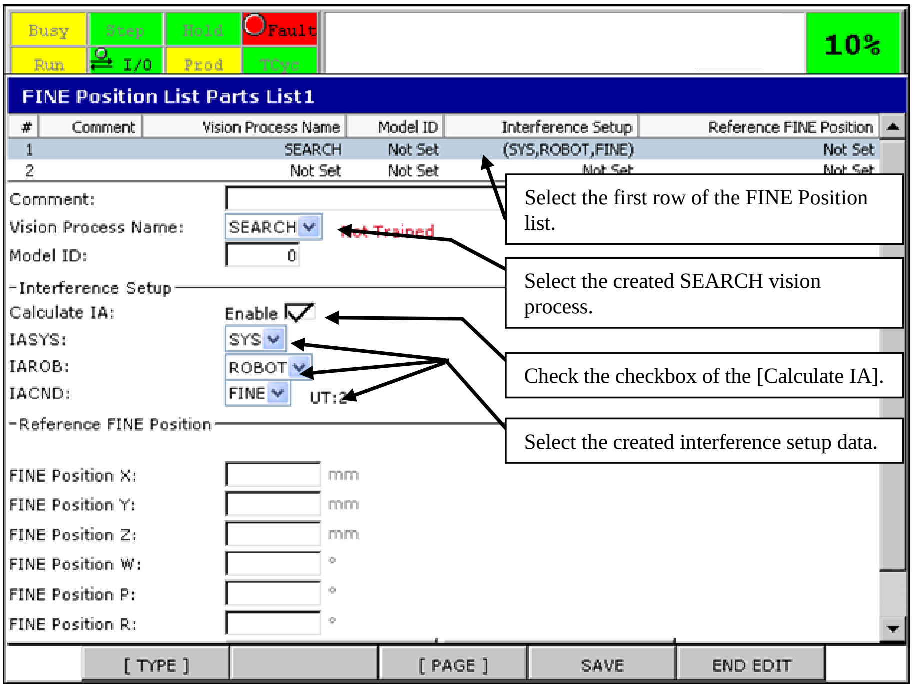


4.3.12 Reference FINE Position Setup

On the FINE Position List of the Parts List Manager of Part List[1], teach the reference position to execute the FINE Vision Process. In this document, one reference position to execute the FINE Vision Process is referred to as "reference FINE position".

Setting Parameters

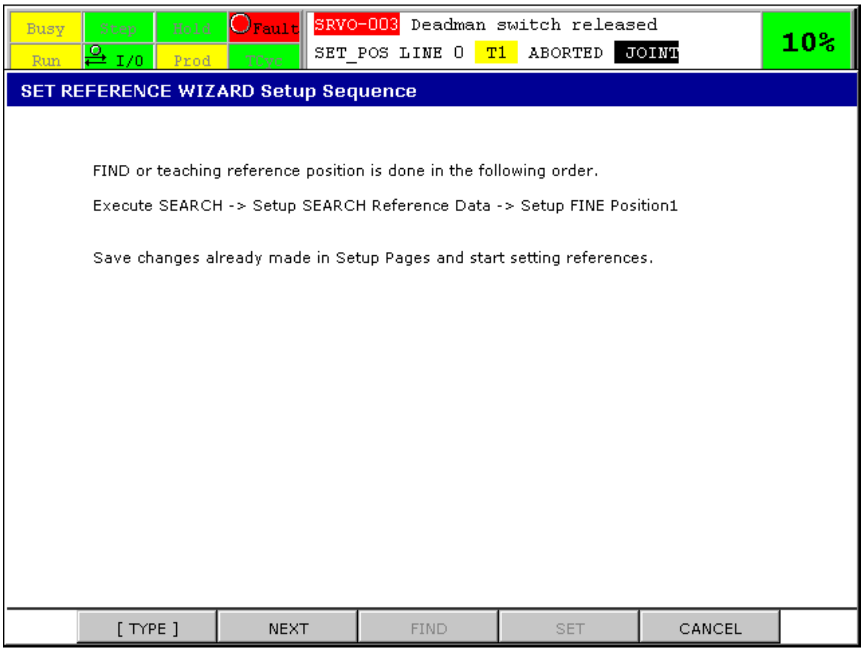
Open the Parts List Manager setup screen of the Parts List [1], and display the FINE Position List.



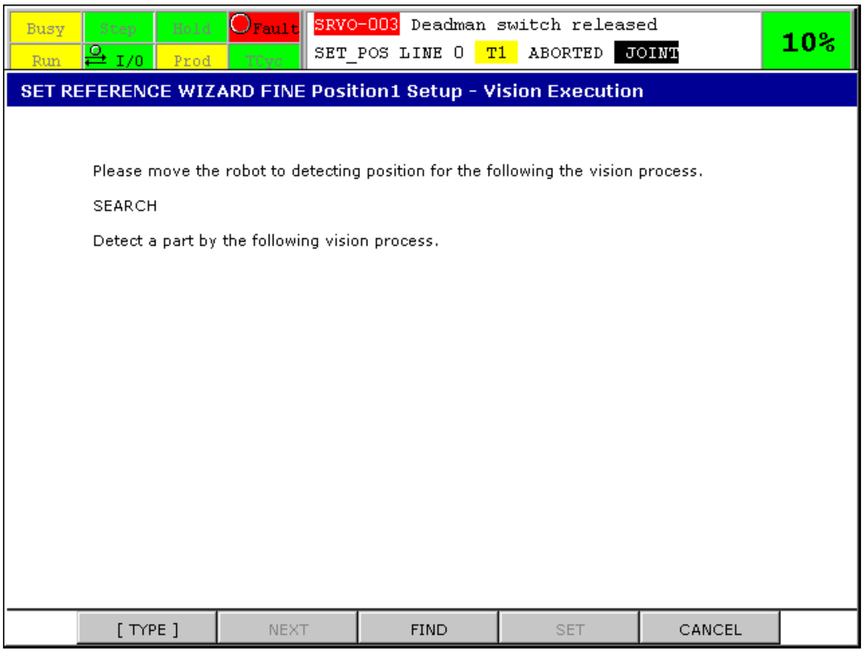
Teaching the Reference FINE position and Setting the Reference Data of the SEARCH Vision Process

Teach the reference FINE position and Set the reference data of the SEARCH Vision Process by pressing the [Start Set Reference Wizard] button.

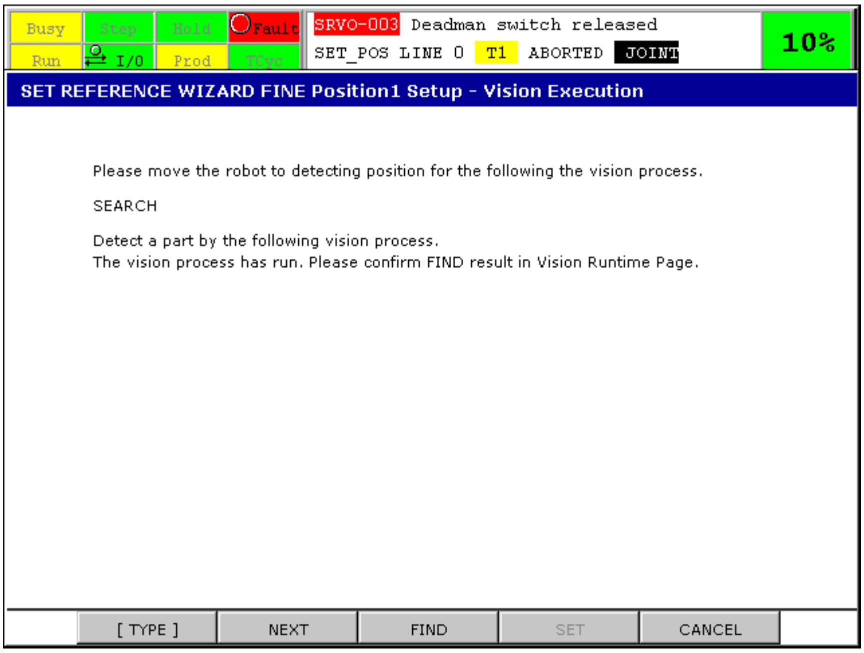
The following screen is displayed by pressing the [Start Set Reference Wizard] button. Then, press F2 NEXT to start the Set Reference Wizard after confirming the setup procedures.



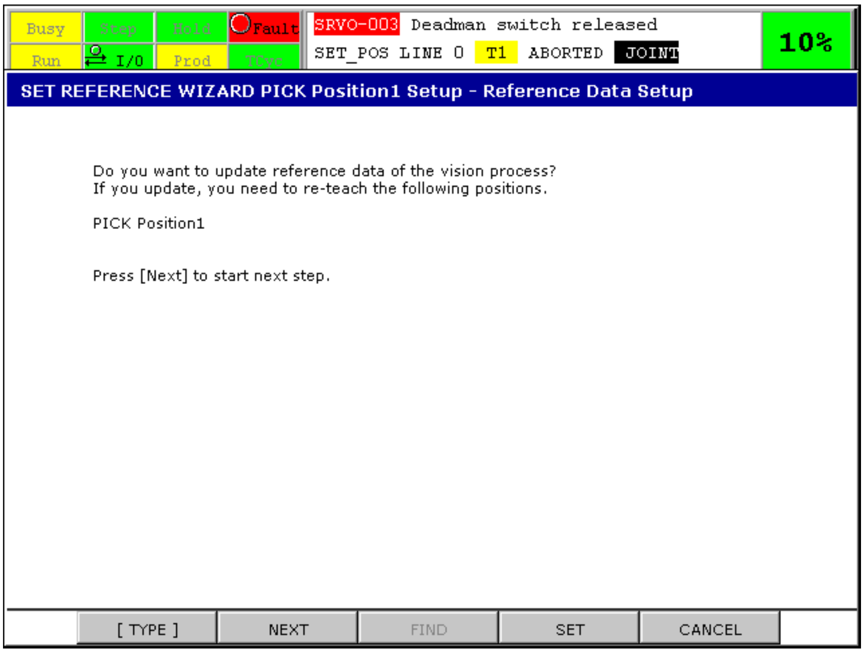
Then, the following screen to execute a vision process is displayed. Press F3 FIND after moving the robot outside of the container.



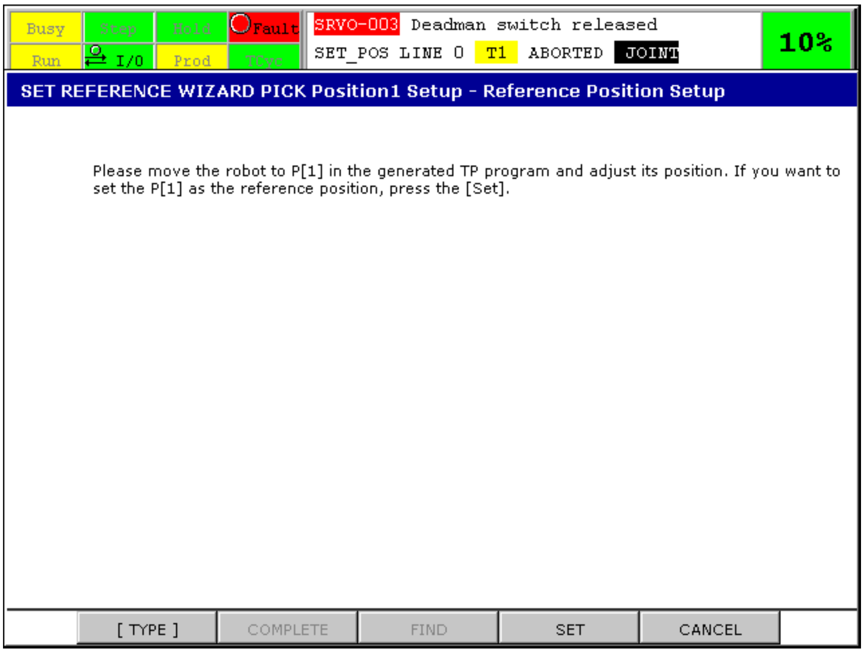
Then, the message "The vision process has run. Please confirm FIND result in Vision Runtime Page" is displayed as follows. Press F2 NEXT after confirming that the vision process finds part correctly.



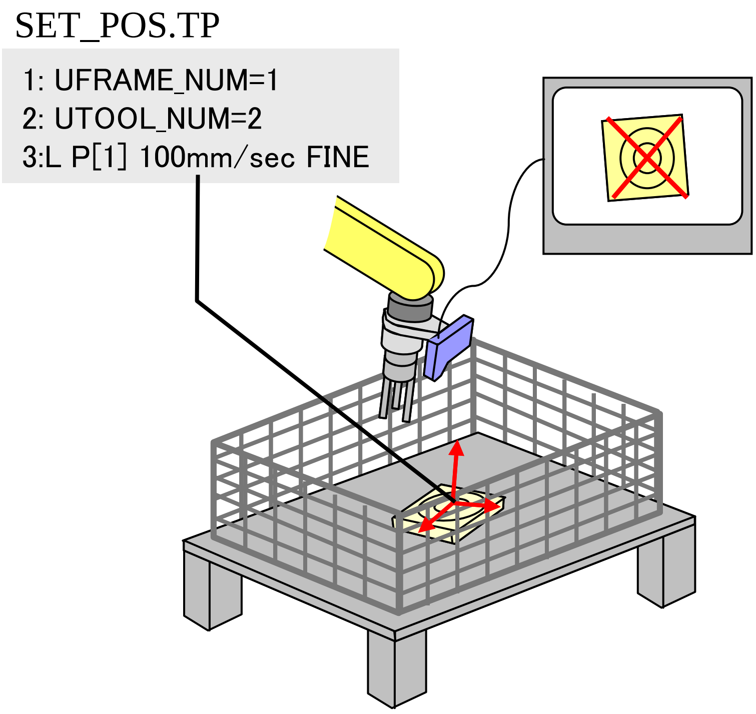
Then, the following screen to set the reference data of the Vision Process is displayed. Press F2 Next after pressing F4 SET to set the reference data of it.



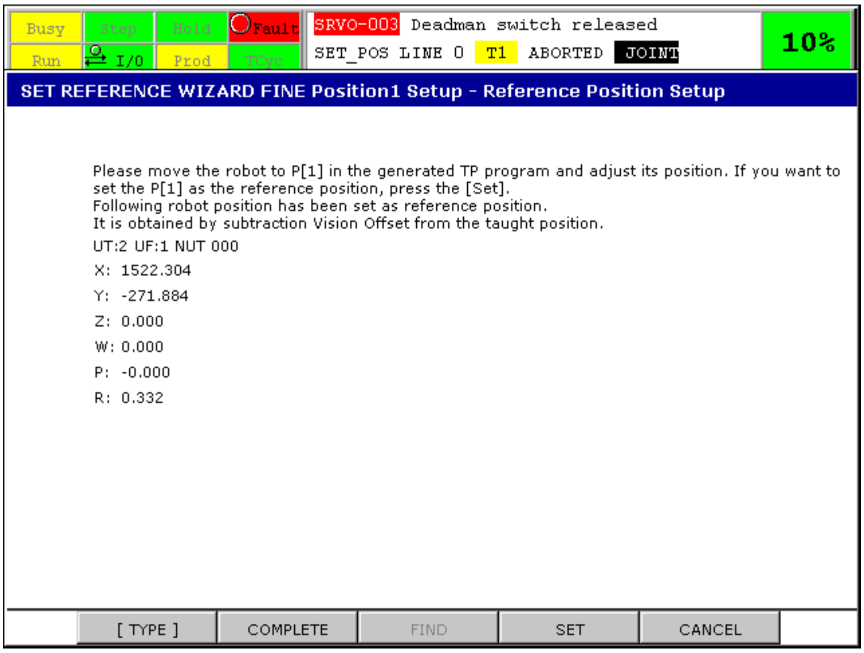
The following screen to set the reference PICK position is displayed.



And then, the following TP program, which is "SET_POS.TP", is automatically generated. Move the robot to the P[1] in the SET_POS.TP by executing the TP Program. The P[1] is automatically set to a found position of the SEARCH Vision Process in the laser frame, which is a position that the cross of the laser is located at the center of the image snapped by the 3D Laser Vision Sensor. If the cross of the laser is not located at the center of the image, move the robot with tool mode along the Z-axis.



Press F4 SET to set the reference FINE position after confirming that the P[1] is an appropriate position to execute the FINE Vision Process. The set reference FINE position is displayed as follows.

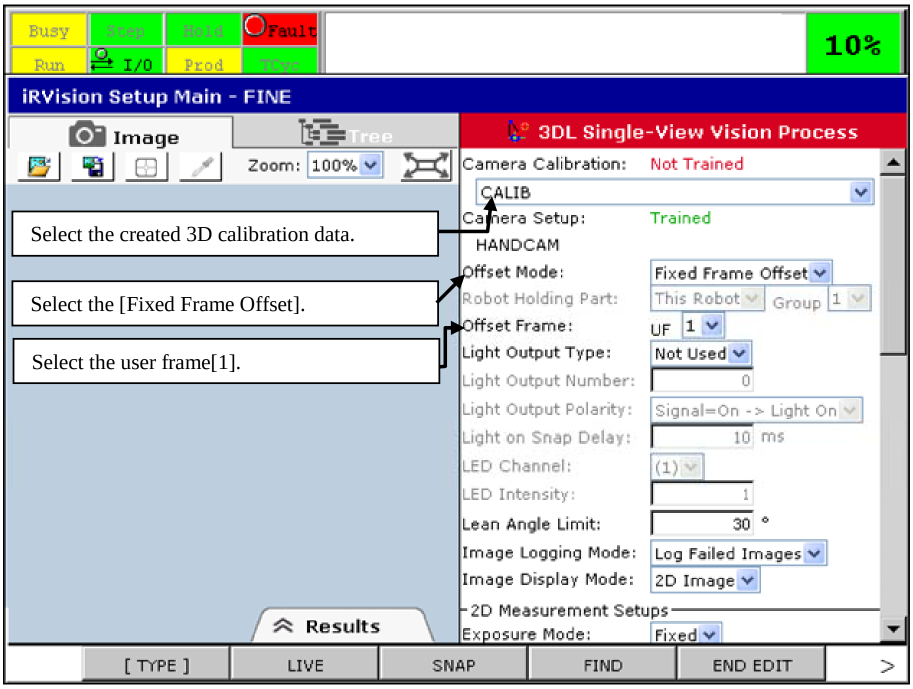


Press F2 COMPLETE after confirming that the set reference FINE position is correct.

4.3.13 FINE Vision Process Setup

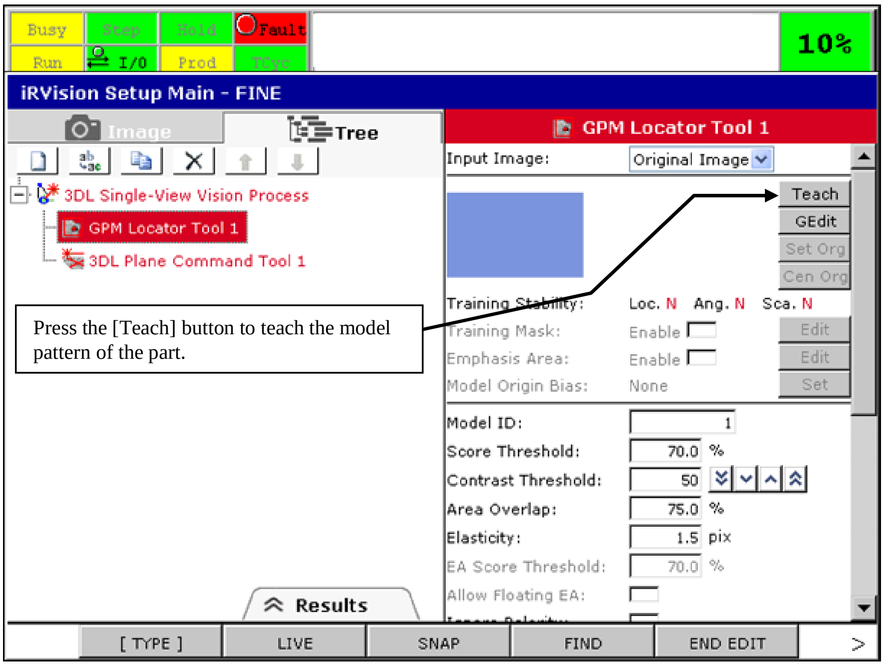
Creating a FINE Vision Process and Setting the Parameters

Create a 3DL Single-View Vision Process data, and set the following parameters.



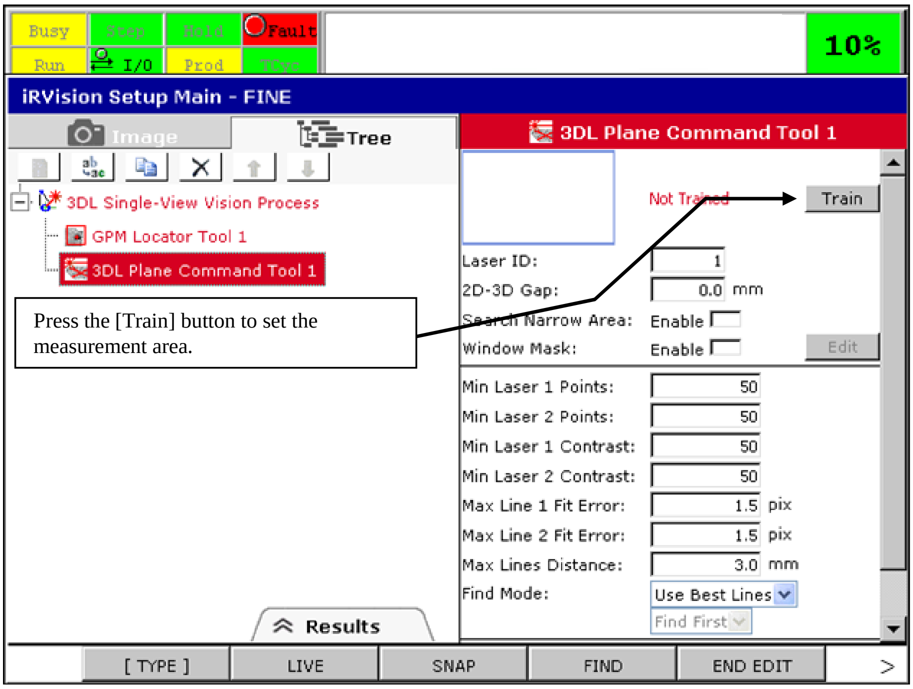
Teaching the GPM Locator Tool

On the tree view of the 3DL Single-View Vision Process, select the [GPM Locator Tool 1] and teach it. For setup procedures of the GPM Locator Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR’S MANUAL (Reference)".



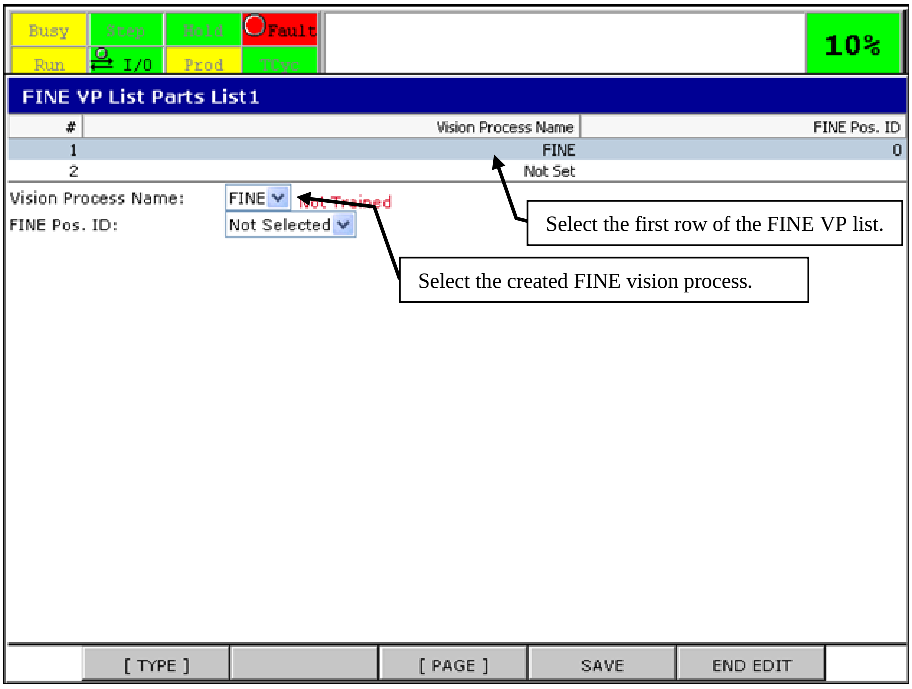
Teaching the 3DL Plane Command Tool

On the tree view of the 3DL Single-View Vision Process, select the [3DL Plane Command Tool1] and teach it. For setup procedures of the 3DL Plane Command Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



Setting the FINE VP List

Set the created FINE vision process to the FINE VP list in the Parts List Manager. On the FINE VP List setup screen of the Parts List Manager of Part List[1], set the following parameters.

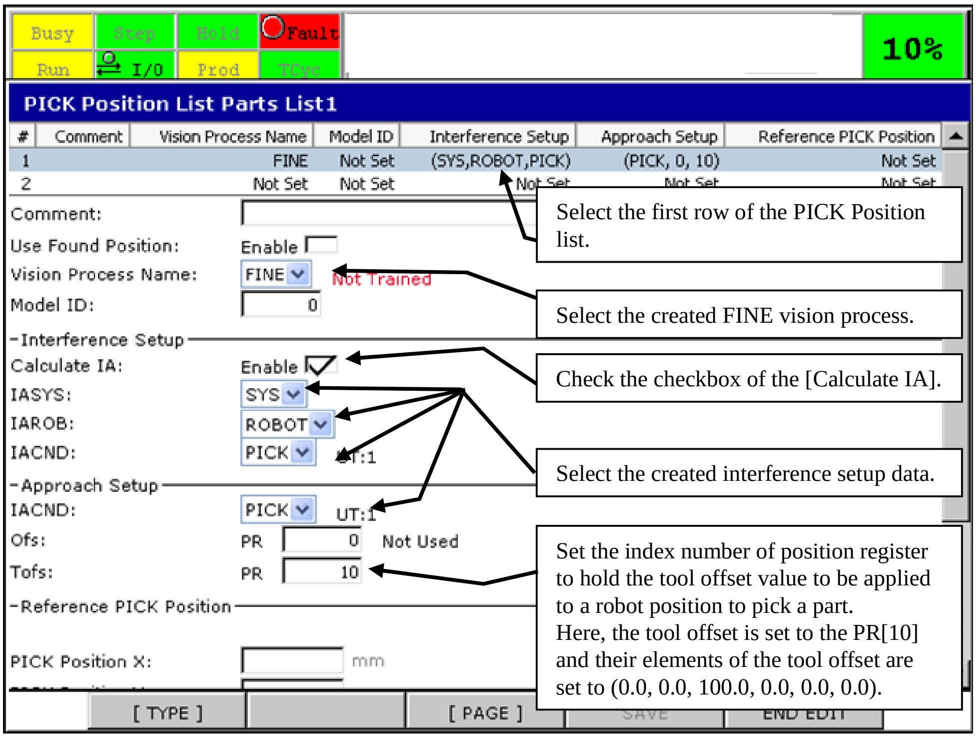


4.3.14 Reference PICK Position Setup

Teach the reference position to pick the part and set it to the PICK Position List in the Parts List Manager.

Setting Parameters

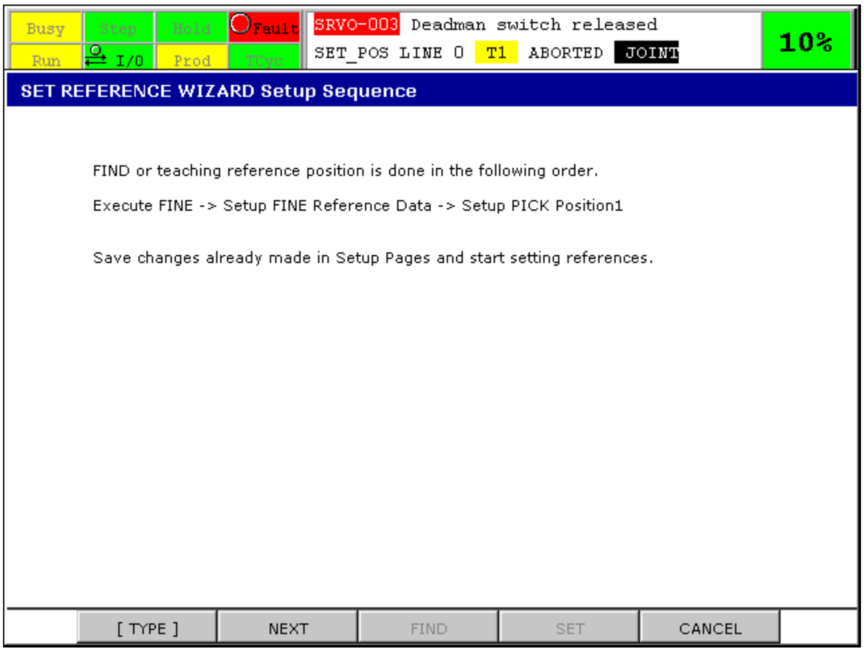
On the PICK Position List setup screen of the Part List Manager of Part List[1], set the following parameters.



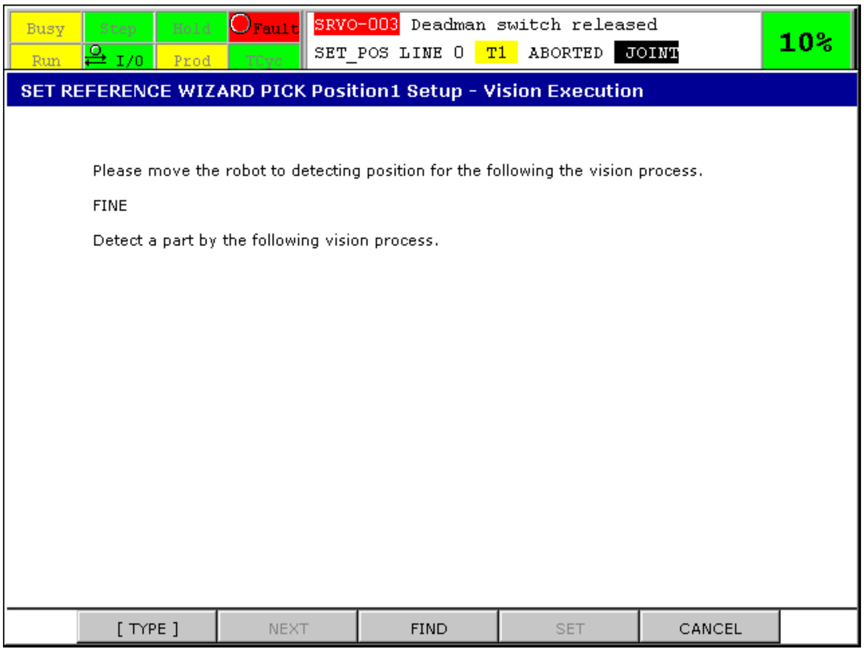
Teaching the Reference PICK position and Setting the Reference Data of the FINE Vision Process

Teach the reference PICK position and Set the reference data of the FINE Vision Process by pressing the [Start Set Reference Wizard] button.

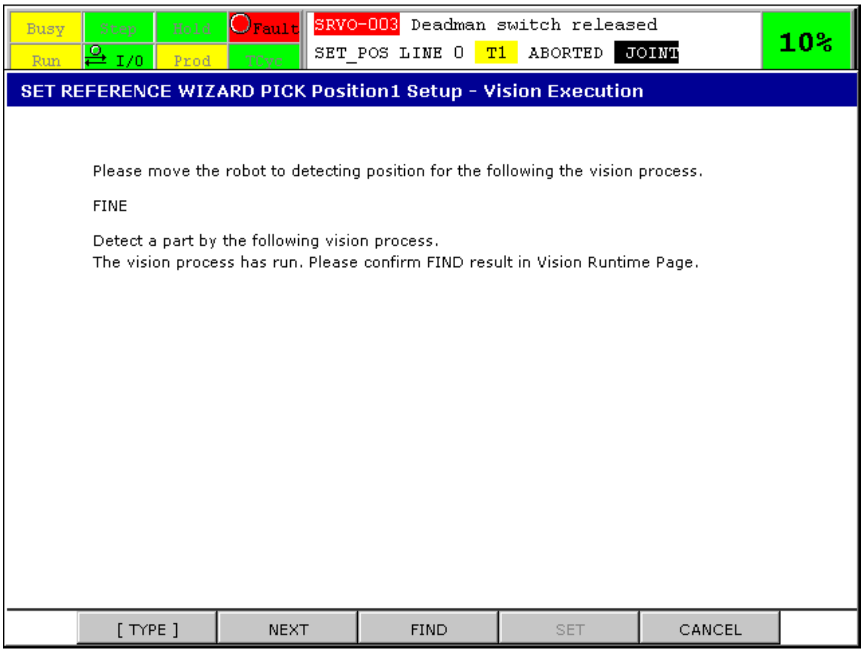
The following screen is displayed by pressing the [Start Set Reference Wizard] button. Then, press F2 NEXT to start the Set Reference Wizard after confirming the setup procedures.



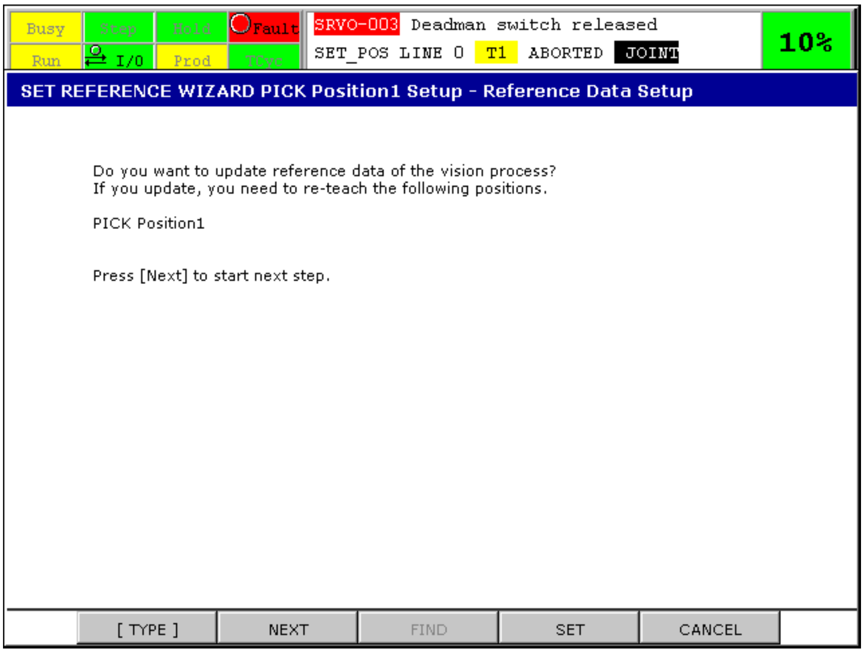
Then, the following screen to execute a vision process is displayed. Press F3 FIND after moving the robot to execute the FINE vision process.



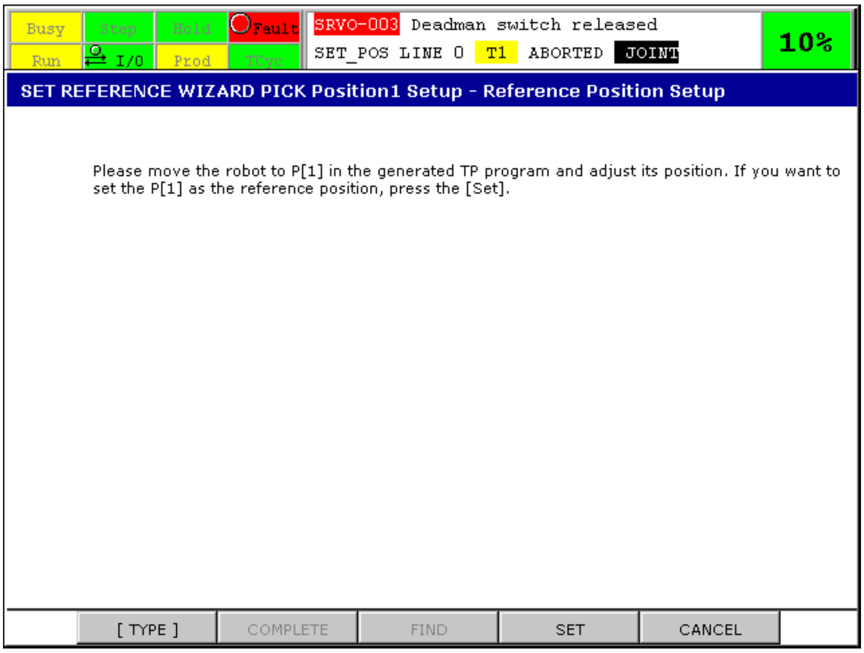
Then, the message "The vision process has run. Please confirm FIND result in Vision Runtime Page" is displayed as follows. Press F2 NEXT after confirming that the vision process finds part correctly.



Then, the following screen to set the reference data of the Vision Process is displayed. Press F2 Next after pressing F4 SET to set the reference data of it.



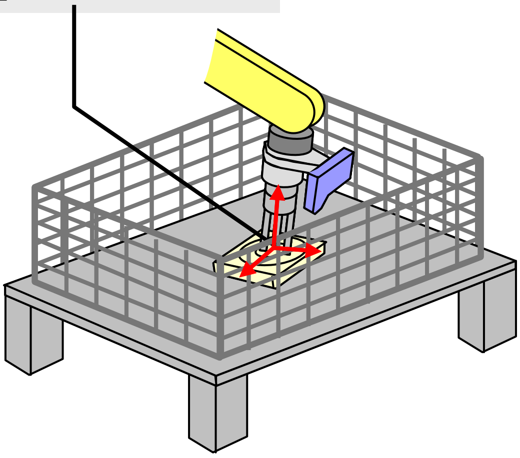
The following screen to set the reference PICK position is displayed.



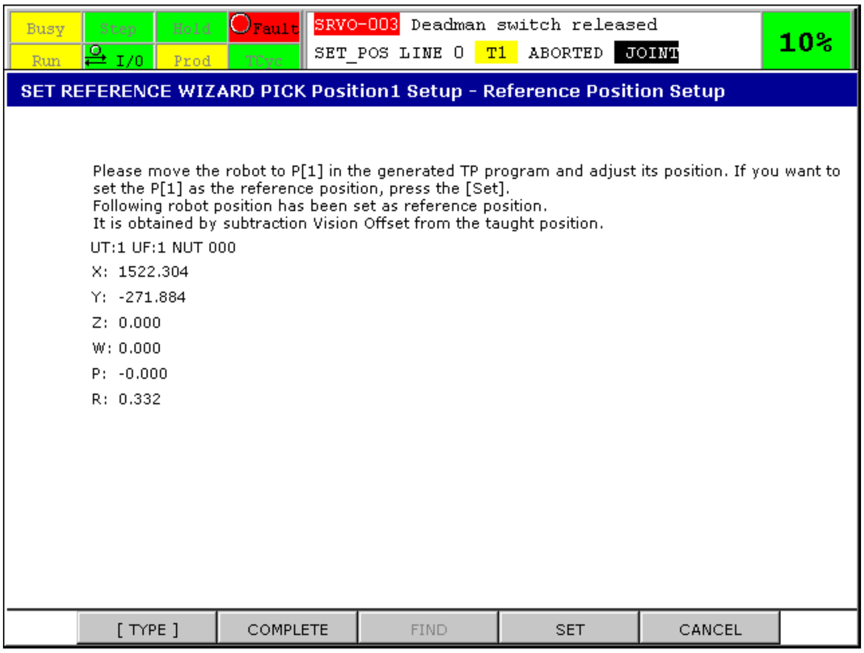
And then, the following TP program, which is "SET_POS.TP", is automatically generated. Move the robot to the P[1] in the SET_POS.TP by executing the TP Program. The P[1] is automatically set to the found position of the FINE Vision Process. Confirm that the found position is on a point of a part by moving the robot to the P[1].

SET_POS.TP

```
1: UFRAME_NUM=1
2: UTOOL_NUM=1
3:L P[1] 100mm/sec FINE
```



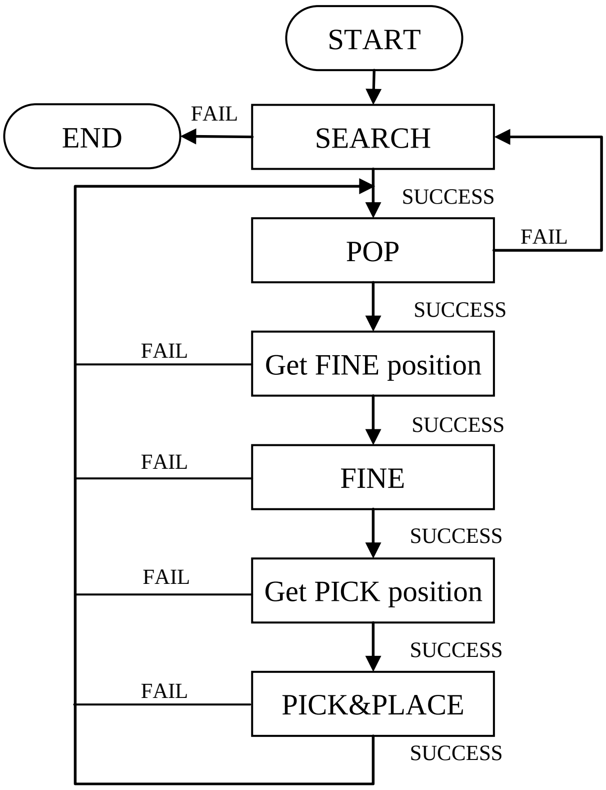
Press F4 SET to set the reference PICK position after confirming that the P[1] is an appropriate position to pick a part. If the P[1] is set to inappropriate position to pick a part, adjust the P[1]. The set reference PICK position is displayed as follows.



Press F2 COMPLETE after confirming that the set reference PICK position is correct.

4.3.15 Creating TP Program

Create a TP program for the Bin picking system with 3D Laser Vision Sensor. The flow chart of the TP program is as follows.



Then, the following TP programs use the following registers, position registers, vision registers and tool frame and user frame.

BIN_PICKING.TP

The following TP program is a sample program for the Bin Picking System with 3D Laser Vision Sensor. For description of the KAREL Programs such as IMSEARCH.PC, refer to Chapter 7, "Parts List Manager Reference".

Table of Registers

R[10]	The status of the SEARCH Vision process 0: SUCCESS (Some new part data are added to a Parts List) 1: FAIL (No Part Data is added to a Parts List)
R[11]	The status of POP 0: SUCCESS 1: FAIL (Any Part Data is not popped from a Parts List)
R[12]	The Model ID of the popped Part Data
R[13]	The status of the process to get a FINE position 0: SUCCESS 11: Failed to get a FINE position
R[14]	The status of the process to get a PICK position 0: SUCCESS 11: Fail
R[15]	The Model ID of the FINE found result
R[16]	The status of the process to get a PICK position 0: SUCCESS 12: Failed to get a PICK position 13: Failed to get a position to approach a part (approach position)

Table of Position Register

PR[20]	Result of interference avoidance for the FINE position (avoidance position)
PR[21]	Result of interference avoidance for the FINE position (tool offset value)
PR[22]	Result of interference avoidance for the PICK position (avoidance position)
PR[24]	Result of interference avoidance for the approach position (avoidance position)
PR[25]	Result of interference avoidance for the approach position (tool offset value)

Table of Tool frame

UTOOL[1]	The TCP of the gripper
UTOOL[2]	Laser frame

Table of User frame

UFRAME[1]	Application frame

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  CALL BINPICK_CLEAR (1)
 4:
 5:  ! SEARCH
 6:  LBL[1]
 7:L P[1] 2000mm/sec FINE
 8:  CALL BINPICK_SEARCH(1,1,10)
 9:  IF R [10]<>0,JMP LBL[999]
10:
11:  ! POP
12:  LBL[2]
13:  CALL BINPICK_POP(1,11,12)
14:  IF R[11]<>0,JMP LBL[1]
15:
16:  ! Get FINE position
17:  CALL BINPICK_GETFINEPOS(1,1,13,20,21)
18:  IF R[13]=0,JMP LBL[3]
19:
20:  CALL BINPICK_SETSTAT(1,12)
21:  JMP LBL[2]
22:
23:  ! FINE
24:  LBL[3]
25:  UTOOL_NUM=2
26:L P[2] 2000mm/sec CNT100
27:L PR [20] 2000mm/sec FINE
28:  CALL BINPICK_FINE(1,1,14,15)
29:  UTOOL_NUM=1
30:  IF R[14]=0,JMP LBL[4]
31:
32:  CALL BINPICK_SETSTAT(1,11)
33:  JMP LBL[2]
34:
35:  ! Get PICK position
36:  LBL[4]
37:  CALL IMGETPICKPOS(1,1,16,22,23,24)
38:  IF R[16]=0,JMP LBL[5]
39:
40:  CALL BINPICK_SETSTAT(1,22)
41:  JMP LBL[2]
42:
43:  ! PICK
44:  LBL[5]
45:L PR[24] 2000mm/sec CNT50
46:L PR[22] 500mm/sec FINE
47:  ! Insert program instructions to grasp the part.
48:  CALL BINPICK_SETSTAT(1,20)
49:
50:  ! PLACE
51:L P[3] 1000mm/sec CNT100 INC
52:J  P [4] 100% CNT100
53:L P[5] 1000mm/sec CNT100  TOOL_OFFSET, PR [23]
54:L P[6] 200mm/sec FINE TOOL_OFFSET, PR[23]
55:  ! Insert program instructions to place the part.
56:L P[5] 2000mm/sec FINE  TOOL_OFFSET, PR [23]
57:
58:  JMP LBL[2]
59:
60:  LBL[999]
61:J P [5] 100% FINE
```

- Specify the user frame set in Subsection 4.3.3, “User Frame Setup” (line 1)
- Execute a SEARCH vision process to find some parts. (line 8)
- If any part can not be found, terminate the process. (line 9)
- If any part data can not be popped from the parts list, go to the process to execute the vision process. (line 14)
- If the calculation of a robot position to execute a FINE vision process fails, go to the process to pop next part data. (line 18)
- Execute a FINE vision process to measure 3D position of the part. (line 28)
- If the FINE process fails, go to the process to pop next part data. (line 33)
- If the calculation of a position to pick up a part fails, go to the process to pop next part data. (line 38)
- Execute the process to pick up a part. (line 47)
- Move upward from the position to pick up the part. (line 51)
- Place the picked part after compensating with an offset calculated by the interference avoidance function. (line 53)
- Execute a process to place a part. (line 55)
- After placing a part, go to the process to pop next part data. (line 58)

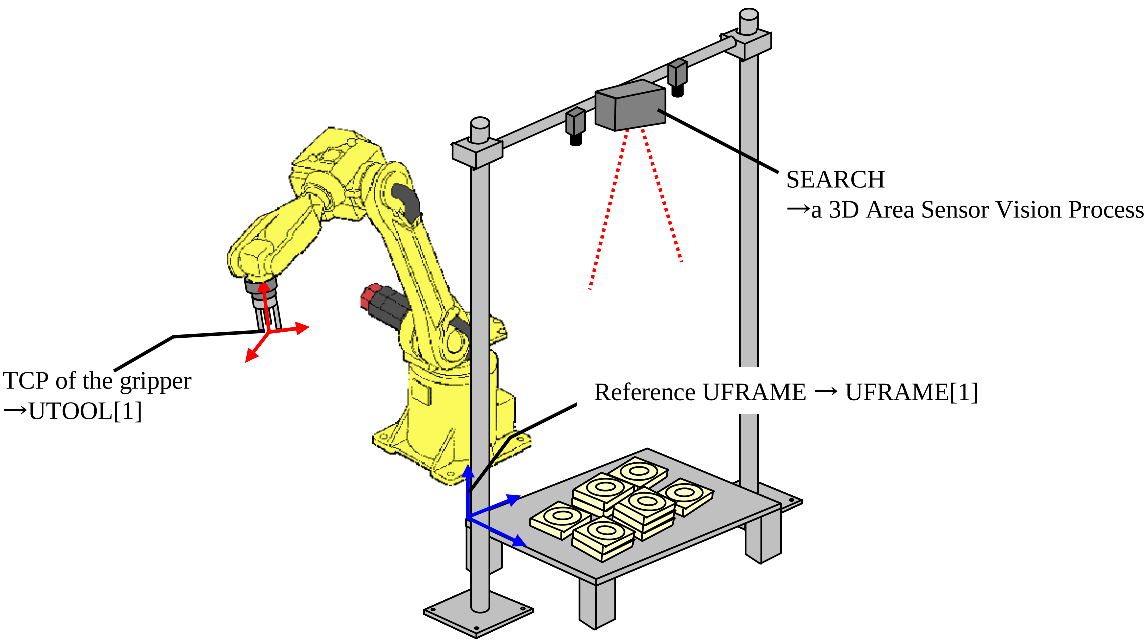
4.3.16 Robot Compensation Operation Check

Check that a part gripped by the robot can be detected and positioned precisely at a desired location.

- Place the part on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting.
- Move the part without rotation, find it and check the handling accuracy.
- Rotate the part, find it and check the handling accuracy.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

4.4 FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR

Described below is the procedure of setting up a fixed frame system with 3D Area Sensor.



The setup procedures are as follows.

4.4.1 Installation and Connection of 3D Area Sensor

Installation of 3D Area Sensor

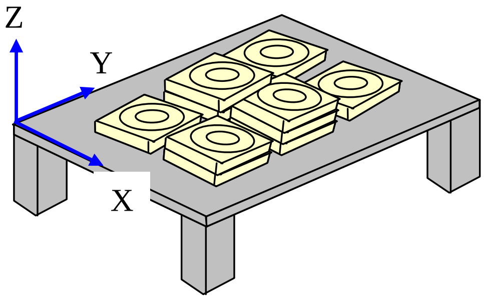
Install the 3D Area Sensor on the camera mount. See Chapter 7, "3D AREA SENSOR REFERENCE" to refer the layout of the 3D Area Sensor.

Connecting the 3D Area Sensor

Connect the 3D Area Sensor to a robot controller. For details, refer to Section 2.6 in the "R-30*i*B/R-30*i*B Mate CONTROLLER Sensor Mechanical Unit/Control Unit OPERATOR'S MANUAL".

4.4.2 User Frame Setup

Set the user frame which is the reference frame of an offset data calculation. Set it on the stand surface which parts are put as described below. For setup procedures of user frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".



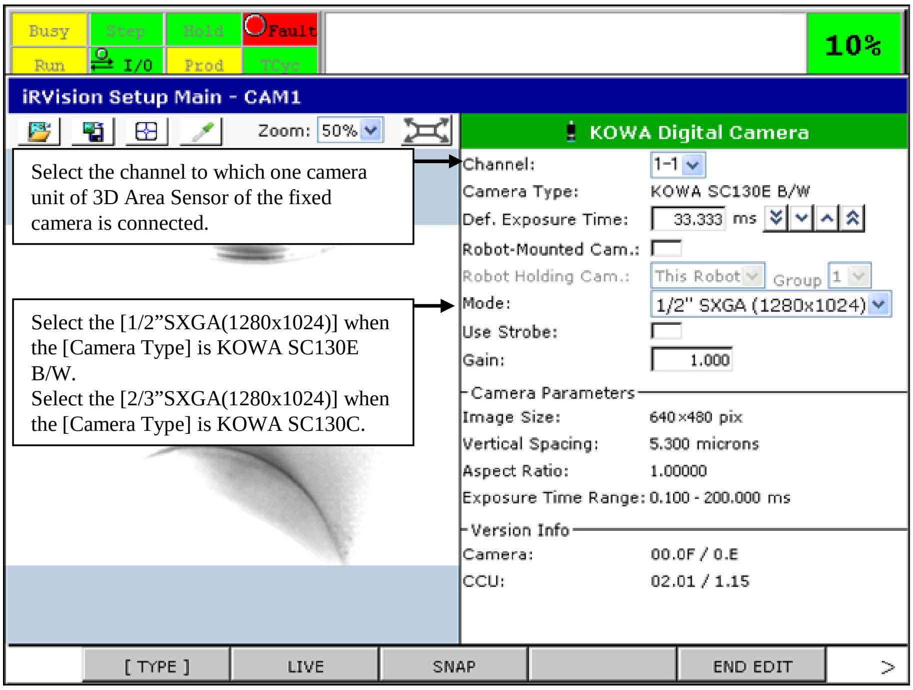
Here, set the user frame to UFRAME[1] as described in Section 4.4, "FIXED FRAME SYSTEM WITH 3D AREA SENSOR".

4.4.3 3D Area Sensor Setup

Set the camera data of the two camera units in KOWA digital camera type.

Creating two Camera Data

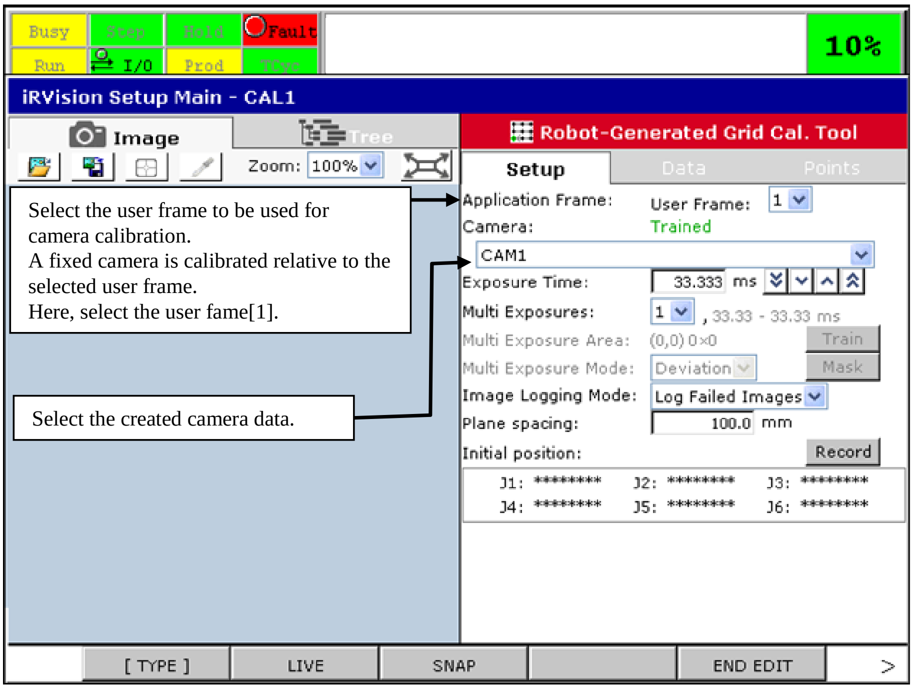
Create a KOWA Digital Camera data, and set the following parameters.



For the other camera of the 3D Area Sensor, do the above same procedures.

Creating two Calibration Data

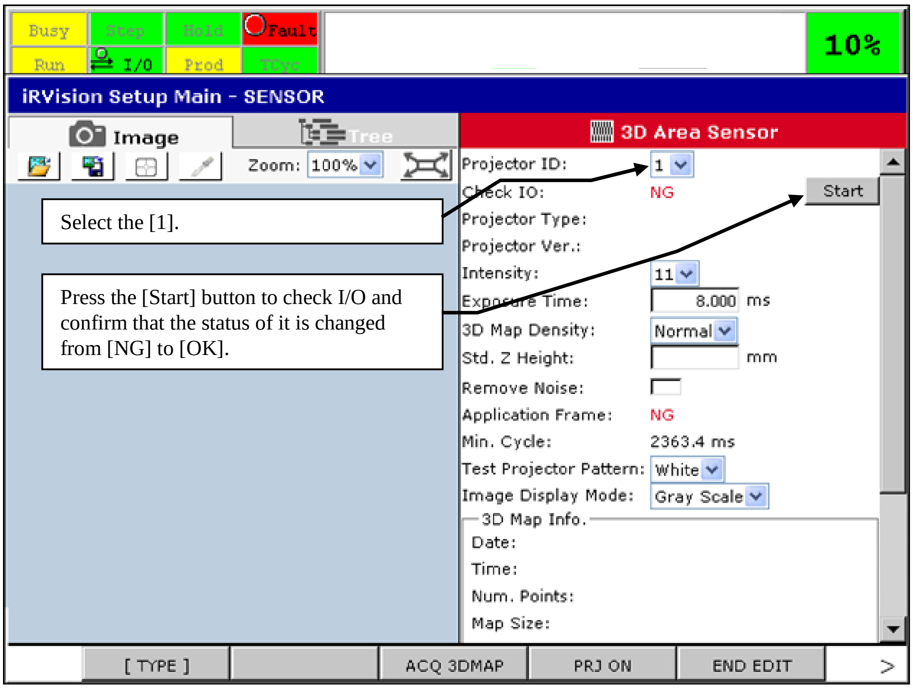
Create a Robot-Generated Grid Calibration data, and set the following parameters.

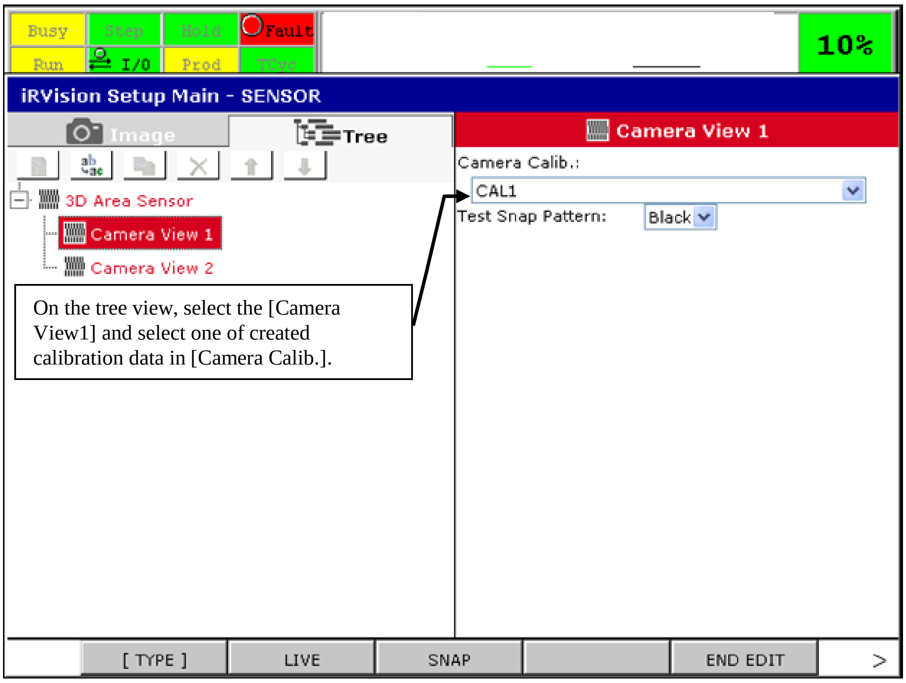


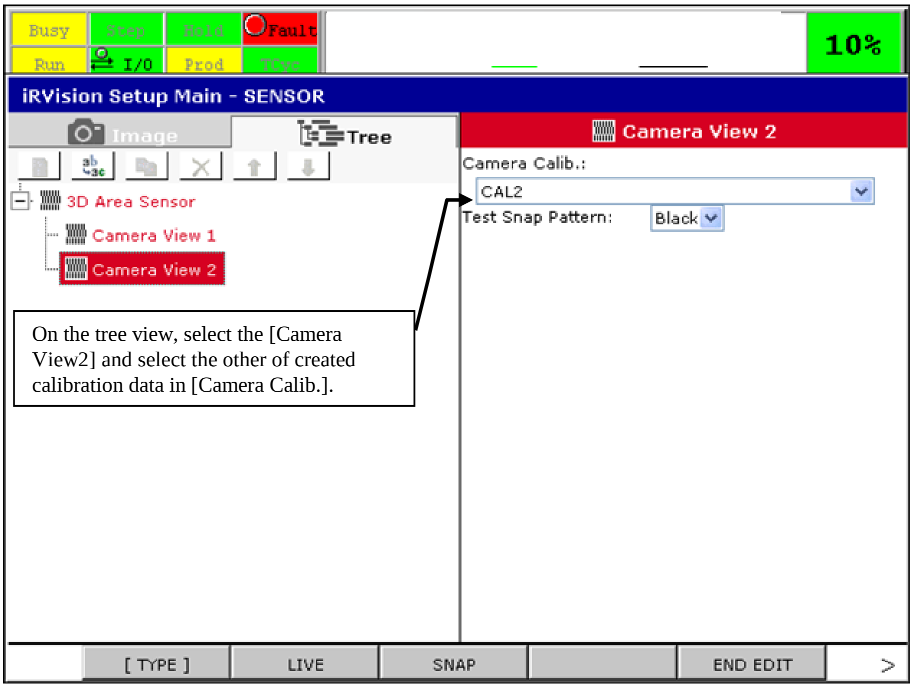
For the other camera of the 3D Area Sensor, do the above same procedures.

Creating a 3D Area Sensor Data and Setting the Parameters

Create a 3D Area Sensor data, and set the following parameters to adjust layout.







Adjusting the Layout of the 3D Area Senor

Adjust the layout of the 3D Area Sensor. For detail, refer to Subsection 7.4.1 "Adjusting the Layout of 3D Area Sensor".

Adjusting the focus of the Projector Unit of the 3D Area Senor

Adjust the focus of the projector unit of the 3D Area Sensor. For detail, refer to Subsection 7.4.2 "Adjusting the Focus of the Projector Unit ".

Adjusting the focus of the Camera Units of the 3D Area Senor

Adjust the focus of the camera units of the 3D Area Sensor. For detail, refer to Subsection 7.4.3 "Adjusting the Focus of the Camera Units ".

Calibrating the Camera Units

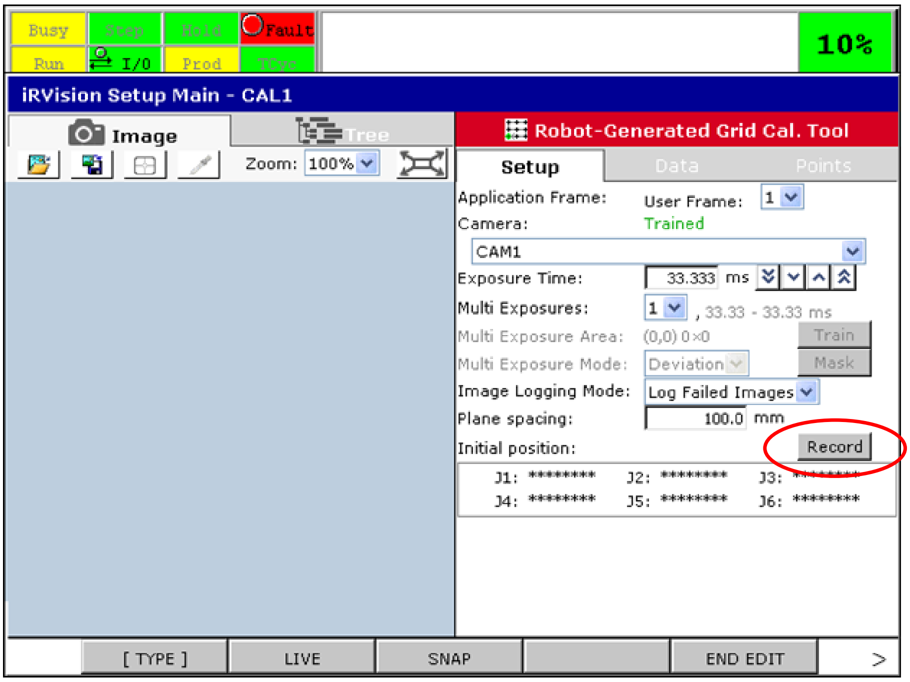
Calibrate the two camera units of the 3D Area Sensor in the following procedures. For detail of each procedure, refer to Section 6,1 "Robot-Generated Grid Calibration".

Mounting the Target

The function moves the target, mounted on the robot end of arm tooling, in the camera's field of view to Make sure that the target does not get blocked by the robot arm or the tooling while the robot moves in the camera's field of view.

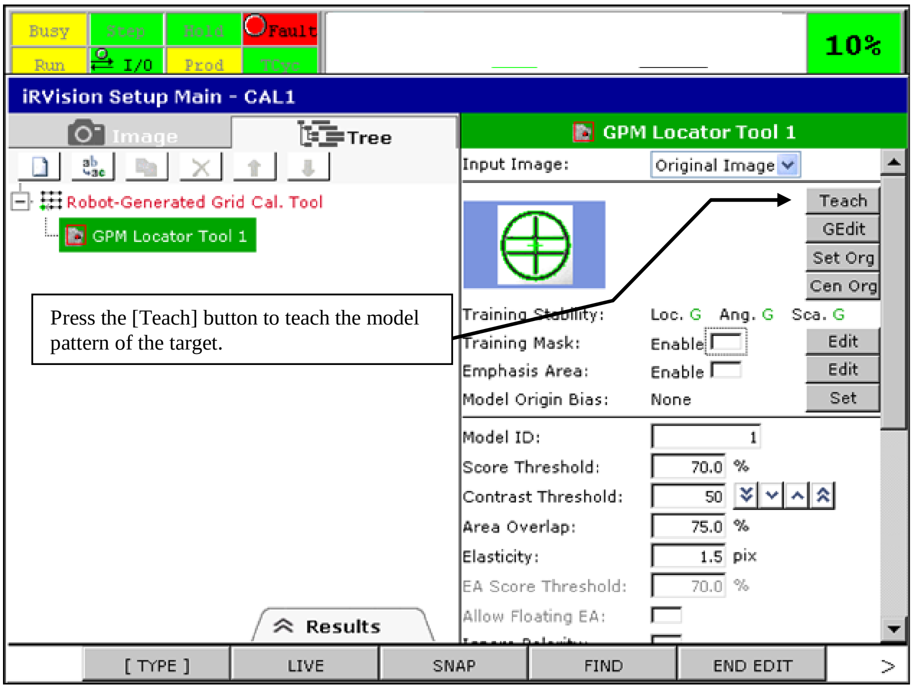
Teaching the Initial Position

Open one of calibration data. In the [Initial Position], set the current robot position as the starting position to measure the target position. The starting positions should be set as the robot gripper is about the center of FOV.



Teaching the GPM Locator Tool

With the target located at the starting position set in the [Initial Position], select the [GPM Locator Tool1] on the tree view and teach the model pattern of the target.

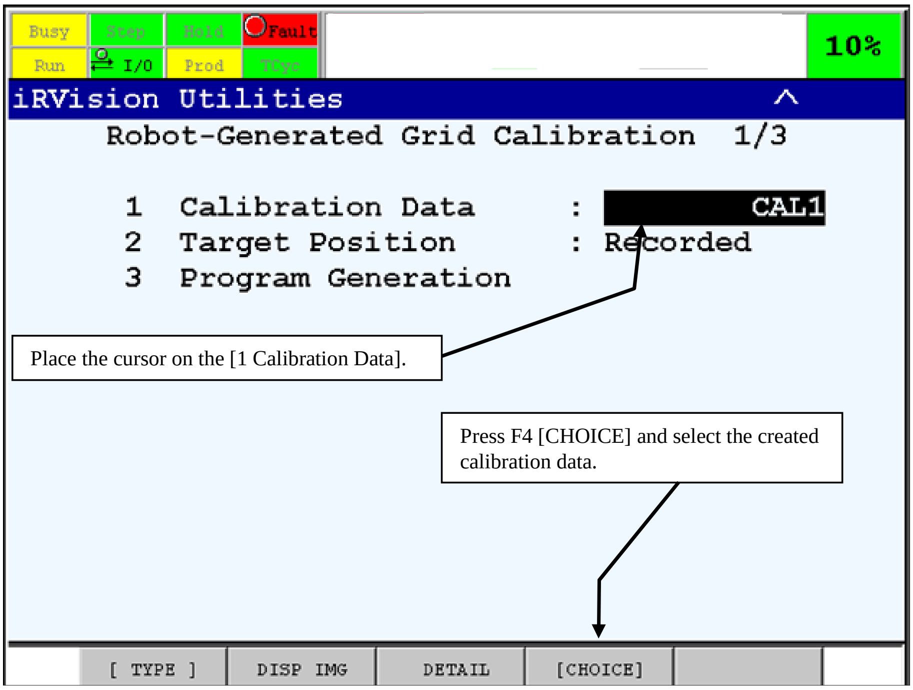


> ⚠ **CAUTION**
> After setting the calibration data, press F5 END EDIT to close the setup page. If the calibration setup page is opened, the Robot-Generated Grid Calibration fails to measure the target position.

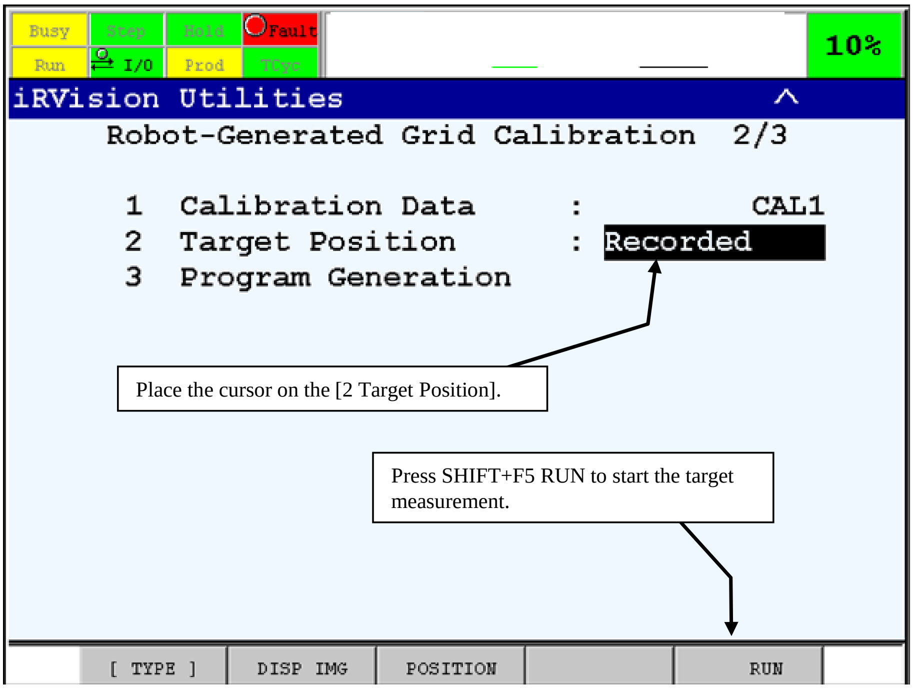
Measuring Target Position

Visit the [Robot-Generated Grid Calibration] in the iRVision > Vision Utility Menu.

Select the calibration data in the following procedures.

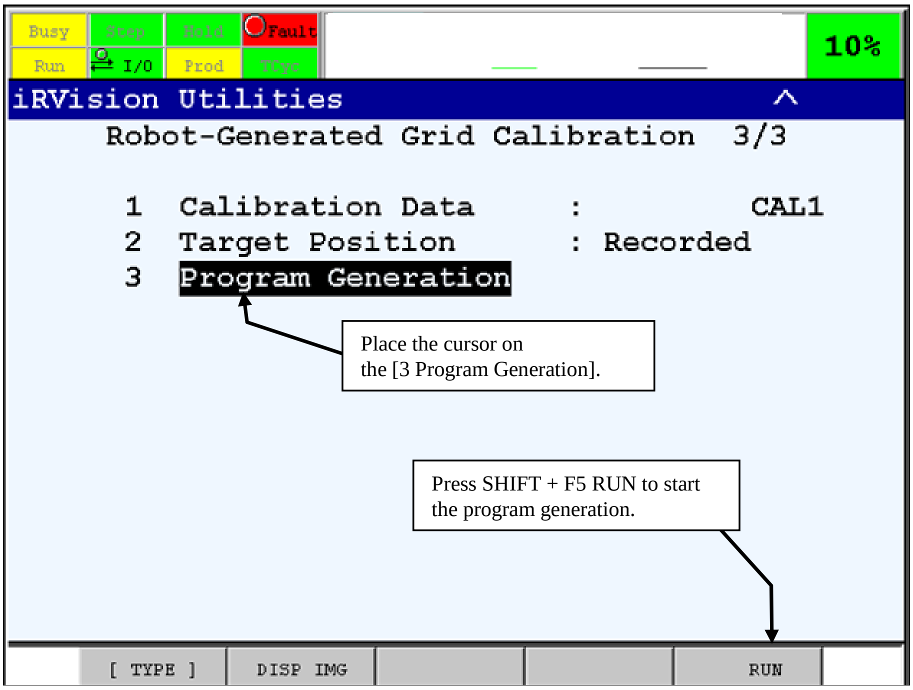


Measure the target position in the following procedures.



Generating Calibration Program

Generate a calibration program in the following procedures.

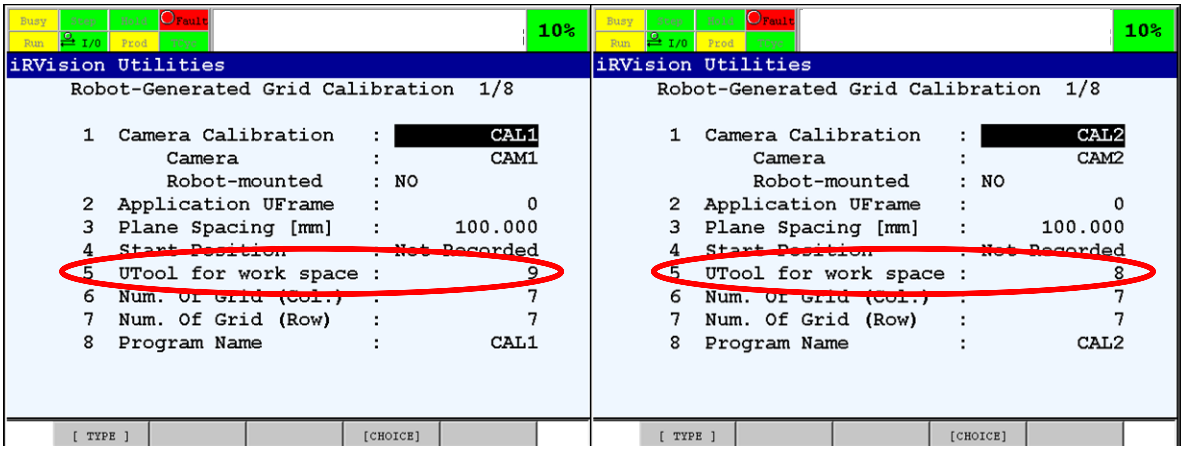


Executing Calibration Program

Select the generated calibration program in the SELECT menu, and play it back from first line to calibrate camera.

Do the same procedure on the other calibration data. Then calibration of 2 camera units is completed.

If the installation of the target has reproducibility, set the set different tool frame index for each calibration data as follows. As long as the position where the target is mounted remains unchanged, you can re-calibrate the camera by executing the generated calibration program.

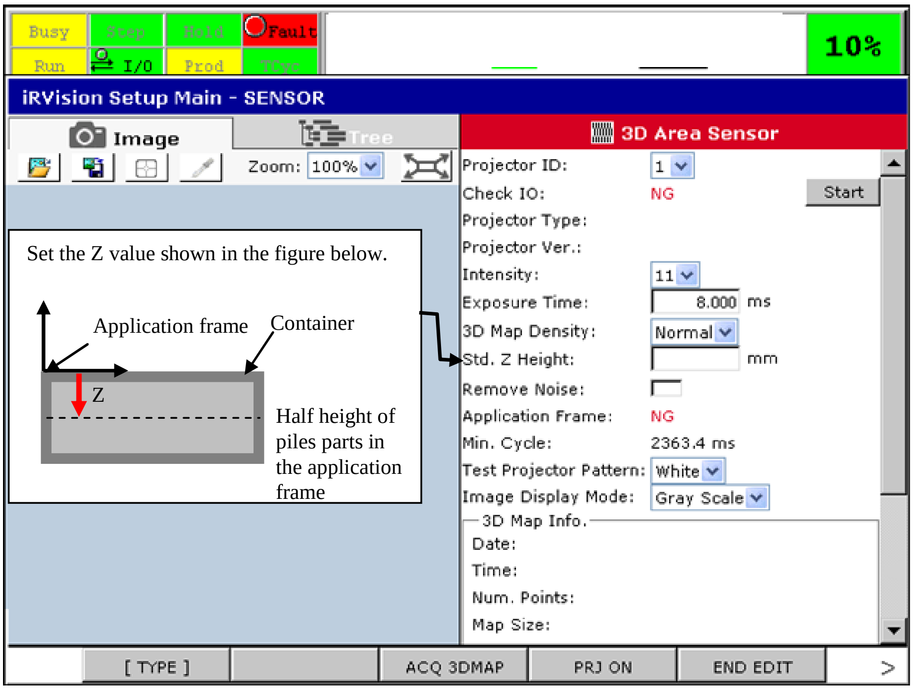


Checking the Calibration Data

Check that the calibration result is correct. To check the calibration data, refer to Subsection6.1.6 "Camera Calibration Checking".

Teaching of condition of acquiring 3D Map

Open the 3D Area Sensor data and set the following parameter.



Confirm that a 3D map is acquired correctly by pressing F3 ACQ 3DMAP. If there is an area that 3D points are not acquired, adjust the [Exposure Time] and the [Intensity] by referring to Subsection 7.4.4 "Adjusting the Condition of Acquiring 3D Map".

4.4.4 Tool Frame Setup

TCP of the Gripper

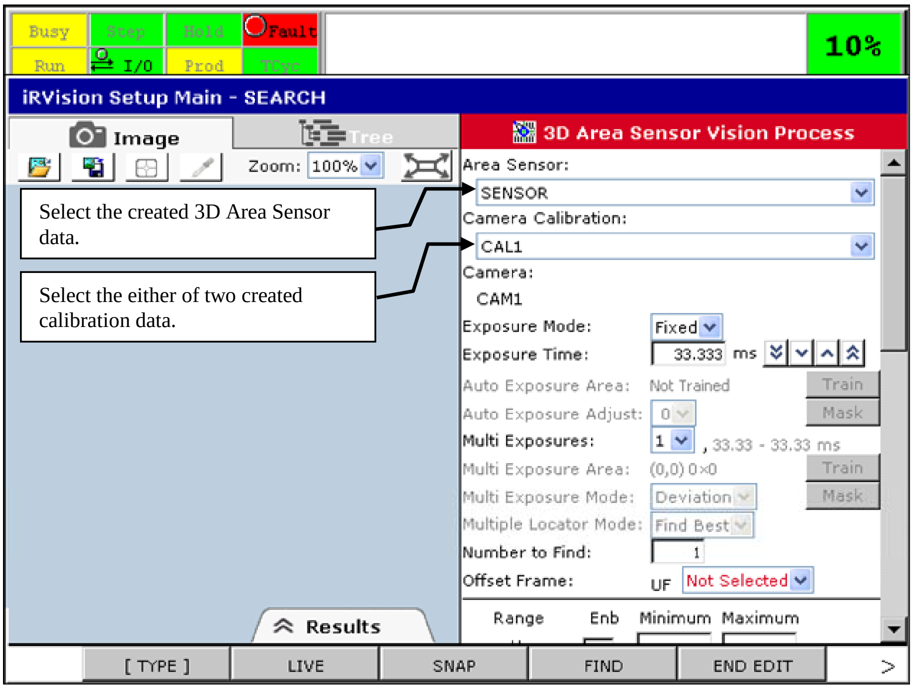
Set the tool frame on the TCP of the end of robot gripper. This frame is useful for ensuring that the TCP of the gripper is moved to the part pick position when fixed frame offset or interference avoidance is applied to the part pick position. The Z-axis of this frame should be set along the direction in which the robot proceeds and retreats as it picks up a part. For setup procedures of tool frame, refer to Chapter 5 "FRAME SETUP REFERENCE ".

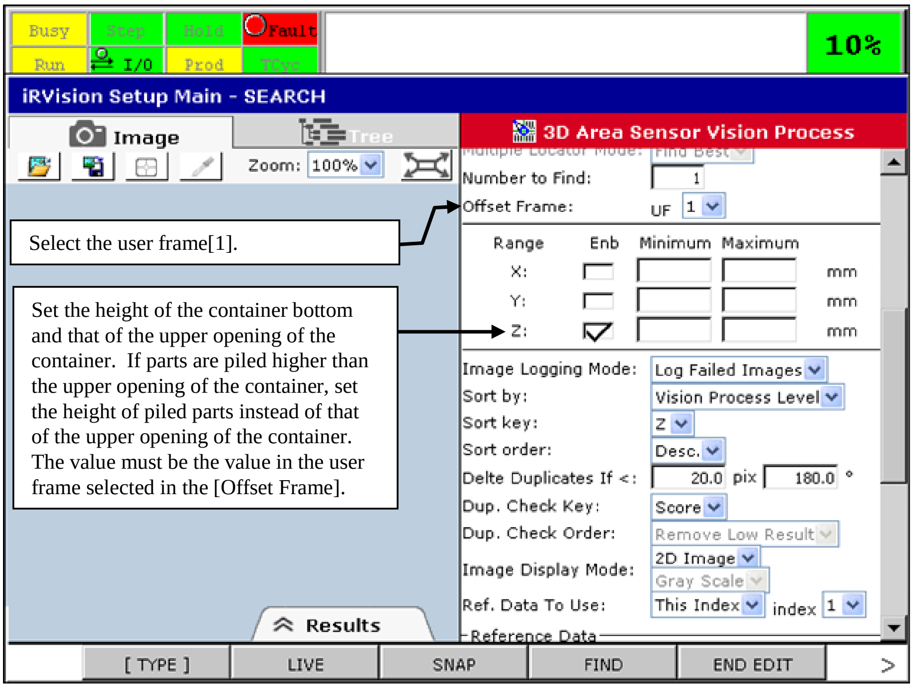
Here, set the tool frame to UTOOL [1] as described in Section 4.4, "FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR".

4.4.5 SEARCH Vision Process Setup

Creating a Vision Process and Setting Parameters

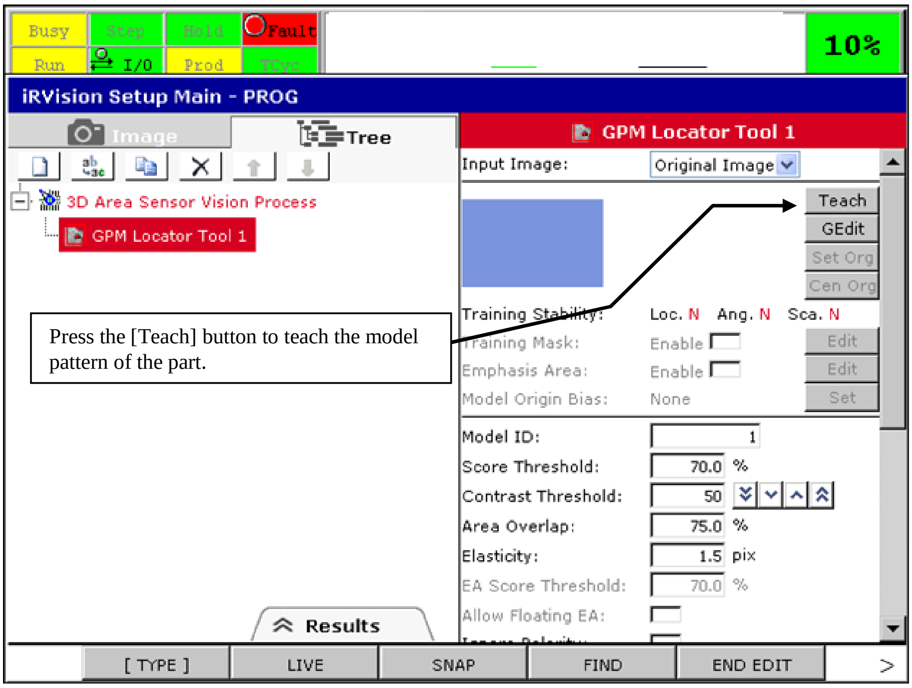
Create a 3D Area Sensor Vision Process, and set the following parameters.





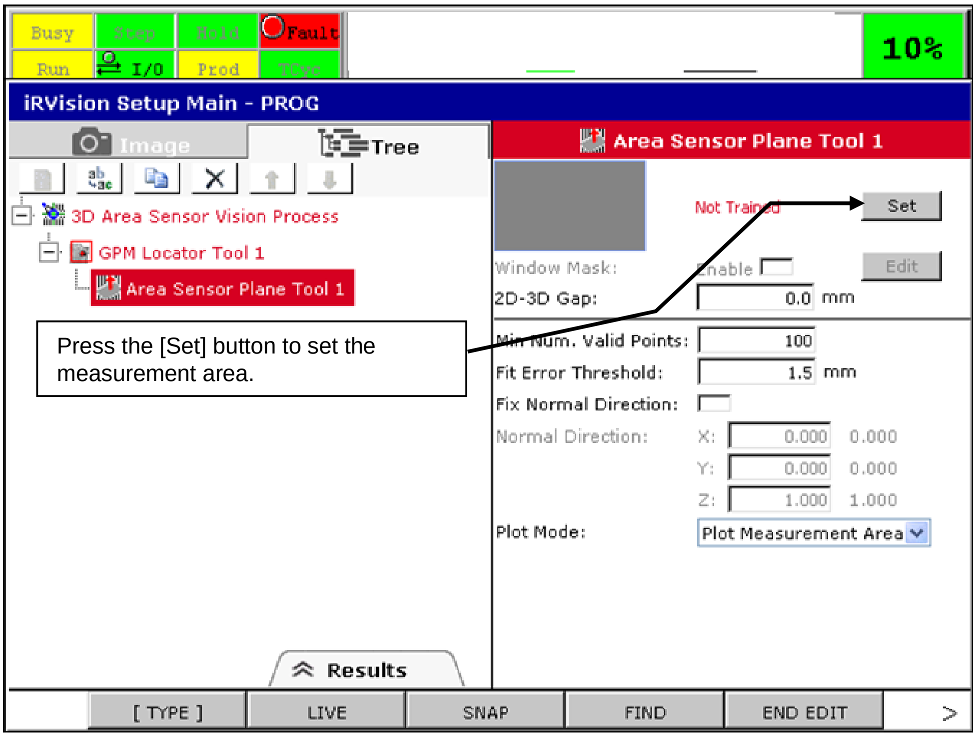
Teaching the GPM Locator Tool

On the tree view of the 3D Area Sensor Vision Process, select the [GPM Locator Tool 1] and teach it. For setup procedures of the GPM Locator Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



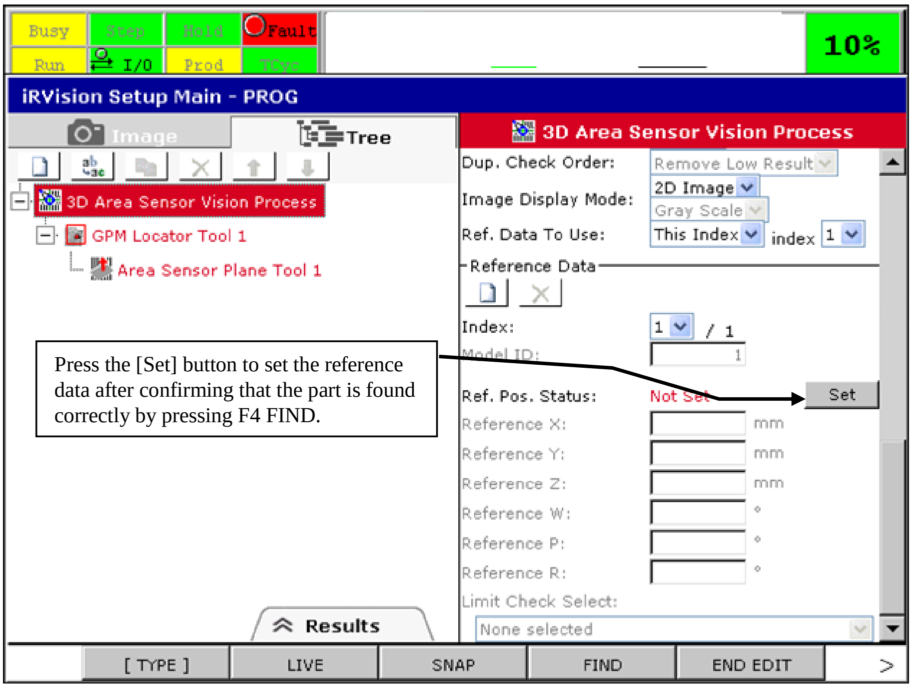
Teaching the Area Sensor Plane Tool

On the tree view of the 3D Area Sensor Vision Process, select the [Area Sensor Plane Tool 1] and teach it. For setup procedures of the Area Sensor Plane Tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



Setting the Reference Data

Select the [3D Area Sensor Vision Process] on the tree view, and set the reference data in the following procedures.

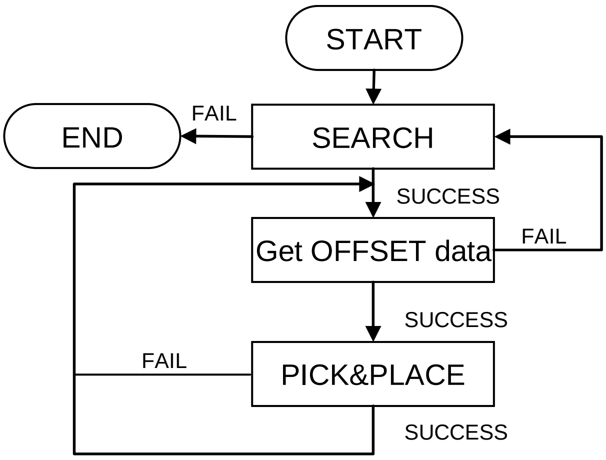


Setting the Reference PICK Position

Set the reference robot position to pick the part. The reference position is compensated with the vision offset outputted by the 3D Area Sensor Vision Process. Here, set the reference position to the PR[10]. (The position register is used in the TP program described below.)

4.4.6 Creating TP Program

Create a TP program for the fixed frame system with 3D Area Sensor. The flow chart of the TP program is as follows.



Then, the following TP programs use the following the registers, position registers, vision registers and tool frame and user frame.

Table of Register

R[1]	The number of parts found by the vision process

Table of Position Register

PR[10]	Reference robot position to pick a part
PR[11]	Tool offset to be applied to a robot position to approach a part.

Table of Vision Register

VR[1]	Found results of the vision process

Table of Tool frame

UTOOL[1]	The TCP of the gripper

Table of User frame

UFRAME[1]	Application frame

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:
 4:  !SEARCH
 5:  LBL[1]
 6:L P[1] 2000mm/sec FINE
 7:  CALL BINPICK_ACQUIRE3DMAP('SENSOR')
 8:  VISION RUN_FIND 'PROG'
 9:  VISION GET_NFOUND 'PROG' R [1]
10:  IF R[1]=0,JMP LBL[999]
11:
12:  LBL[2]
13:  VISION GET_OFFSET 'PROG' VR[1] JMP LBL[1]
14:
15:  !PICK
16:L P[2] 2000mm/sec CNT100
17:L PR[10] 500mm/sec CNT50 VOFFSET, VR[1] Tool_Offset,
PR[11]
18:L PR[10] 300mm/sec FINE VOFFSET, VR[1]
19:  ! Insert program instructions to grasp the part.
20:
21:  !PLACE
22:L P[3] 2000mm/sec CNT100
23:L P[4] 2000mm/sec FINE
24:  !Insert program instructions to place the part.
25:
26:  !Continuous
27:  JMP LBL[2]
28:
29:  !END
30:  LBL[999]
31:J P[5] 100% FINE
32:
```

- Line 1: Specify the user frame set in Subsection 4.4.2 "User Frame Setup."
- Line 7: Acquire a 3D map.
- Line 8: Execute a SEARCH vision process to find some parts.
- Line 10: If any part can not be found, terminate the process.
- Line 13: If the process to get a vision offset fails, go to the process to execute the SEARCH vision process.
- Line 19: Execute the process to pick up a part.
- Line 24: Execute the process to place the part.
- Line 27: After placing the part, go to the process to get next vision offset.

4.4.7 Robot Compensation Operation Check

Check that a part gripped by the robot can be detected and positioned precisely at a desired location.

- Place the part on the reference position, find it and check the handling accuracy. If the accuracy of compensation is low, retry the reference position setting.
- Move the part without rotation, find it and check the handling accuracy.
- Rotate the part, find it and check the handling accuracy.
- Start with lower override of the robot to check that the logic of the program is correct. Next, increase the override to check that the robot can operate continuously.

5 FRAME SETUP REFERENCE

This chapter explains the setup procedures of frame. When an application frame or an offset frame is set, refer to this chapter. Refer to Section 3.9 "SETTING COORDINATE SYSTEMS" in the "R-30iB/ R-30iB Mate CONTROLLER OPERATOR’S MANUAL (Basic Operation) (B-83284EN)" about a general method of frame setting. This chapter explains the following items.

1 Frame Setup with a pointer tool (Section 5.1)
2 Frame with the Automatic Grid Frame Set Function (Section 5.2)

5.1 FRAME SETTING WITH A POINTER TOOL

A user frame or a tool frame is set by physically teaching with a pointer attached on the robot end of the arm tooling or a pointer secured to a secured stand. This section explains the following items.

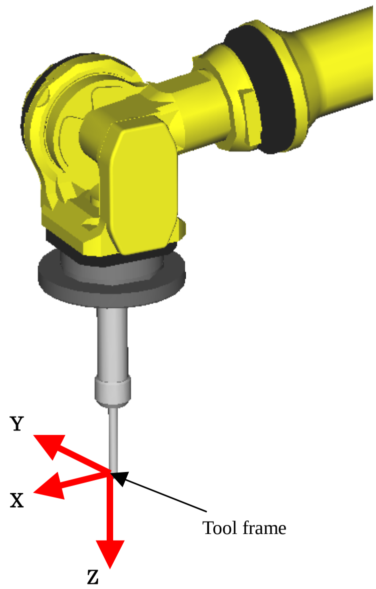
1 User Frame Setup with a pointer tool (Subsection 5.1.1)
2 Tool Frame Setup with a pointer tool (Subsection 5.1.2)

5.1.1 Setting the User Frame with a Pointer Tool

This subsection explains a method for user frame setting on an arbitrary plane with a pointer attached on the robot end of the arm tooling. It is necessary to perform a TCP setup to an arbitrary tool frame number.

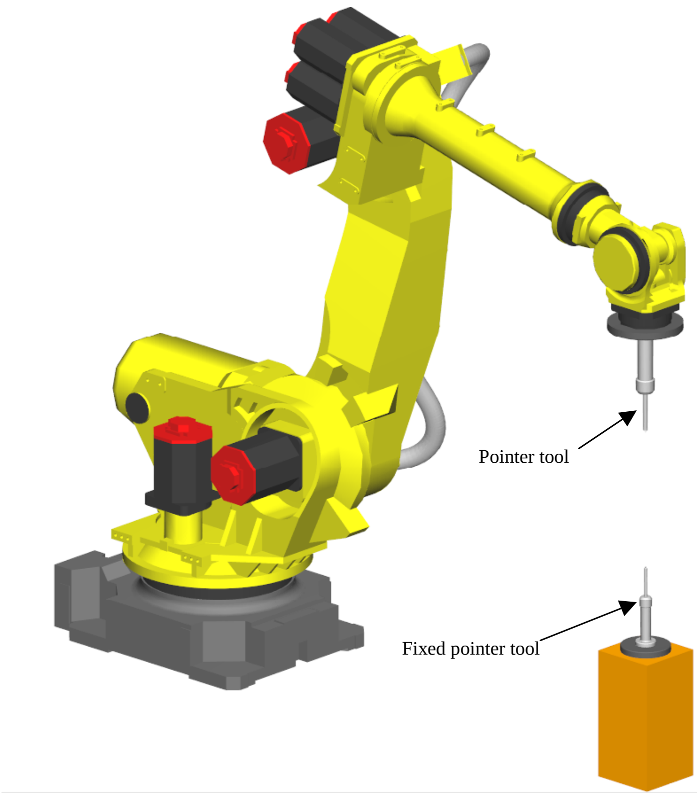
5.1.1.1 Setting a TCP

Attach a pointer tool on the robot end of the arm tooling, and set TCP to an arbitrary tool frame number.



Prepare a pointer tool with a sharp tip. Make sure that the pointer tool is fixed securely to the robot end of arm tooling so that it remains in place while the robot moves. It is recommended that positioning pins or other appropriate means may be used so that the pointer tool can be mounted at the same position. Moreover, prepare another pointer with a sharp tip, and fixed on the table. The position of the fixed pointer on the table is arbitrary. TCP is set up by touch-up the tip of the fixed pointer with the tip of the pointer attached on the robot end of the arm tooling. Use the "Tree point method" for setting a TCP.

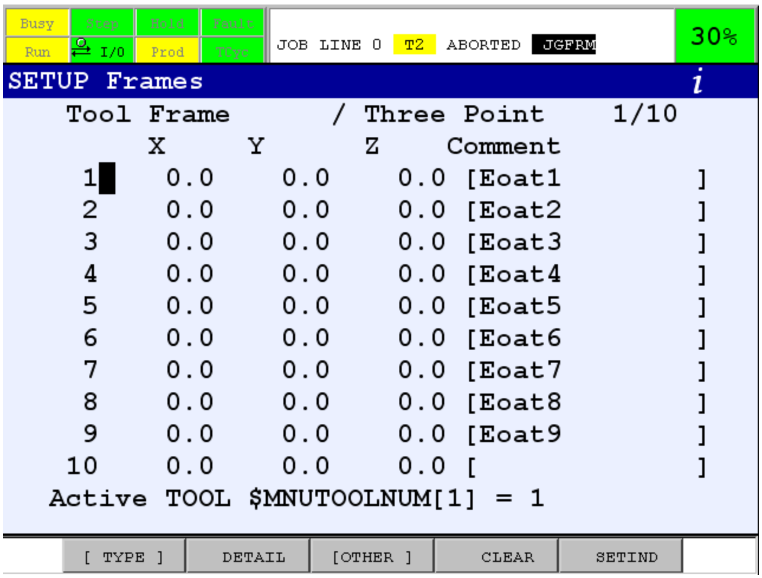
Set the TCP accurately. If the accuracy of this TCP setting is low, the precision in handling of a part by the robot is also degraded.



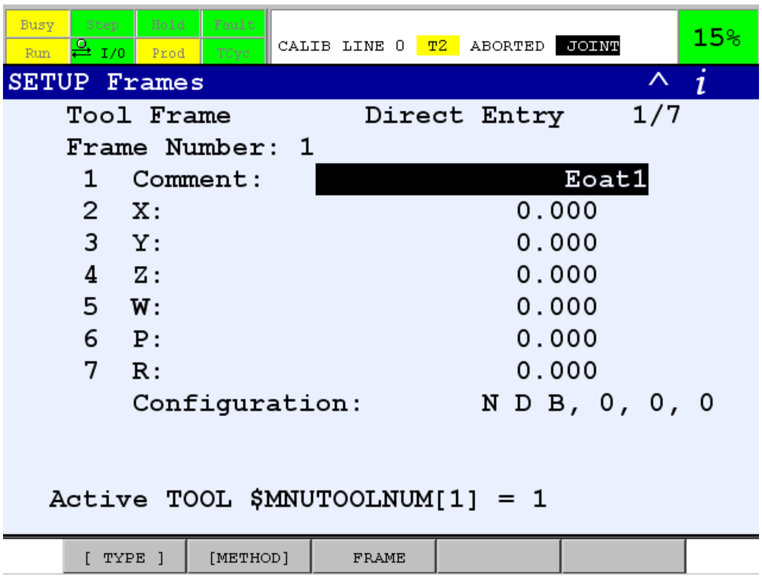
Three Point Method

Use the three point method to define the tool center point (TCP). The three approach points must be taught with the tool touching a common point from three different approach statuses. As a result, the location of TCP is automatically calculated. To set the TCP accurately, three approach directions had better differ from others as much as possible. In the three point method, only the tool center point (x, y, z,) can be set. The setting value of tool orientation (w, p, r) is the standard value (0, 0, 0). It is not necessary that change the (w, p, r) value.

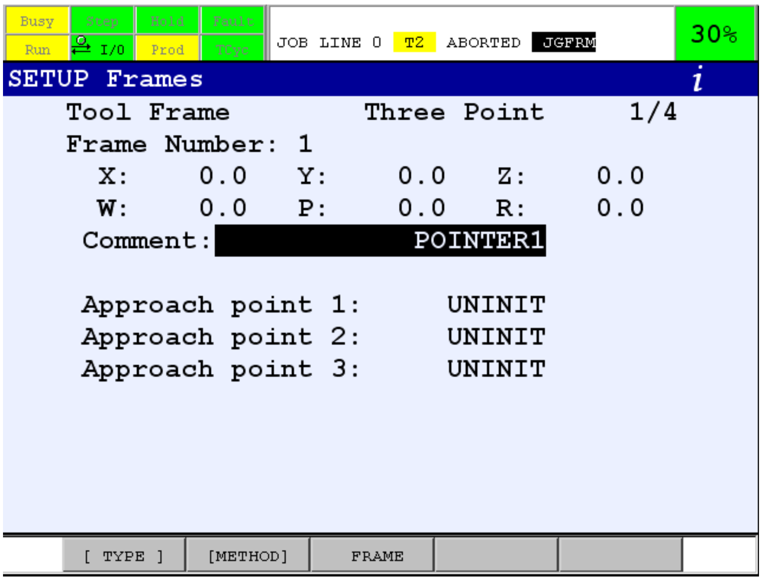
1 Press the MENU key. The screen menu is displayed.
2 Select "6 SETUP"
3 Press the F1 [TYPE]. The screen change menu is displayed.
4 Select Frames.
5 Press F3 [OTHER].
6 Select Tool Frame. Tool frame list screen is displayed.



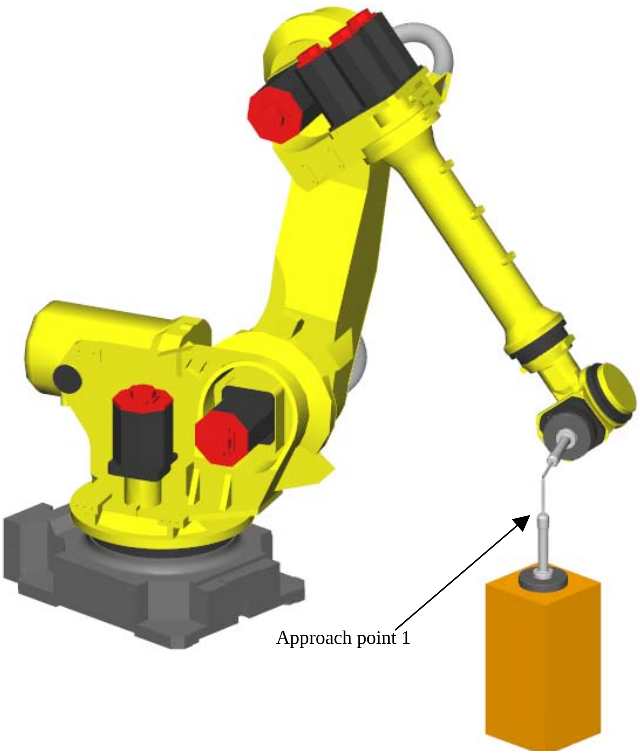
7 Move the cursor to the list of the tool frame number you want to set.
8 Press F2 DETAIL. The tool frame setup screen of the selected frame number is displayed.



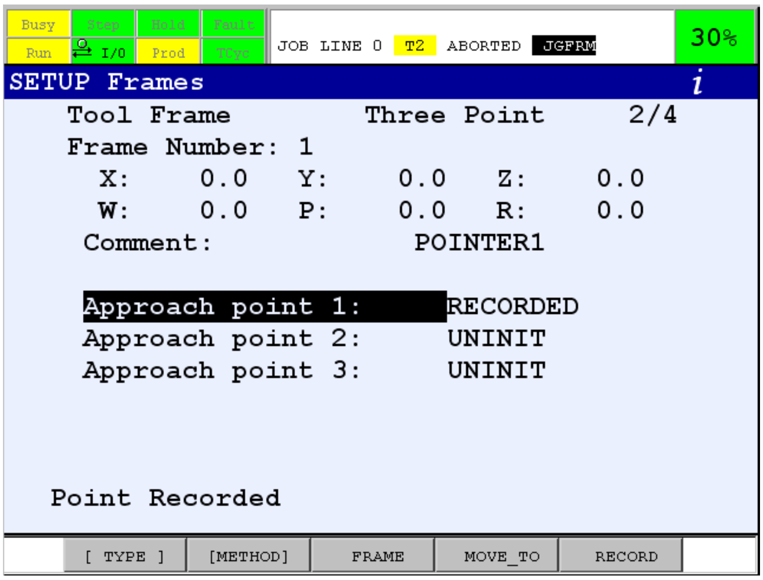
9 Press F2 [METHOD].
10 Select the [Tree Point].



11 It recommends inputting a comment, in order to make it easy to distinguish from other tool frame numbers.
12 Move the cursor to the [Approach point 1].
13 Jog the robot and touch up the fixed pointer with the pointer tool.

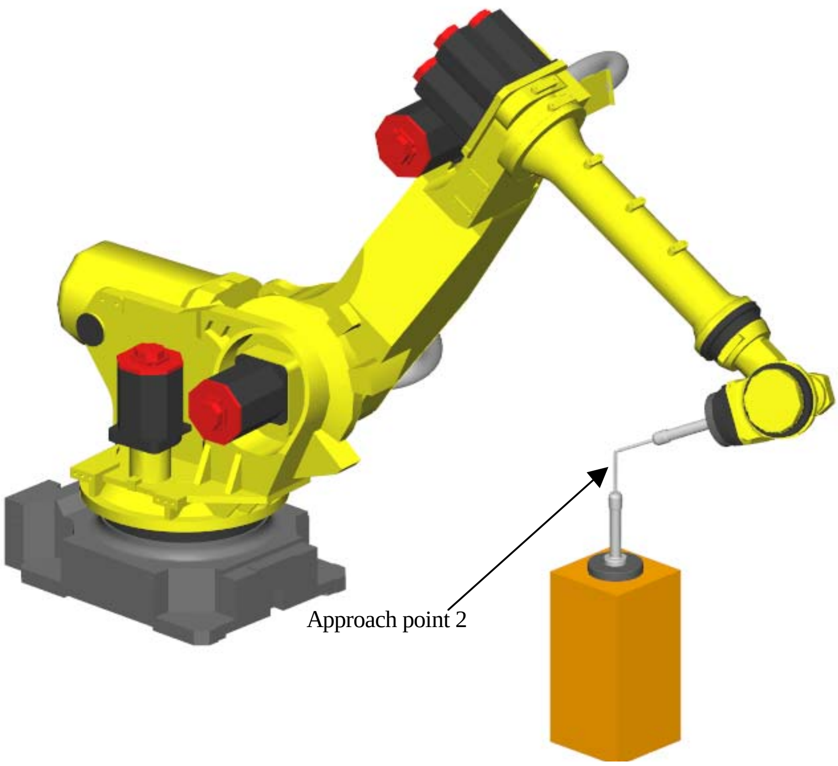


14 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the reference position. As for the taught reference point, RECORED is displayed.

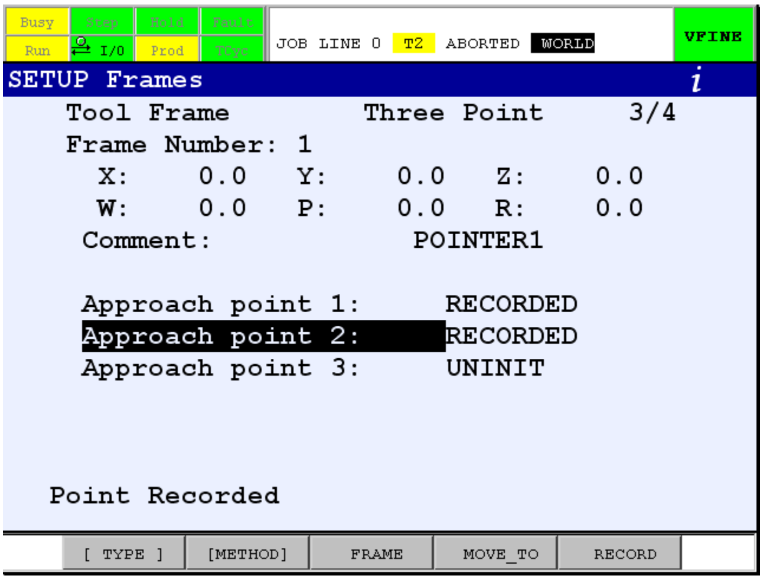


15 Move the cursor to the [Approach point 2].

16 Jog the robot and touch up the fixed pointer with the pointer tool. The position of approach point 2 is same position as the approach point 1. However, the posture of approach point 2 is different from posture of approach point 1.

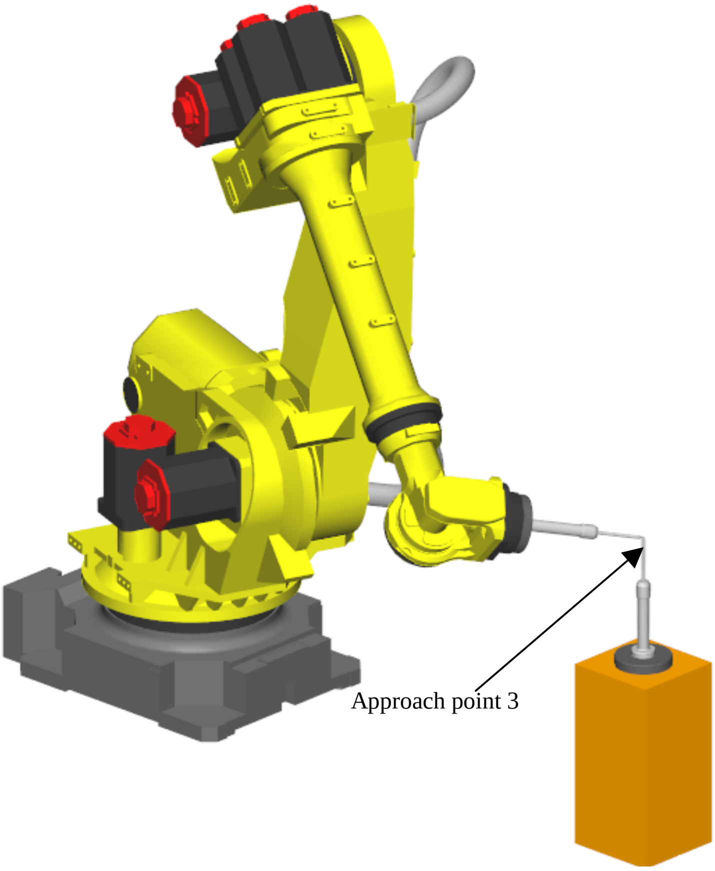


17 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the reference position. As for the taught reference point, RECORED is displayed.



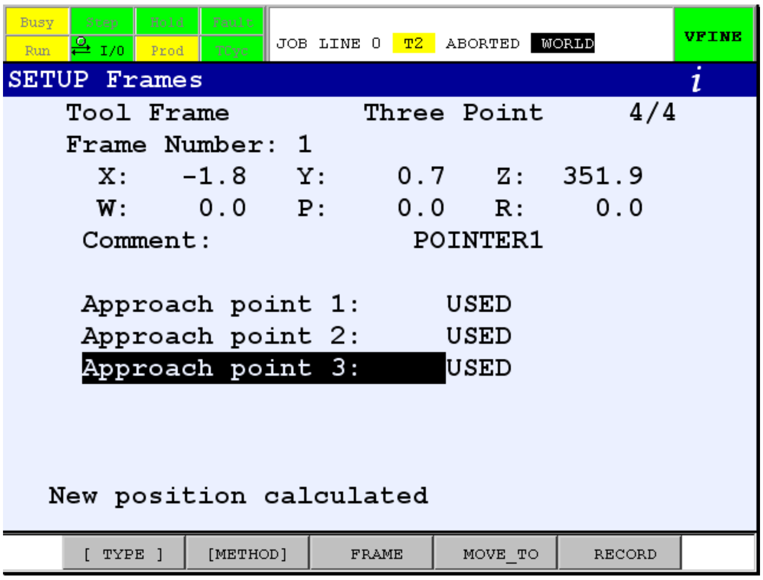
18 Move the cursor to the [Approach point 3].

19 Jog the robot and touch up the fixed pointer with the pointer tool. The position of approach point 3 is same position as the approach point 1 and 2. However, the posture of approach point 3 is different from posture of approach point 1 and 2.

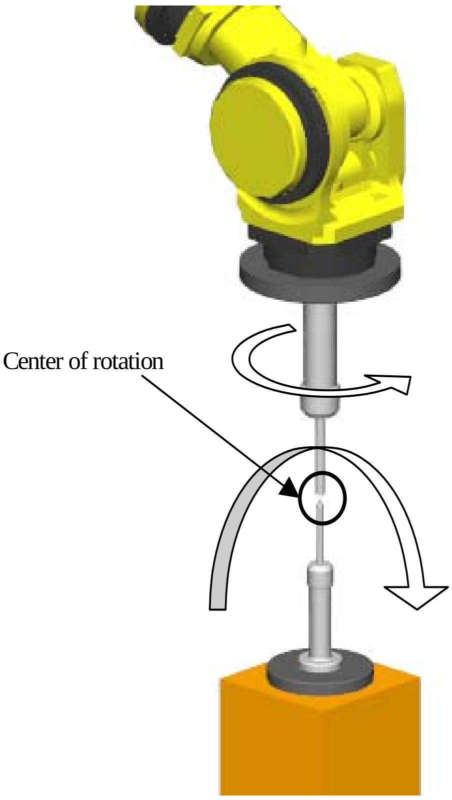


20 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the reference position.

21 When all the reference points are taught, USED is displayed. The tool frame has been set.



22 To display the tool frame list screen, press the PREV key.
23 Check the TCP is set accuracy. Press F5 SETIND and select the set tool frame number as an effective tool frame now.
24 Jog the robot and touch up the fixed pointer with the pointer tool.
25 Jog the robot around TCP and change the posture (w, p, r) of pointer tool. If TCP is set accuracy, the tip of pointer tool always points to the tip of the fixed pointer.

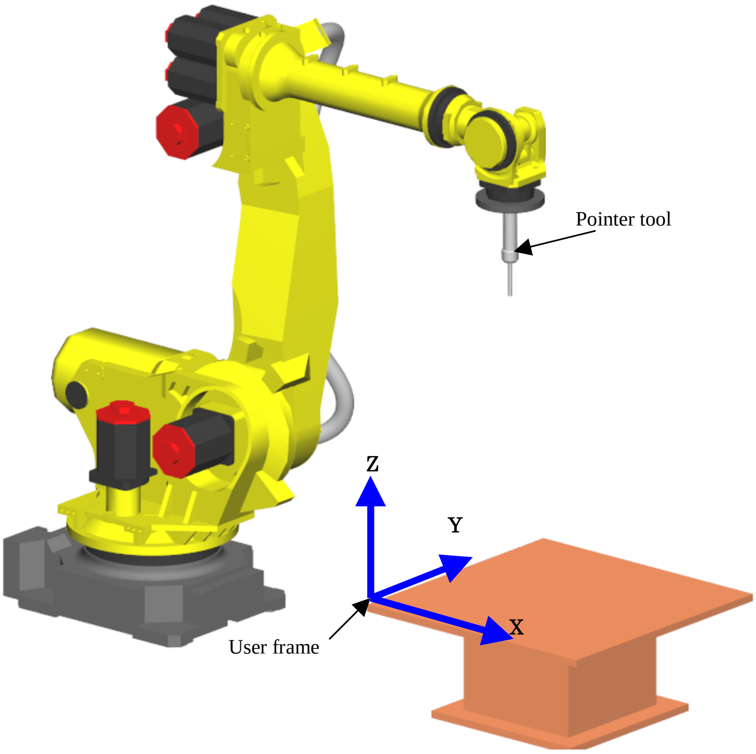


5.1.1.2 User frame setting

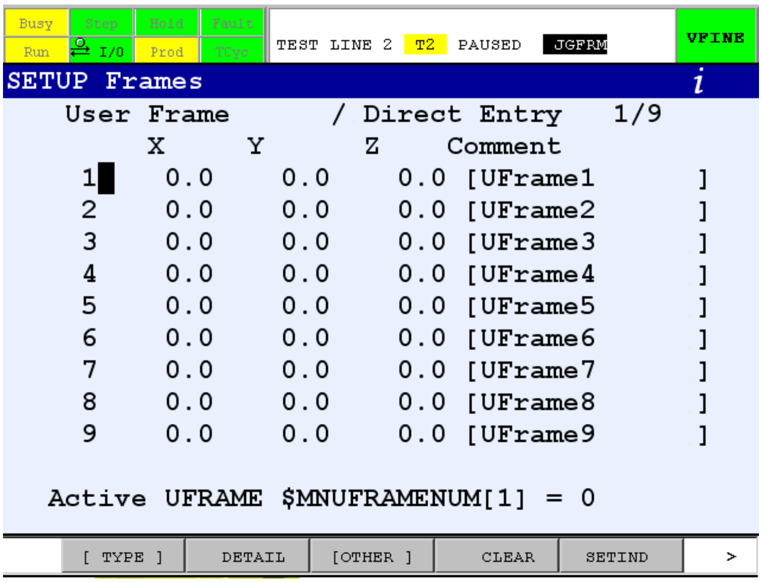
To set an user frame, there are three methods that are "Three point method", "Four point method" and "Direct list method". When use the "Three point method" or "Four point method", use the pointer tool that is set in the Subsection 5.1.1.1 "TCP setting". Moreover, the accuracy of user frame setting becomes better as the distance of each taught points is far. When set the calibration grid frame, the distance of each taught points by using "Four point method" become longer than using the "Three point method". When set the calibration grid frame, the "Four point method" is recommended. The "Three point method" and "Four point method" is explained as shown below.

Three point method

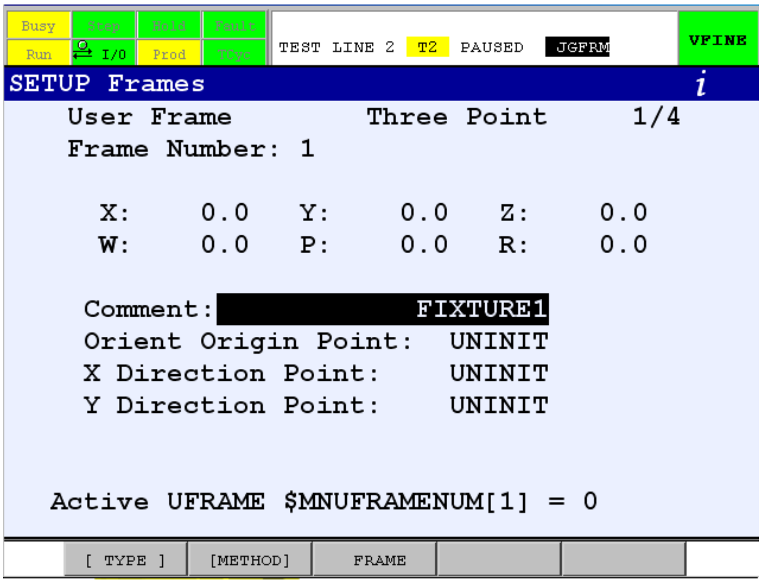
Teach the following three points: the origin of the x–axis, the point which specifies the positive direction of the x–axis, and the point on the x–y plane. In the example of the following figure, the user frame is set on the table so that the XY plane of the user frame is parallel with the table plane.



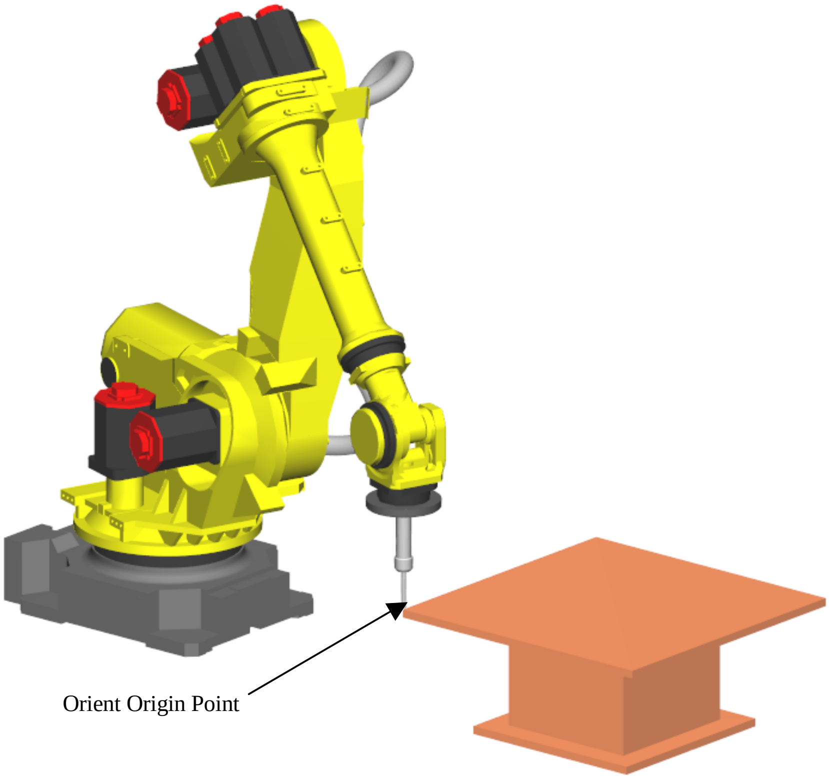
1 Press the MENU key. The screen menu is displayed.
2 Select [6 SETUP]
3 Press the F1 [TYPE]. The screen change menu is displayed.
4 Select [Frames].
5 Press F3 [OTHER].
6 Select [User Frame]. User frame list screen is displayed.



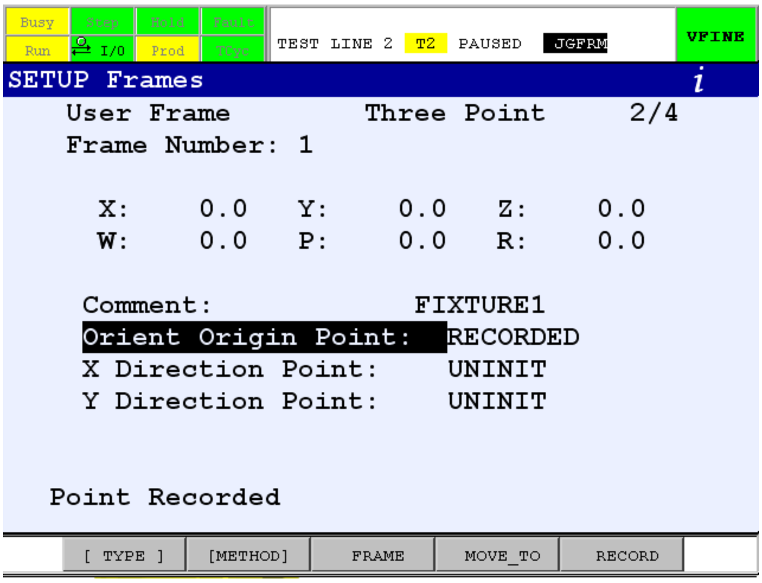
7 Move the cursor to the list of the user frame number you want to set.
8 Press F2 DETAIL. The user frame setup screen of the selected frame number is displayed.
9 Press F2 [METHOD].
10 Select the [Tree Point].



11 It recommends inputting a comment, in order to make it easy to distinguish from other user frame numbers.
12 Move the cursor to the [Orient Origin Point].
13 Jog the robot and touch up the Orient Origin Point with the pointer tool.

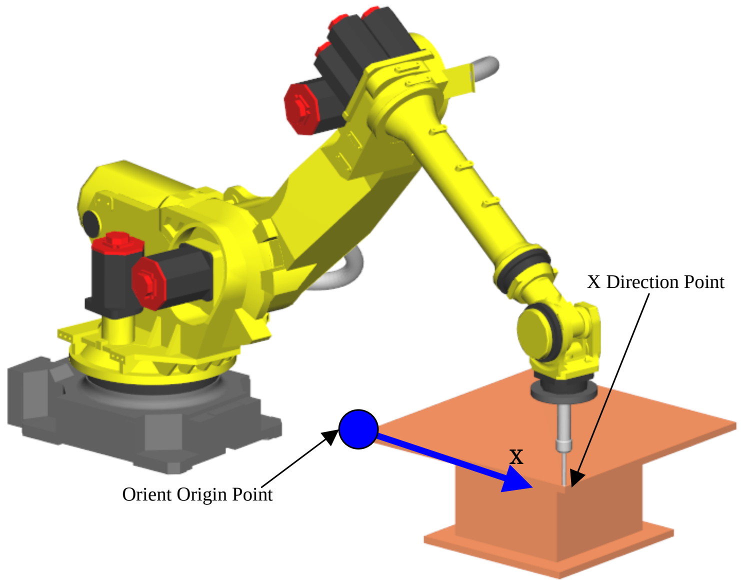


14 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Orient Origin Point. As for the taught Orient Origin Point, RECORED is displayed.

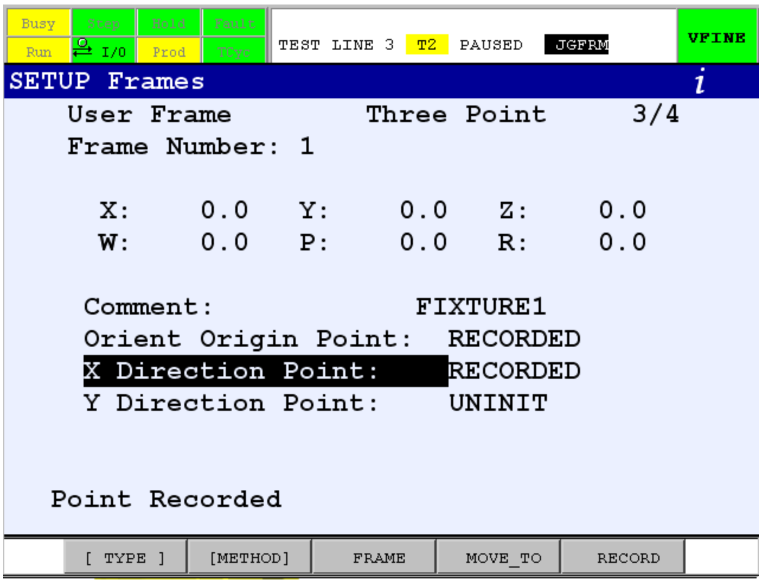


15 Move the cursor to the [X Direction Point].

16 Jog the robot and touch up the X Direction Point with the pointer tool. The direction that connects the Orient Origin Point and the X Direction Point is the x–axis of user frame.

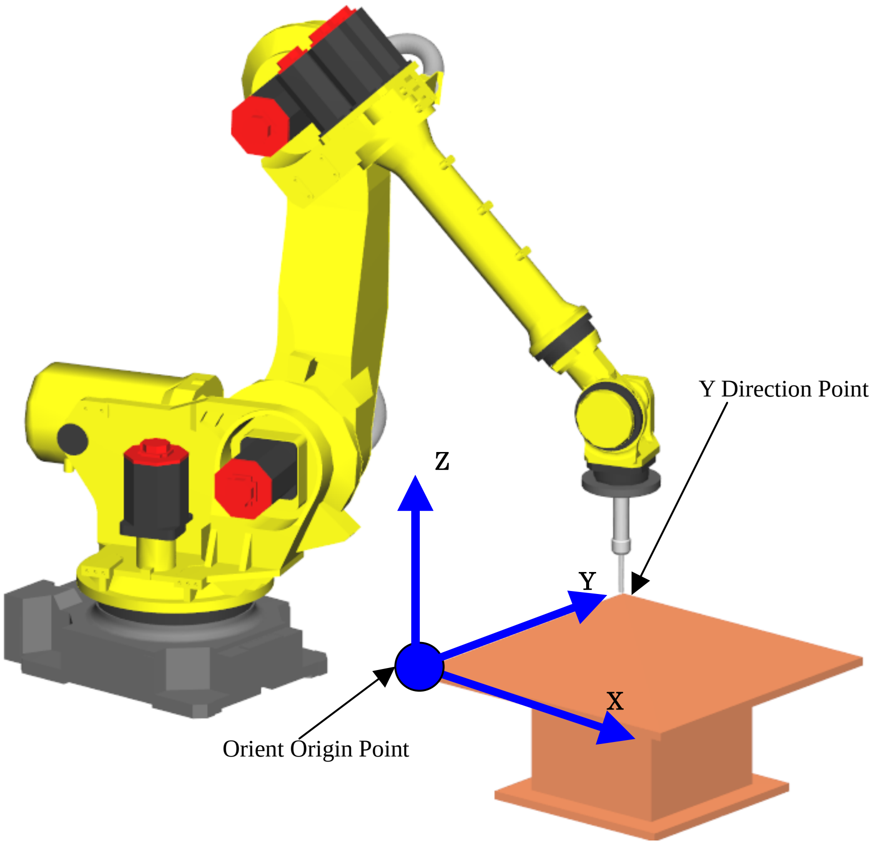


17 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the X Direction Point. As for the taught X Direction Point, RECORED is displayed.

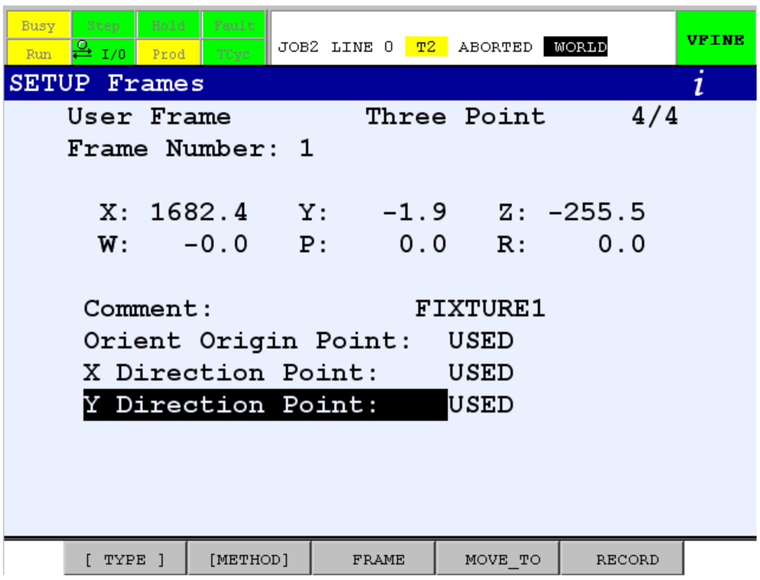


18 Move the cursor to the [Y Direction Point].

19 Jog the robot and touch up the Y Direction Point with the pointer tool. If the Y Direction Point is taught up, the XY plane of frame will be set.



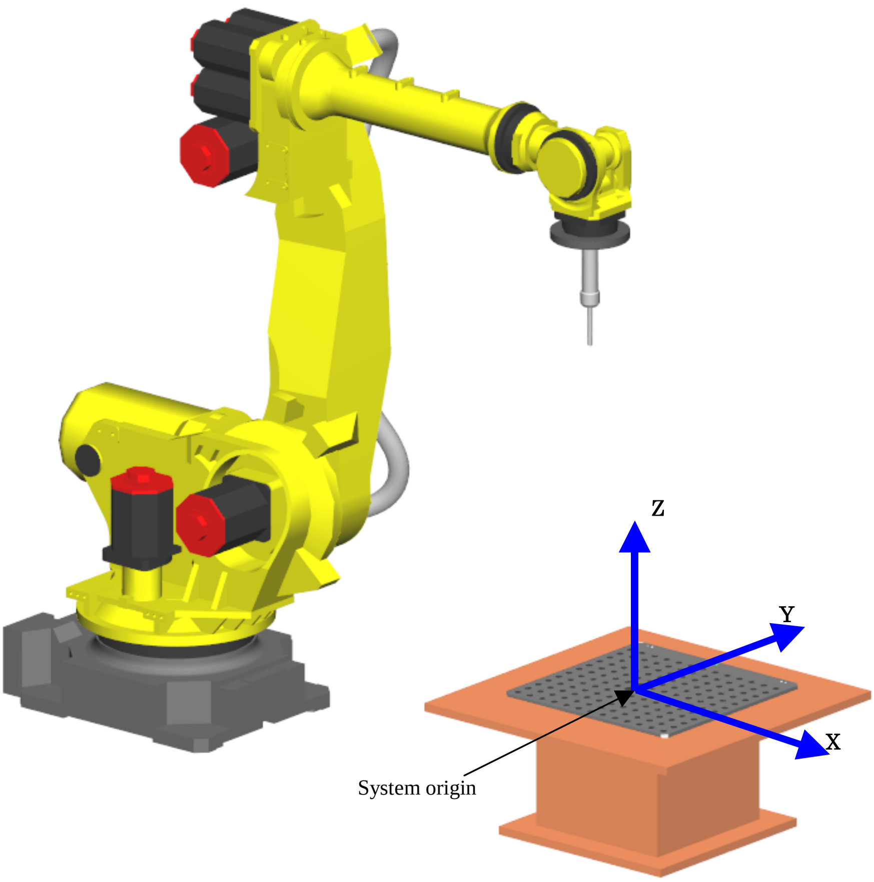
20 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Y Direction Point.
21 When all the reference points are taught, USED is displayed. The user frame has been set.



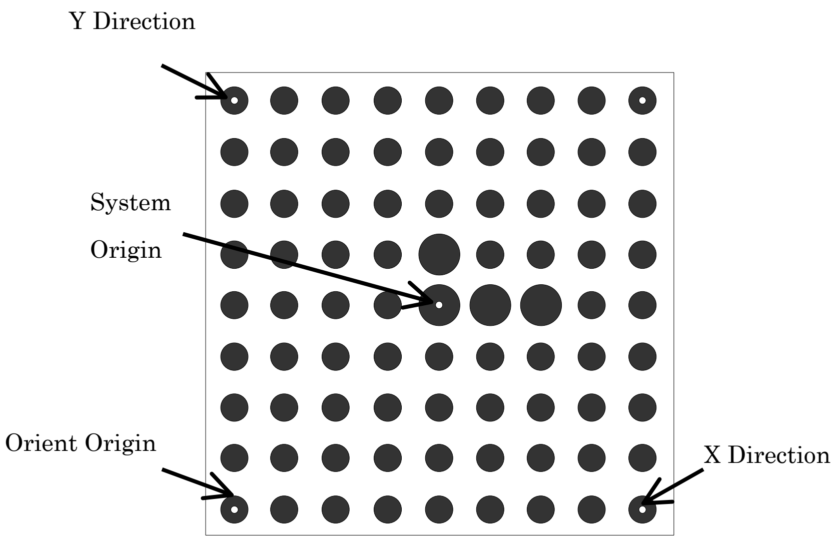
22 To display the user frame list screen, press the PREV key.
23 Press F5 SETIND and select the set user frame number as an effective user frame now.

Four point method

Teach the following four points: the origin of the x–axis parallel to the frame, the point which specifies the positive direction of the x–axis, a point on the XY plane, and the origin of the fame. In the example of the following figure, the user frame is set on the fixed calibration grid.

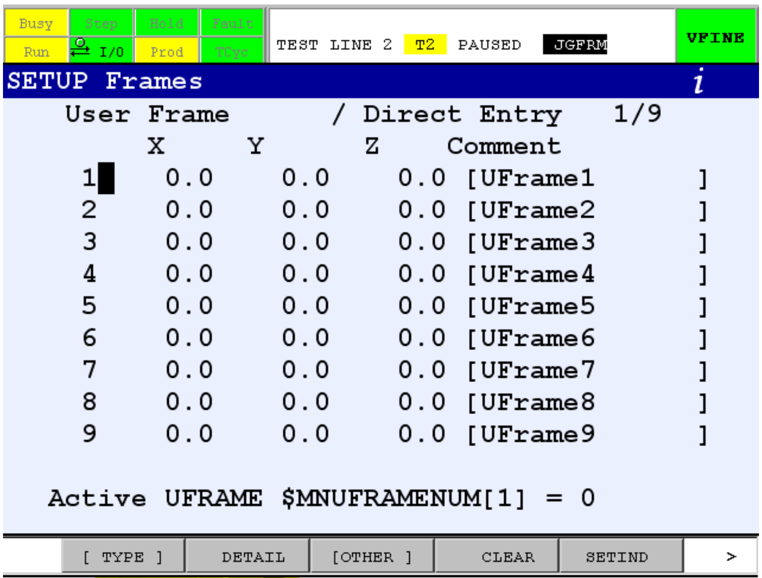


The following figure is a calibration grid. When perform the 3DL Calibration for camera calibration, it is necessary to set up a user frame such as shown in the following figure. Since it is necessary to a System origin on the center of the calibration grid, when the [Three point method] is used, the distance form the System origin to the X Direction Point or the Y Direction Point is near. By using [Four point method], the accuracy of user frame setting becomes better.

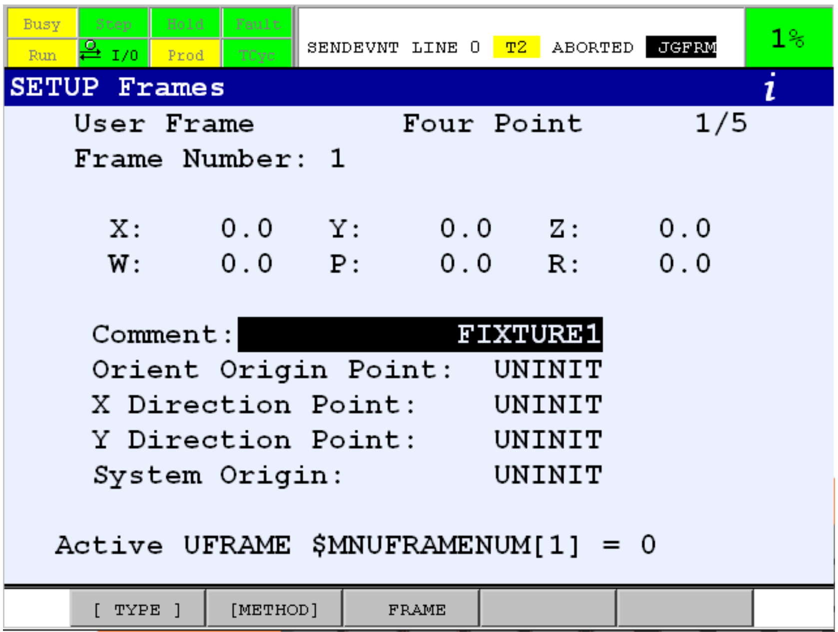


1 Press the MENU key. The screen is displayed.
2 Select [6 SETUP].
3 Press F4 [TYPE]. The screen change menu is displayed.
4 Select [Frames].

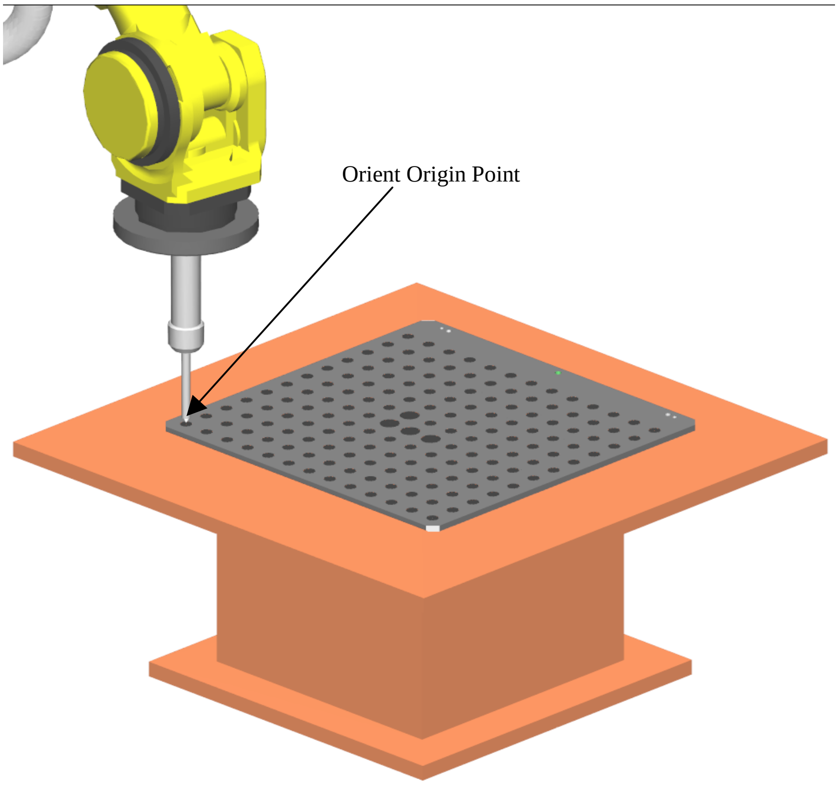
5 Press F3 [OTHER].
6 Select [USER FRAME]. User frame list is displayed.



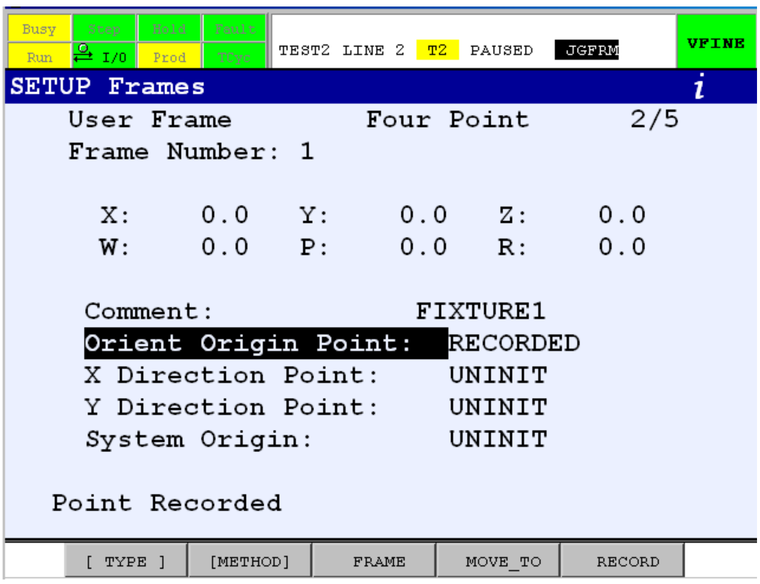
7 Move the cursor to the list of the user frame number you want to set.
8 Press F2 DETAIL. The user frame setup screen of the selected frame number is displayed.
9 Press F2 [METHOD].
10 Select the [Four Point].



11 It recommends inputting a comment, in order to make it easy to distinguish from other user frame numbers.
12 Move the cursor to the [Orient Origin Point].
13 Jog the robot and touch up the Orient Origin Point with the pointer tool.

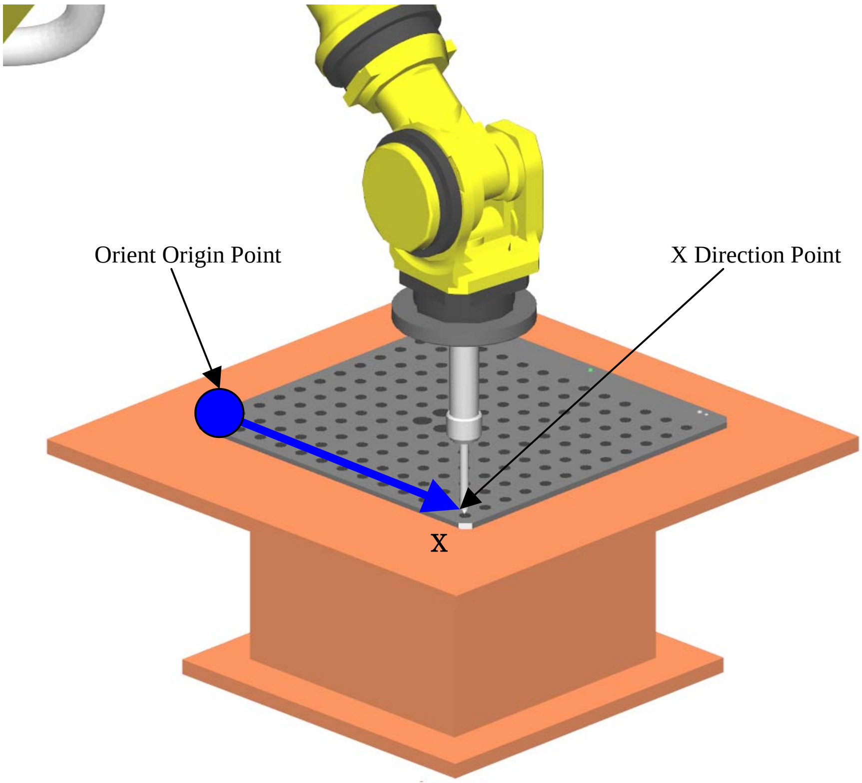


14 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Orient Origin Point. As for the taught Orient Origin Point, RECORED is displayed.

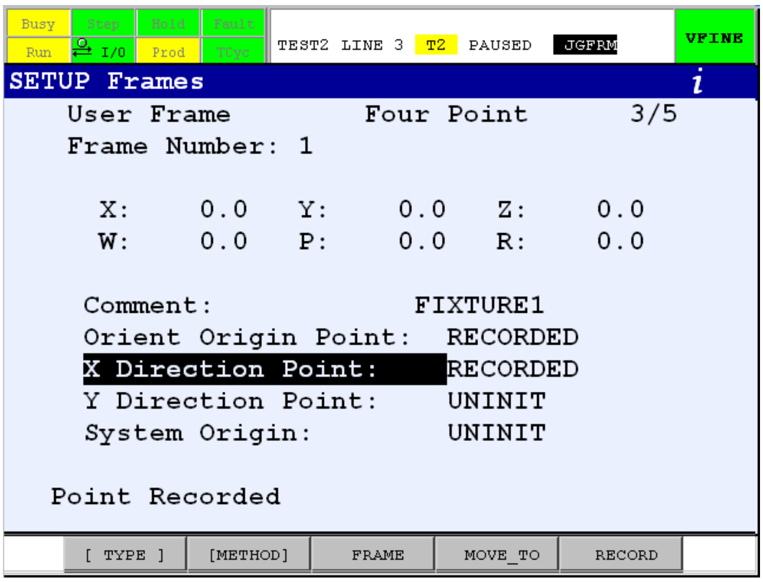


15 Move the cursor to the [X Direction Point].

16 Jog the robot and touch up the X Direction Point with the pointer tool. The direction that connects the Orient Origin Point and the X Direction Point is the x–axis of user frame.

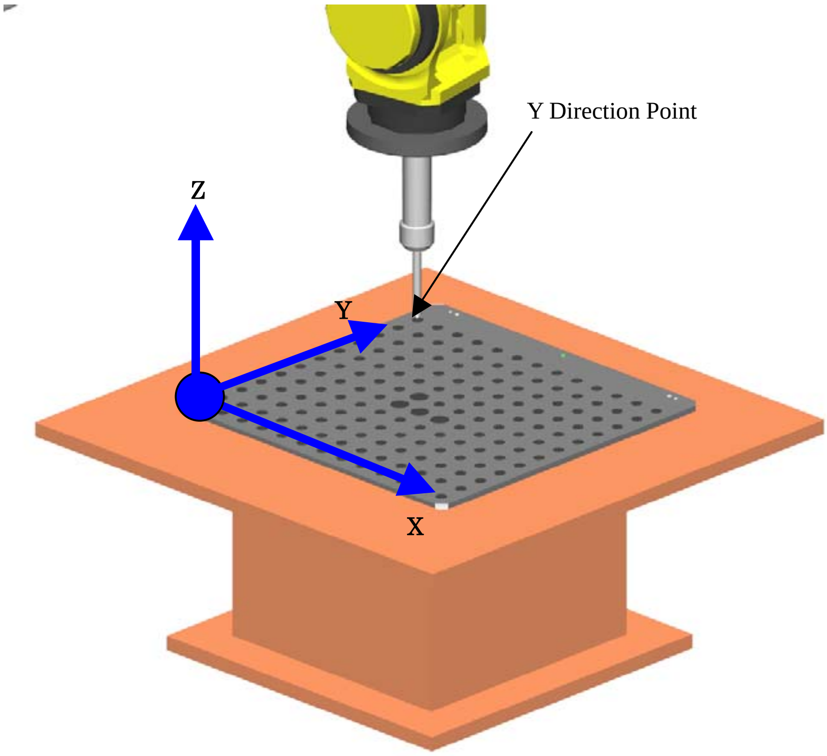


17 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the X Direction Point. As for the taught X Direction Point, RECORED is displayed.

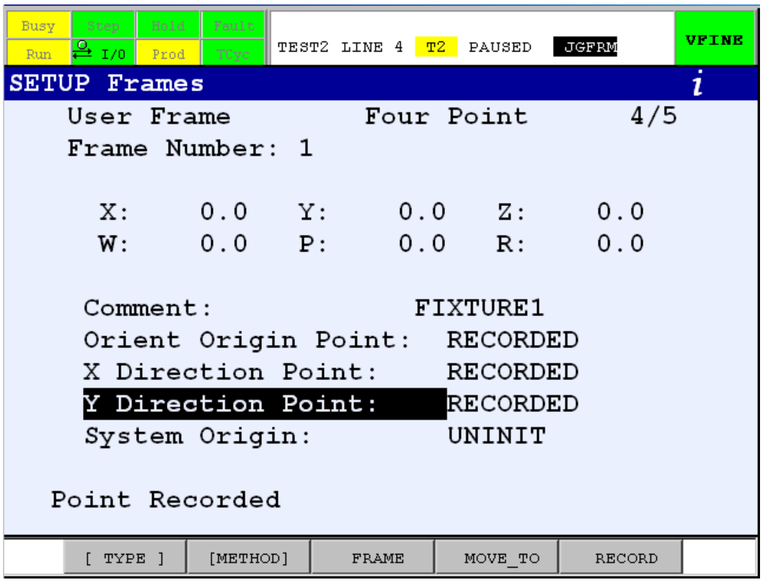


18 Move the cursor to the [Y Direction Point].

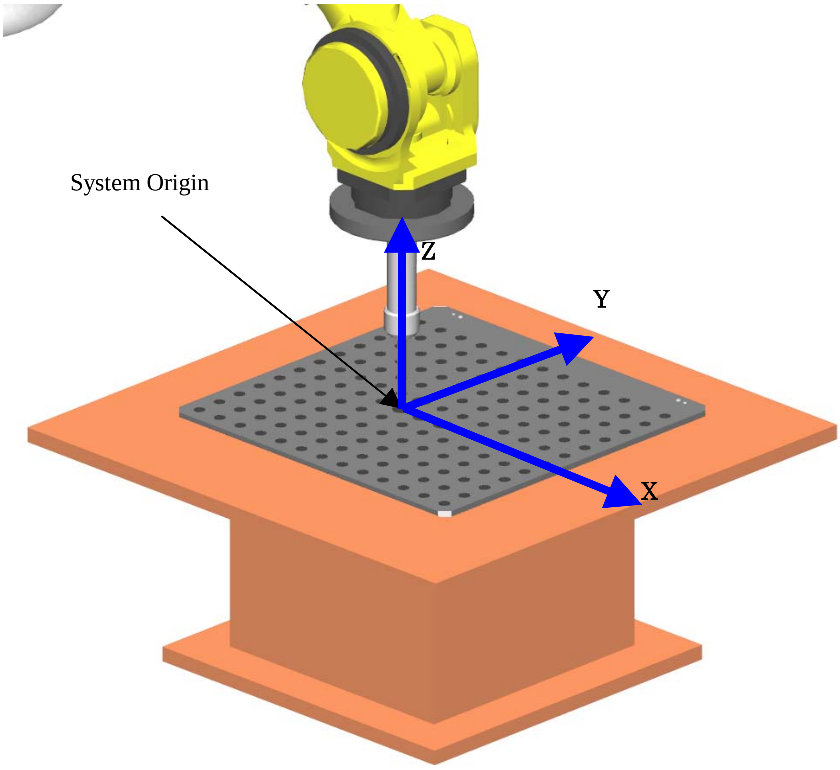
19 Jog the robot and touch up the Y Direction Point with the pointer tool. If the Y Direction Point is taught up, the XY plane of frame will be set.



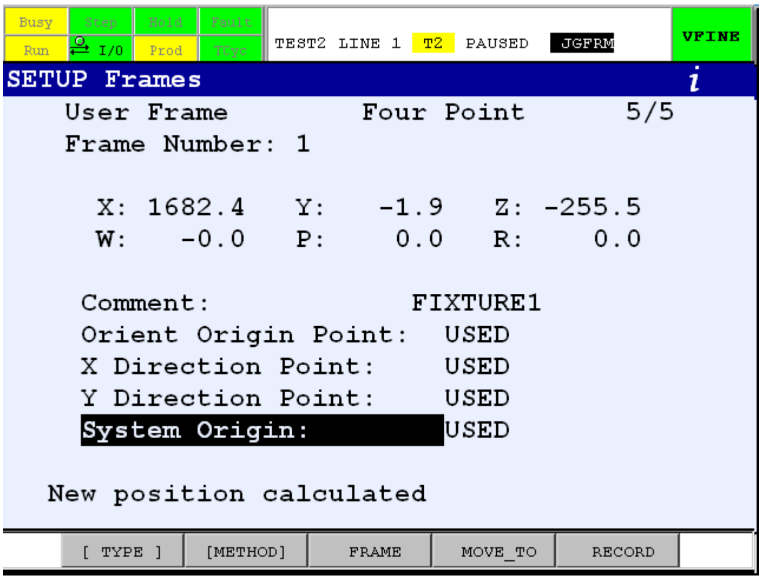
20 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Y Direction Point. As for the taught Y Direction Point, RECORED is displayed.



21 Jog the robot and touch up the System Origin with the pointer tool.



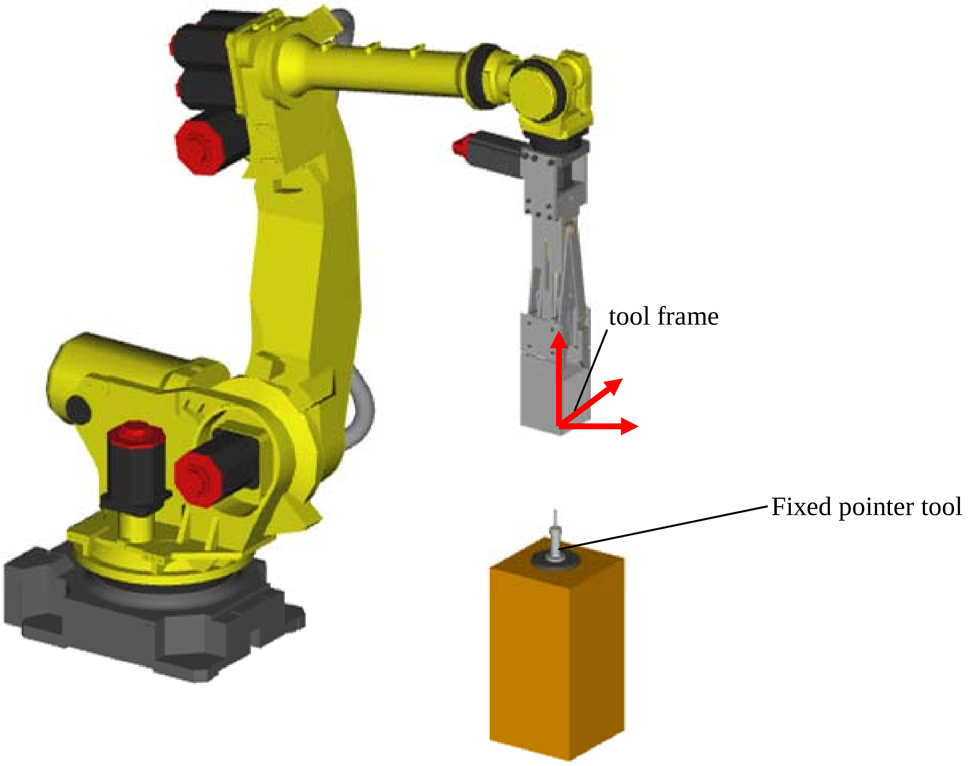
22 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the System Origin. When all the reference points are taught, USED is displayed. The user frame has been set.



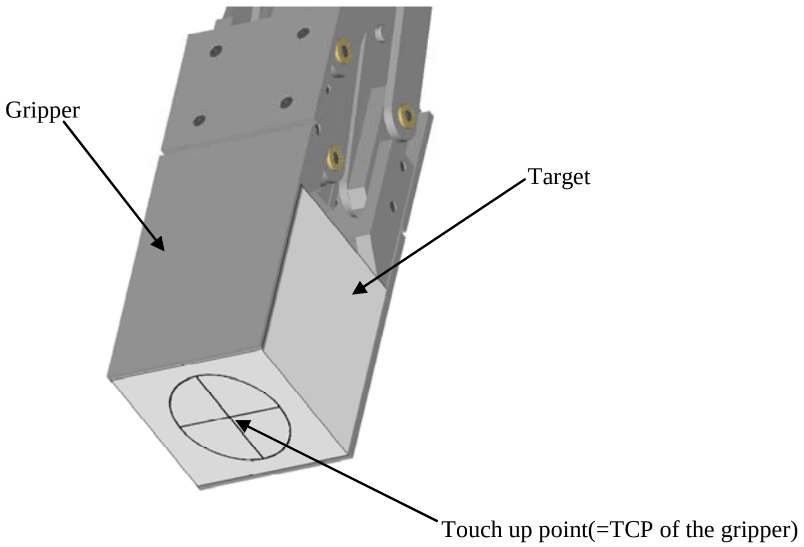
23 To display the user frame list screen, press the PREV key.
24 Press F5 SETIND and select the set user frame number as an effective user frame now.

5.1.2 Setting the Tool Frame with a Pointer Tool

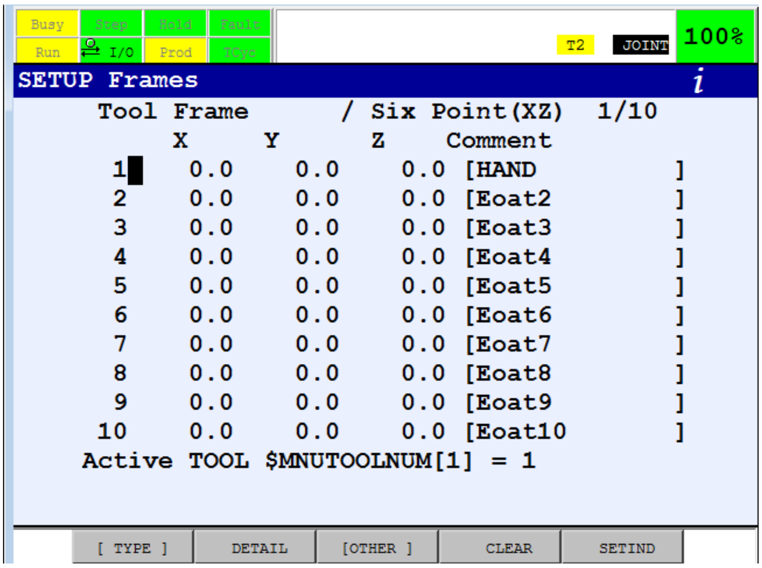
This subsection explains a tool frame setting on the TCP of the gripper mounted on the robot.



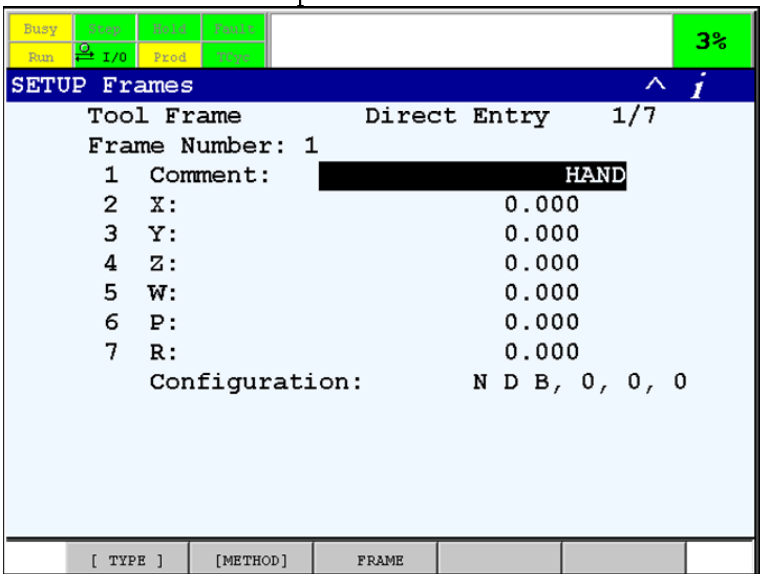
After the pointer for touch-up is secured to a secured stand, select "Tool Frame Setup / Six Point(XZ)", and teach the six points shown in the figure below by touch-up operation. The position of fixed pointer is arbitrarily. A target fixture as shown in the figure below is provided and is installed to the gripper of the robot. Then, be sure that the origin of the target corresponds to the TCP of the gripper of the robot.



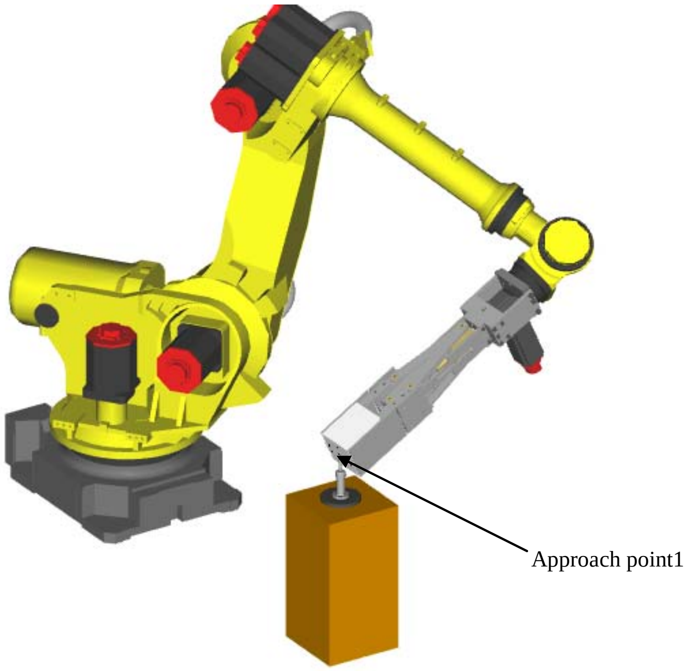
1 Press the MENU key. The screen menu is displayed.
2 Select [6 SETUP]
3 Press the F1 [TYPE]. The screen change menu is displayed.
4 Select [Frames].
5 Press F3 [OTHER].
6 Select [Tool Frame]. Tool frame list screen is displayed.



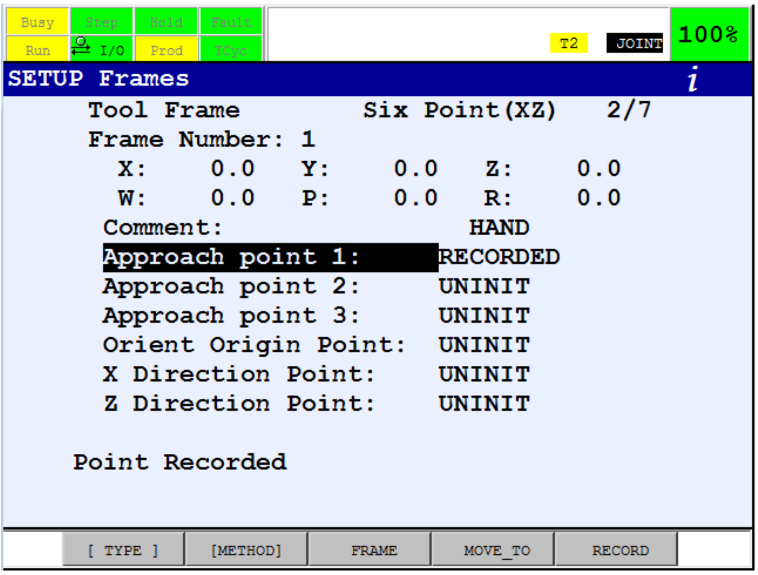
7 Move the cursor to the list of the tool frame number you want to set.
8 Press F2 DETAIL. The tool frame setup screen of the selected frame number is displayed.



9 Press F2 [METHOD].
10 Select the [Six Point(XZ)].
11 It recommends inputting a comment, in order to make it easy to distinguish from other tool frame numbers.
12 Move the cursor to the [Approach point1].
13 Jog the robot and touch up the Approach point1 with the pointer tool.

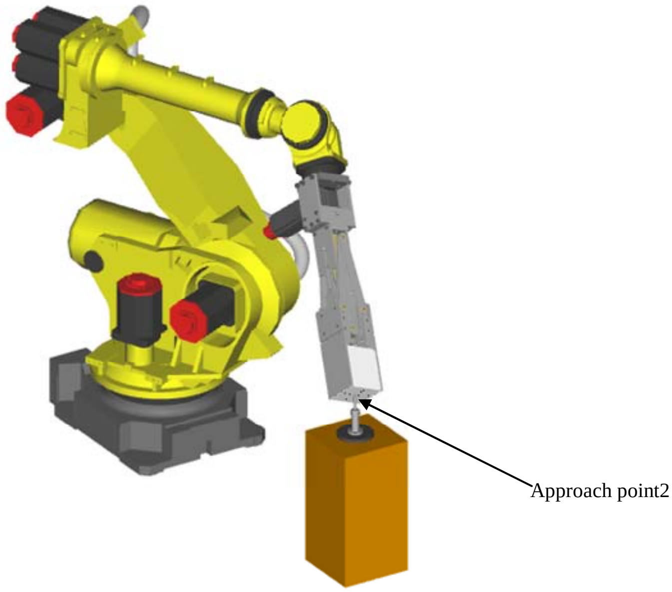


14 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Approach point1. As for the taught Approach point1, RECORED is displayed.

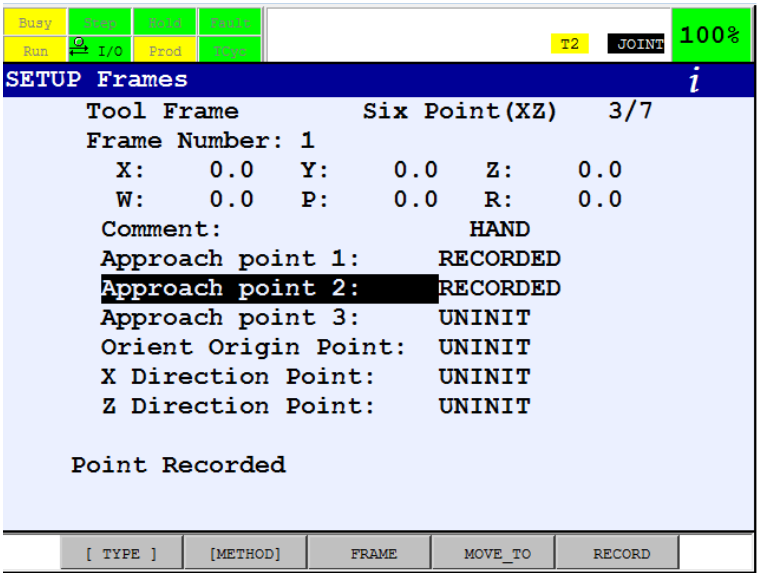


15 Move the cursor to the [Approach point 2].

16 Jog the robot and touch up the Approach point2 with the pointer tool. The position of Approach Point 2 is same position as the Approach Point 1. However, the posture of Approach Point 2 is different from posture of Approach Point 1.

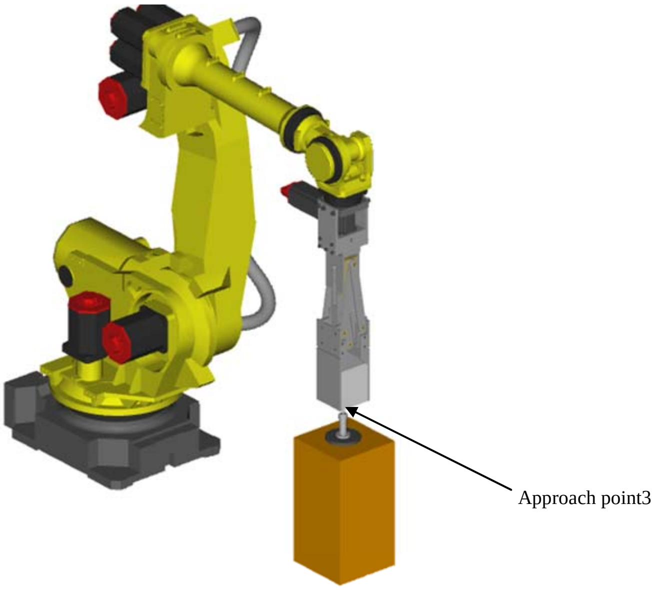


17 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Approach Point2. As for the taught Approach point2, RECORED is displayed.

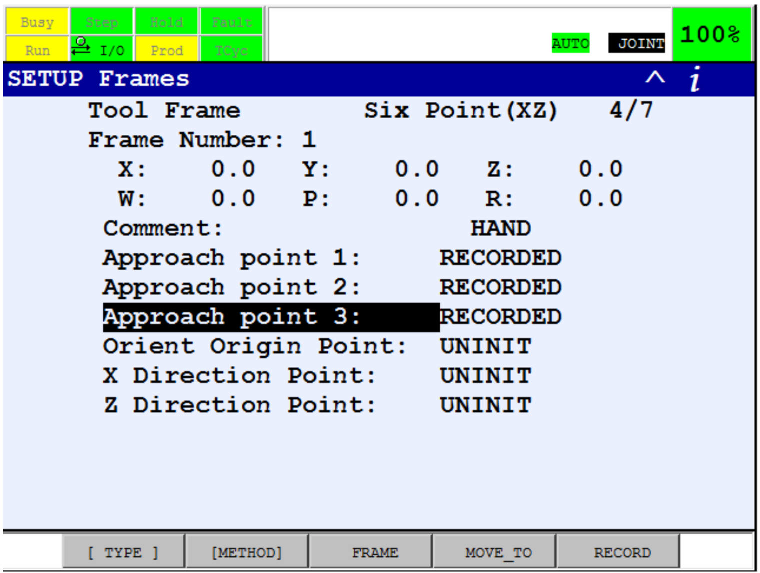


18 Move the cursor to the [Approach Point3].

19 Jog the robot and touch up the Approach point3 with the pointer tool. The position of Approach Point3 is same position as the Approach Point 1 and the Approach Point2. However, the posture of the Approach Point3 is different from posture of Approach Point1 and Approach Point2.

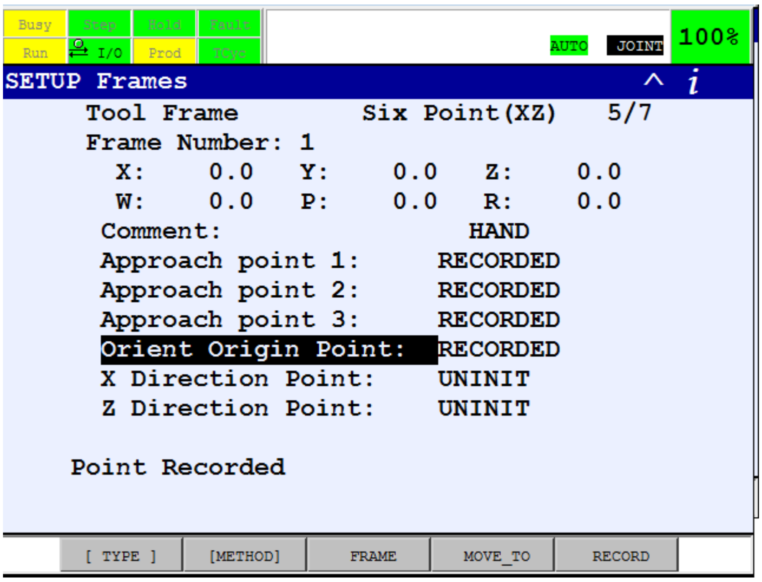


20 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Approach Point3. As for the taught Approach point3, RECORED is displayed.



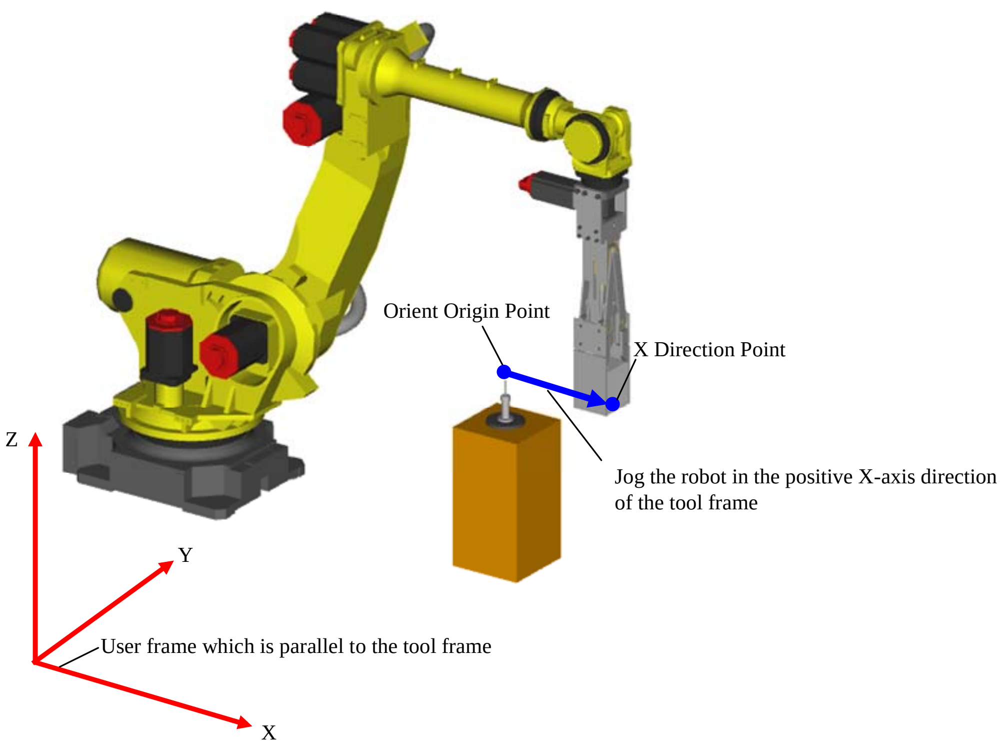
21 Move the cursor of the [Orient Origin Point].

22 The position and posture of Orient Origin Point is same position and posture as the Approach Point3. Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the Orient Origin Point. As for the taught Orient Origin Point, RECORED is displayed.

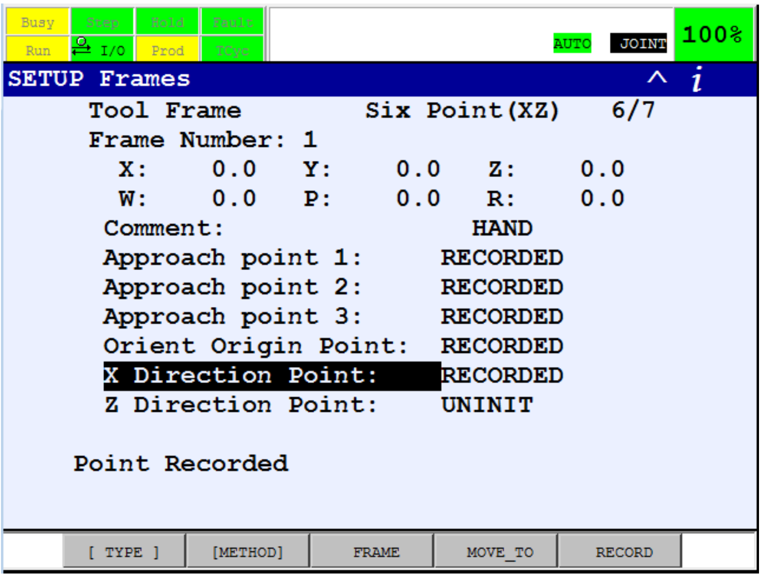


23 Move the cursor of the [X Direction Point].

24 Jog the robot to a position in the positive direction of the X-axis parallel to the tool frame. Then move the robot using Cartesian or tool jog so that the posture of the robot does not change.

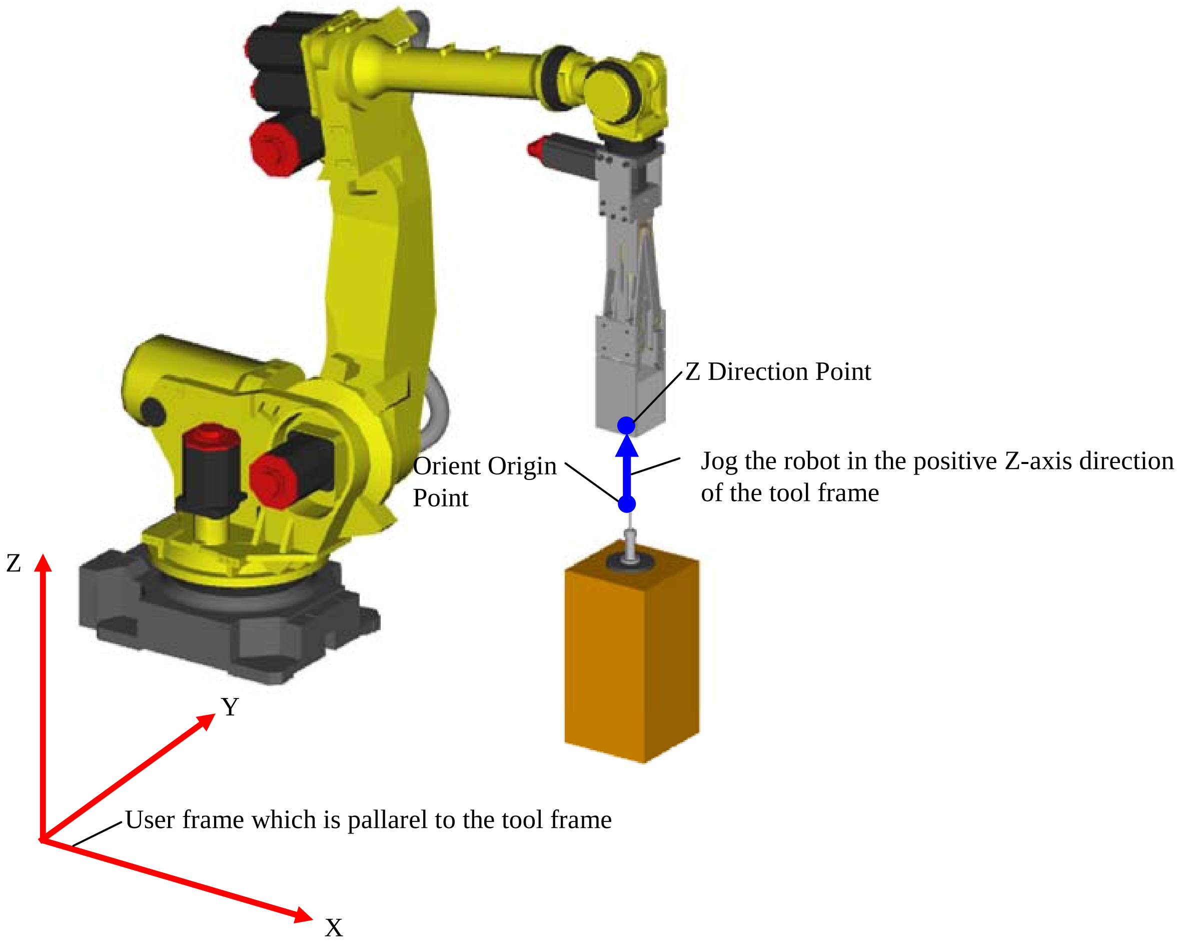


25 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the X Direction Point. As for the taught X Direction Point, RECORED is displayed.

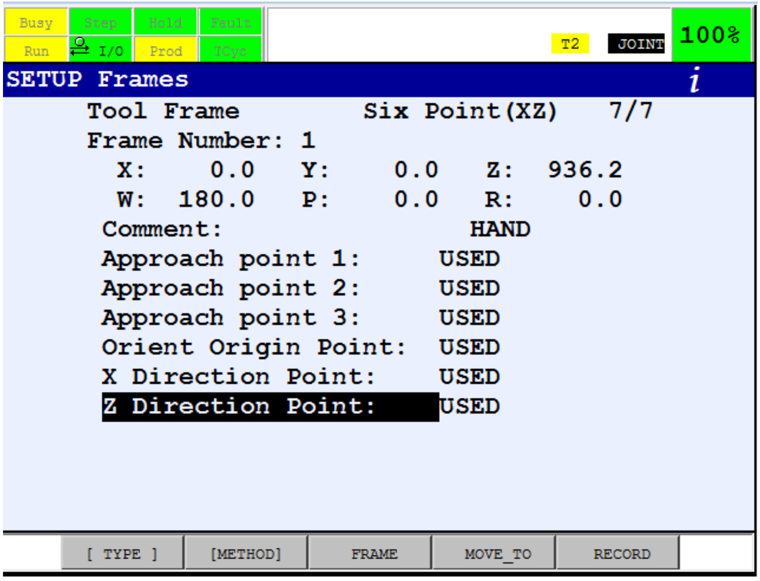


26 Move the cursor of the [Z Direction Point].

27 Jog the robot to a position in the positive direction of the Z-axis parallel to the tool frame. Then move the robot using Cartesian or tool jog so that the posture of the robot does not change.



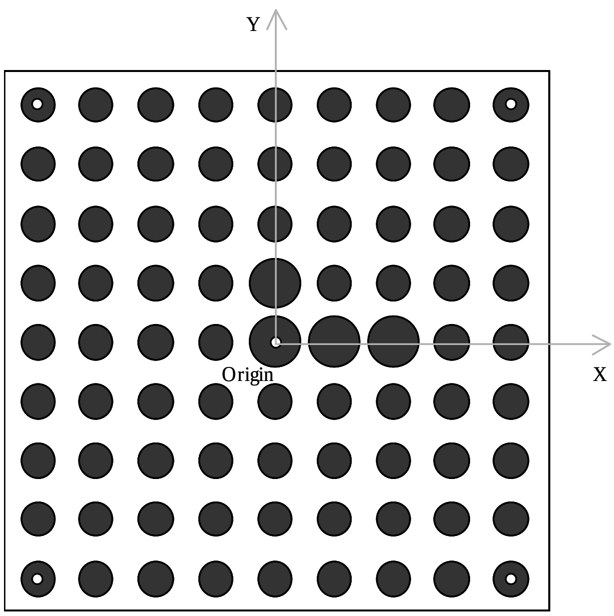
28 Press and hold the SHIFT key and press F5 RECORD to record the data of current position as the X Direction Point. As for the taught X Direction Point, RECORED is displayed.



29 Check the TCP is set accuracy. Press F5 SETIND and select the set tool frame number as an effective tool frame now.
30 Jog the robot and touch up the center of the target with the pointer.
31 Jog the robot around the center of the target and change the posture (w, p, r) of the target. If tool frame is set accuracy, the tip of fixed pointer always points to the center of the target.

5.2 FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION

In the Grid Frame Setting Function, the robot holding the camera or the robot holding calibration grid automatically moves to change relative position and orientation between the camera and the calibration grid, and find the grid pattern repeatedly. Finally, the position of the calibration grid frame relative to the robot base frame or the robot mechanical interface frame (the robot face place) is identified. When the Grid Frame Setting Function is executed, a frame is set on the calibration grid, as shown in the following figure.



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.

> ⚠ **CAUTION**
> The Grid Frame Setting Function is usable with 6-axis robots only. The function cannot be used with 4-axis robots and 5-axis robots.

5.2.1 Setup Procedures

Use the following setup procedures for the Grid Frame Setting Function.

1. Mounting the calibration grid

⇩

2. Camera data creation and teaching

⇩

3. Setting the parameters

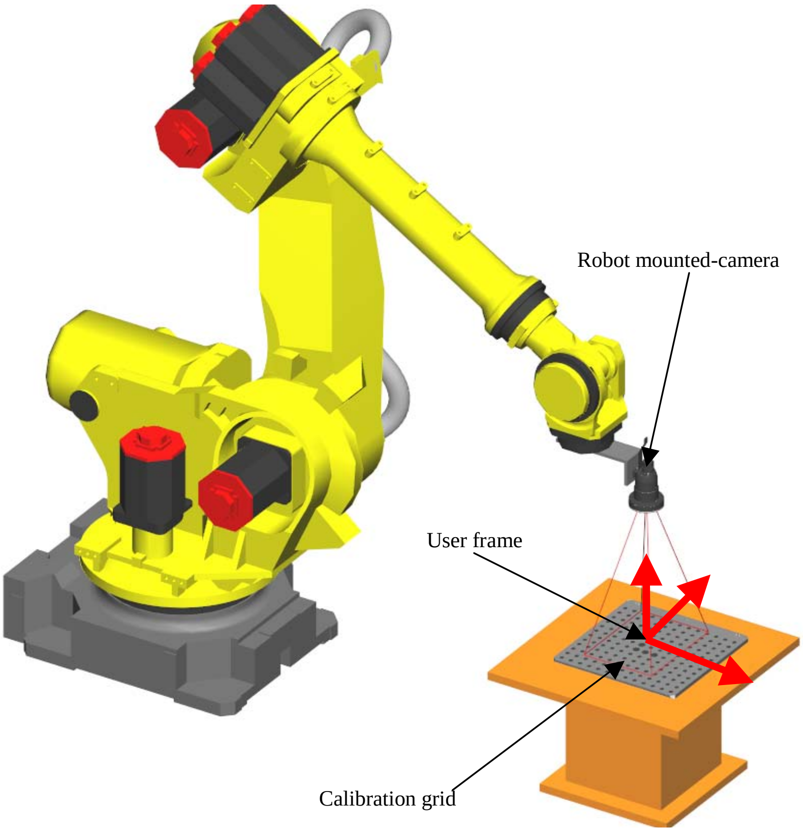
⇩

4. Run Measurement

5.2.1.1 Mounting the calibration grid

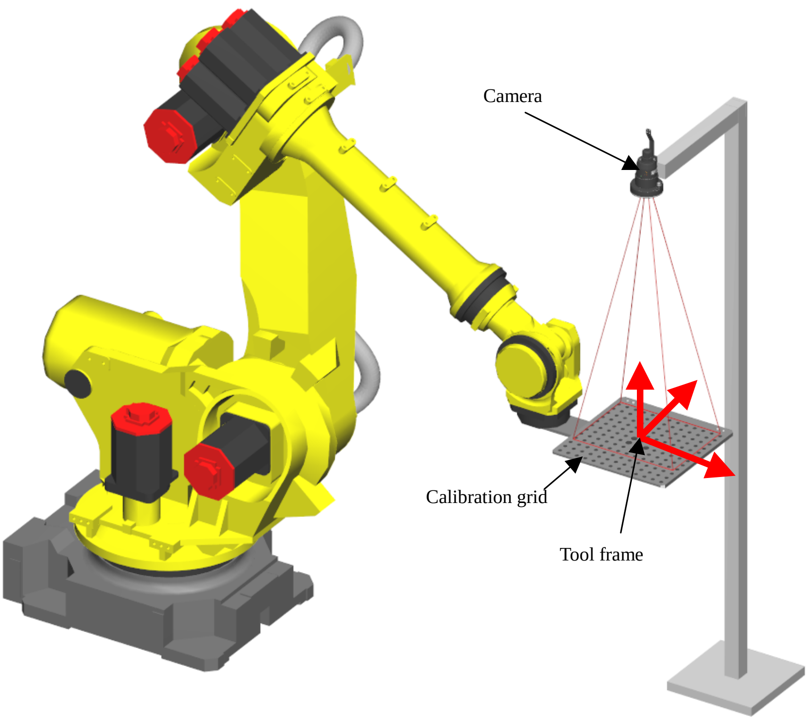
When the calibration grid is secured to a fixed surface

When the calibration grid is secured to fixed surface, a camera mounted on the robot end of arm tooling is used to measure the position of the calibration grid frame. The Grid Frame Setting Function identifies the position of the calibration grid frame relative to the robot base frame (world), and sets the results in a user specified user frame. When use a robot-mounted camera, the Grid Frame Setting Function can be performed with the camera currently used. When use a fixed camera, prepare another camera for the Grid Frame Setting Function separately. Then, perform the Grid Frame Setting Function using the camera attached to the arbitrary positions of the robot end of arm tooling.



When the calibration grid is mounted on the robot

When the calibration grid is mounted on the robot, a fixed camera is used to measure the position of the calibration grid frame. The robot moves the calibration grid within the field of view of the fixed camera. The Grid Frame Setting Function identifies the position of the calibration grid frame relative to the robot mechanical interface frame (the robot face plate), and the results is written in a user defined user tool. The Grid Frame Setting Function can be performed with the camera currently used. When there is not sufficient space to perform Grid Frame Setting Function with the camera currently used, prepare another fixed camera and Grid Frame Setting Function can be performed.

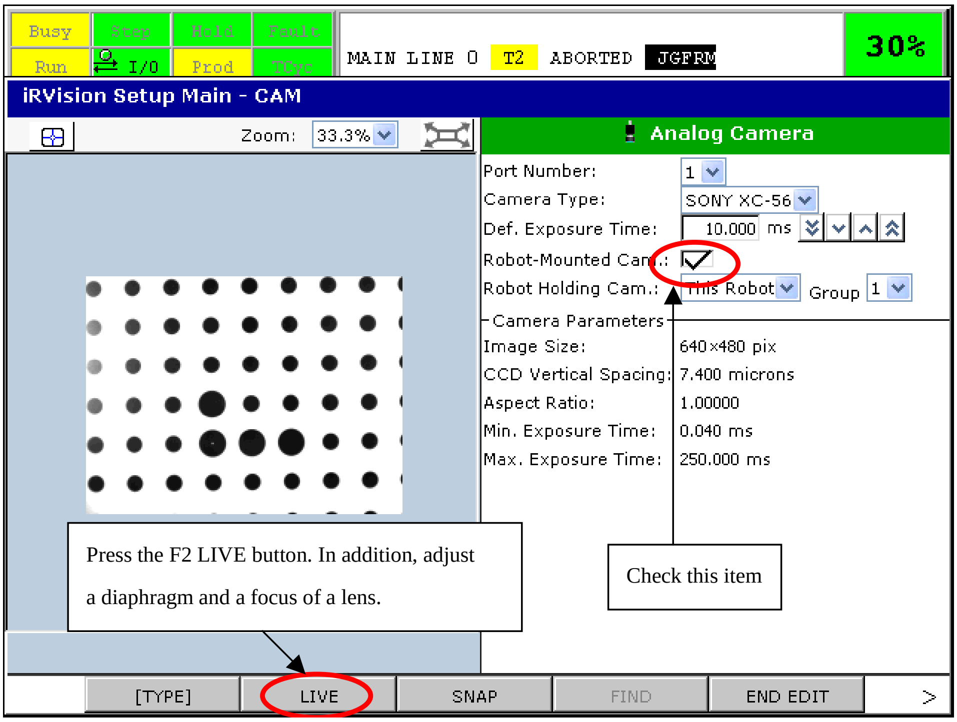


Make sure that the calibration grid is fixed securely so that it does not move during measurement.

NOTE
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.

5.2.1.2 Camera data creation and teaching

With *i*RVision, items such as a camera type and camera installation method are set in camera setup data. Whether to install a camera on the robot or on a fixed stand is set in the camera setting data. When using a robot-mounted camera, be sure to check this item. When using a fixed camera, do not check "Robot-Mounted Camera".

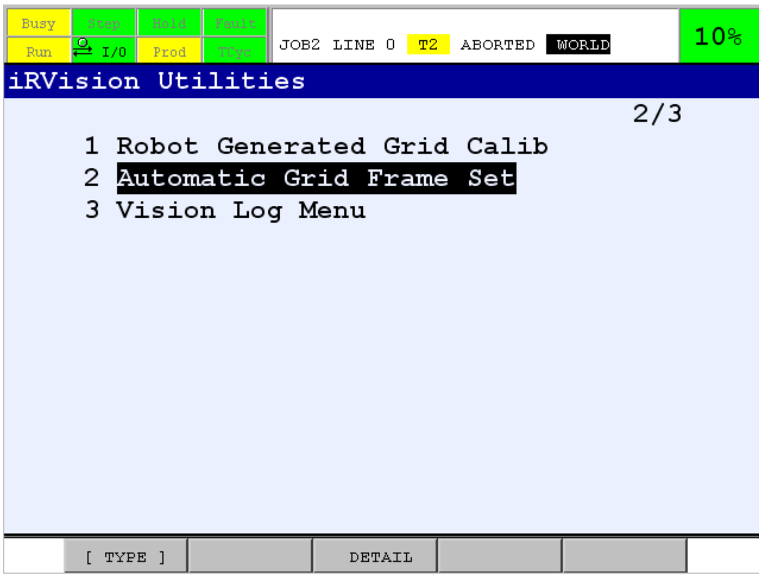


Press the F2 LIVE button, and adjust the aperture and a focus of a lens.

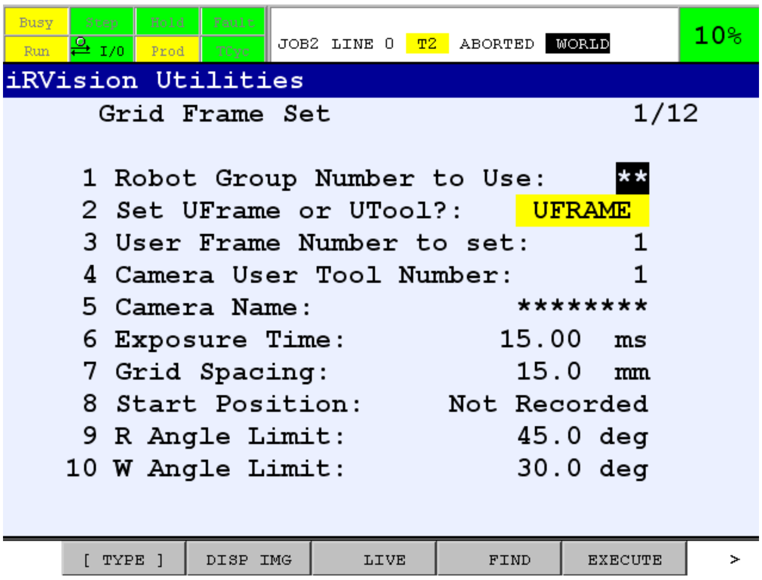
5.2.1.3 Setting the parameters

Move to the UTILITY MENU page in the following procedures.

1 Press the MENU key on teach pendant, and select the [5 Vision Utility] in the [8 *i*RVision].



2 If you select the [Automatic Grid Frame Set] on the *i*RVision utility menu, a menu like the one shown below appears.



> ⚠ **CAUTION**
> The Grid Frame Set menu cannot be opened in more than one window at a time.

Robot Group Number to Use

Specify the group number of the robot to be used for measurement.

Set UFrame or UTool?

Select the frame to be set with the Grid Frame Setting Function - user frame or user tool. To set the user tool with the calibration grid mounted on the robot, select F4 UTOOL. To set the user frame with the calibration grid secured to a table or other fixed surface, select F5 UFRAME.

User Frame Number to set

Specify the number of the user frame to be set. This parameter is used only when [UFRAME] is selected for the [Set UFrame or UTool?]. The range of specifiable user frame numbers is 1 to 9.

Tool Frame Number to set

Specify the number of the user tool to be set. This parameter is used only when [UTOOL] is selected for [Set UFrame or UTool?]. The range of specifiable user tool numbers is 1 to 10.

Camera User Tool Number

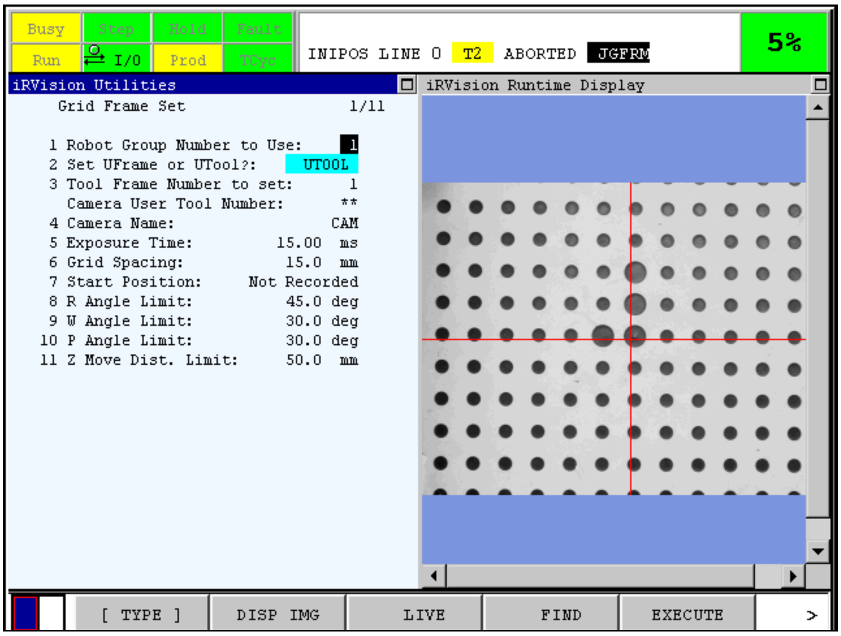
Specify the number of the user tool for the work space to be used during calculation. This parameter is used only when [UFRAME] is selected for [Set UFrame or UTool?]. The user tool you specify here will be rewritten during the measurement for grid frame setting. The range of specifiable user tool numbers is 1 to 10.

Camera Name

Specify the name of the camera to be used for measurement. Place the cursor on the line of [Camera Name], press F4 CHOICE, and select a camera from the pull down menu.

F2 DISP_IMG

Pressing F2 DISP IMG provides a double-window display, with the vision runtime display (camera image) shown on the right side.



F3 LIVE

Pressing F3 LIVE displays the live image of the selected camera on the vision runtime display, as the F3 label changes to "STOP LIVE". If you press F3 STOP LIVE, the display of the live image is stopped and the F3 label returns to "LIVE".

F4 FIND

Pressing F4 FIND detect the calibration grid for a trial. The found result is displayed on the vision runtime display.

Exposure Time

Specify the exposure time for the camera to capture an image. Adjust the exposure time so that the black circles of the calibration grid are clearly visible.

Grid Spacing

Set the grid spacing of the calibration grid in use.

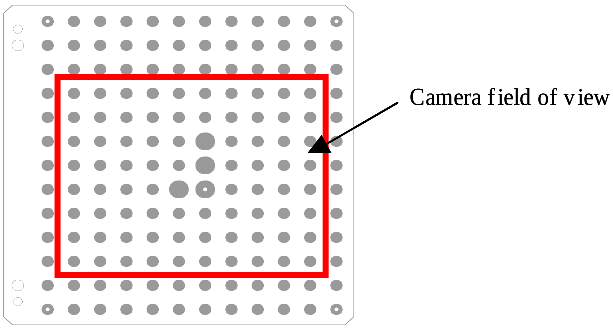
Start Position

Teach the position where measurement is to be started. To teach the start position, take the following steps:

1 Move the cursor to [7 Start Position].

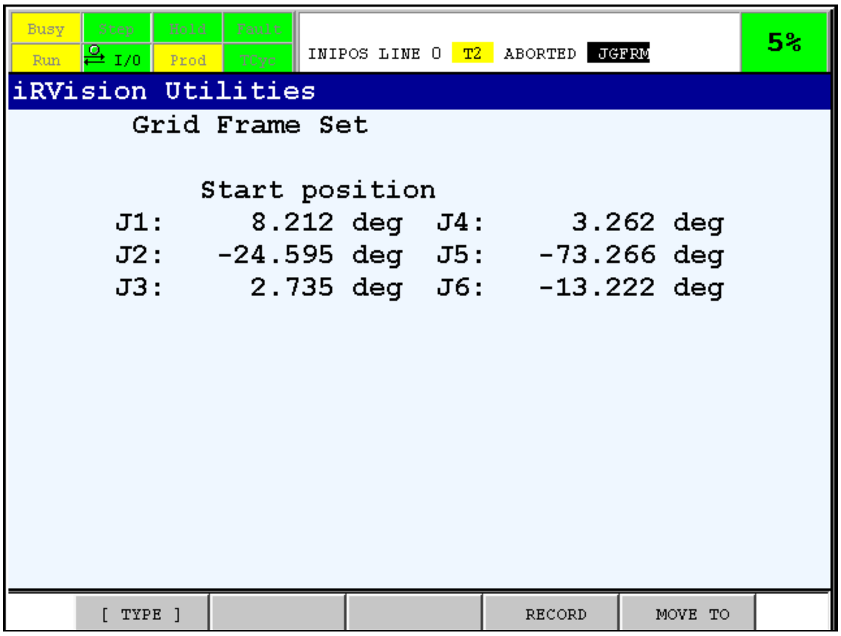
2 Jog the robot so that the camera's optical axis is approximately perpendicular to the plate surface of the calibration grid and that all of the four large black circles of the calibration grid are inside the camera's field of view. The distance between the calibration grid and the camera should be appropriate for the grid to come into focus, which is, under normal circumstances, roughly the same as the distance at which camera calibration is performed.

> ⚠ **CAUTION**
>
> The entire of the grid pattern does not need to be within the camera field of view. If the area that is captured the grid pattern on the image is small, the accuracy of the calibration is low. Please set the [Start Position] so that the grid pattern is captured on the entire image.



3 Press SHIFT and F4 RECORD at the same time to record the start position. When the start position is recorded, the label changes to "Recorded".

To check the trained start position, press F3 POSITION. The value of each axis of the start position is displayed, as shown below. To return to the previous menu, press PREV.



To move the robot to the start position, press SHIFT and F5 MOVE TO at the same time.

Operation range

During measurement, the robot automatically moves within the range specified by parameters. To prevent the robot from interfering with peripheral equipment, make sure that there is a sufficient operation space around the measurement area. When the default settings are used, the robot makes the following motions:

- Move ±100 mm horizontally in the X, Y, and Z directions
- Rotate by ±45 degrees around the camera's optical axis
- Rotate at ±30-degree inclination (WP) relative to the camera's optical axis at the robot start position
- Rotate at ±30-degree inclination (WP) relative to the camera's optical axis at the position where the camera directly faces the calibration grid

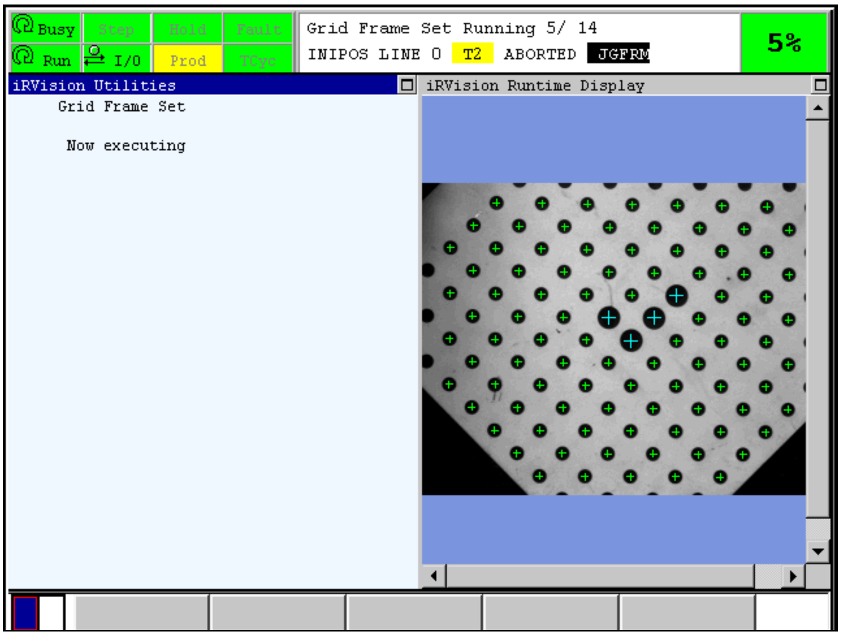
If the operation range defined by the default settings cannot be secured, you can make the operation range smaller by changing the parameters such as [R Angle Limit], [W Angle Limit], [P Angle Limit], and [Z Move Dist. Limit]. Note, however, that the precision of grid frame setting depends on the amount of motion at the time of measurement. A smaller operation range can lead to lower measurement precision. It is therefore recommended that measurements be made using a range as close to the default operation range as possible.

Value initialization

If you press F7 DEFAULT, the set values are initialized. Note that the [Camera Name] and the [Start Position] are not initialized; set these parameters again individually.

5.2.1.4 Run measurement

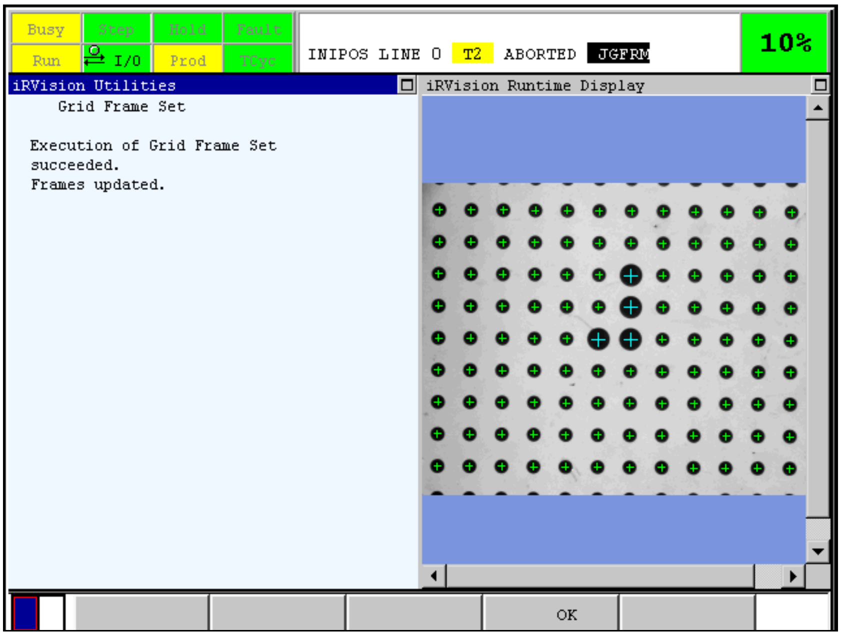
Pressing SHIFT and F5 EXECUTE at the same time starts measurement, causing the robot to start moving. During execution watch image display and verify that there are no improperly found calibration grid circles.



⚠ CAUTION

1. Releasing SHIFT while measurement is in progress stops the measurement. In that case, perform the measurement again. 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 running the Grid Frame Set, check that the related parameters are set correctly and decrease the override to 30% or less to ensure that the robot does not interfere with peripheral equipments.
4. If another program is paused, the Grid Frame Set may not be able to move the robot. In that case, abort all the programs using the FUNC menu.

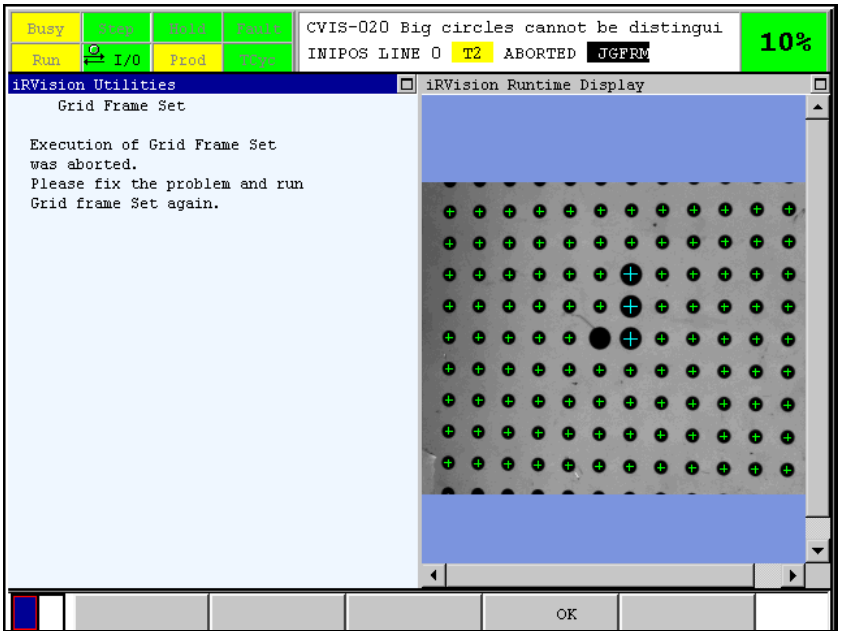
When the measurement is successfully completed, a menu like the one shown below appears. The robot stops after moving to a position where the camera directly faces the calibration grid and the origin of the calibration grid comes to the center of the image.



NOTE

You can confirm that the frame is set accurately with the following procedures.
First, change the manual-feed coordinate system to the measured frame.
When you set a user tool with Grid Frame Setting, change the manual-feed coordinate system to the user tool. When you set a user frame, change the manual-feed coordinate system to the user frame, and then select the user tool selected as "Setting the Parameters" in the Subsection 5.2.1.3.
Next, start the live image display and jog the robot around the X-, Y- and Z-axes. If the frame is set accurately, the center grid of the gird pattern will keep appearing at the center of the image.

If the measurement fails, a menu like the one shown below appears. In that case, press F4 OK to return to the previous menu. Then, change the parameters as appropriate and perform the measurement again. After changing the parameters, pressing SHIFT and F5 RUN at the same time starts the measurement again from the beginning. If the Grid Frame Set does not operate as expected, see Chapter 11 "Troubleshooting".



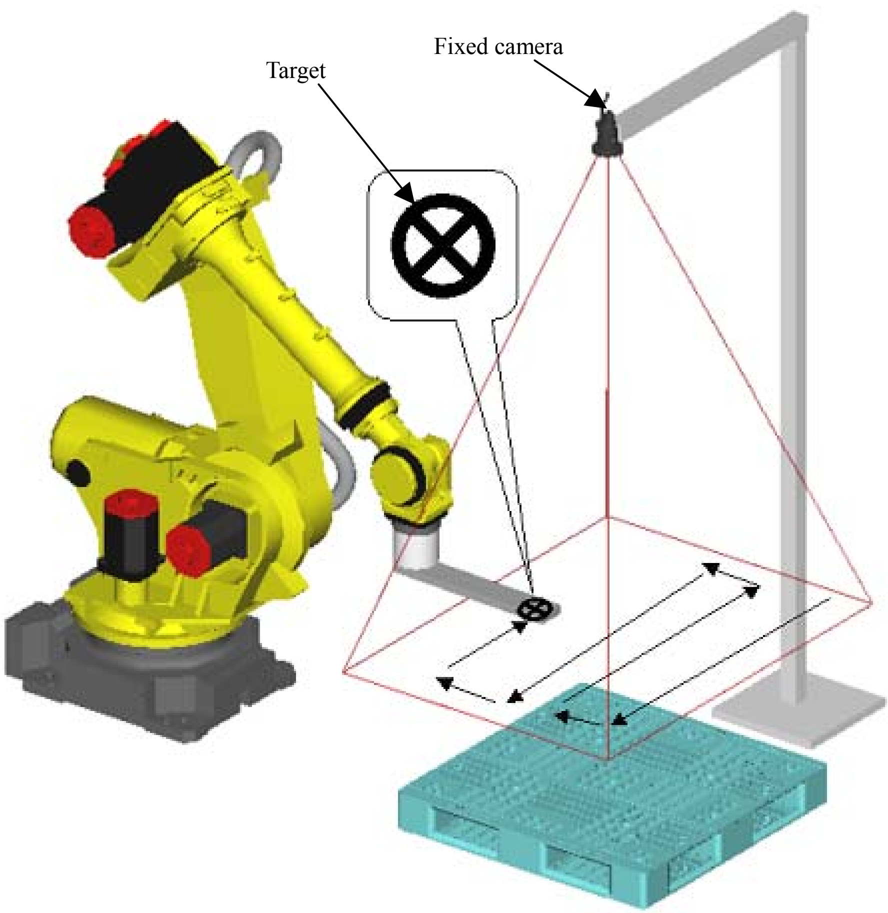
6 CAMERA CALIBRATION REFERENCE

This chapter explains the setting procedures of camera calibration. The following items are explained in this chapter.

- Robot-generated Grid Calibration
- 3DL Calibration

6.1 ROBOT-GENERATED GRID CALIBRATION

Robot-Generated Grid Calibration is a type of general-purpose camera calibration function. The function moves the target, mounted on the robot end of arm tooling, in the camera's field of view to generate a virtual grid pattern for camera calibration. Since it performs 2-plane calibration, the calibration method enables you to accurately calculate the position of the camera and the focal distance of the lens in use. The robot automatically moves and measures the position of the target and the size of the camera's field of view. When performing the calibration of the fixed camera, the Robot-generated Grid Calibration can be used. When using a robot-mounted camera, the Robot-generated Grid Calibration cannot be used. When using a robot-mounted camera, perform the Grid Pattern Calibration for a camera calibration.



The setup procedures of the [Robot-Generated Grid Calibration] are as follows.

1 Selecting and mounting the target

⇩

2 Setting the calibration data

⇩

3 Measuring position of the target

⇩

4 Generating calibration program

⇩

5 Executing calibration program

⇩

6 Checking the calibration data

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, the re-calibration can execute by performing only the procedure 5 "Executing calibration program". When the 3D Area Sensor is used, it is necessary to perform "2 Setting the calibration data ", "4 Generating calibration program.", "5 Executing calibration program." and "6 Checking the calibration data" for each camera.

6.1.1 Selecting and Mounting the Target

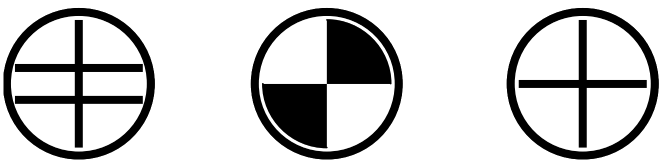
Select the target make to be used for calibration.

Geometry of the target

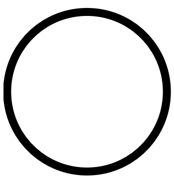
The target must meet the following conditions:

- The features to be taught are on the same one plane.
- The target has a geometry for which any rotation of ±45° or so can be identified.
- The target has a geometry whose size can be identified.

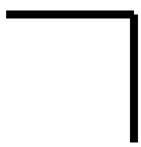
Examples of appropriate target geometries:



Examples of inappropriate geometries:



The rotation angle cannot be identified.



The size cannot be identified.

Size of the target

Make sure that the size of the target, when captured as an image, is 80 to 100 pixels in both vertical and horizontal directions. For example, when the camera's field of view is about 900 mm (8-mm lens; distance between camera and target is 2000 mm or so), prepare a target that is 120 to 160 mm in diameter.

Mounting the target

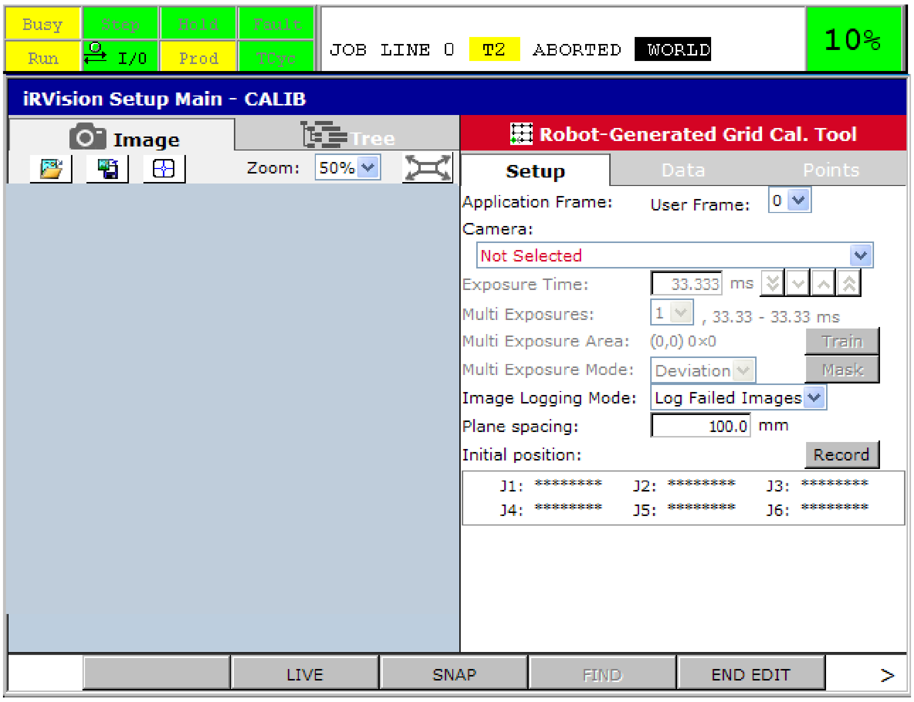
Mount the target at the robot end of arm tooling. Make sure that the target does not get behind the robot arm or the tooling even when the robot moves in the camera's field of view.

> ⚠ **CAUTION**
> Make sure that the target is fixed securely to the robot end of arm tooling so that it remains in place while the robot moves.

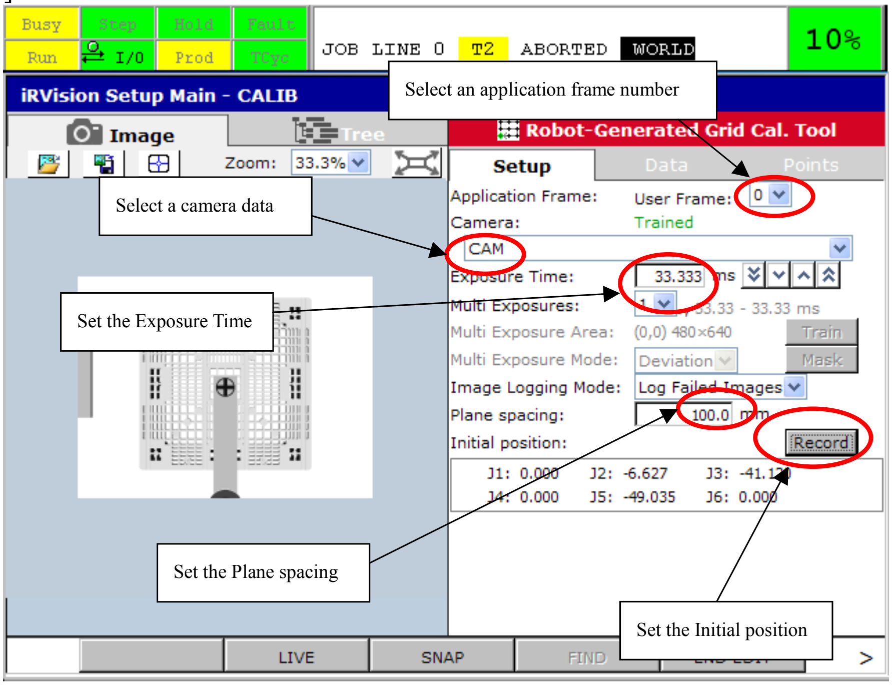
> **NOTE**
> 1 Normally, the robot position and posture are set so that the range of robot motion becomes maximal when the robot actually operates. Therefore, mounting the target so that it can be captured by the camera when the robot is in a posture that it takes during operation makes it easier to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

6.1.2 Setting the Calibration Data

Visit the Vision Setup screen, create a Robot-Generated Grid Calibration Tool and teach some parameters necessary prior to the execution. If you open the Robot-Generated Grid Calibration setup page, a page like the one shown below appears.



Set the [Application Frame number], the [Camera], the [Exposure Time], the [Plane Spacing] and the [Initial position].

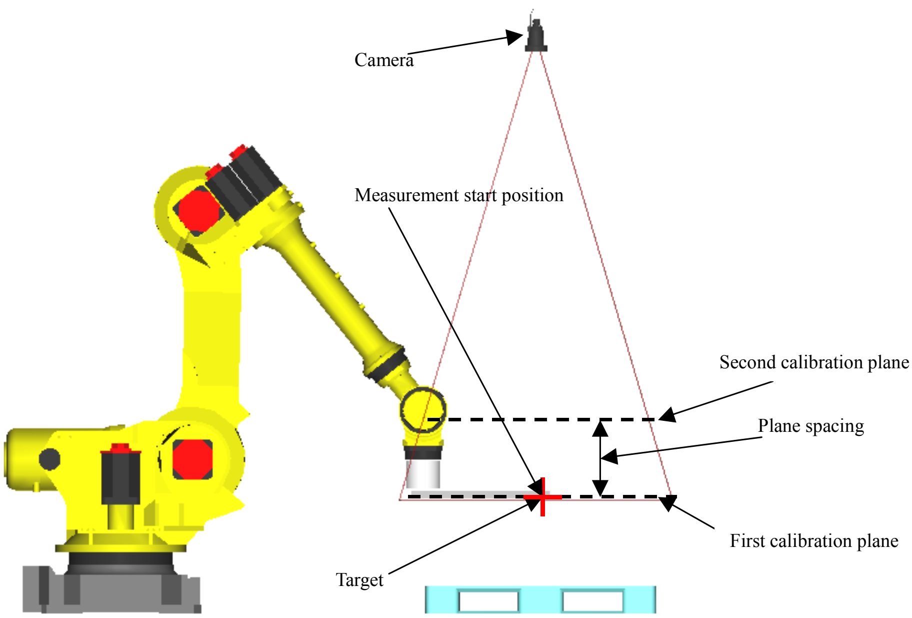


Plane spacing

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

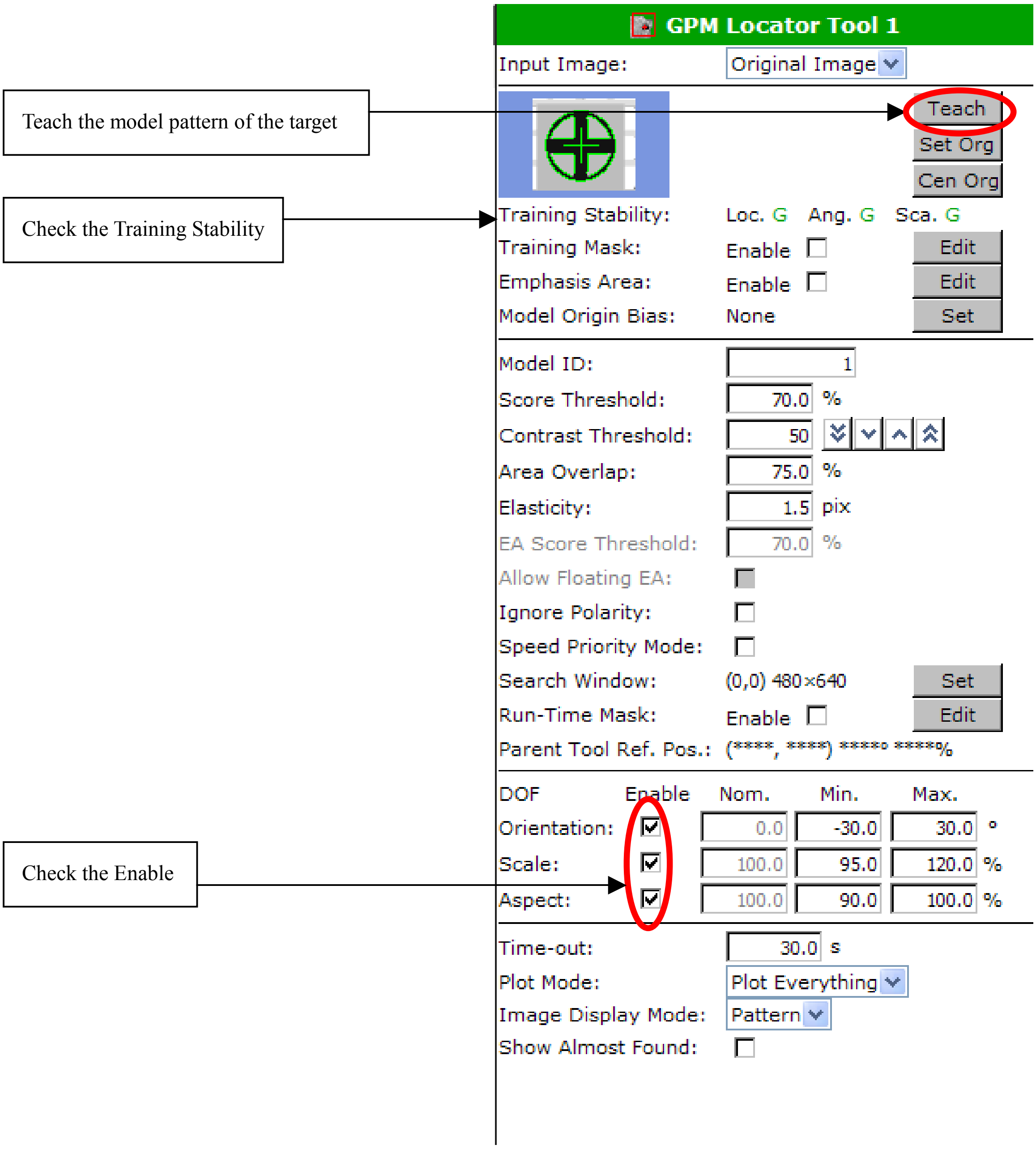
Initial position

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



GPM Locator Tool Setup Page

Select the "GPM Locator Tool" on the tree view, and teach the model pattern. After moving the robot to the recorded start position, teach the model.



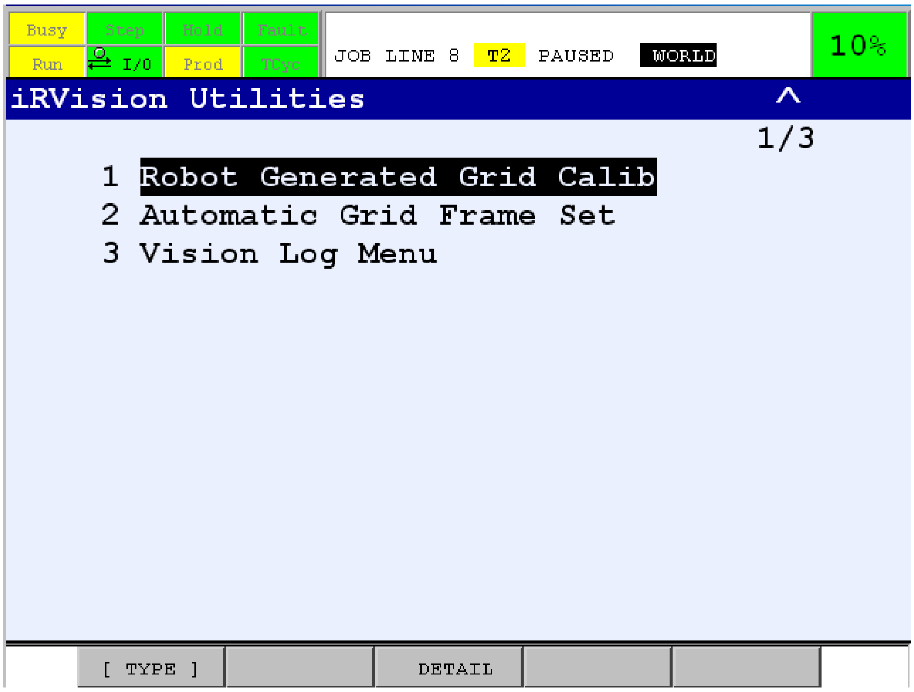
Verify the [Training Stability] of the model pattern to see if [Good] is shown for [Location], [Orientation], and [Scale], respectively. If [None] is shown for any of these items, calibration cannot be performed properly. In that case, use a different shape of target mark.

By default, the range of [Angle] is set to be searched to ±30° and the range of [Scale] is set to be searched to 95% to 120% and the range of [Aspect Ratio] is set to be searched to 90% to 100%. Usually, you don't have to change these parameters. Please adjust these parameters if necessary.

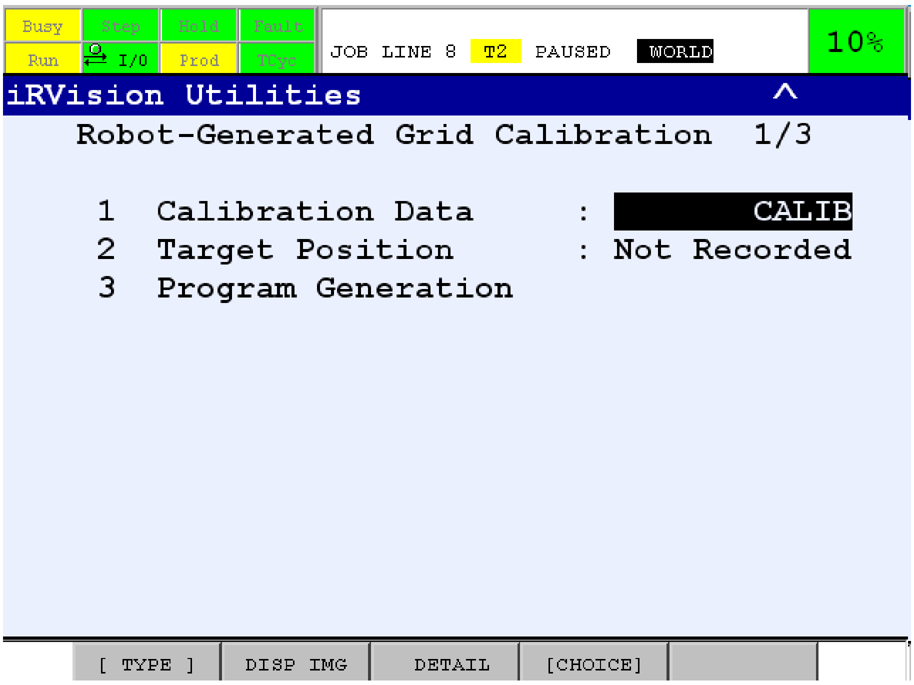
> **NOTE**
> When training the model pattern, the rectangle should not be unnecessarily larger than the area of the target mark. The robot moves the target mark keeping the trained rectangle within the search area. So the larger the trained rectangle is, the smaller the target mark displacement range is, therefore more likely to decrease the accuracy of the camera calibration.

Set up the calibration data. Move to the UTILITY MENU page in the following procedures.

1 Press the MENU key on teach pendant, and select the "5 Vision Utilities" in the "8 *i*RVision".



Visit the [Robot-Generated Grid Calibration] in the Vision Utility screen, and select the camera calibration data that you just created in [1 Calibration Data].

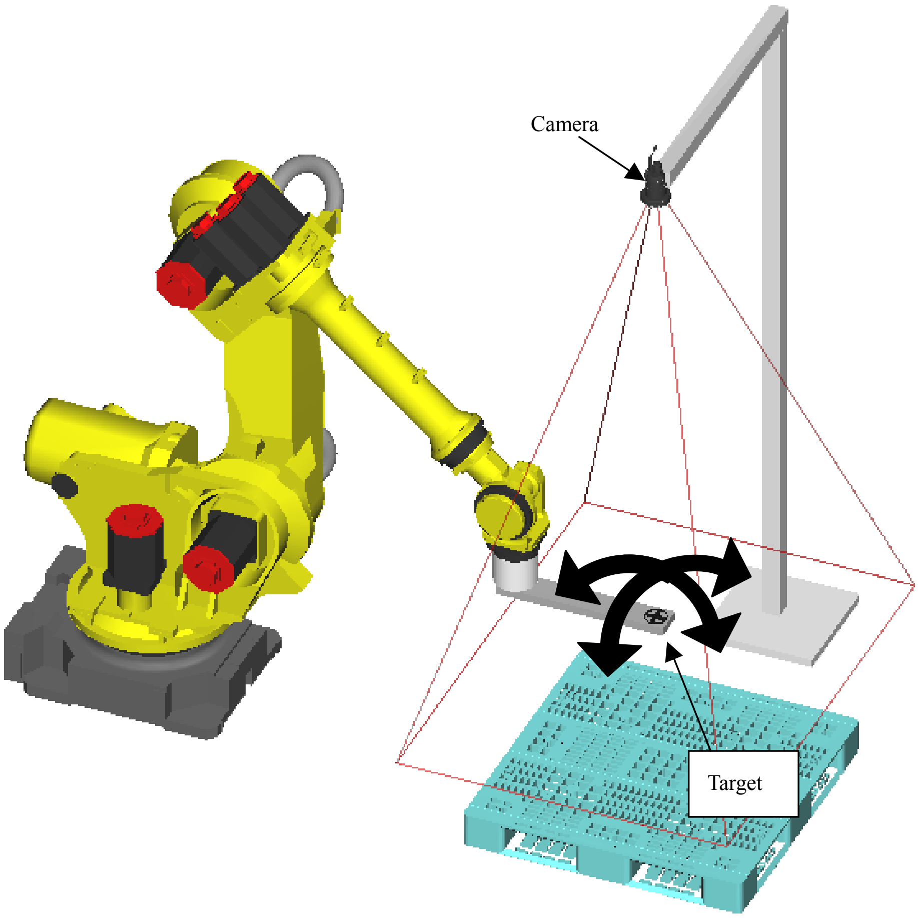


6.1.3 Measuring Target Position

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

6-axis robot

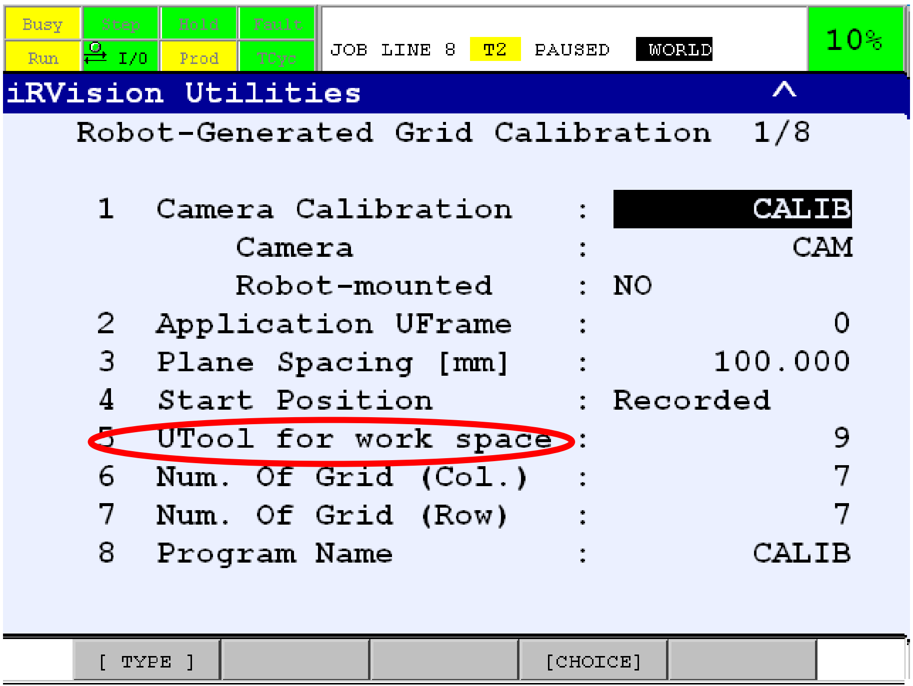
A 6-axis robot can measure the position of robot-mounted target mark by vision. A robot measures the target by changing the position and posture of the target as shown below.



The target location is measured as the following procedures.

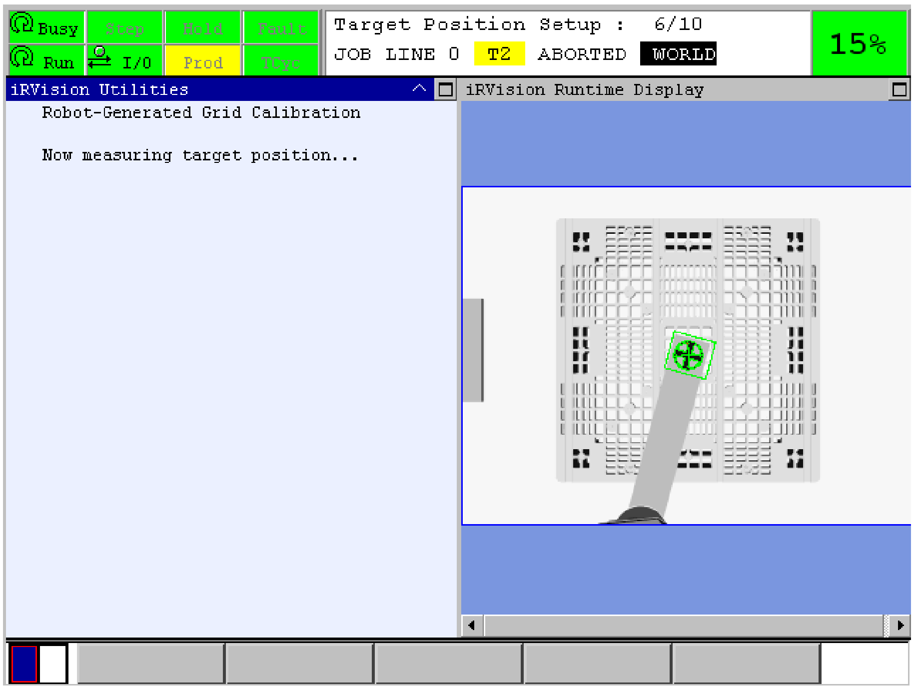
1 Verify whether the calibration data which is selected [1 Calibration Data] is proper.

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

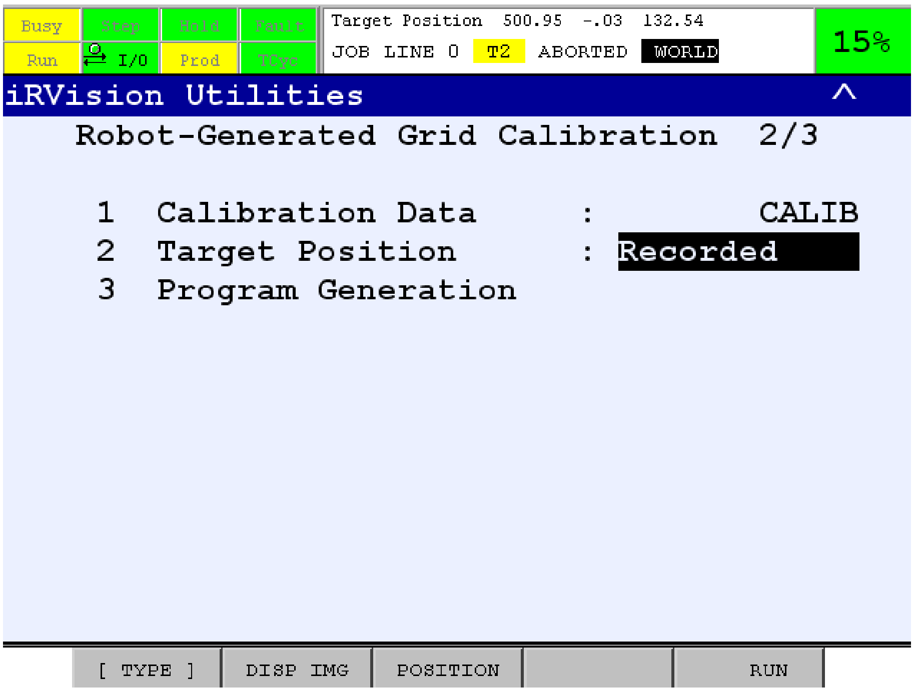


> ⚠ **CAUTION**
> Robot-Generated Grid Calibration uses a user tool for the work space when measuring the position of the target or generating a calibration program. Here, specify the number of the user tool for the work space. Since the function conducts the measurement as it rewrites the values of the specified user tool, specify the number of a user tool whose values can be changed without causing any problem.

3 Place the cursor on [2 Target Position].
4 Enable the teach pendant, and reset the alarm.
5 Press SHIFT + F5 RUN to start the measurement. Keep holding down SHIFT while the measurement is in progress.



6 When the measurement is complete, the robot stops and the message "Measurement is successfully finished." appears on the screen.
7 Release the SHIFT button and press F4 OK button.
8 Check that "2 Target Position" becomes "Recorded".



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 on the procedure number 5. 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.

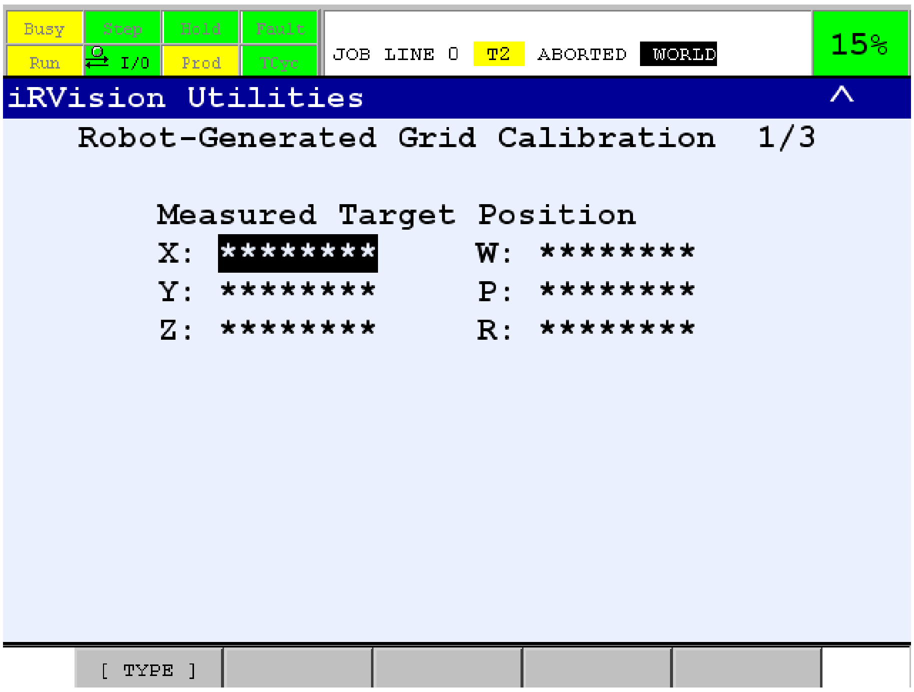
NOTE

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 the target position by the same steps as a 4-axis or 5-axis robot.

4- or 5-axis robot

A 4- or 5-axis robot cannot use vision-based measuring. Train the position of the target mark manually.

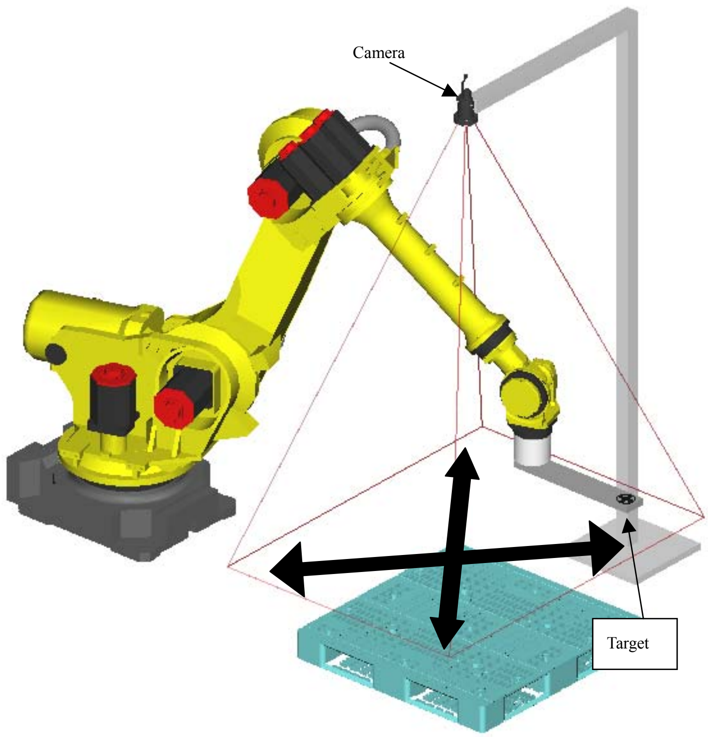
1 Place the cursor on [2 Target Position], and press F3 POSITION to visit the target position menu.
2 Calculate the model origin position of the target that relative to the robot mechanical interface frame with the tool plan. Then, input X, Y and Z as the position of the target mark. Input W, P and R to zero.



> ⚠ **CAUTION**
> The target position should correspond to the model origin trained in section in 6.1.2. If the positions are different, the camera cannot be calibrated properly.

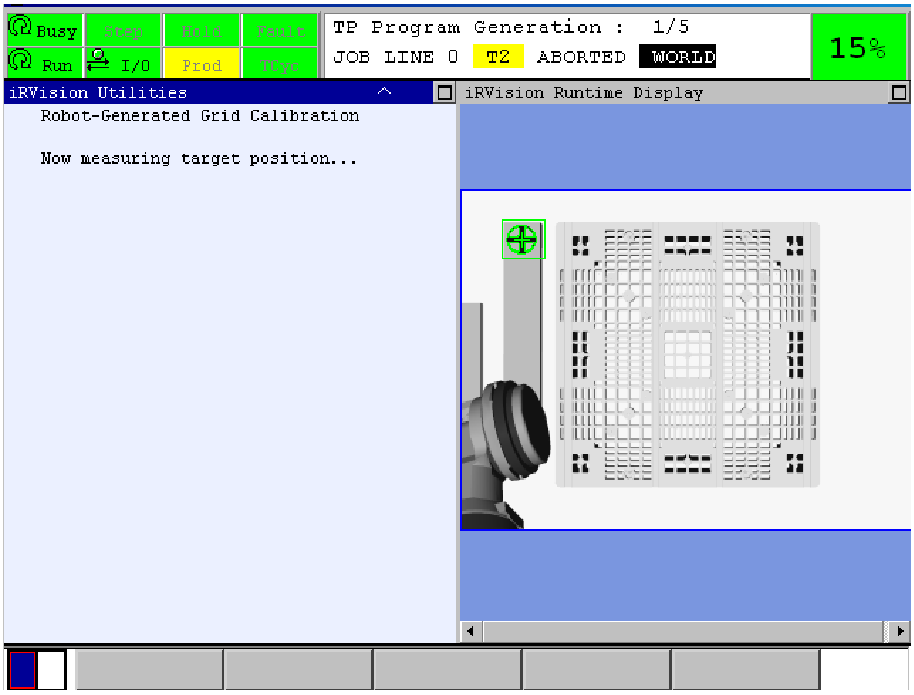
6.1.4 Generating Calibration Program

A robot measures the size of field of view while changes the target position as shown below, and generates a robot program for camera calibration.



1 Verify whether the calibration data which is selected [1 Calibration Data] is proper.

2 Verify whether [2 Target Position] is RECORDED.
3 Place the cursor on [3 Program Generation].
4 Enable the teach pendant, and reset the alarm.



5 Press SHIFT + F5 RUN to start the program generation. Keep holding down SHIFT while the measurement is in progress.
6 When the measurement is complete, the robot stops and the message "Measurement is successfully finished. " appears on the screen.
7 Press F4 OK.

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 on the procedure number 5. To resume the process, press SHIFT + F4 RESUME. To restart the process from the beginning, press SHIFT + F5 RESTART.

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

The way to limit the target displacement range

In order to avoid the interference with peripheral equipment, you can limit the target displacement range.

1 Open the camera calibration setup page and choose GPM Locator Tool in the tree view.
2 Shrink the search window and omit the area that the interference occurred.
3 Press F10 SAVE to save the camera calibration.
4 Press F5 END EDIT to close the setup page.
5 Visit the Robot-Generated Grid Calibration in Vision Utility, and generate a calibration program again.

Calibration Program

The generated calibration program is like the one shown below. All the robot positions in the calibration program are taught in the joint format.

```
  1:   UFRAME_NUM=2
  2:   UTOOL_NUM=2
  3:L P[1] 1000mm/sec FINE
  4:   VISION CAMREA_CALIB 'CALIB1' REQUEST=1
  5:L P[1001] 1000mm/sec FINE
  6:   CALL IRVBKLSH(1)
  7:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1001
  8:L P[1002] 1000mm/sec FINE
  9:   CALL IRVBKLSH(1)
 10:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1002

        (Repeat as many times as the number of points)

293:L P[2048] 1000mm/sec FINE
294:   CALL IRVBKLSH(1)
295:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2048
296:L P[2049] 1000mm/sec FINE
297:   CALL IRVBKLSH(1)
298:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2049
299:L P[2] 1000mm/sec FINE
300:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
```

The section of the program that finds an individual calibration program consists of the three lines shown below. This set of three lines is repeated in the middle of the calibration program above.

```
  5:L P[1001] 1000mm/sec FINE
  6:   CALL IRVBKLSH(1)
  7:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1001
```

Each command in the program is briefly explained below.

```
  4:   VISION CAMREA_CALIB 'CALIB1' REQUEST=1
```

If you specify 1 in the request code of the CAMERA_CALIB command, all the calibration points in the specified camera calibration are deleted. This is the first command to be executed in the calibration program.

```
300:   VISION CAMERA_CALIB 'CALIB1' REQUEST=2
```

If you specify 2 in the request code of the CAMERA_CALIB command, camera calibration data is calculated using the found calibration points. This is the last command to be executed in the calibration program.

```
  7:   VISION CAMERA_CALIB 'CALIB1' REQUEST=1001
```

If you specify 1000 or a larger value in the request code of the CAMERA_CALIB command, the program attempts to find a calibration point. The value specified in the request code is recorded as the index of the calibration point, along with the found position.

In an automatically generated calibration program, 1000 to 1999 represent the calibration points on calibration plane 1, and 2000 to 2999 the calibration points on calibration plane 2. Note also that the index of the position data of the preceding motion statement is the same as the request code that is passed to the CAMERA_CALIB command.

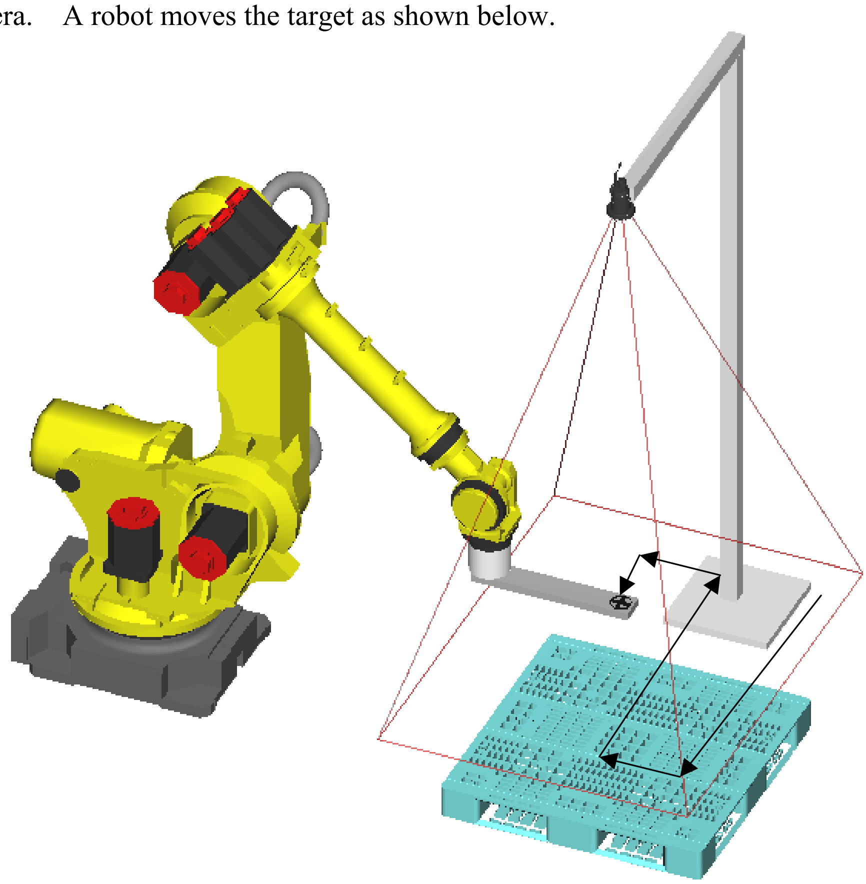
Calibration points do not necessarily need to be found in the order of request codes. If a calibration point is found twice with the same request code, the data of the calibration point that is found first is overwritten by the data of the calibration point found later.

```
6:   CALL IRVBKLSH(1)
```

If the KAREL program IRVBKLSH.PC is called, the robot performs an operation intended to remove the backlash effect at its current position. As the argument, specify the motion group number of the robot that performs the backlash removal operation.

6.1.5 Executing Calibration Program

Select the generated calibration program in the SELECT menu, and play it back from the first line to calibrate the camera. A robot moves the target as shown below.



> ⚠ **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.

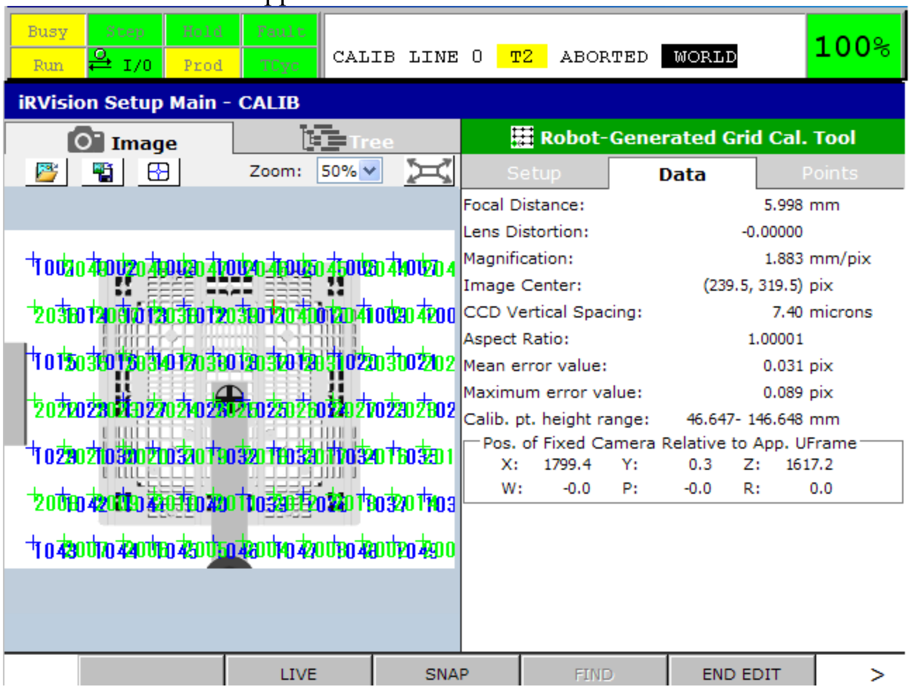
> ⚠ **CAUTION**
> The calibration program does not stop even if the target fails to be found or it is found incorrectly during the program execution. After the program ends, open the Robot-generated Grid Calibration setup page in the Vision Setup screen and check to see if there is any point incorrectly found.

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

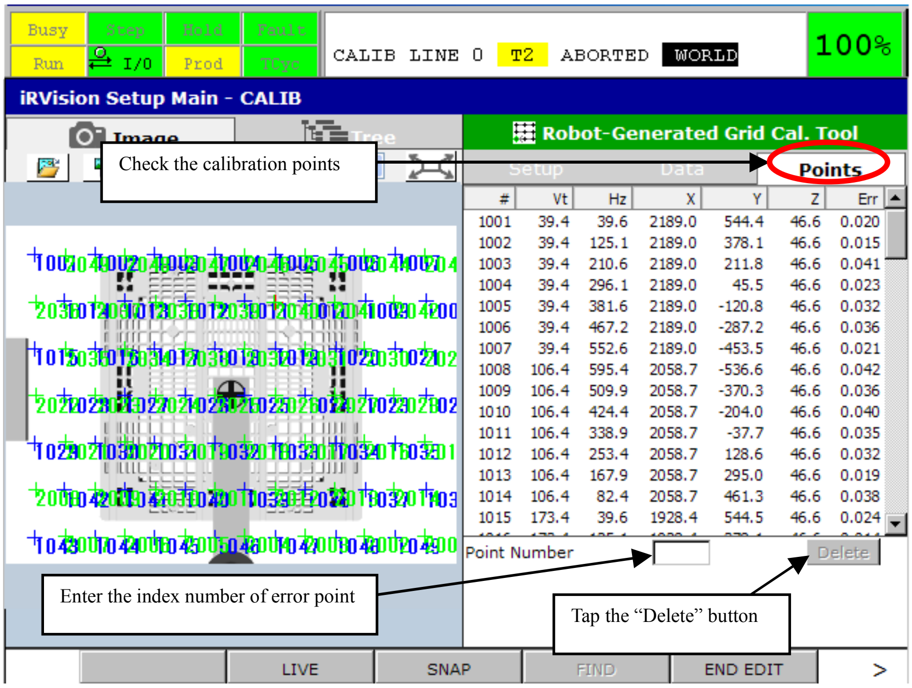
After executing the calibration program to the last, camera calibration is complete. Please verify the calibration points and the calibration results.

6.1.6 Camera Calibration Data Checking

The following figure is camera calibration screen. Check that the calculated focal distance and the position of fixed camera relative to application frame are correct.

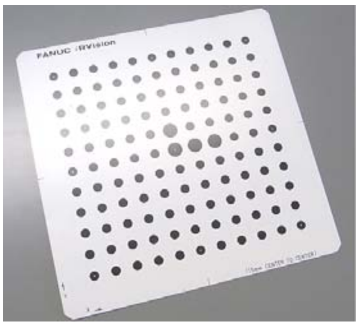


The Points in the calibration page are shown below. If a crosshair is displayed at a location where no grid point is present, enter the index number of that point in the text box to the left of the [Delete] button and then tap the [Delete] button.



6.2 3DL CALIBRATION

The 3DL Calibration is the standard method to calibrate the 3D Laser Sensor. A fixture called the calibration grid is used to calibrate the 3D Laser Sensor. Prepare a calibration grid beforehand. Usually, prepare a calibration grid which is the bigger than a field of view. A standard calibration grid is available from FANUC in several sizes. It is strongly recommended that you order a calibration grid as well as a camera and lens.



It is not necessary to detect all the dots on the calibration grid. There are 11 × 11 dots in the standard calibration grid of FANUC. If 7 × 7 dots are detected, the camera calibration is performed with sufficient accuracy. (The four big dots need to be detected.) In order to show all the dots in field of view, it is not necessary to prepare a small calibration grid. In order to perform a calibration with accuracy sufficient to the edge of the field of view, even if the number of detectable dots became fewer, prepare the bigger calibration grid than a field of view.

In this section, the setup procedures of the 3D Laser Sensor mounted on the robot arm tooling is explained.

1. Application frame setting

2. Camera setting data creation and teaching

3. Calibration grid frame setting

4. Camera calibration data creation and teaching

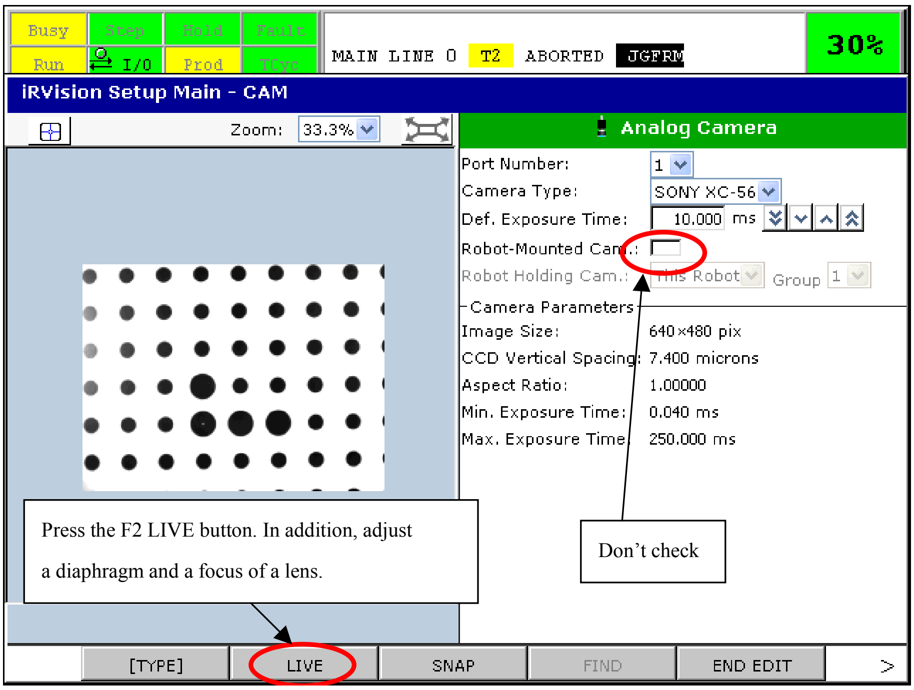
5. Camera calibration data checking

6.2.1 Application Frame Setting

An application frame is the robot's user frame to be used for camera calibration. The application frame number is set in subsection 6.2.4, "Camera Calibration Data Creation and Teaching". As for the initial value, the user frame number 0 is chosen. In almost all cases, it is change needlessness.

6.2.2 Camera Setting Data Creation and Teaching

With *i*RVision, items such as a camera type and camera installation method are set in camera setup tool. Whether to install a camera on the robot or on a fixed stand is set in the camera setup tool. When using a camera mounted on the robot arm tooling, check "Robot-Mounted Camera".



6.2.3 Calibration Grid Frame Setting

Teach the calibration grid location in a user frame. To perform calibration by setting the calibration grid that is fixed, teach a user frame to the grid. There are two methods to teach the user frame, one is touch-up with the pointer tool, and another is the Automatic Grid Frame Setting Function, but the Automatic Grid Frame Setting Function is recommended. Note that the frame used for the calibration grid setup might differ from "application frame" and "offset frame".

Touch-up

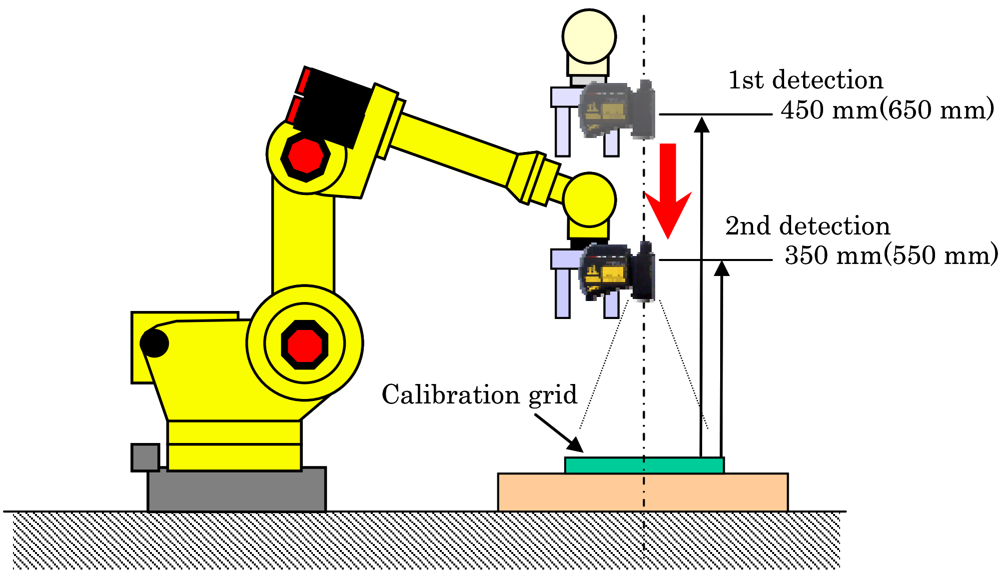
To set up by touch-up, a pointer tool with a taught TCP is required. In general, set the TCP accurately on the pointer installed on the robot gripper. If the accuracy of this TCP setting is low, the precision in handling of a part by the robot is also degraded, especially when the part is rotated. Set a robot TCP in an arbitrary tool frame. To reuse the pointer TCP, the reproducibility of pointer installation is required. If the reproducibility of pointer installation is not assured, a TCP needs to be set each time a pointer is installed. For details, see Section 5.1.1, "Setting the User Frame with a Pointer Tool ".

Grid Frame Setting Function

The Grid Frame Setting Function sets the calibration grid frame using a camera. Install a calibration grid so that the XY plane of the calibration grid is parallel with the plane on which the part moves, and perform the Grid Frame Setting Function. For details, see Section 5.2, "FRAME SETTING WITH THE GRID FRAME SETTING FUNCTION". In the case of a camera mounted on the robot arm tooling, perform the Grid Frame Setting Function using the camera. And perform the Grid Frame Setting Function using another camera attached to the arbitrary positions of a robot's hand if there is no space for the Grid Frame Setting Function. In addition, the Grid Frame Setting Function is usable with 6-axis robots only. The function cannot be used with 4-axis robots and 5-axis robots. When using 4-axis robots or 5-axis robots, set the calibration grid frame by touch-up.

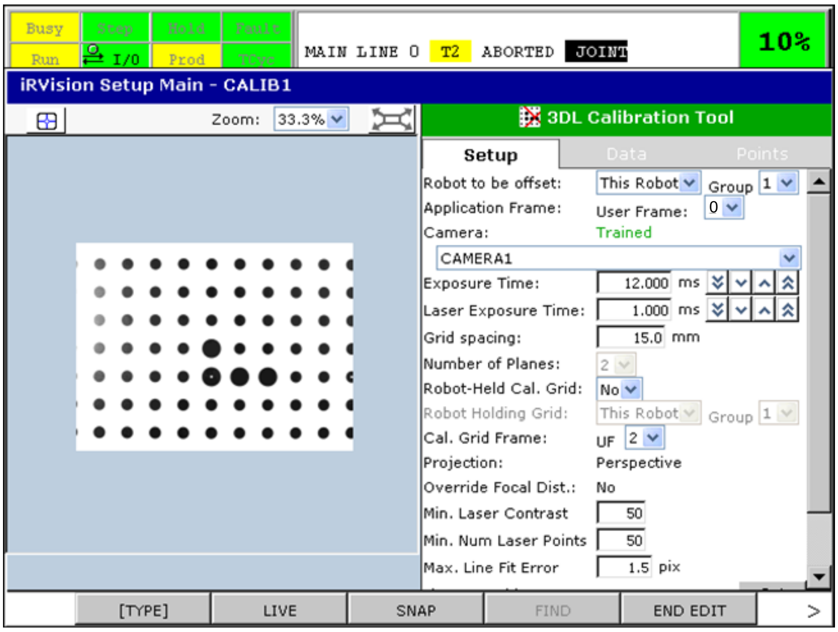
6.2.4 Camera Calibration Data Creation and Teaching

For a robot-mounted camera, perform 2-plane calibration by moving the robot end of arm tooling up and down as shown in the figure below. For calibration, the appropriate distances between the 3D Laser Vision Sensor and calibration grid are near 350mm and 450mm (near 550mm and 650mm if the standoff of the 3D laser sensor is 600mm). When the calibration grid is detected with the robot and is made to have the same posture as it does when the part is detected, the precision is increased.



After one set of calibration tool is created with 3DL vision calibration, another set of calibration tool does not need to be created even after the camera measurement position is changed. This is because *i*RVision uses the current robot position when calculating the position of the part.

The teach screen for 3DL calibration is shown below. A calibration grid image is displayed.



Select the number of the "user frame" set as the "application frame" in [User Frame].

Enter [Exposure Time] to be applied for grid detection.

Enter [Laser Exposure Time] to be applied for laser measurement.

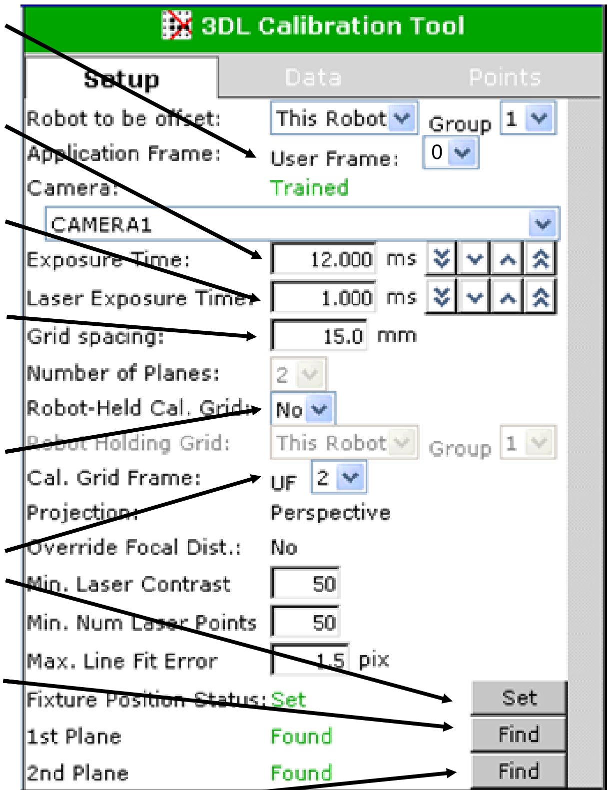
Enter [Grid Spacing] between grid points on the calibration grid.

Select [No] if the calibration grid is a fixed position.

Select the number of the "user frame" in which "calibration grid frame" is set in [User Frame], then click the [Set] button.

Move the camera from the calibration grid by a proper distance, then click the [Find] button for [1st Plane].

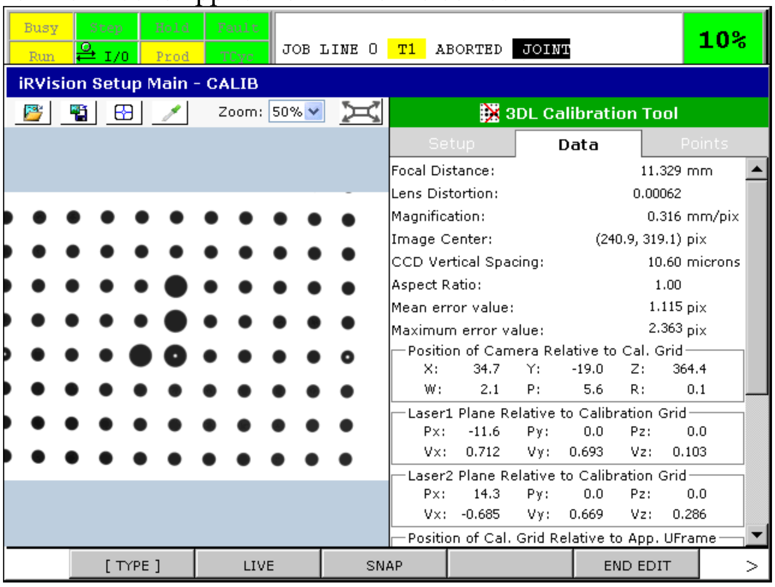
Change the distance between the camera and calibration grid, then click the [Find] button for [2nd Plane].



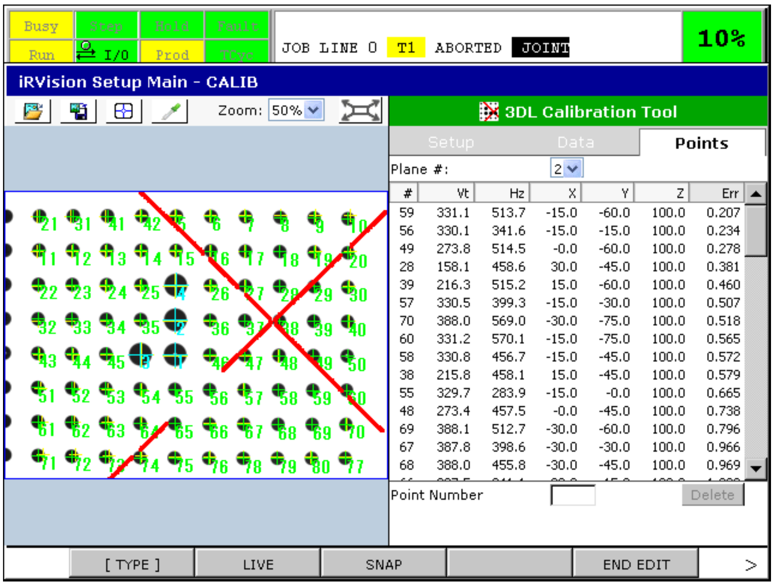
> ⚠ **CAUTION**
> When recalibrating a camera, if you change the position of the calibration grid, set the user frame of the calibration grid frame again.
> Then click the [Set] button for the calibration grid frame and recalculate it.

6.2.5 Camera Calibration Data Checking

The following figure is camera calibration screen. Check that the calculated focal distance and the position of fixed camera relative to application frame are correct.



The Points in the calibration page are shown below. If a crosshair is displayed at a location where no grid point is present, enter the index number of that point in the text box to the left of the [Delete] button and then tap the [Delete] button.



7 3D AREA SENSOR REFERENCE

7.1 3D AREA SENSOR GUIDANCE

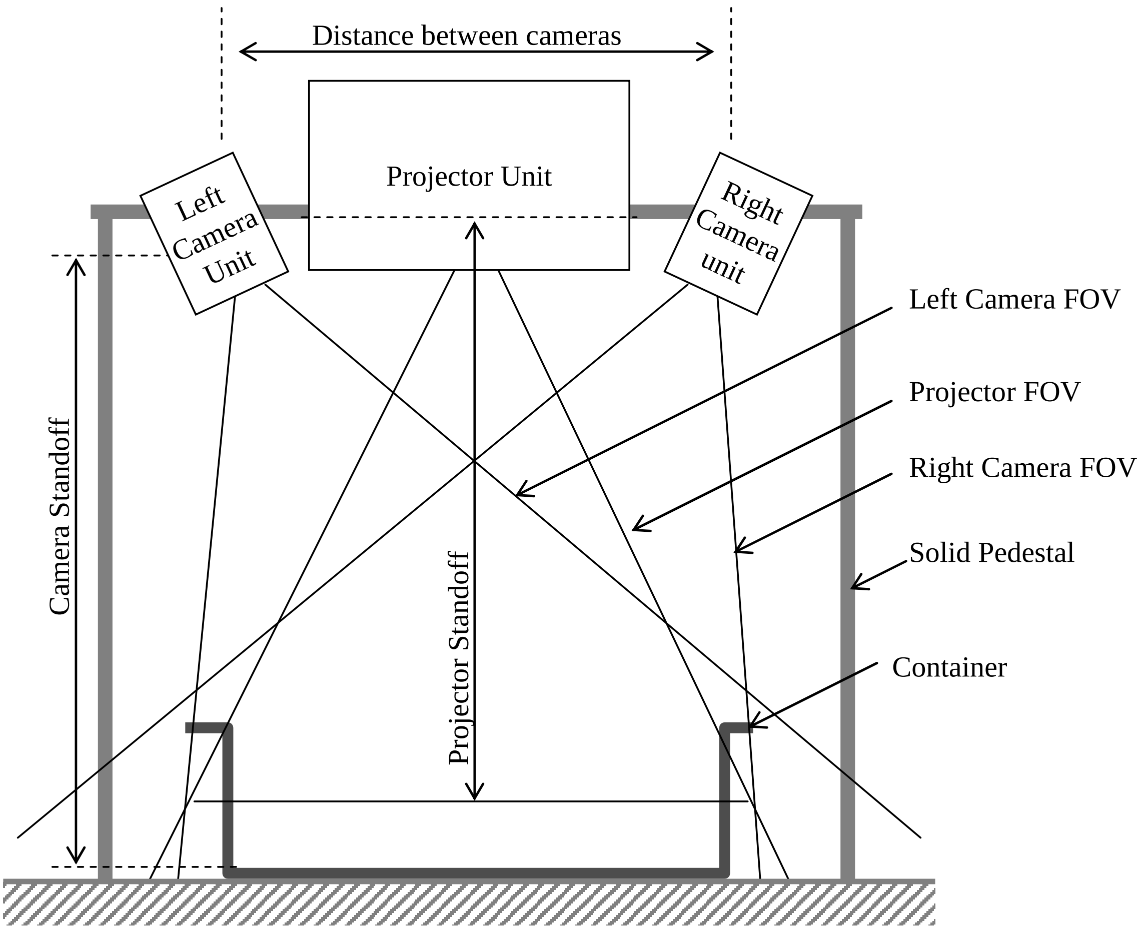
3D Area Sensor is composed of three units, two camera units and one projector unit. The projector unit projects stripe patterns very quickly and the two camera units snap their images, and then 3D information in a wide area is calculated at once. In this document, a single element of the acquired 3D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

The camera units and the projector unit of 3D Area Sensor should be mounted on a solid mounting structure. Each unit of 3D Area Sensor needs to be securely mounted above the target container.

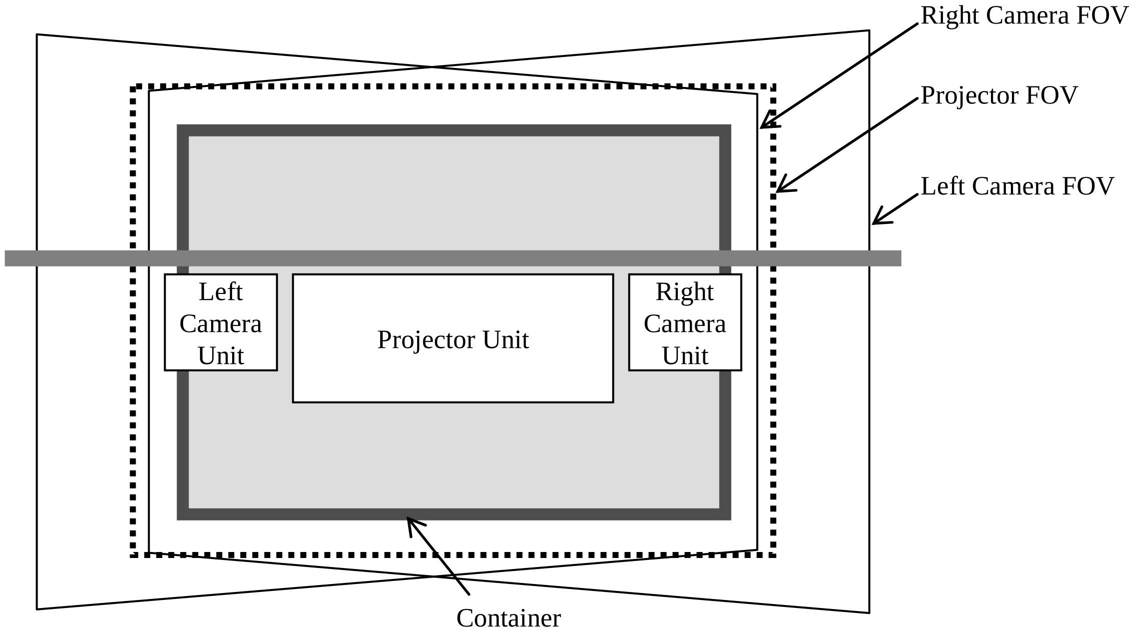
> ⚠ **CAUTION**
> The 3D Area Sensor cannot be mounted on a robot.

Standard Layout

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



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



As you can see in the figures above, the two camera units and the projector unit should be located roughly on a line. Mount the two camera units as far apart as possible; this will maximize the Z depth accuracy. Do not make the camera units too far apart; each camera unit must be able to see inside the entire container. If the camera units are too far apart, the sides of the container will block the camera view of the bottom of the container. Any portion of the container that is not within view of both cameras will fail to have any 3D data.

The distance between cameras, the camera standoff and the Z accuracy have the following relationship.

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

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

The camera standoff and the projector standoff do not have to be the same, but the standoff of the two camera units should be the same.

> ⚠ **CAUTION**
> 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.

Camera Calibration

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

> ⚠ **CAUTION**
> Z axis of the application frame should be perpendicular to the floor of the container and its +Z direction should toward the sensor.

Projection FOV and Standoff of Projector Unit

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

3D Area Sensor calculates a certain number of 3D points within projector's FOV, e.g. 239x192 points if Normal density mode is selected. Therefore, the spatial density or resolution of the measured 3D points depends on the projector's FOV size. Therefore, the larger the projector's FOV is, the longer the spatial distance of the measured 3D points is.

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

Determine the projector's FOV then determine the proper standoff.

FOV of Cameras

The FOV of the camera units should cover the upper opening of the container. 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's FOV, it would be difficult to detect the patterns accurately, because each pattern that appears in the camera image would not be clear enough. Mount the camera units so that their FOV and the FOV of the projector unit are close to the same size. The optical axis of each camera unit should roughly pass through the center point of the upper opening of the container.

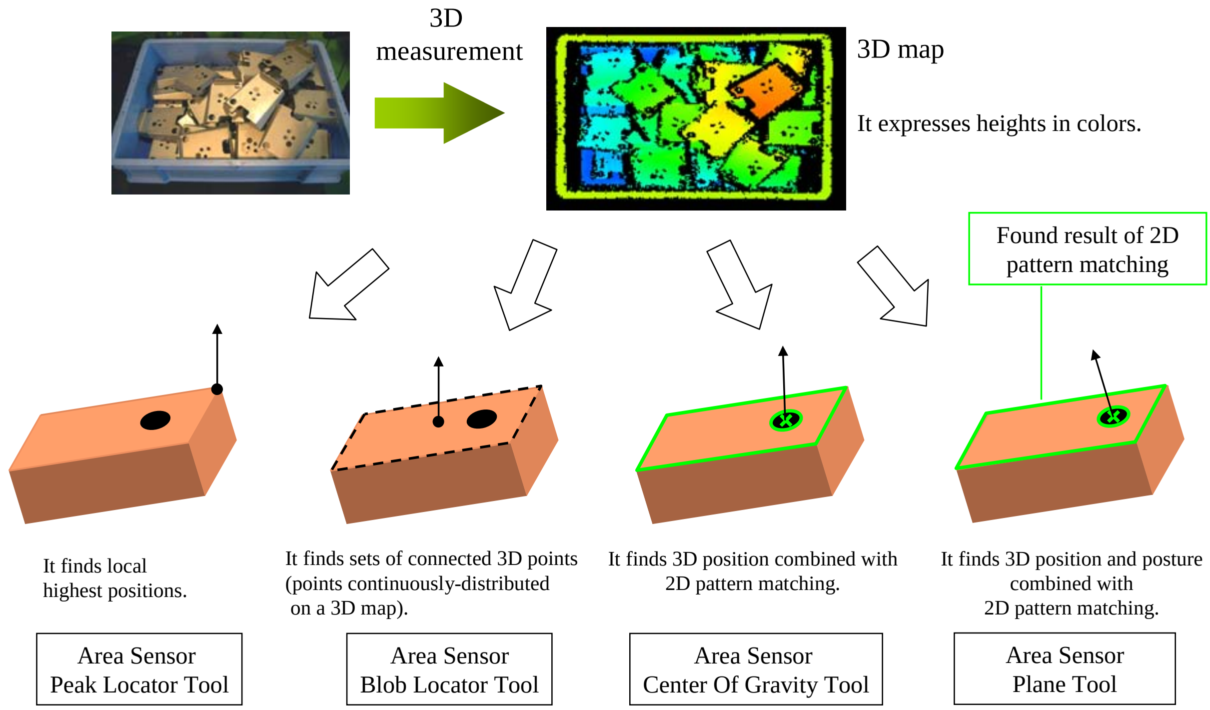
Ambient Lights

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.

> ⚠ **CAUTION**
>
> Lighting for 2D detection (e.g. GPM Locator Tool) is also an ambient light. The lighting for 2D detection should be turned off while acquiring 3D Area Sensor. Control the overhead lights to be on while performing the 2D detection and off while running capturing the 3D Area Map with the 3D Area Sensor.

7.2 GENERAL DESCRIPTION OF 3D AREA SENSOR FRATURES

The major detection methods using the 3D Area Sensor are following.



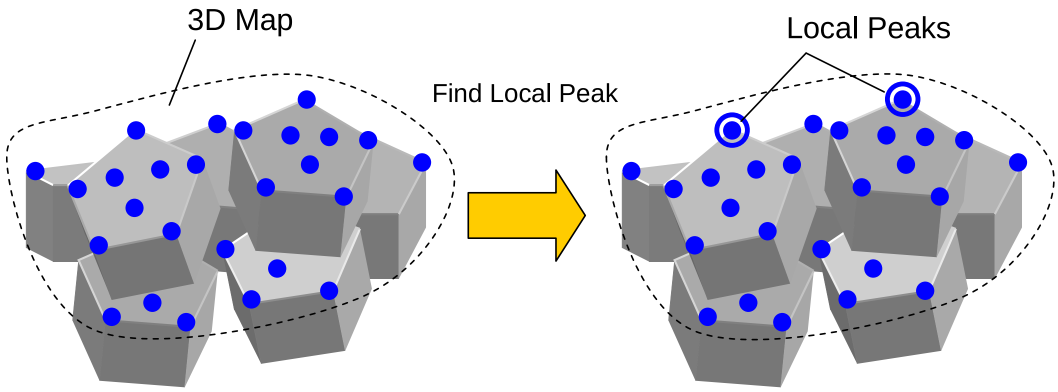
Broadly speaking, there are 2 detection methods that use the 3D area sensor. These are "3D detection with only 3D map" and "3D detection with combination of 2D Locator Tool". The 2D Locator Tool finds a pattern which is the same as taught model pattern such as the GPM Locator Tool or the CSM Locator Tool.

7.2.1 3D Detection with Only 3D Map

"3D detection with only 3D map" detects parts only with 3D map without the camera image. If the postures of parts vary greatly then the 2D image of them from overhead is not consistent. However this method can execute stable detection independent of the postures. The Area Sensor Peak Locater Tool and the Area Sensor Blob Locator Tool, are provided for "3D Detection with Only 3D Map". These two tools are useful when the parts are postures are completely random. The Area Sensor Preprocess Tool is also provided in order to remove some incorrect or useless 3D points.

Area Sensor Peak Locator Tool

The Area Sensor Peak Locator Tool can detect local peaks which are the highest positions in the 3D map. This tool enables the robot to pick up parts at the highest positions. This tool needs no pattern models like the GPM locator or the CSM locator tools. This tool can detect parts whose figures are unknown. This tool can also detect non-uniform mixtures of parts. For details of this command tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

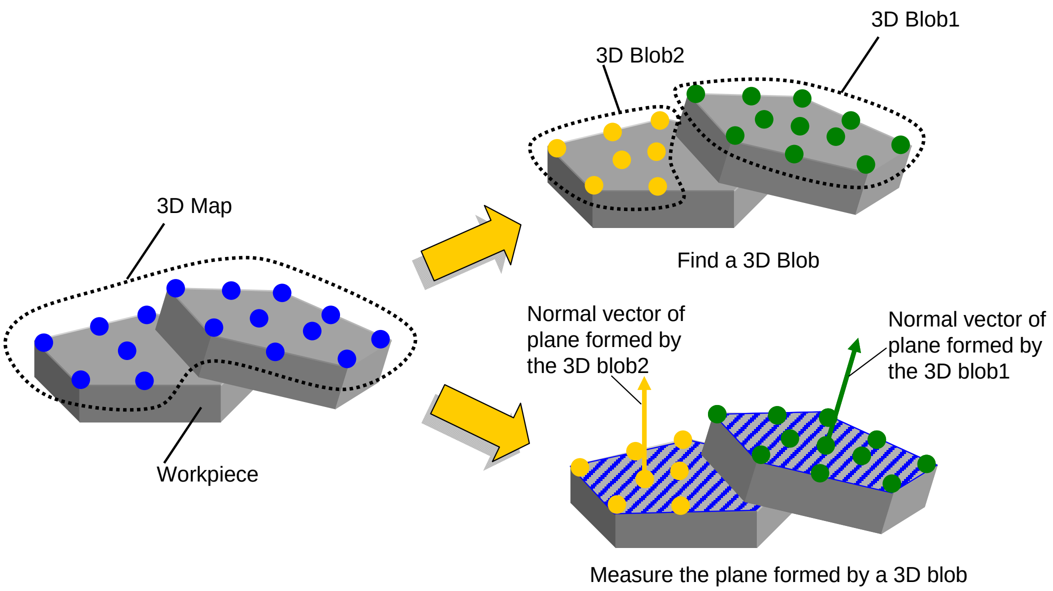


Caution

- The Area Sensor Peak Locator tool doesn't measure the postures of parts. Therefore, the W, P and R of the postures of found results are always 0.0.
- Found local peaks are not always located at a specific pretrained position on the parts because this function finds the highest positions of the part from the 3D map.
- For the above reasons, the Area Sensor Peak Locator Tool is not suitable for the robot to pick up parts by using the postures of the parts. Therefore, the robot gripper which can pick up parts regardless of their postures is required. For example, a vacuum or magnet gripper is required.

Area Sensor Blob Locator Tool

The Area Sensor Blob Locator Tool detects sets of connected 3D points in a 3D map. The planes formed by the sets of connected 3D points can also be measured. This tool needs no pattern models like the GPM locator or the CSM locator tools. This tool can detect workpieces whose features are unknown. This tool can also detect non-uniform mixtures of parts. For details of this command tool, refer to Chapter 7 in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".



Caution

- When the measurement of planes is not used, the W, P and R of the postures of the found results are always 0.0.
- Obtained 3D points changes depending on the postures and the piles of workpieces. Therefore the found positions are not always located at a specific pretrained position on the parts.
- For the above reasons, the Area Sensor Blob Locator Tool is not suitable for the robot to pick up the workpieces by using specific pretrained postures of the parts. Therefore, the robot gripper which

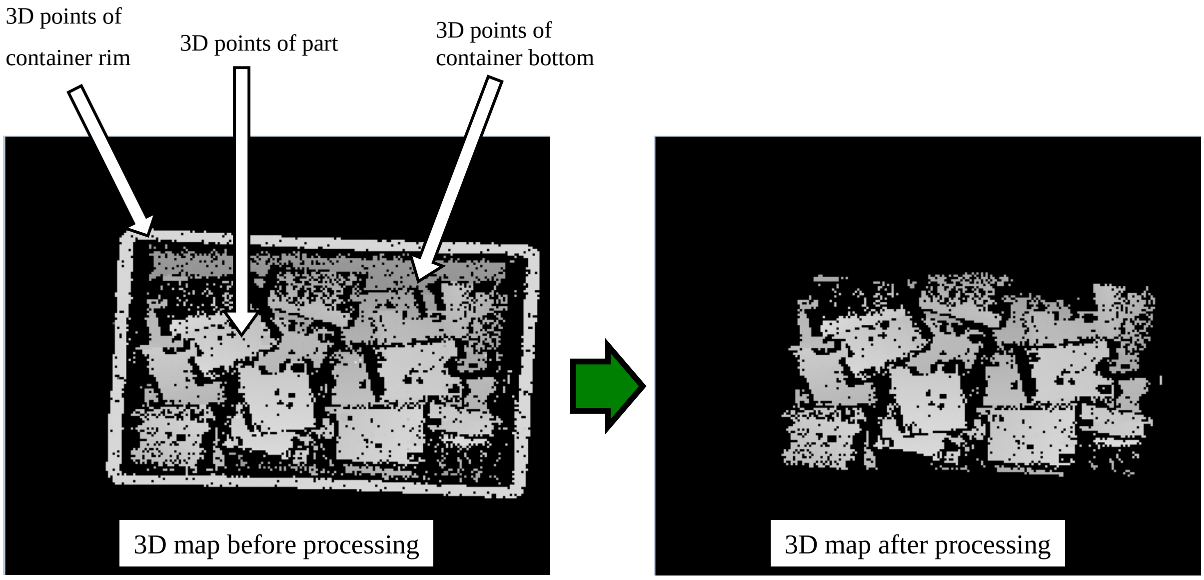
can pick up parts regardless of their postures is required. For example, a vacuum or magnet gripper.

Area Sensor Preprocess Tool

The Area Sensor Preprocess Tool prevents 3D command tools, such as the Area Sensor Peak Locator Tool, from processing incorrect 3D points and shortens the processing time of 3D command tool by removing unnecessary 3D points from a the 3D map. This function removes the following 3D points.

- 3D points on the bottom or the top of the wall of the container.
- Outlier 3D points

The area sensor peak locator tool and the Area Sensor Blob Locator tool use this function.



Even if the position of a container changes, the 3D points on the container can be removed from the 3D map using the Window Shift tool. For details of this command tool, refer to Chapter 7 in the "R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

Caution

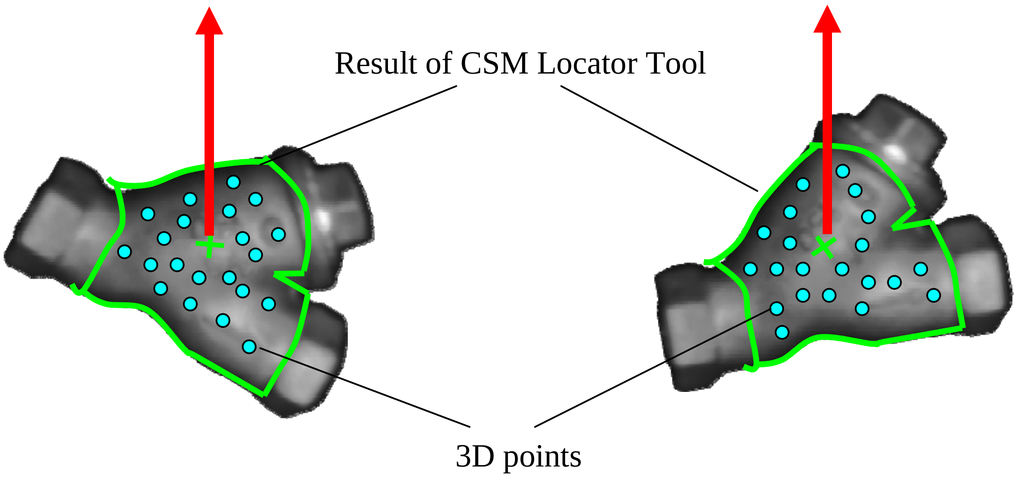
- To use this tool, camera units should be calibrated on the application frame whose Z axis is nearly parallel to the wall of the container and is directed upwards from the container bottom.

7.2.2 3D Detection with Combination of 2D Locator Tool and 3D Map

"3D detection with combination of 2D locator tool and 3D map" detects parts by a combination of a 2D locator tool and a 3D map. In this detection, the 2D locator tool finds the parts, and the position and the posture of the found parts is measured by the 3D points within the specified area centered at the origin of the 2D locator tool. Because of the 2D locator tool, this detection provides the position and posture of the parts. The following two command tools, which are the Area Sensor COG Tool and the Area Sensor Plane tool, are provided for "3D detection with combination of 2D locator tool and 3D map".

Area Sensor COG Tool

The Area Sensor COG Tool measures the center of gravity of the 3D map points in the measurement area. Combining the result of this tool with a result of 2D locator tool makes it possible to measure the 3D position of a part. For details of this command tool, refer to Chapter 7 in the "R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

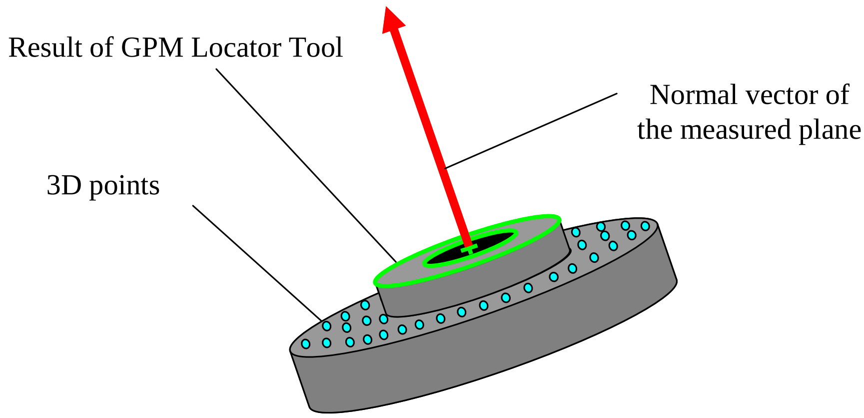


Caution

- At first, it is necessary to find a part by 2D locator tool. If the part looks differently depending on its posture, teach several model patterns
- The +Z direction outputted by this tool is the same as that of the offset frame selected in the 3D area sensor vision process which is a parent of this tool. Thus, W and P of the found positions are always 0.0.

Area Sensor Plane Tool

The Area Sensor Plane Tool measures a plane from the 3D points in the measurement area. Combining the result of this tool with the result of the 2D locator tool makes it possible to measure the 3D position and posture of a part. The features for the 2D locator tool do not have to be on the same plane measured by this tool. For details of this command tool, refer to Chapter 7 in the "R-30*i*B/ R-30*i*B Mate CONTROLLER *i*RVision OPERATOR’S MANUAL (Reference)".



Caution

- At first, it is necessary to find a part by 2D locator tool. If the part looks differently depending on its posture, teach several model patterns.

7.3 MEASURABLE WORKPIECES

Parts Suitable for Area Sensor Peak Locator Tool

The Area Sensor Peak Locator Tool can simply detect local peaks in the 3D map. Therefore this tool can detect almost all parts as long as a 3D map is obtainable. However, because the detected position on a part is always different every time this tool detects, this tool is suitable for workpieces that do not care about the approaching direction. For example, the following parts are suitable for this tool.

- Spherical shaped
- Column shaped

Parts Suitable for Area Sensor Blob Locator Tool

The Area Sensor Blob Locator Tool is suitable for the smooth-faced part because this tool detects the sets of connected 3D points. For example, the following parts are suitable for this tool.

- Sheet shaped

Parts Unsuitable for 3D Area sensor

3D Area sensor obtains 3D maps by using projected pattern light. Therefore, in the case the pattern light is difficult to capture by the 2 camera units, obtaining 3D map is difficult. For example, the following parts are not suitable for this tool.

- Transparent
- Reflective
- Thin wire

7.4 SETUP PROCEDURES OF 3D AREA SENSOR

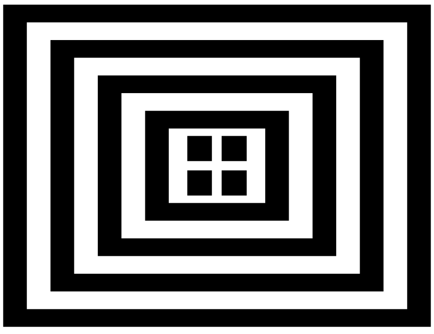
This section explains the following setup procedures for 3D Area Sensor setup.

- Adjusting the layout of 3D Area Sensor
- Adjusting the focus of the projector unit
- Adjusting the focus of the camera unit
- Adjusting the condition of acquiring 3D Map

7.4.1 Adjusting the Layout of 3D Area Sensor

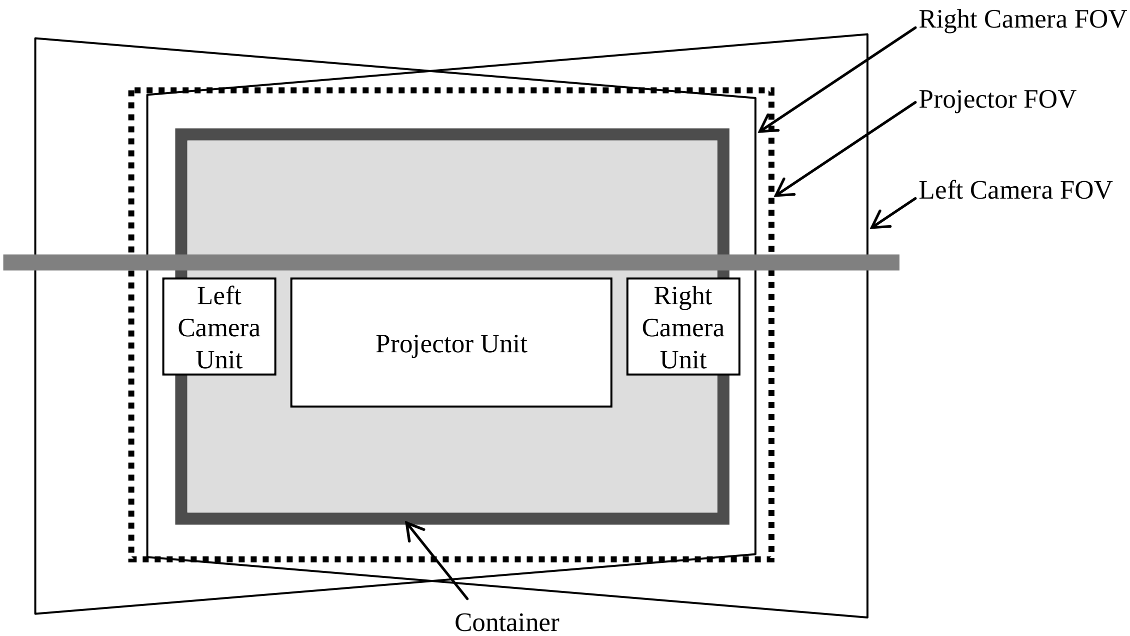
This subsection explains the procedures for adjusting the layout of the camera units and the projector unit. Adjust the position of the projector unit in the following procedures.

1 Open the 3D Area Sensor setup screen.
2 In the [Test Projector Pattern], select the [Frame] and press F3 PRJ_ON to project frame pattern. Then, the pattern below is projected.



3 Adjust the position of the projector unit so that the pattern is projected properly on the whole container and the center of the pattern matches that of container.

Next, adjust the position of camera units. As you can see in the figures below, the two camera units and the projector unit should be located roughly on a line. Mount the two camera units as far apart as possible; this will maximize the Z depth accuracy. Do not make the camera units too far apart; each camera unit must be able to see inside the entire container. If the camera units are too far apart, the sides of the container will block the camera view of the bottom of the container. Any portion of the container that is not within view of both cameras will fail to have any 3D data.



Adjust the direction of the camera unit in the following procedures.

1 Open the 3D Area Sensor setup screen.
2 On the tree view of the 3D Area Sensor, select the [Camera View1] to display the Camera View1 setup screen.
3 In the [Test Snap Pattern], select the [Frame].
4 Start the camera live mode by pressing F2 LIVE and adjust the direction of the camera so that the center of pattern locates at the center of the image and the image includes the whole container.

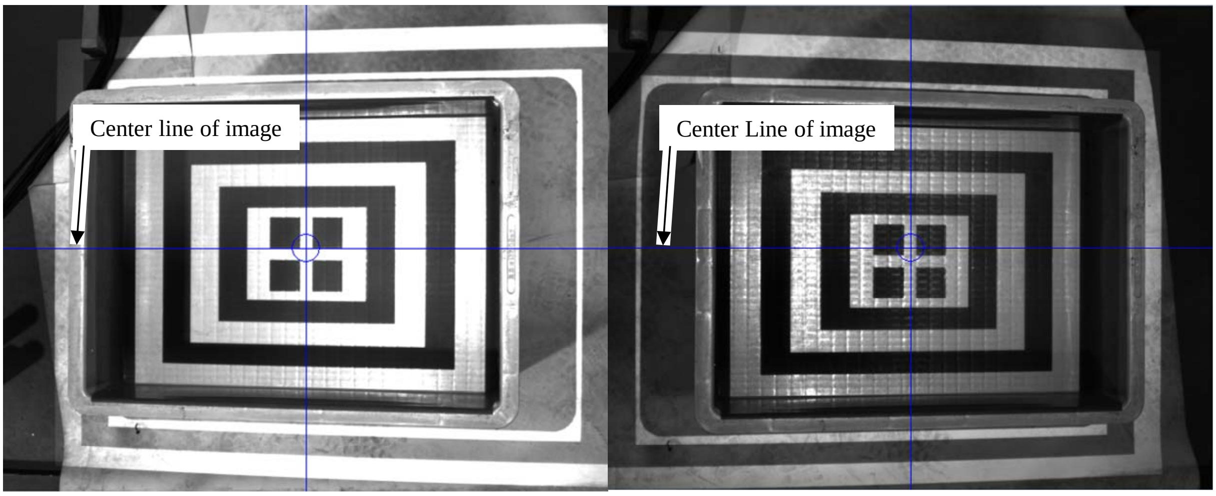
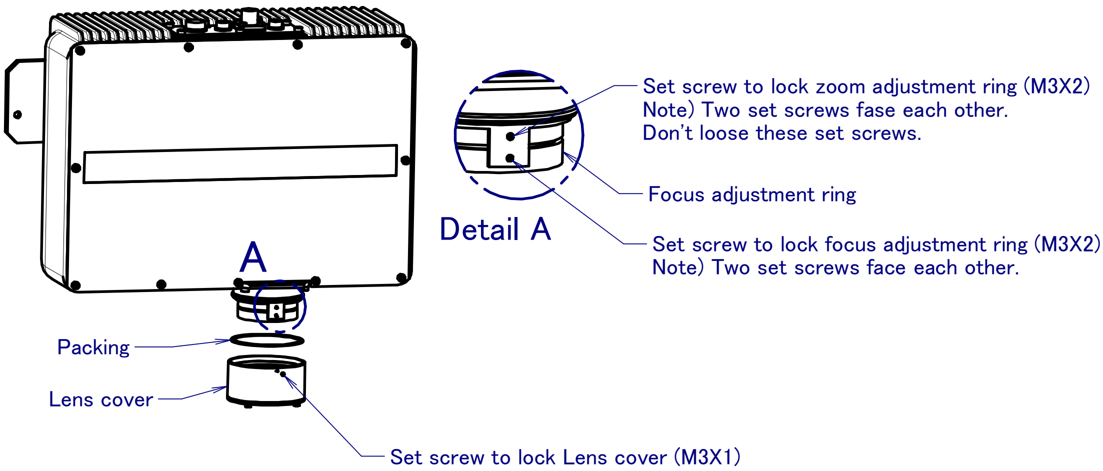


Image of Camera View1 Image of Camera View2

> ⚠ **CAUTION**
> When the container is displayed fully on the image, adjust the direction of the camera unit so that the center of pattern locates at the center of the image after placing a flat plane on the upper surface of the container

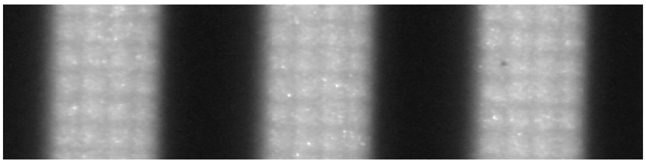
7.4.2 Adjusting the Focus of the Projector Unit

This subsection explains the procedures for adjusting the focus of the projector unit. Adjust the focus of the projector unit in the following procedures.



1 Place a flat plane at the center of the area where you want to measure.
2 Loosen Set Screw that locks Lens Cover.
3 Turn Lens Cover counterclockwise and take off Lens Cover and Packing.
4 Loosen two Set Screws that lock Focus Adjustment Ring. Caution: Don't loosen Set Screws that lock Zoom Adjustment Ring.
5 Open the 3D Area Sensor setup page on *i*Pendant or PC.
6 Select the [Chess] in the [Test Projection Patten], and press PRJ_ON button. Then the chess pattern is projected from the projector unit.

7 With observing the projected pattern, turn Focus Adjustment Ring to adjust focus of the projector unit. When the projector is in focus, you will be able to see a checked pattern as shown in the image below.

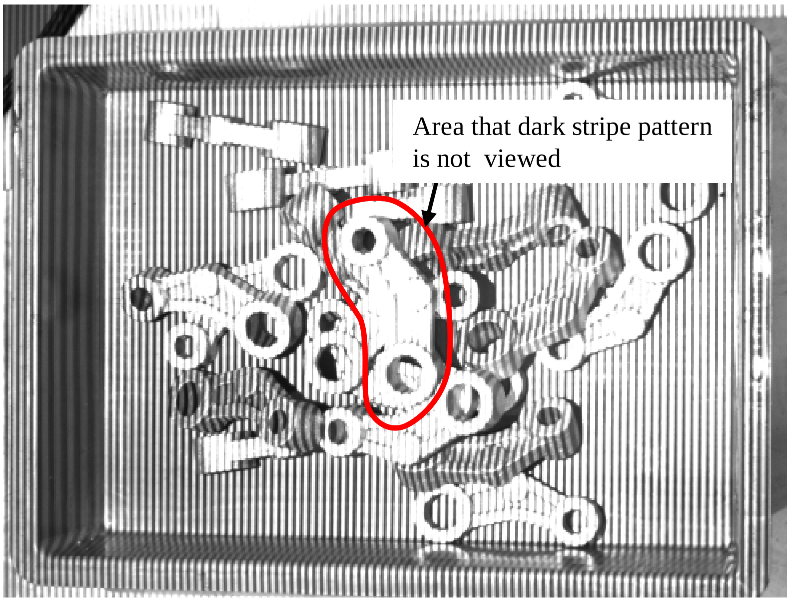


8 Tighten two Set Screws that lock Focus Adjustment Ring, and fix Focus Adjustment Ring. Caution: If one of two Set Screws is tightening too much at a time, excessive pressure would be applied to the projection lens. So be sure to screw them by bits alternately.

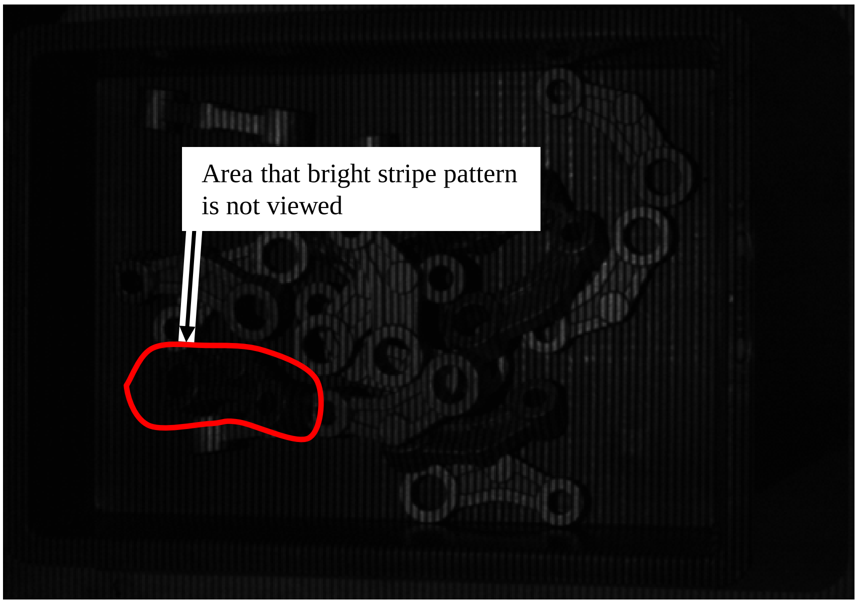
7.4.3 Adjusting the Focus of the Camera Unit

This subsection explains the procedures for adjusting the focus of the camera unit. Adjust the focus of the camera unit in the following procedures.

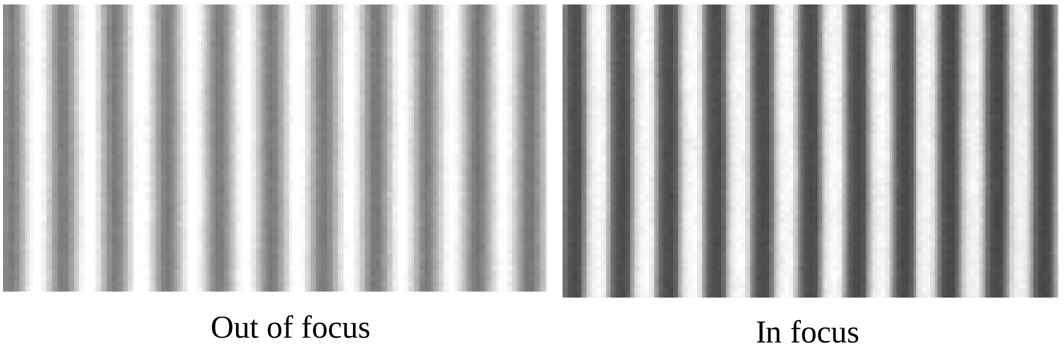
1 Loosen four Set Screw that locks the cover of the camera unit and take off it.
2 Open the 3D Area Sensor setup screen and set the following initial values to the following setup items.
[Intensity] 11
[Exposure Time] 10 ms
3 On the tree view of the 3D Area Sensor, select the [Camera View1] to display the Camera View1 setup screen.
4 Loosen a Set Screw that locks the lens aperture.
5 Adjust the lens aperture of the camera unit selected in the Camera View1.
In the [Test Snap Pattern], select the [Stripe] and start the camera live mode by pressing F2 LIVE. If there is an area that the dark stripe cannot be viewed by a halation, then close the lens aperture.



If there is an area that the bright stripe cannot be viewed, then open the lens aperture.



6 Adjust the lens aperture with changing position of parts in the container.
7 Tighten the set screw, Rotate it until tip the set screw hit the tip of the lens. After tip of set screw hits the lens side, rotate it 3/8 (135 degree).
8 Loosen a Set Screw that locks the lens focus.
9 Adjust the lens focus of the camera unit selected in the Camera View1.
In the [Test Snap Pattern], select the [Stripe] and start the camera live mode by pressing F2 LIVE. Adjust the lens focus so that the boundary of the dark stripe and bright stripe can be identified clearly as shown in the figure below



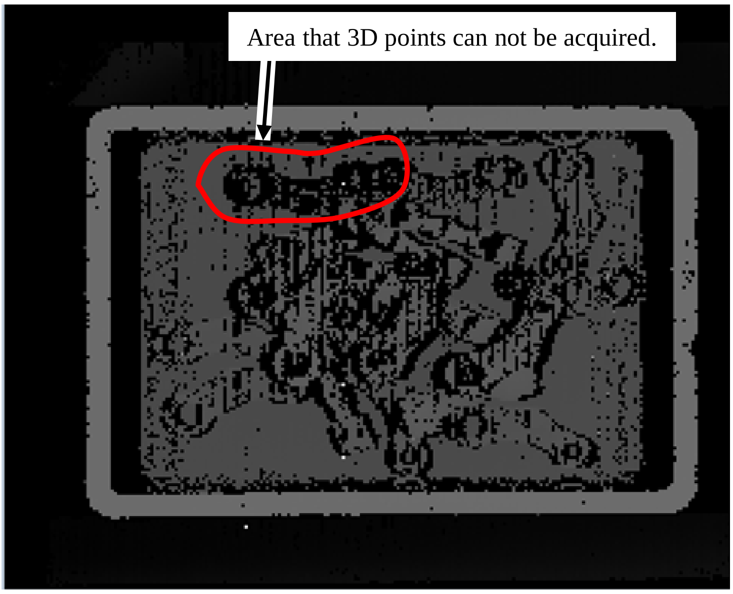
10 Tighten the set screw, Rotate it until tip the set screw hit the tip of the lens. After tip of set screw hits the lens side, rotate it 3/8 (135 degree).
11 For the other camera unit of the 3D Area Sensor, do the above same procedures to adjust the lens aperture and lens focus. Then adjust the lens aperture of the camera unit so that the brightness of images acquired by two camera unit is almost same.

7.4.4 Adjusting a Condition of Acquiring 3D Map

This subsection explains the procedures for adjusting a condition of acquiring 3D map when there is an area that 3D points are not acquired.

Confirming the condition of the area that 3D points are not acquired

1 Open the 3D Area Sensor setup screen.
2 Acquire a 3D Map by pressing F3 ACQ 3DMAP.
3 Confirm an area that 3D points are not acquired.



4 Open each camera view setup screen and confirm the condition of stripe pattern at the area that 3D points are not acquired. In the following figures, there is an area that dark stripe cannot be viewed on the image of the camera view2. Therefore, the area cannot be acquired 3D points.

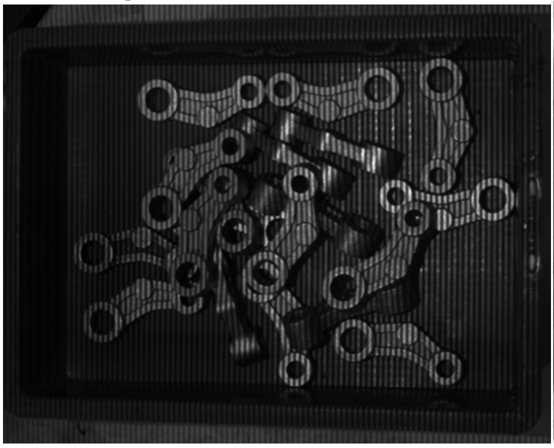


Image of Camera View1

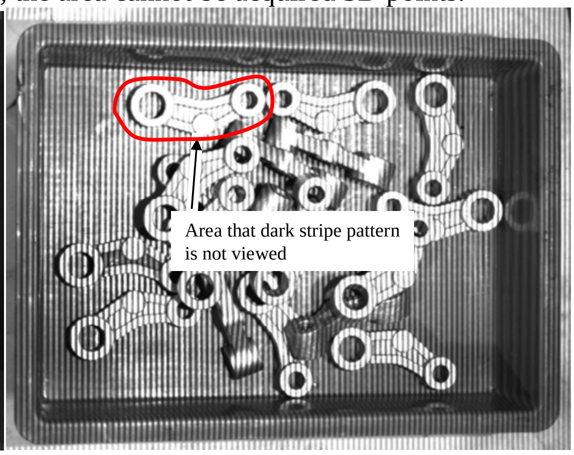


Image of Camera View2

Adjusting the exposure time

Set a smaller value to the [Exposure Time] if there is an area that dark stripe cannot be viewed on each camera view image and set a larger value to the [Exposure Time] if there is an area that bright stripe cannot be viewed on each camera view image. Then, set a value that the brightness of the acquired image does not change while in camera live mode to the [Exposure Time] in the following procedures.

1 Open the 3D Area Sensor setup screen.
2 On the tree view of the 3D Area Sensor, select the [Camera View1] to display the Camera View1 setup screen.
3 In the [Test Snap Pattern], select the [Black] and start the camera live mode by pressing F2 LIVE.
4 Confirm that the brightness of the acquired image does not change while in camera live mode.
5 On the tree view of the 3D Area Sensor, select the [Camera View2] to display the Camera View2 setup screen.
6 In the [Test Snap Pattern], select the [Black] and start the camera live mode by pressing F2 LIVE.
7 Confirm that the brightness of the acquired image does not change while in camera live mode.

Adjusting the intensity

After adjusting the [Exposure Time], adjust the intensity of the projector.

1 Open the 3D Area Sensor setup screen.

2 Adjust a value to the [Intensity].
Set a larger value to the [Intensity] if there is an area that dark stripe cannot be viewed on each camera view image and set a smaller value to the [Intensity] if there is an area that bright stripe cannot be viewed on each camera view image.
3 Acquire a new 3D Map by pressing F4 ACQ 3DMAP.
4 If there is an area that 3D points are not acquired, go to the procedure 5.
5 Open each camera view setup screen and confirm the condition of stripe pattern at the area that 3D points are not acquired. After confirming it, go to procedure2.
If the problem that there is an area that 3D points are not acquired cannot solve by adjusting the [Intensity], adjust the [Exposure Time] again.

If the problem cannot solve by adjusting the [Exposure Time] and the [Intensity], perform the procedures described in Subsection 7.4.2 "Adjusting the Focus of the Projector Unit" and 7.4.3 "Adjusting the Focus of the Camera Unit" again.

NOTE
It is important to keep the projector intensity high to reduce the amount of influence of disturbing ambient light and get a good contrast between the bright and dark stripes.

7.5 MACRO PROGRAMS

BINPICK_ACQUIRE3DMAP and BINPICK_CLEAR3DMAP are provided for 3D Area Sensor control.

BINPICK_ACQUIRE3DMAP

This program acquires a 3D map of the specified 3D Area Sensor.
The BINPICK_ACQUIRE3DMAP requires the following argument.

Argument1:
Specify the vision data name of the 3D Area Sensor

The BINPICK_ACQUIRE3DMAP is the following macro program.

```
1:  !Acquires a 3D map of the
2:  !specified [3D Area Sensor].
3:
4:  !arg1:Name of [3D Area Sensor]
5:  CALL ACQVAMAP(AR[1])
```

By opening the macro program, the function and the arguments of the macro program can be referred.

BINPICK_CELAR3DMAP

This program clears a 3D map of the specified 3D Area Sensor.
The BINPICK_ACQUIRE3DMAP requires the following argument.

Argument1:
Specify the vision data name of the 3D Area Sensor

The BINPICK_CELAR3DMAP is the following macro program.

```
1:  !Clears a 3D map of the specified
2:  ![3D Area Sensor].
3:
4:  !arg1:Name of [3D Area Sensor]
5:  CALL CLRVAMAP(AR[1])
```

By opening the macro program, the function and the arguments of the macro program can be referred.

8 INTERFERENCE AVOIDANCE REFERENCE

8.1 BASIC OPERATION FOR INTERFERENCE SETUP

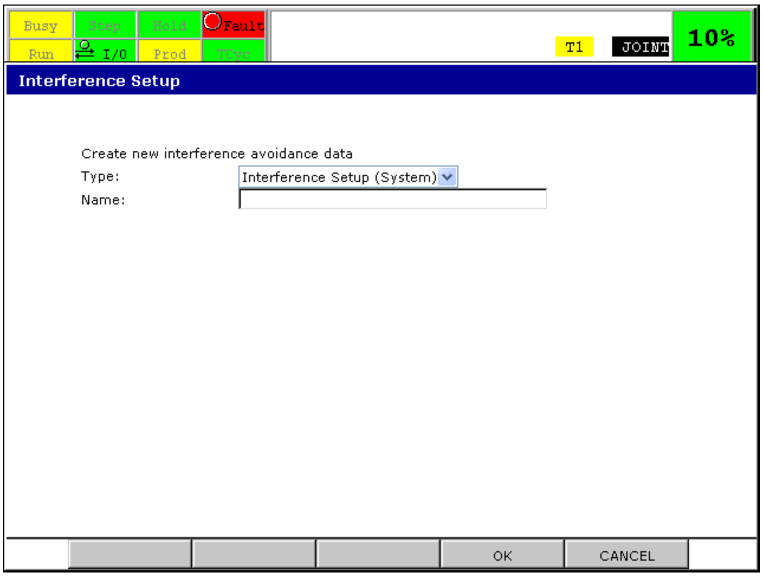
This section explains the basic operation for the setup of data for the interference avoidance function.

8.1.1 Operation for Interference Setup Data

Creating New Data

Use the following procedure to create interference setup data:

1 On the data list screen, press F2 CREATE. This causes the following screen to appear:



2 For [Type], select the type of interference setup data to create from [Interference Setup (System)], [Interference Setup (Robot)], and [Interference Setup (Condition)].
3 For [Name], enter the name of the interference setup data.
4 Press F4 OK.

Opening the Setting Screen

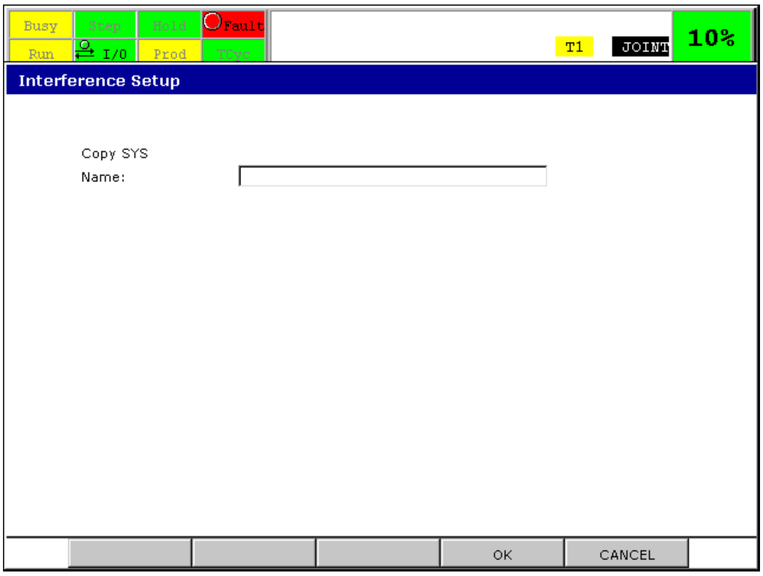
Use the following procedure to open the interference setup data setting screen:

1 On the data list screen for interference setup data, select the interference setup data to set.
2 Press F3 EDIT.

Copying

Use the following procedure to copy the data:

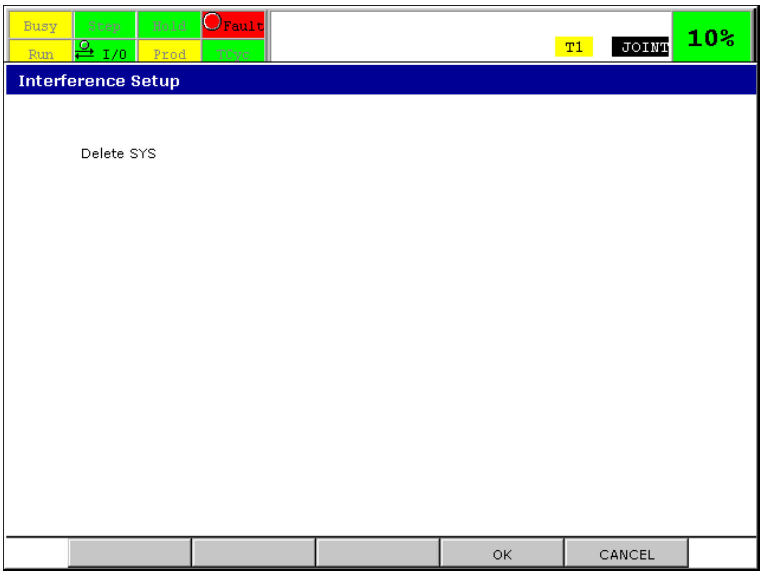
1 On the data list screen for interference setup data, select the interference setup data to copy.
2 Press F4 COPY. This causes the following screen to appear:



3 For [Name], enter the name of the data to create by copying.
4 Press F4 OK.

Deletion

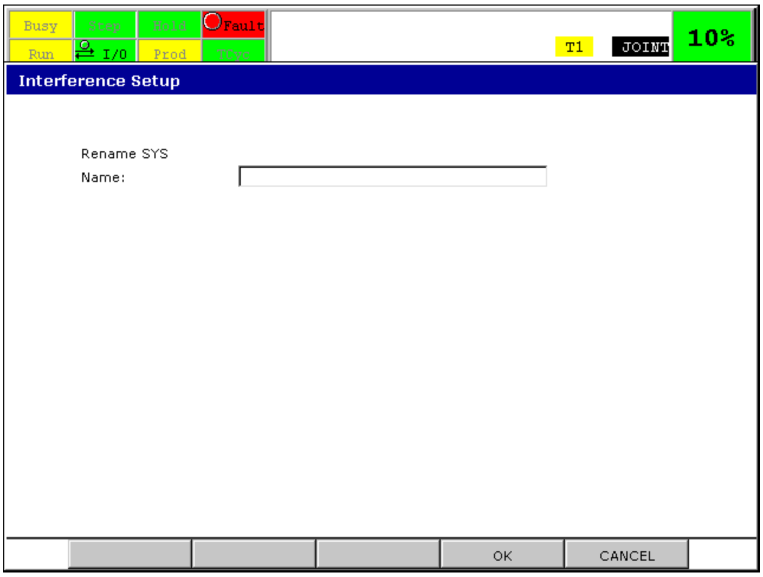
Use the following procedure to delete interference setup data:
1 On the data list screen for interference setup data, select the interference setup data to delete.
2 Press F5 Delete. This causes the following screen to appear:



3 Press F4 OK.

Renaming

Use the following procedure to rename data:
1 On the data list screen for interference setup data, select the interference setup data to rename.
2 Press F6 RENAME. This causes the following screen to appear:



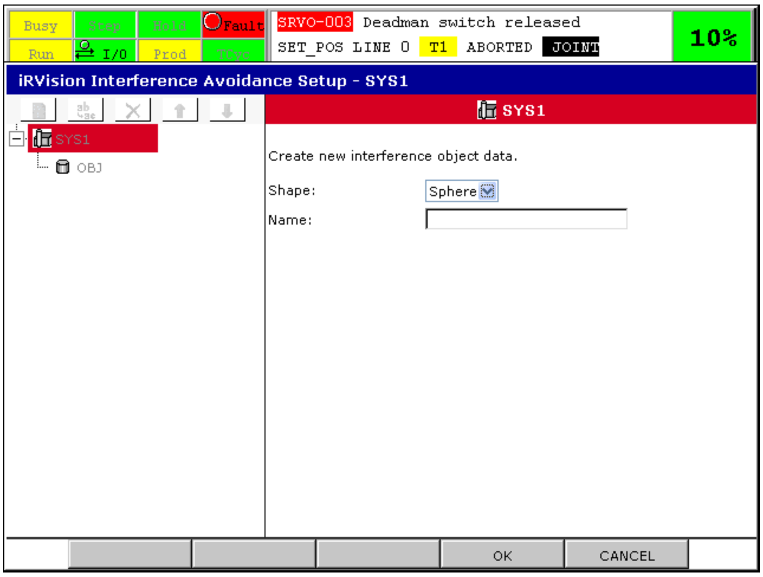
3 For [Name], enter the new name.
4 Press F4 OK.

8.1.2 Operating Objects

Creating New Object Data

Use the following procedure to create object data:

1 In the tree view on the interference setup data setting screen, press the button. This causes the following screen to appear:

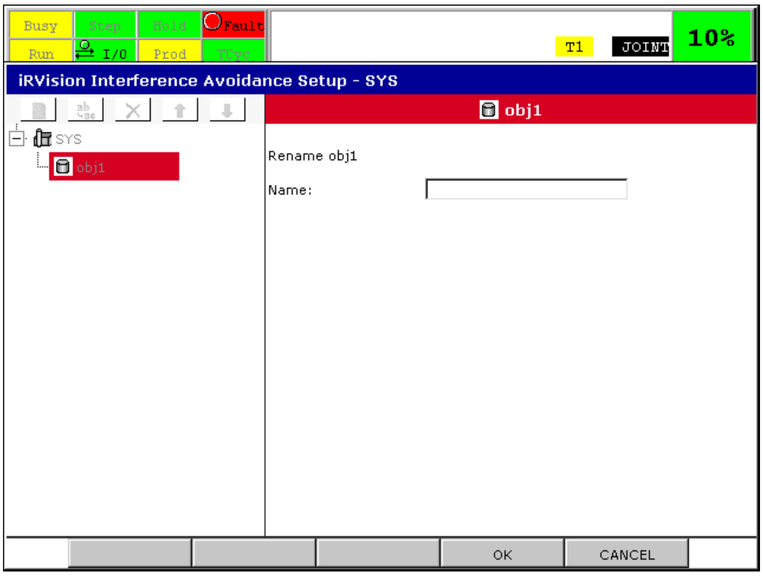


2 For [Shape], select the shape of the object to create.
3 For [Name], set the name of the object.
4 Press F4 OK.

Renaming

Use the following procedure to rename object data:

1 In the tree view on the interference setup data setting screen, select the object to rename.
2 In the tree view, press the button. This causes the following screen to appear:



3 For [Name], set the new name of the object.

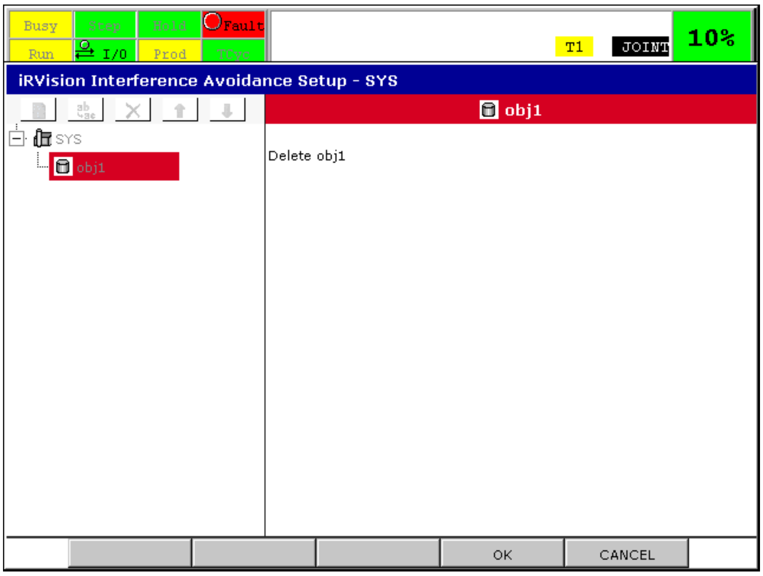
4 Press F4 OK.

Deletion

Use the following procedure to delete object data:

1 In the tree view on the interference setup data setting screen, select the object to delete.

2 In the tree view, press the button. This causes the following screen to appear:



3 Press F4 OK.

Moving Data Up

Use the following procedure to move object data up:

1 In the tree view on the interference setup data setting screen, select the object to move up.

2 In the tree view, press the button.

Moving Data Down

Use the following procedure to move object data down:

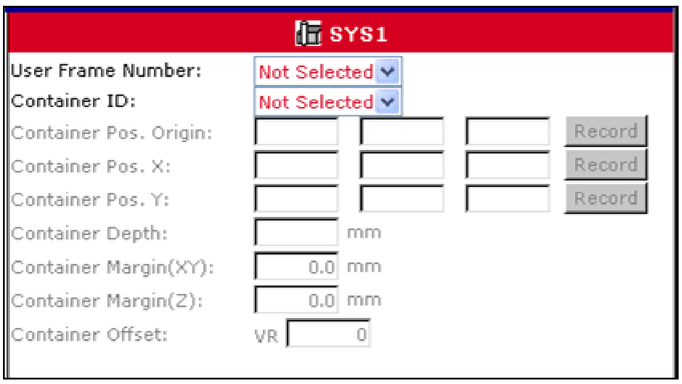
1 In the tree view on the interference setup data setting screen, select the object to move down.

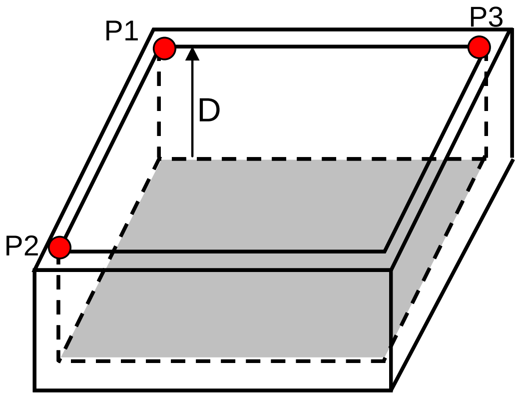
2 In the tree view, press the  button.

8.2 INTERFERENCE SETUP (SYSTEM)

In an interference setup (system), set the position and size of the container from which to pick up parts. If there is any object other than the container that needs interference checking (e.g., camera stand), set the position and size of that object as well.

8.2.1 Setting of User Frame Number and Container





User Frame Number

Select the number of the user frame to be used as the reference for the position of the container or other fixed object.

Container ID

Select the number of container ID. The set container data is distinguished from other data by using this number and can be used in other interference setup data by specifying the number of container ID.

Container Pos. Origin

Set the position of P1 in the above figure. Pressing the [Record] button sets the current robot position. It is described by the tool frame which is selected currently and the user frame which is set in [User Frame Number].

Container Pos. X

Set the position of P2 in the figure above.

Container Pos. Y

Set the position of P3 in the figure above.

Container Depth

Set the length of D in the figure above. The depth is a positive number

Container Margin (XY)

Set the XY-direction margin of the container size in mm. The margin represents the amount the container can deviate from the size specified by the Container Pos. X and Y. Setting a negative value makes the container size larger by the set value.

Container Margin (Z)

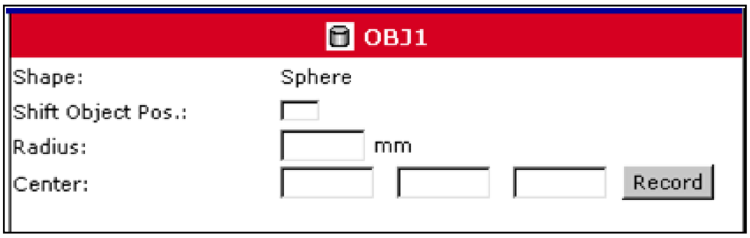
Set the Z-direction margin of the container size in mm. If a positive value is set, the height of the top of the container is increased by the set value while the height of the bottom remains unchanged. Setting a negative value reduces the container height by the set value.

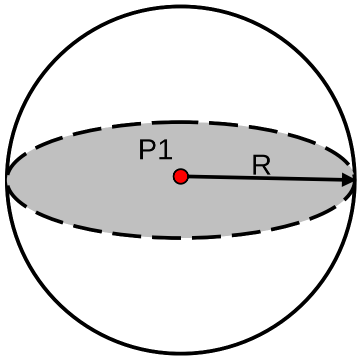
Container Offset

If the location of the container changes from container to container, set the number of the vision register in which the container offset detected by the vision process is set. The container position will not be offset if 0 is set in this vision register.

8.2.2 Setting of Fixed Object Data

8.2.2.1 Sphere shaped fixed object





Shape

The shape which is selected in creating object data is shown.

Shift Object Pos.

If the fixed object moves together with the container, check this box.

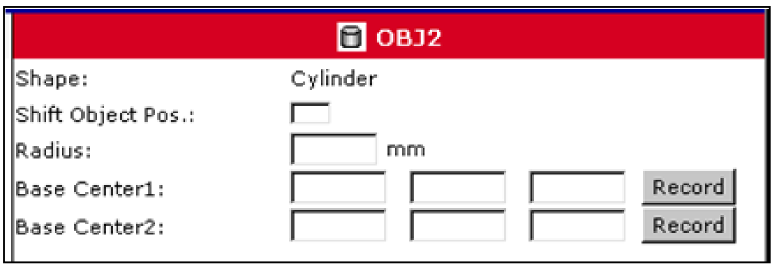
Radius

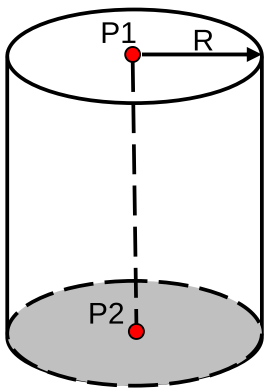
Set R in the above figure.

Center

Set the position of P1 in the figure above. Pressing the [Record] button sets the current robot position to the Center. The current robot position is described by the active tool frame and the user frame.

8.2.2.2 Cylinder shaped fixed object





Shape
The shape which is selected in creating object data is shown.

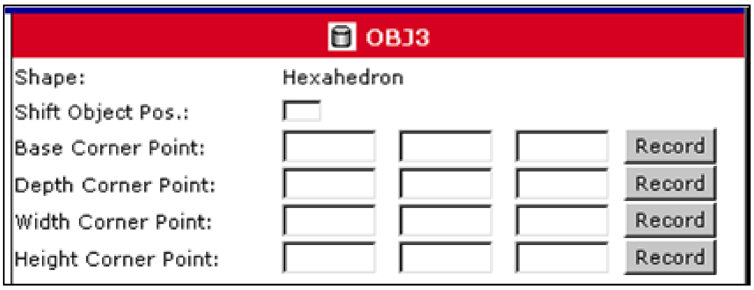
Shift Object Pos.
If the fixed object moves together with the container, check this box.

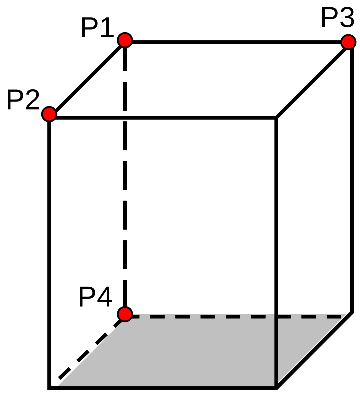
Radius
Set R in the above figure.

Base Center1
Set the position of P1 in the figure above. Pressing the [Record] button sets the current robot position to the Base Center 1. The current robot position is described by the active tool frame and the user frame.

Base Center2
Set the position of P2 in the figure above. Pressing the [Record] button sets the current robot position to the Base Center 2. The current robot position is described by the active tool frame and the user frame.

8.2.2.3 Hexahedron shaped fixed object





Shape
The shape which is selected in creating object data is shown. Set a parallelepiped.

Shift Object Pos.
If the fixed object moves together with the container, check this box.

Base Corner Point
Set P1 in the figure above. Pressing the [Record] button sets the current robot position to the Base Corner Point. The current robot position is described by the active tool frame and the user frame.

Depth Corner Point
Set P2 in the figure above. Pressing the [Record] button sets the current robot position to the Depth Corner Point. The current robot position is described by the active tool frame and the user frame.

Width Corner Point
Set P3 in the figure above. Pressing the [Record] button sets the current robot position to the Width Corner Point. The current robot position is described by the active tool frame and the user frame.

Height Corner Point
Set P4 in the above figure. Pressing the [Record] button sets the current robot position to the Height Corner Point. The current robot position is described by the active tool frame and the user frame.

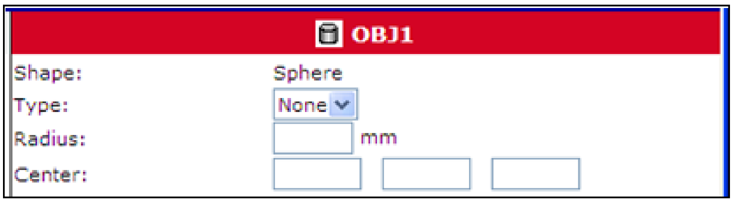
8.3 INTERFERENCE SETUP (ROBOT)

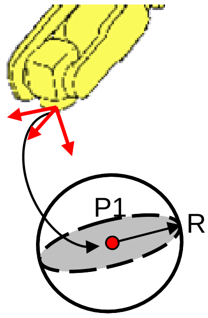
In an interference setup (robot), set the position and size of the gripper, camera, or other object mounted on the robot end of arm tooling. Such a mounted object is called a tool object.

> ⚠ **Caution**
> The position of the tool object must be measured from the robot face plate, UTool[0].

8.3.1 Setting of Tool Object Data

8.3.1.1 Sphere shaped tool object





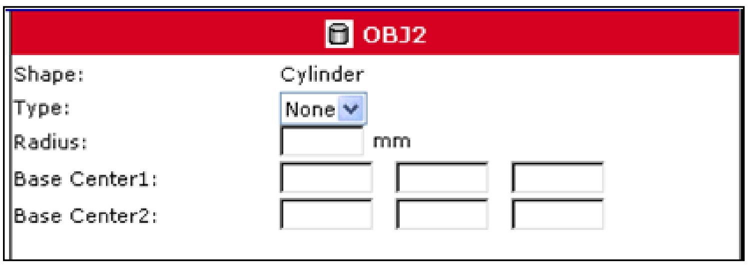
Shape
The shape which is selected in creating object data is shown.

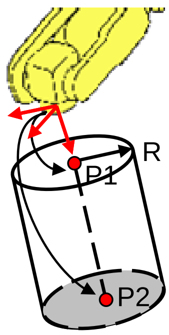
Type
Select the tool object type from [None], [Camera], and [Hand]. If [Camera] or [Hand] is specified as the tool object type, and if [Camera] or [Hand] is specified for [Search Pos. Inside Container] in the interference setup (condition), interference can be avoided inside the container only for the objects of the specified type.

Radius
Set R in the above figure.

Center
Set the position of P1 in the figure above.

8.3.1.2 Cylinder shaped tool object





Shape
The shape which is selected in creating object data is shown.

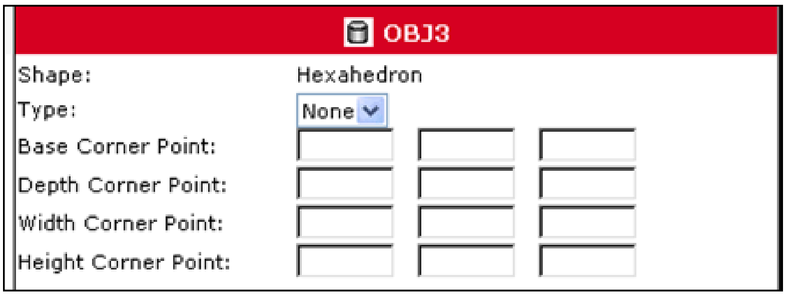
Type
Select the tool object type from [None], [Camera], and [Hand]. If [Camera] or [Hand] is specified as the tool object type, and if [Camera] or [Hand] is specified for [Search Pos. Inside Container] in the interference setup (condition), interference can be avoided inside the container only for the objects of the specified type.

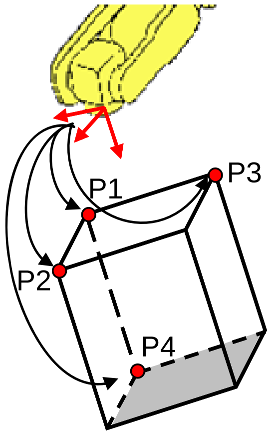
Radius
Set R in the above figure.

Base Center1
Set the position of P1 in the figure above.

Base Center2
Set the position of P2 in the figure above.

8.3.1.3 Hexahedron shaped tool object





Shape
The shape which is selected in creating object data is shown. Set a parallelepiped.

Type
Select the tool object type from [None], [Camera], and [Hand]. If [Camera] or [Hand] is specified as the tool object type, and if [Camera] or [Hand] is specified for [Search Pos. Inside Container] in the interference setup (condition), interference can be avoided inside the container only for the objects of the specified type.

Base Corner Point
Set P1 in the figure above.

Depth Corner Point
Set P2 in the figure above.

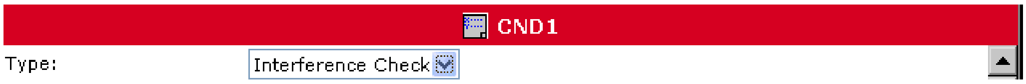
Width Corner Point
Set P3 in the figure above.

Height Corner Point
Set P4 in the figure above.

8.4 INTERFERENCE SETUP (CONDITION)

In an interference setup (condition), specify which of the following the created interference setup (system) and interference setup (robot) is to be used for: Interference check, Interference avoidance, and Wall avoidance. If using them for interference avoidance, set an interference avoidance range and so on.

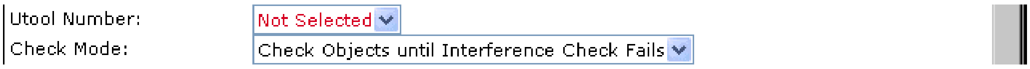
8.4.1 Setting of Data Type



Type

Select the data type from [Interference Check], [Interference Avoidance], or [Wall Avoidance] according to purpose. See Section 2.4 "OVERVIEW OF INTERFERENCE AVOIDANCE" about each mode.

8.4.2 Setting of Interference Check



Utool Number

Select the number of the tool frame to be used for interference check calculation. If this interference setup (condition) is used for the PICK positions, set the tool frame number which is set the TCP of the gripper. If this is used for FINE positions, set tool frame number which is set the camera frame or laser frame which is used in the FINE process.

Check Mode

Select from [Check Objects until Interference Check Fails] or [Check All Objects]. If [Check Objects until Interference Fails] is selected, the Interference check will stop at finding an interfering object. If [Check All Objects] is selected, all objects will be checked for interference.

8.4.3 Setting of Wall Avoidance

Set the following parameters, if [Wall Avoidance] is selected as [Type].

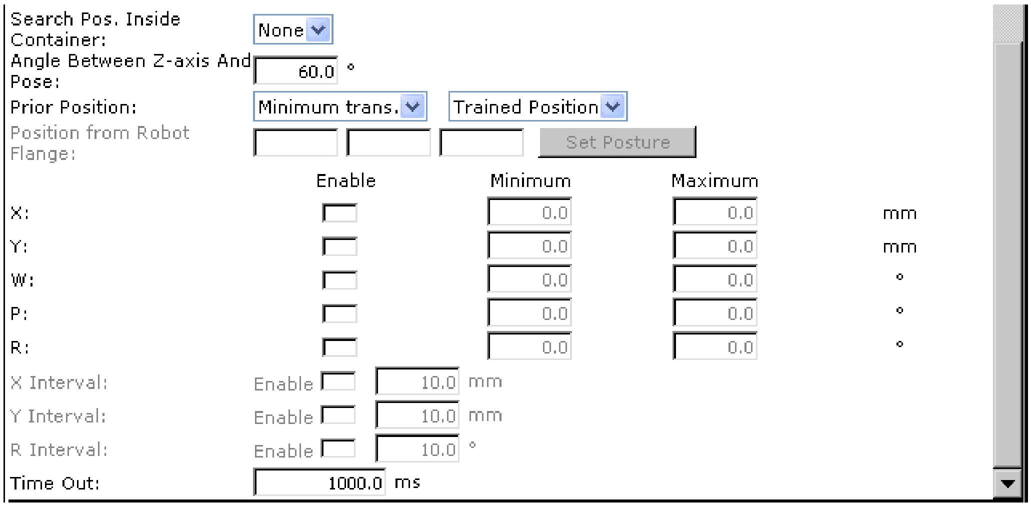
Distance of Avoidance

Set the offset value for having the robot end of arm tooling retreat from the wall to the center of the container.

Distance of Avoidance(Z)

Set the offset value along the Z axis in Wall Avoidance.

8.4.4 Setting of Interference Avoidance

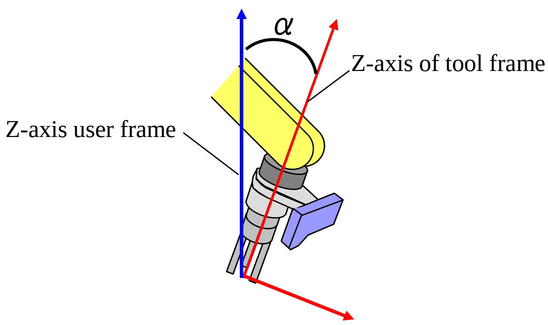


Search Pos. Inside Container

This item is enabled only if [Interference Avoidance] is selected for [Type]. Select the type of the tool object that calculates the avoidance position so that it is contained inside the container from [None], [Camera], and [Hand].

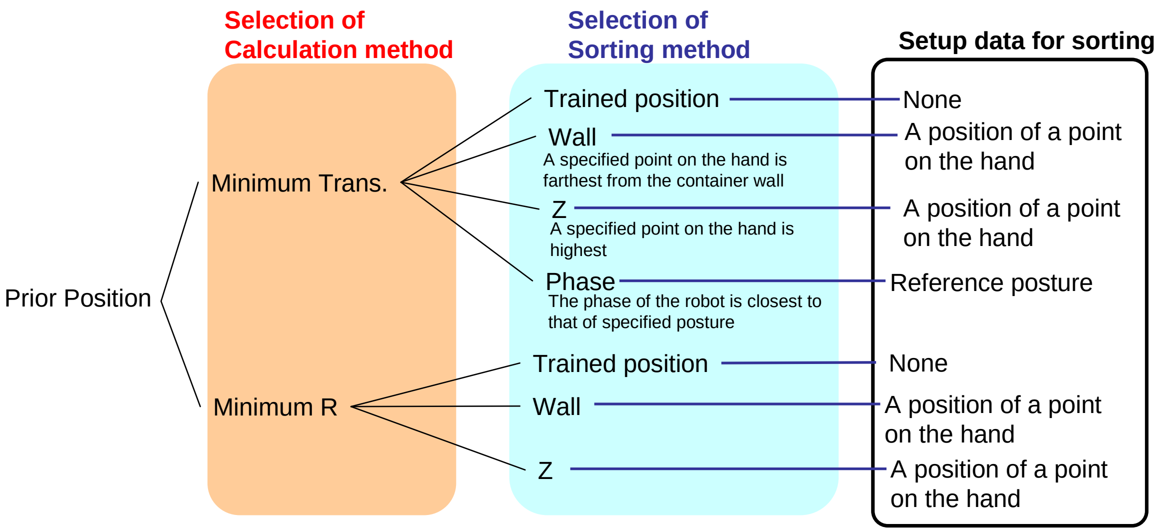
Angle Between Z-axis And Pose

This item is enabled only if [Interference Avoidance] is selected for [Type]. For [Angle Between Z-axis And Pose], set the limit on the angle between the Z-axis of the user frame and the Z-axis of the tool frame selected with [Utool Number]. The output avoidance position and posture will be such that the α in the figure below does not exceed the value set here. If such avoidance position and posture cannot be found, it will be judged that the interference avoidance position and posture calculation fails.



Prior position

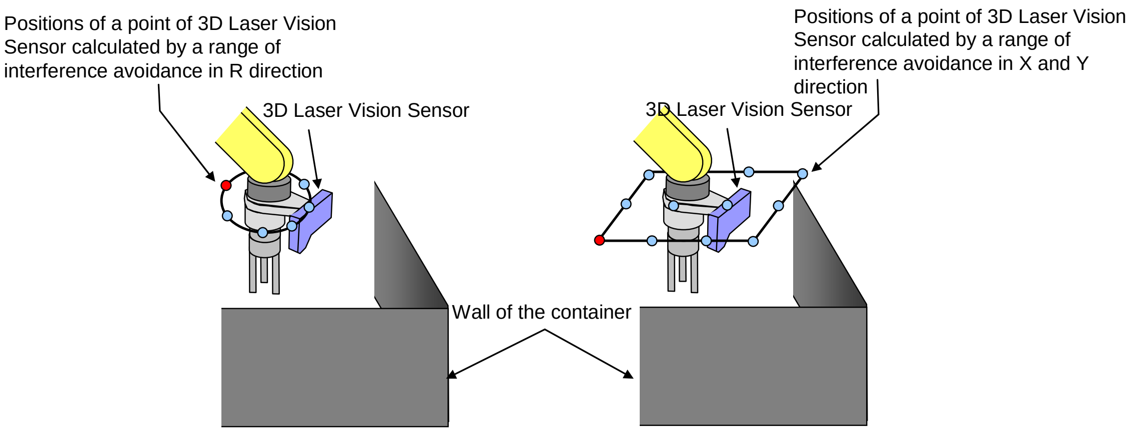
This setup item decides the preference of avoidance direction and condition. It consists of three components as the followings.



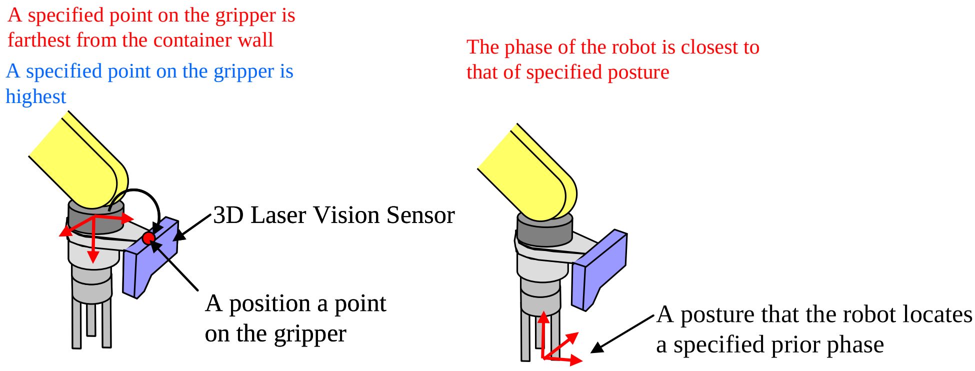
- Calculation method
  For this setup item, select which avoidance amount should be smaller. The selection items are the followings.
  - [Minimum trans.]
    If this item is selected, avoidance amount of X and Y becomes smaller and robot positions are changed preferentially in R direction to search avoidance positions. This item should be selected when avoidance in X and Y direction is disabled or when the changes in R direction do not much affect robot tasks, such as grasping a circle shaped part.
  - [Minimum R]
    If this item is selected, avoidance amount of R becomes smaller and robot positions are changed preferentially in X and Y direction to search avoidance positions. This item should be selected when avoidance in R direction is disabled or when the changes in X or Y direction do not much affect robot tasks, such as grasping a pipe shaped part.
- Sorting method
  For this setup item, select a condition for the avoidance position which should be output in preference. The selection items are the followings.
  - [Trained Position]
    If this item is selected, avoidance amount becomes smaller.
  - [Wall]
    If this item is selected, the position which is set in the setup data for sorting becomes farther from the wall of the container.
  - [Z]
    If this item is selected, the position which is set in the setup data for sorting becomes higher.
  - [Phase]
    If this item is selected, avoidance position which is more similar to the posture which is set in the setup data for sorting is output. This item is available when [Minimum trans.] is set as the calculation method.

  If [Minimum trans.] is selected as the calculation method, the changes of robot positions in R direction are sorted by the sorting method and they are applied to calculate candidates for avoidance position. If [Minimum R] is selected as the calculation method, the changes of robot positions in X and Y directions are sorted by the sorting method and they are applied to calculate candidates for avoidance position.

  The figures below show examples in which [Wall] is selected and sorting is performed in such a way that 3D Laser Vision Sensor moves away from the wall of the container. The left figure below shows the sorting of avoidance positions and postures if [Minimum trans.] is selected for the calculation method. The right figure below shows the sorting of avoidance positions and postures if [Minimum R] is selected. In the right and left figures, the blue and red circles represent the positions of 3D Laser Vision Sensor when it moves to the avoidance position and posture candidates calculated from the avoidance range. Of the avoidance position and posture candidates calculated from the respective ranges that have been set, specific avoidance positions and postures are calculated, starting with the red circle.

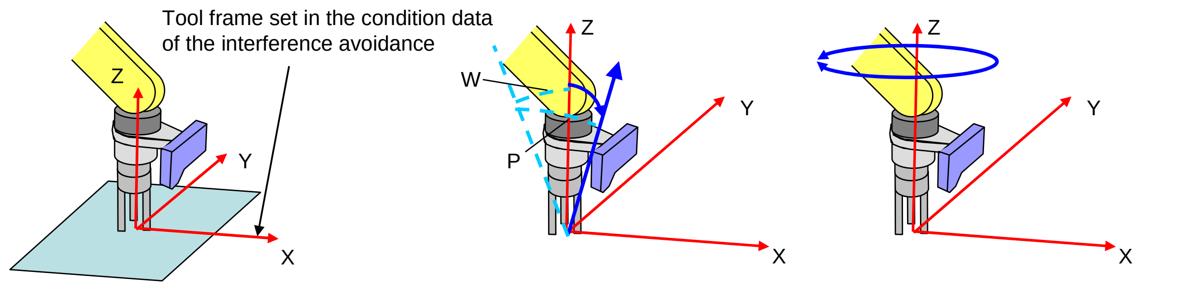


- Setup data for sorting
  If [Wall] or [Z] is selected for the sorting method, set the position of a single point from the flange of the robot. For this position, set the position on the gripper of the robot that is farthest from the container wall or that is the highest in the user frame (for example, the mounting position of 3D Laser Vision Sensor).
  If [Phase] is selected for the sorting method, set the robot posture data in the phase to be prioritized (posture in the R direction of the tool frame).



Avoidance Range

Set the amounts of change in the position and posture in the X and Y, W and P, or R direction in the tool frame selected for [Utool Number]. If the X and Y avoidance range is enabled, the avoidance position and posture as translated in the range such as a in the figure below are calculated. If the W and P avoidance range is enabled, the avoidance position and posture as rotationally transferred about the X- or Y-axis so that the W and P value shown in b in the figure below are in the specified range are calculated. If the R avoidance range is enabled, the avoidance position and posture as rotationally transferred about the Z-axis in the range such as c in the figure below are calculated. If multiple avoidance ranges are enabled, the position is changed in the X and Y avoidance range, and the posture is changed in the W and P avoidance range, and then the position and posture acquired by changing that posture in the R avoidance range are calculated as the avoidance position and posture.



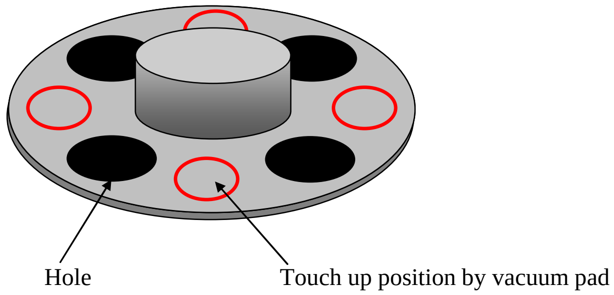
a. Range of interference avoidance in X and Y direction

b. Range of interference avoidance in W and P direction

c. Range of interference avoidance in R direction

Avoidance Interval

Usually, the interference avoidance function automatically calculates multiple position and posture candidates from the avoidance range that has been set. It outputs the positions and postures from the candidates that have undergone interference avoidance. At this time, positions and postures calculated as candidates have regular intervals. To specify the intervals, enable [X Interval], [Y Interval], or [R Interval], and set the avoidance interval. For example, to set an avoidance range of -180 to 180 degrees in the R direction and pick a part with the holes shown in the figure below with a gripper that has four vacuum cups, teach the robot about the picking position in advance so that the individual vacuum cup come to the positions indicated by red circles in the figure below, enable [R Interval] and set 90 degrees for the avoidance interval.



Time Out

Set the limit on the time that interference avoidance calculation can take. If the system is set so that multiple avoidance positions and postures are to be acquired, those avoidance positions and postures that are calculated within the time specified here are output.

8.5 KAREL PROGRAM OF INTERFERENCE AVOIDANCE

The *i*RVision bin picking options provide the following KAREL programs for interference avoidance function. These KAREL programs are invoked from a TP program to avoid interference. This section describes the specifications of the KAREL programs provided.

IACHECK.PC

Calculates the interference between the tool object and the container or fixed object that may occur when the robot moves to the target position, and outputs 0 to a register if no interference occurs or 1 if there is any interference. Arguments are as follows.

Argument 1:

Specify the index number of the position register in which the target position is set. Using arguments 2 to 4, the position offset, vision offset, and tool offset can be applied to the target position to calculate the interference at the offset target position.

Argument 2:
Specify the type of offset to be applied to the robot position specified in argument 1. If V is specified, the vision offset is applied. If O is specified, the position offset is applied. Even if no offset is applied, set either V or O.

Argument 3:
If V is specified in argument 2, specify the index number of the vision register to be used for vision offsetting. If O is specified, specify the index number of the position register to be used for position offsetting. If no offset is applied, specify 0.

Argument 4:
Specify the index number of the position register to which to apply the tool offset. The tool offset is applied in the same way as when J PR[ARG 1] VOFFSET, VR[ARG 3] Tool_Offset, PR[ARG 4] or J PR[ARG 1] Offset, PR[ARG 3] Tool_Offset, PR[ARG 4] are specified. When not applying the tool offset, specify 0.

Argument 5:
Specify the name of the interference setup (system) to be used.

Argument 6:
Specify the name of the interference setup (robot) to be used.

Argument 7:
Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Interference Check] set in [Type] in the setup screen.

Argument 8:
Specify the index number of the register to which to output the result. Output values are as follows.

0. No interference
1. An interference occurs

IACALAVOID.PC

Calculates the interference between the tool object and the container or fixed object that may occur when the robot moves to the target position and the interference avoidance position (robot position where interference can be avoided). To obtain the interference avoidance position calculated by IACALAVOID, execute IAGETAVOID described next. Arguments are as follows.

Argument 1:
Specify the index number of the position register in which the target position is set. Using arguments 2 to 4, the position offset, vision offset, and tool offset can be applied to the target position to calculate the interference at the offset target position.

Argument 2:
Specify the type of offset to be applied to the robot position specified in argument 1. If V is specified, the vision offset is applied. If O is specified, the position offset is applied. Even if no offset is applied, set either V or O.

Argument 3:
If V is specified in argument 2, specify the index number of the vision register to be used for vision offsetting. If O is specified, specify the index number of the position register to be used for position offsetting. If no offset is applied, specify 0.

Argument 4:
Specify the index number of the position register to which to apply the tool offset. The tool offset is applied in the same way as when J PR[ARG 1] VOFFSET, VR[ARG 2] Tool_Offset, PR[ARG 4] or J PR[ARG 1] Offset, PR[ARG 3] Tool_Offset, PR[ARG 4] are specified. When not applying the tool offset, specify 0.

Argument 5:
Specify the name of the interference setup (system) to be used.

Argument 6:
Specify the name of the interference setup (robot) to be used.

Argument 7:

Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Interference Avoidance] set in [Type] in the setup screen.

Argument 8:

Specify the index number of the register to which the number of calculated interference avoidance positions is output.

Argument 9:

Specify the index number of the register to which the status of interference avoidance is output. Output values are as follows.

0. Interference avoidance calculation succeeds.
11. All candidates of interference avoidance position are rejected by limitation of angle Between Z-axis And Pose
12. Interference avoidance calculation timed out.
13. No interference avoidance position is found.

IAGETAVOID.PC

Obtains the interference avoidance position calculated by IACALAVOID and outputs the obtained position to a position register. When IAGETAVOID is executed, one of the interference avoidance positions calculated by IACALAVOID is output. When IAGETAVOID is repeated, an interference avoidance position other than the previously output one or ones is output as long as there is any different interference avoidance position. Arguments are as follows.

Argument 1:

Specify the name of the interference setup (system) to be used. Specify the same value that is specified in IACALAVOID.

Argument 2:

Specify the name of the interference setup (robot) to be used. Specify the same value that is specified in IACALAVOID.

Argument 3:

Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Interference Avoidance] set in [Type] in the setup screen. Specify the same value that is specified in IACALAVOID.

Argument 4:

Specify the index number of the register to which to output the result of the operation of obtaining the interference avoidance position. When the interference avoidance position has successfully been obtained, 0 is output. When the operation has failed, 1 is output.

Argument 5:

Specify the index number of the position register to which to output the interference avoidance position.

Argument 6:

Specify the index number of the position register to which to output the tool offset value. When the robot picks up the workpiece at the interference avoidance position, the position of the gripper relative to the workpiece becomes different from that of the original target position. This makes it impossible to set the workpiece onto the grid or machine. In that case, the tool offset needs to be applied.

IAAVDWALL.PC

Calculates and outputs the position offset value to be used to make the robot end of arm tooling retreat from the wall to the center of the container. Arguments are as follows.

Argument 1:

Specify the index number of the position register in which the start position for wall avoidance is set. Using arguments 2 to 4, the position offset, vision offset, and tool offset can be applied to the start position to calculate the interference at the offset target position.

Argument 2:

Specify the type of offset to be applied to the robot position specified in argument 1. If V is specified, the vision offset is applied. If O is specified, the position offset is applied. Even if no offset is applied, set either V or O.

Argument 3:

If V is specified in argument 2, specify the number of the vision register to be used for vision offsetting. If O is specified, specify the number of the position register to be used for position offsetting. If no offset is applied, specify 0.

Argument 4:

Specify the index number of the position register to which to apply the tool offset. The tool offset is applied in the same way as when J PR[ARG 1] VOFFSET, VR[ARG 3] Tool_Offset, PR[ARG 4] or J PR[ARG 1] Offset, PR[ARG 3] Tool_Offset, PR[ARG 4] are specified. When not applying the tool offset, specify 0.

Argument 5:

Specify the name of the interference setup (system) to be used.

Argument 6:

Specify the name of the interference setup (robot) to be used.

Argument 7:

Specify the name of the interference setup (condition) to be used. The interference setup (condition) to be specified should have [Wall Avoidance] set in [Mode] in the setup screen.

Argument 8:

Specify the number of the register to which to output the wall avoidance operation. When the wall avoidance operation is successful, 0 is output. When it has failed, 1 is output.

Argument 9:

Specify the index number of the position register to which to output the position offset value for wall avoidance.

9 PARTS LIST MANAGER REFERENCE

The Parts List Manager is a collection of functions required for bin picking. For example, the Parts List Manager creates part data based on the result of detection by a vision process executed as SEARCH and pushes the found part data to the parts list. For the overview of the Parts List Manager, see Section 2.3, "OVERVIEW OF PARTS LIST MANAGER".

9.1 BASIC OPERATIONS OF PARTS LIST MANAGER

This section describes basic operations performed in the Parts List Manager. One Parts List Manager element is provided for each parts list. In the initial status, there is one parts list. So, the initial data list screen of the Parts List Manager displays one setup data created for the Parts List Manager. To configure the number of parts list, see Subsection 10.2, "PARTS LIST MANAGER CONFIGURATION".

Setting Type

Part lists Manager can have three types as follows.

SEARCH

Select this type if your bin picking system does not perform FINE process. Parts List Manager of this type does not display items about FINE process.

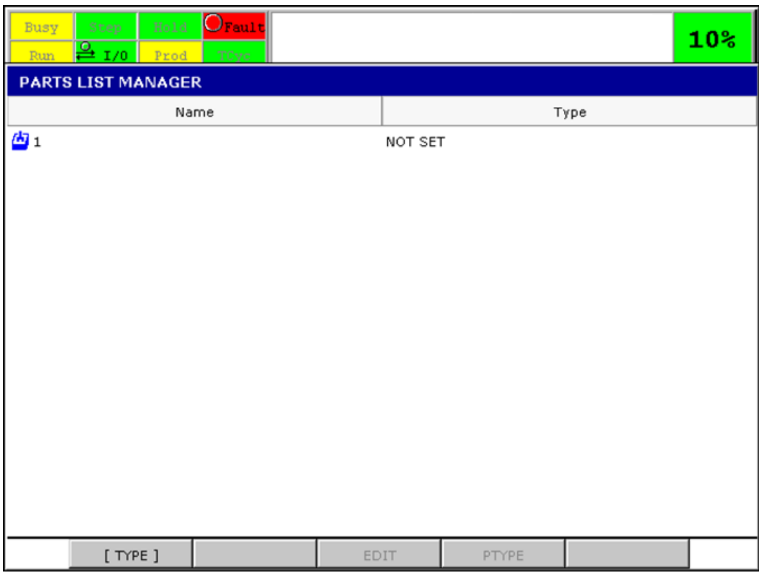
SEARCH + FINE

Select this type if your bin picking system performs FINE process. This type can be selected and performed a bin picking system even if a bin picking system does not perform FINE process.

NOT SET

This type means that the type of a Parts List Manager is not set. Before starting up setup of Parts List Manager, the type of a Parts List Manager must be set. Set the type of a Parts List Manager by the following procedures described below:

1 In the data list screen of Parts List Manager, select a Parts List Manager whose type is "NOT SET".
2 Press F3 EDIT.



3 The screen shown below appears. In the [Type], select the type of the Parts List Manager.

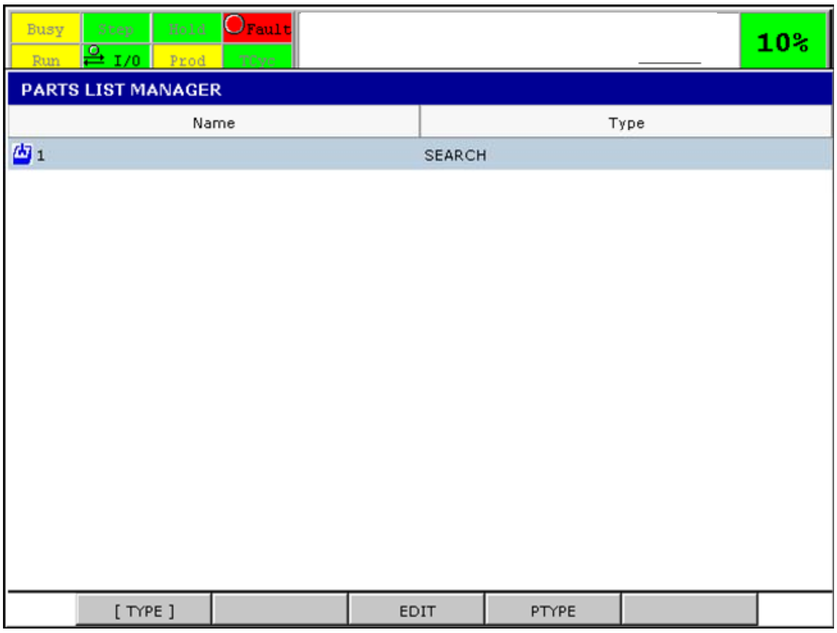
4 Press F4 OK .

Opening the Setup Screen

Open the Parts List Manager setup screen by following the procedures below:

1 In the data list screen of the Parts List Manager, select a Parts List Manager you want to set up.

2 Press F3 EDIT.



Changing Type

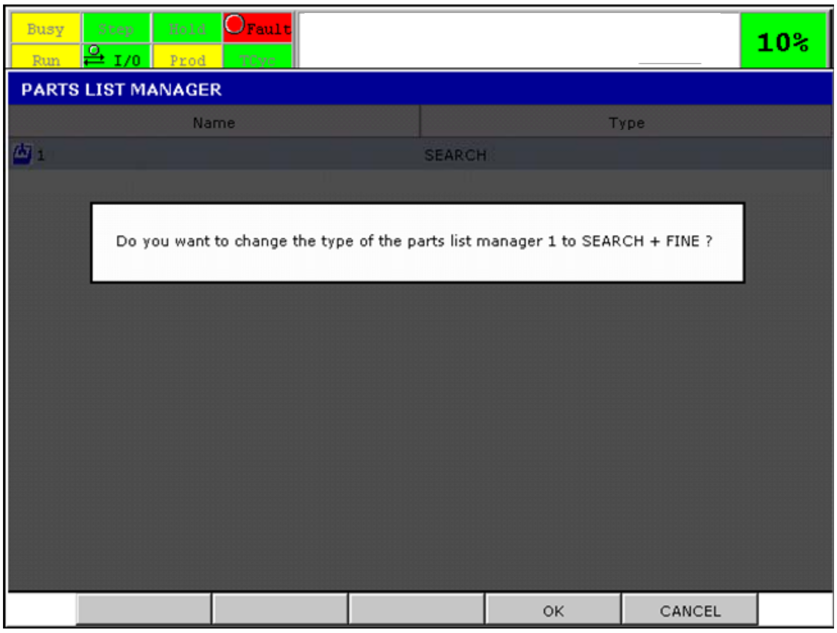
Change a type of Parts List Manager by following the procedures below:

1 In the data list screen of Parts List Manager, select a Parts List Manager you want to change type.

2 Press F4 PTYPE.

3 The screen shown below appears. Press F4 OK to change type. Even if you have changed the type of the Parts List Manager from [SEARCH + FINE] to [SEARCH], setting data about FINE

process is saved. So if you have changed back the type of the Parts List Manager from [SEARCH+FINE] to [SEARCH], setting data about FINE process is restored.

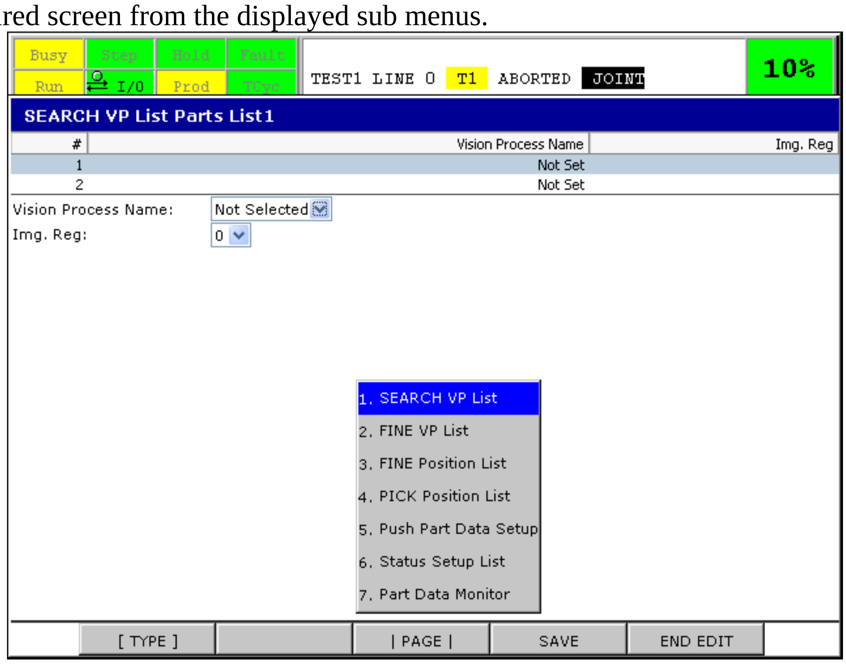


Displaying a Desired Screen

The Parts List Manager has multiple setup screens including [SEARCH VP List] and [FINE VP List]. To display one of these setup screens, follow the procedure below:

1 Press F3 PAGE in the Parts List Manager setup screen.

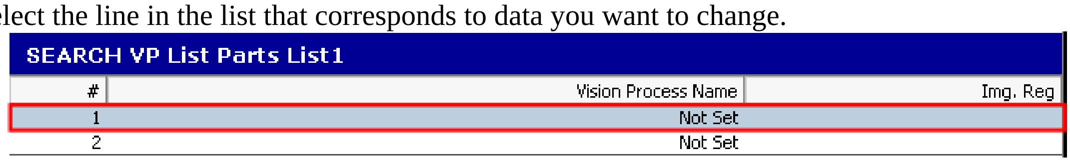
2 Select a desired screen from the displayed sub menus.



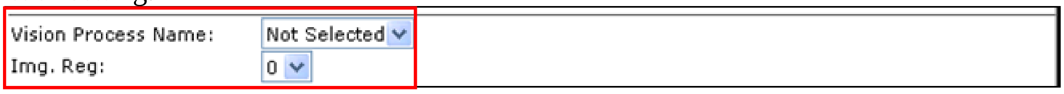
Changing List Data

To change list data in a setup screen containing a list and settings, such as [SEARCH VP List] or [FINE VP List], follow the procedures below:

1 Select the line in the list that corresponds to data you want to change.



2 Set each setting.



9.2 BASIC RULES OF PARTS LIST MANAGER

This section describes the rules of the parts list and part data and basic things to know when using the Parts List Manager.

Parts List and part data

The rules of the parts list and part data are described below.

- The data in the parts list and the part data are lost when the robot controller is turned off.
- The part data of parts included in one container needs to be managed by a single parts list.
- The number of pushes performed after the robot controller is powered up is used as an index indicating the timing at which part data is added to the parts list.

The number of pushes

- When the robot controller power is cycled the number of pushes is initialized to 0.
- When some part data are pushed to a parts list after performing the following operations, the number of pushes is incremented by 1.
    - Turn on the power of the robot controller again
    - Pops a part data from a parts list successfully

Status

The statuses that can be set for part data are shown below.

- AWAITING
- PICK SUCCESS
- PICK FAIL
- PICK IA FAIL
- PICK CL FAIL
- FINE SUCCESS
- FINE FAIL
- FINE IA FAIL
- FINE CL FAIL

Data included in parts list

A parts list includes the following data.

- Part data list (detailed below)
- Number of pushes performed after the power up of the robot controller (Current Number of Pushes)
- Number of pops performed after the power up of the robot controller

Data included in part data

Part data includes the following data

- Part data ID
  The ID number is uniquely assigned to part data when the part data is pushed to a parts list. The part data ID of the part data that is first pushed after the power up of the robot controller is 1. The ID is incremented by 1 each time a part is pushed.
- Flag indicating whether the part data is popped
- Status
- Priority
- Count of the blacklist

- Detection result by SEARCH vision process
  The vision process name, model ID, found position, offset, 10 measurements, and user frame number in the found position are included.
- Detection result by FINE vision process
  The vision process name, model ID, found position, offset, 10 measurements, and user frame number in the found position are included.
- Number of pushes when the part is found by the SEARCH vision process and the part data corresponding to the found part is pushed to the parts list (Number of Pushes of Part Data)
  This data of the part data in the blacklist is updated when the part corresponding to the part data in the blacklist is found by the SEARCH vision process to the current total number of pushes. By comparing this data with the current total number of pushes, you can see whether this part data has been found recently.
- Number of pushes of the parts list when this part data is pushed to the blacklist

9.3 PARTS LIST MANAGER SETUP AND PART DATA OPERATIONS

This section explains some necessary settings and operations for the following operations of the parts list manager.

- Clear all part data in a parts list
- Push some part data to a parts list
- Pop a part data from a parts list
- Calculate a PICK position
- Set a status to a popped part data
- Calculate a FINE position
- Execute a FINE vision process for a popped part data

In this manual, "PICK position" means a robot position to pick up a part and "FINE position" means a robot position to execute a FINE vision process.

9.3.1 Clear All Part Data in a Parts List

To clear all part data in a parts list, the following operations are required.

- Call the BINPICK_CLEAR in a TP program

9.3.1.1 Call the BINPICK_CLEAR in a TP program

Call the BINPICK_CLEAR in a TP program to clear all part data in a parts list.
The BINPICK_CLEAR requires the following argument.
Argument 1:
Specify the number of a parts list.

The BINPICK_CLEAR is the following macro program.

```
1:  !Clears part data in a Parts
2:  !List.
3:
4:  !arg1:Parts List ID
5:  CALL IPCLR(AR[1])
```

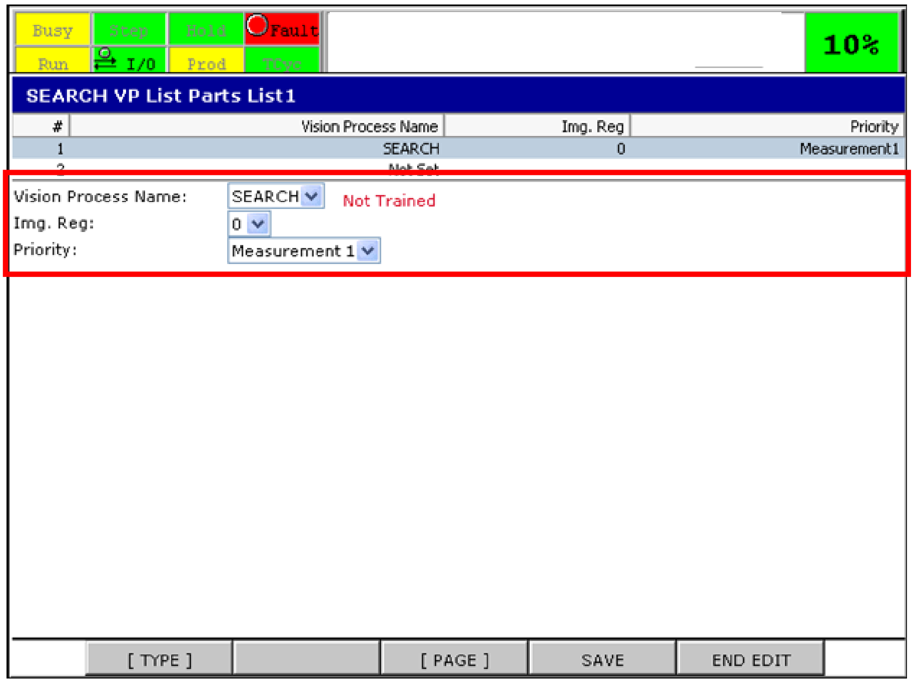
9.3.2 Push Some Part Data to a Parts List

To push some part data to a parts list, the following operations and settings are required.

- Set up the SEARCH VP List.
- Set up the parameters for deleting older part data when some part data are pushed
- Set up the parameters for checking some duplicated part data when some part data are pushed
- Call the BINPICK_SEARCH in a TP program

9.3.2.1 Set up the SEARCH VP List

Select [SEARCH VP List] from the sub menus displayed by pressing F3 PAGE and set a vision process you want to execute as the SEARCH vision process.



Vision Process Name

Select the vision process you want to execute as the SEARCH vision process from the drop-down box.

Img. Reg

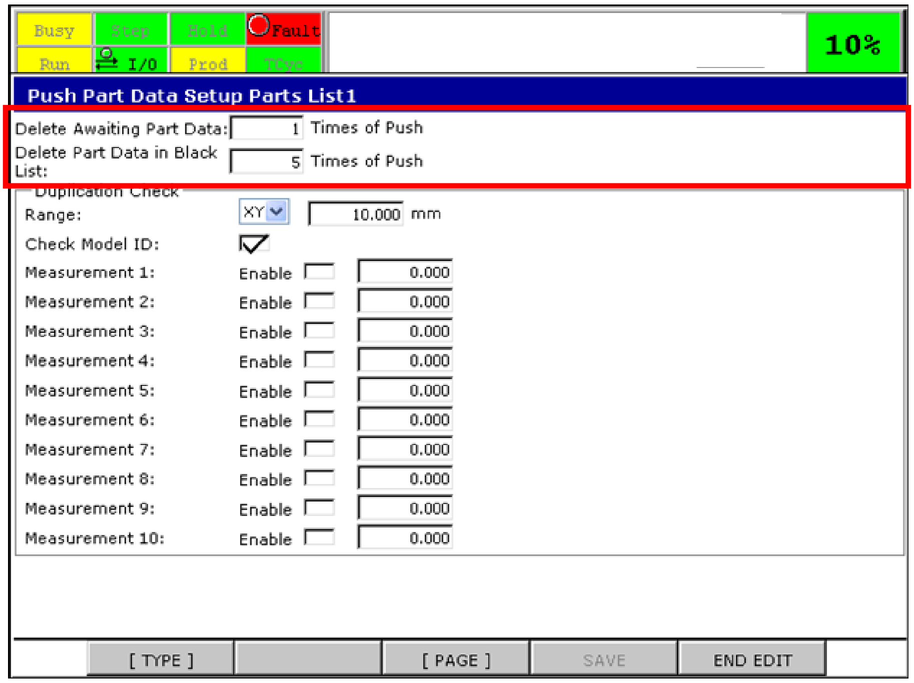
If you want to use the image register function, select the number of the image register to be used. If you do not want to use the image register function, select [0]. Please see Subsection

Priority

Specify the index number of measurement array. The specified measurement value is set as the priority of Part Data when a Part Data is added to the Parts List.

9.3.2.2 Set up the parameters for deleting older part data when some part data are pushed

Select [Push Part Data Setup] from the sub menus displayed by pressing F3 PAGE and set the parameters for deleting older part data when some part data are pushed.



Delete Awaiting Part Data

When part data is pushed, older part data (with a smaller number of pushes) is deleted. The following part data is deleted from the parts list: Its status is awaiting and the value (Current Number of Pushes – Number of Pushes of Part Data) is greater than or equal to the value set in this text box.

Delete Part Data in Blacklist

When part data is pushed, older part data in the blacklist is deleted. The following part data in the blacklist is deleted from the parts list: The value (Current Number of Pushes – Number of Pushes of Part Data) is greater than or equal to the value set in this text box.

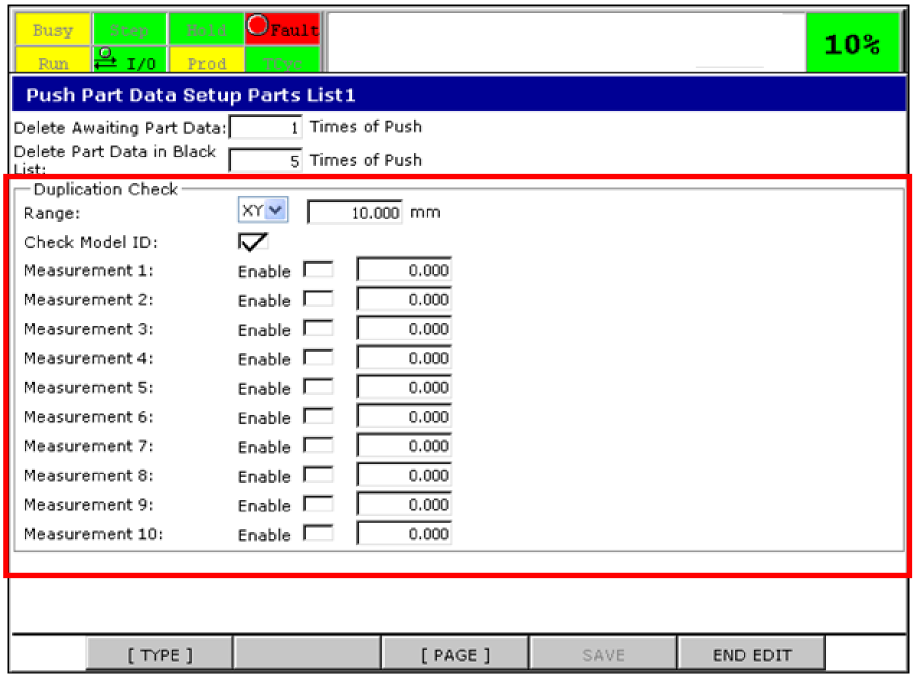
> ⚠ **CAUTION**
> The deletion process of the part data is not performed to part data whose Number of Pushes of Part Data is same as the Current Number of Pushes.

9.3.2.3 Set up the parameters for checking some duplicated part data when some part data are pushed

When a new part data are pushed to the parts list, the new part data is checked if there is duplicated part data in the parts list. If there is duplicated part data in the parts list, the following processes are done.

- When the status of the duplicated part data is awaiting, the duplicated older part data is deleted and the new part data is pushed to the parts list.
- When the status of the duplicated part data is in the blacklist, the new part data is not pushed to the parts list and the Number of Pushes of Part Data of the duplicated older part data is updated.

Select [Push Part Data Setup] from the sub menus displayed by pressing F3 PAGE and set the parameters for checking some duplicated part data when some part data are pushed.



Range

Set a distance between found positions to be used for determining whether part data are duplicated. Select a type of distance to be calculated from the drop-down box and set a distance threshold in each text box. The Parts List Manager calculates the distance between the found position of part data to be pushed in the parts list and the found position of each part data already stored in the parts list. If the obtained (calculated) distance is smaller than the threshold set in this box, the Parts List Manager assumes that there are duplicate part data.

Check Model ID

Use this check box to select whether to check the model IDs when a duplication check is made. When this box is checked, part data items that satisfy the condition set in [Range] or [Measurement] are not assumed to be duplicated if their model IDs are different.

Measurement

Set a threshold to be used for determining whether part data items are duplicated, using differences in measurement values in SEARCH results. Any of the values set for [Measurement 1] to [Measurement 10] can be used for a duplication check. Check the [Enable] box to the right of a measurement value you want to use for a duplication check and set a threshold. Even if the condition set in [Range] or [Check Model ID] is satisfied, part data is not assumed to be duplicated when the absolute difference between the measurement value of part data to be pushed in the parts list and the measurement value of each part data already stored in the parts list is greater than or equal to the value set in this box.

> ⚠ **CAUTION**
> A part data is considered as duplicated when all of the conditions set for a duplication check are satisfied.

9.3.2.4 Call the BINPICK_SEARCH in a TP program

Call the BINPICK_SEARCH in a TP program to push some part data to a parts list.
The BINPICK_SEARCH requires the following arguments.
Argument 1:
Specify the number of a parts list.

Argument 2:
Specify the index number of the SEARCH vision process in SEARCH VP LIST.
Argument 3:
Specify the index number of a register to output the status of whether the SEARCH vision process is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: Some Part Data are added to the specified Parts List.
1: No Part Data is added to the specified Parts List.

The BINPICK_SEARCH is the following macro program.

```
!Executes a SEARCH Vision
!Process. And Part Data are added
!to the Parts List according to
!the Vision Process.

!arg1:Parts List ID
!arg2:Index number of the SEARCH
!     VP in SEARCH VP LIST
!arg3:Index number of R[] to set
!     the SEARCH status
!   0:Part Data are added
!   1:No Part Data is added
CALL IMSEARCH(AR[1],AR[2],0,AR[3])
```

9.3.3 Pop a Part Data from a Parts List

To pop a part data from a parts list, the following operation is required.
- Call the BINPICK_POP in the TP program

> ⚠ **CAUTION**
> The flag indicating whether the part data is popped is disabled after calling the BINPICK_SEARCH.

9.3.3.1 Call the BINPICK_POP in a TP program

Call the BINPICK_POP in a TP program to pop a part data from a parts list.
The BINPICK_POP requires the following arguments.
Argument 1:
Specify the number of a parts list.
Argument 2:
Specify the index number of a register to output the status of whether the pop operation is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: SUCCESS
1: FAIL
Argument 3:
Specify the index number of a register to output the Model ID of the popped part data. This value is used for identifying the type of the SEARCH Vision Process result.
Argument 4:
Specify the index number of a register to output the ID of the popped part data. This argument can be omitted.

The BINPICK_POP is the following macro program.

```
 1:  !Pops a Part Data from the
 2:  !specified Parts List.
 3:
 4:  !arg1:Parts List ID
 5:  !arg2:Index number of R[] to set
 6:  !    status
 7:  !   0:SUCCESS
 8:  !   1:FAIL
 9:  !arg3:Index number of R[] to set
10:  !    a model ID of a popped Part
11:  !    Data
12:  !arg4:Index number of R[] to set
13:  !    a popped Part Data ID
14:  !    (omissible)
15:  CALL IMPOP(AR[1],AR[2],AR[3],AR[4])
```

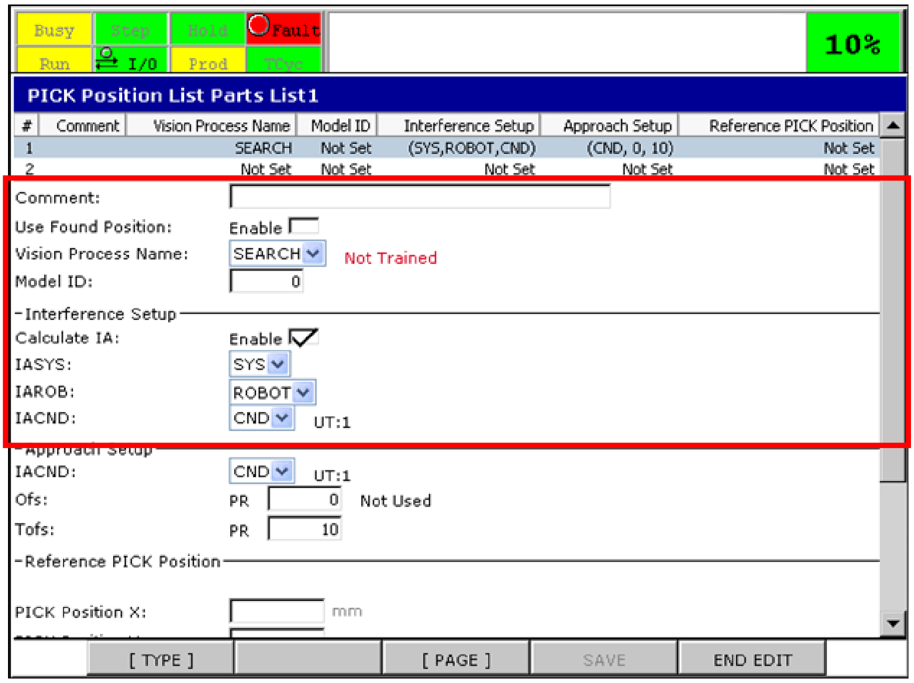
9.3.4 Calculate a PICK Position

To calculate a PICK position, the following operations and settings are required.

- Set up the parameters for calculating a PICK position
- Set up the parameters for calculating a robot position to approach a part
- Set up the reference PICK position
- Call the BINPICK_GETPICKPOS in a TP program

9.3.4.1 Set up the parameters for calculating a PICK position

Select [PICK Position List] from the sub menus displayed by pressing F3 PAGE and set the parameters for calculating a robot position to pick up a part.



Comment

When multiple PICK positions are set, set a comment for a PICK position to be set. Up to 50 characters can be input.

Vision Process Name

Select the name of the vision process that is to get offset data or found positions. The BINPICK_GETPICKPOS checks the FINE vision process name or SEARCH vision process name stored in the part data. If it is different from the vision process name set in the Parts List Manager, an alarm is issued. When no process name is selected, the program does not check any vision process name.

Model ID

Set the model ID the vision process selected in [Vision Process Name] is to output. The BINPICK_GETPICKPOS checks the FINE model ID or SEARCH model ID stored in the part data. If it is different from the model ID set in the Parts List Manager, an alarm is issued. When a value of 0 is set, the program does not check any model ID.

Calculate IA

Use this checkbox to select whether to calculate interference avoidance positions when the PICK position is obtained. When this checkbox is checked, the drop-down boxes for selecting interference avoidance setup data that are located to the right of [IASYS], [IAROB], and [IACND] are enabled. Interference avoidance function calculates a PICK position by using the selected interference avoidance setup data.

IASYS

Select an interference setup (system) data that you want to use for calculating interference avoidance positions when a PICK position is obtained.

IAROB

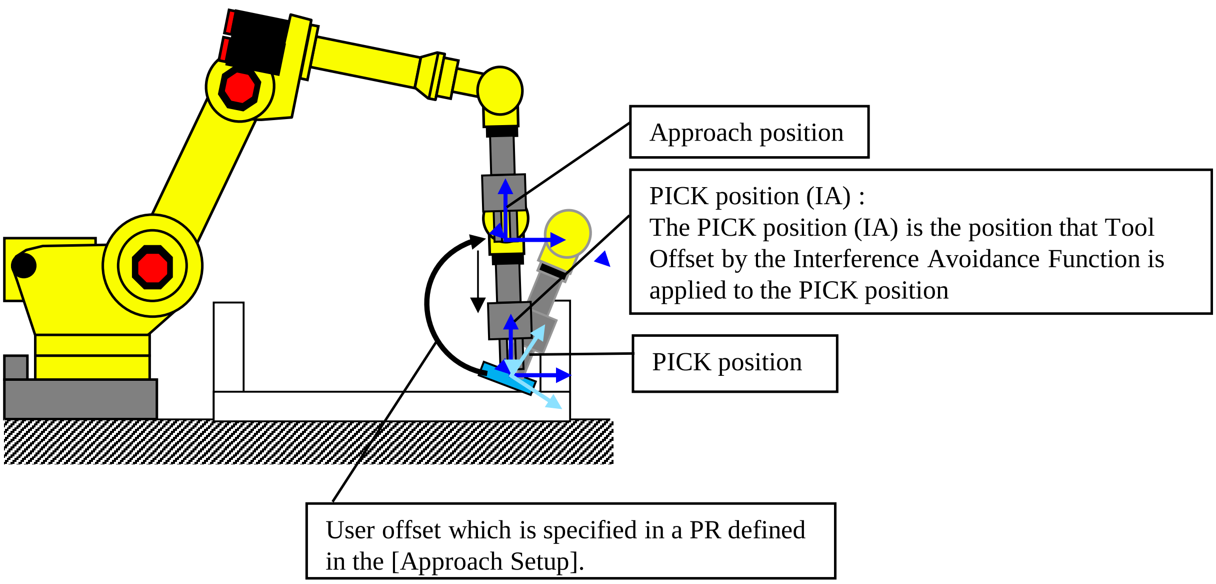
Select an interference setup (robot) data that you want to use for calculating interference avoidance positions when a PICK position is obtained.

IACND

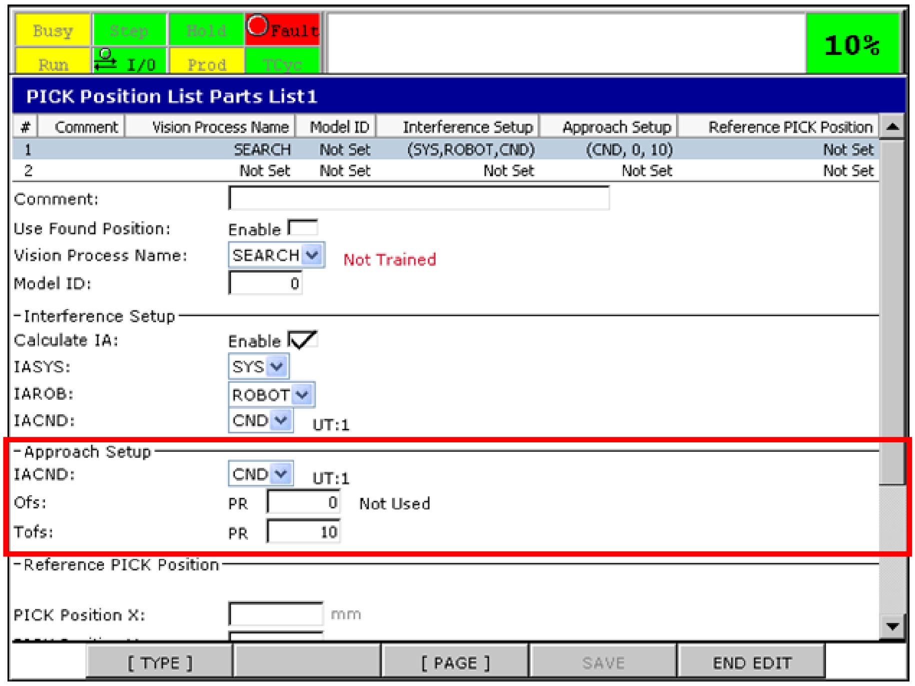
Select an interference setup (condition) setup data that you want to use for calculating interference avoidance positions when a PICK position is obtained.

9.3.4.2 Set up the parameters for calculating a robot position to approach a part

Set the parameters for calculating a robot position to approach a part.



To calculate the robot position to approach a part, set the following parameters. An approach position is calculated by applying the user offset specified in the [Approach Setup] to the PICK position (IA) shown in the figure above.



IACND

Select an interference setup data (condition) that you want to use for calculating interference avoidance positions at a position to approach a part.

Ofs

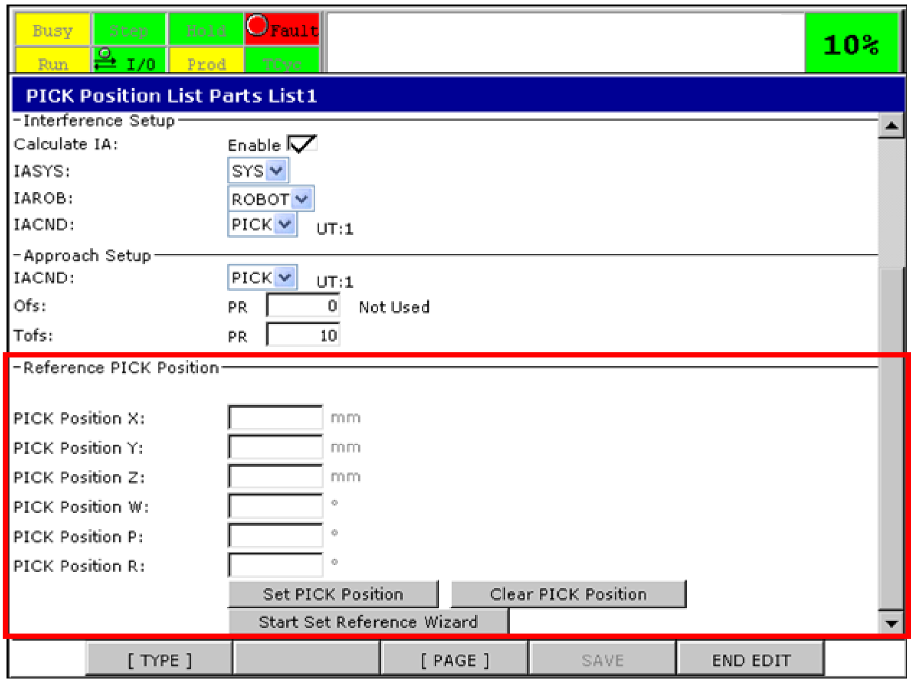
Set the number of a position register containing a position offset. The position offset is applied to a PICK position to calculate a position to approach a part. If you don't want to apply the position offset, set 0.

TOfs

Set the number of a position register containing a tool offset. The tool offset is applied to a PICK position to calculate a position to approach a part. If you don't want to apply the tool offset, set 0.

9.3.4.3 Set up the reference PICK position

Set the reference PICK position to calculate a PICK position. Instead of them, the found position of the vision process can be also output as the PICK position without setting the reference PICK position.



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

The reference PICK position is displayed. When no reference PICK position is set, you cannot change it. If you want to fine-tune a reference PICK position setup, change the value in the corresponding textbox.

Set PICK Position

Click the [Set PICK Position] button to set the current robot position and posture as the reference PICK position.

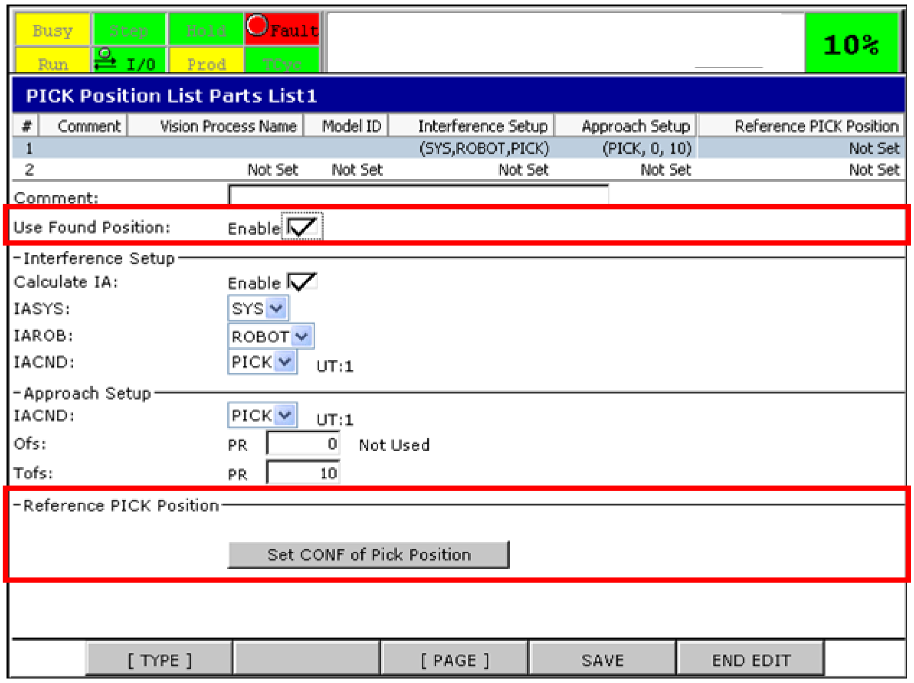
Clear PICK Position

Clears the reference PICK position setups.

Start Set Reference Wizard

Click the [Start Set Reference Wizard] button to start the Set Reference Wizard to set a reference PICK position. For details of the Set Reference Wizard, see Section 9.5, "SET REFERENCE WIZARD".

To output the found position of the vision process as the PICK position without setting the reference PICK position, set the following parameters.



Use Found Position

Check the checkbox if you want to use the found position as the PICK position.

Set CONF of PICK Position

If you want to use the found position as the PICK position, you must set the robot configuration to pick up a part. Press the [Set CONF of Pick Position] button to set the robot configuration to pick up a part.

9.3.4.4 Call the BINPICK_GETPICKPOS in a TP program

Call the BINPICK_GETPICKPOS in a TP program to calculate a PICK position.
The BINPICK_GETPICKPOS requires the following arguments.

Argument 1:
Specify the index number of the parts list.

Argument 2:
Specify the index number of the PICK position in the PICK POSITION LIST.

Argument 3:
Specify the index number of a register to output the status including whether the calculation of the PICK position is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: SUCCESS
12: Fail to calculate a PICK position
13: Fail to calculate a position to approach a part

Argument 4:
Specify the index number of a position register to output the PICK position.

Argument 5:
Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the PICK position.

Argument 6:
Specify the index number of a position register to output a robot position to approach a part.

Argument 7:
Specify the part ID to obtain the PICK position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

The BINPICK_GETPICKPOS is the following macro program.

```
!Calculates a PICK position.

!arg1:Parts List ID
!arg2:PICK POS ID in the PICK
!     POSITION LIST
!arg3:Index number of R[] to set
!     IA Status
!   0:SUCCESS
!  12:Fail to calc PICK POS
!  13:Fail to calc APPROACH POS
!arg4:Index number of PR[] to set
!     PICK POS
!arg5:Index number of PR[] to set
!     IA offset value at PICK POS
!arg6:Index number of PR[] to set
!     APPROACH POS
!arg7:Part Data ID to obtain the
!     PICK POS (omissible)
CALL  IMGETPICKPOS(AR[1],AR[2],AR[3],AR[4],AR[5],
AR[6],0,AR[7])
```

9.3.5 Set a Status to a Popped Part Data

The statuses that can be set for part data are shown below.

- AWAITING
  When a part data is pushed to a parts list, the part data is set to this status. The part data whose status is "AWAITING" is popped from the parts list as a candidate for part data to be picked up.
- PICK SUCCESS
  The status indicates that the operation to pick up a part is done successfully. The part data that corresponds to the picked part is set to this status.
- PICK FAIL
  The status indicates that the operation to pick up a part is done unsuccessfully. The part data that corresponds to the picked part is set to this status.
- PICK IA FAIL
  The status indicates that the calculation of a PICK position is done unsuccessfully. The part data that corresponds to the part that the calculation of a PICK position is done unsuccessfully is set to this status.
- PICK CL FAIL
  When a collision occurs in the middle of the robot moving to the PICK position, the part data that corresponds to the part to which the PICK operation is tried to this status.
- FINE SUCCESS
  The status indicates that the FINE vision process is done successfully. The part data that corresponds to the part that FINE vision process is done successfully is set to this status.
- FINE FAIL
  The status indicates that the FINE vision process is done unsuccessfully. The part data that corresponds to the part that the FINE vision process is done unsuccessfully set to this status.
- FINE IA FAIL
  The status indicates that the calculation of a FINE position is done unsuccessfully. The part data that corresponds to the part that the calculation of a FINE position is done unsuccessfully is set to this status.
- FINE CL FAIL
  When a collision occurs in the middle of the robot moving to the FINE position, the part data that corresponds to the part to which the FINE operation is tried to this status.

Parts List Manager performs the following processing on part data when setting the status for the part data so that parts can be picked up efficiently by making the states of the parts in a container identical to the states of the part data in the parts list.

Deletion

- Since a part is not present in the container if the part is picked up, the "PICK SUCCESS" status is set for the part data corresponding to the part that was picked up and the part data is deleted from the parts list.
- When a part is successfully picked up, parts close to the part that was picked up may have moved. If parts in the bin are moved their data in the parts list is no longer valid. To prevent the robot from trying to pick based on the invalid positions, it is necessary to delete the part data corresponding to parts close to the part that was picked up before setting the "PICK SUCCESS" status for the part that was picked up. This is explained below in the "Deleting part data" section.

Registration in the blacklist

- To prevent the robot from repeatedly trying to pick an uppickable part, it is necessary to set the "PICK FAIL" status for the part data corresponding to unpickable part and register the part data in the blacklist. The registration in the blacklist prevents the unpickable part from being popped again. A user specified positive count is set for the part data registered in the blacklist at the same time. When the count is decreased to 0, the part data is removed from the blacklist and then deleted from the parts list.
- When the following statuses are set to a part data, the part data can be registered in the blacklist.
    - PICK FAIL
    - PICK IA FAIL
    - PICK CL FAIL
    - FINE FAIL
    - FINE IA FAIL
    - FINE CL FAIL

To set a status to a part data, the following operation and setting are required.

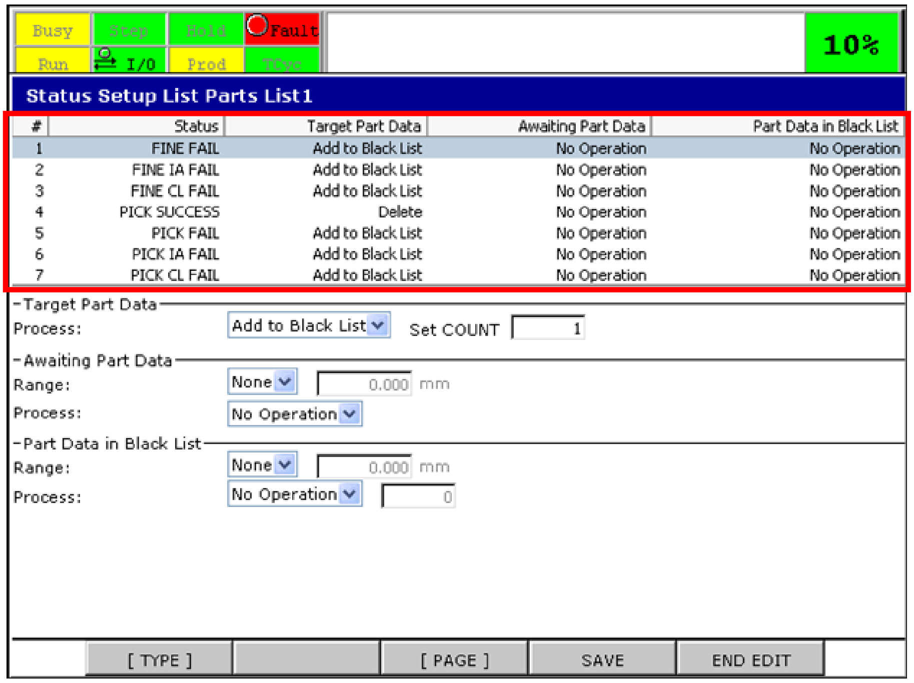
- Set up the process when setting a status to a part data.
- Call the BINPICK_SETSTATARCH in a TP program

9.3.5.1 Set up the process when setting a status to a part data

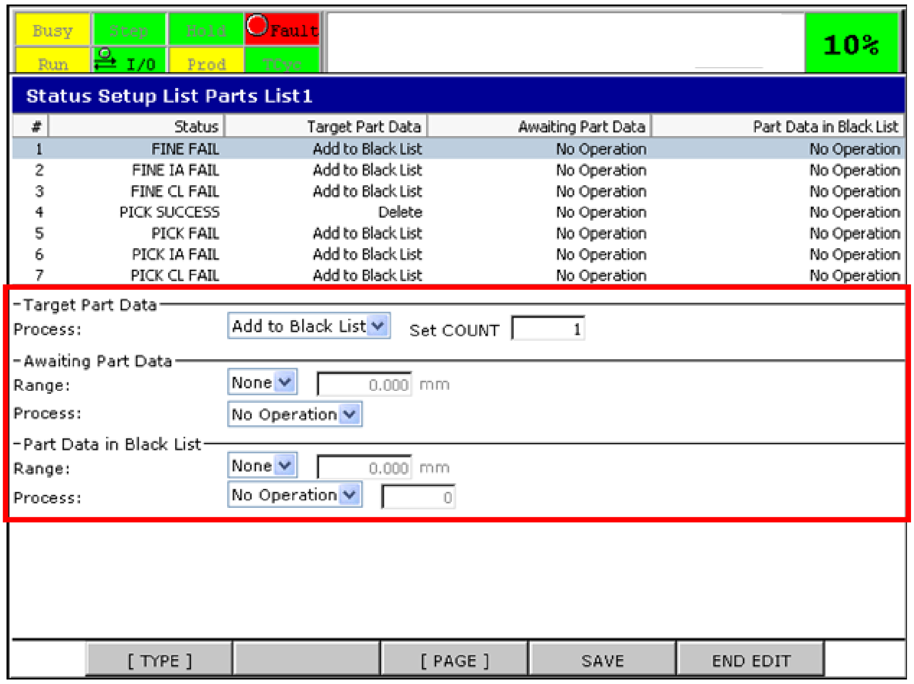
Select [Status Setup List] from the sub menus displayed by pressing F3 PAGE and set a process to be performed according to the status set for each part data.

Selecting a status from the Status Setup List

The displayed [Status Setup List] setup screen contains a list as shown below. The process to be performed according to each status set for part data is displayed in each line in the list. Select the line that corresponds to a process you want to change. In the Parts List Manager whose type is [SEARCH], the lines of [FINE FAIL], [FINE IA FAIL] and [FINE CL FAIL] are not displayed.



After selecting status, set the following parameters.



Target Part Data - Process

Select a process to be performed for target part data (part data to which a status is set). You can select either of two options: [Add to Black List] or [Delete]. When [PICK SUCCESS] is set for [Status], however, you can select only [Delete] as a process for target part data. If you select [Add to Black List] for [Process], set the initial count value for the blacklist in the [Set COUNT] textbox.

Awaiting Part Data - Range

Set a range within which to perform a process. Select a type of distance to be calculated from the drop-down box and set a distance threshold in the textbox. The Parts List Manager calculates the distance between the found position of target part data and the found position of each part data already stored in the parts list whose status is awaiting. If the obtained (calculated) distance is smaller than the threshold set in the textbox, the process selected for [Process] is performed. If you select [None] from the drop-down box for selecting a type of distance, the selected process is performed for all part data in the parts list whose status is awaiting.

Awaiting Part Data - Process

Select a process to be performed for the part data within the range set for [Range]. Select [No Operation] or [Delete].

Part Data in Blacklist - Range

Set a range within which to perform a process. Select a type of distance to be calculated from the drop-down box and set a distance threshold in the textbox. The Parts List Manager calculates the distance between the found position of target part data and the found position of part data in the blacklist that is already stored in the parts list. If the obtained (calculated) distance is smaller than the threshold set in the textbox, the process selected for [Process] is performed. If you select [None] from the drop-down box for selecting a type of distance, the selected process is performed for all part data items in the blacklist in the parts list.

Part Data in Blacklist - Process

Select a process to be preformed for the part data within the range set for [Range]. Select [No Operation], [Delete], [Set COUNT], or [Decrease COUNT]. If you select [Set COUNT] or [Decrease COUNT], also set a number by which to set or decrease the black list count.

9.3.5.2 Call the BINPICK_SETSTAT in a TP program

Call the BINPICK_SETSTAT in a TP program to set a status to the popped part data.
The BINPICK_SETSTAT requires the following arguments.
Argument 1:
Specify the index number of the parts list.
Argument 2:
Specify the status to be set to the popped Part Data. The following status can be set.
10: FINE SUCCESS
11: FINE FAIL
12: FINE IA FAIL
13: FINE CL FAIL
20: PICK SUCCESS
21: PICK FAIL
22: PICK IA FAIL
23: PICK CL FAIL
Argument 3:
Specify the part ID to set a status. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

The BINPICK_SETSTAT is the following macro program.

```
 1:  !Sets a status to a popped Part
 2:  !Data.
 3:
 4:  !arg1:Parts List ID
 5:  !arg2:Status to be set
 6:  !  10:FINE SUCCESS
 7:  !  11:FINE FAIL
 8:  !  12:FINE IA FAIL
 9:  !  13:FINE CL FAIL
10:  !  20:PICK SUCCESS
11:  !  21:PICK FAIL
12:  !  22:PICK IA FAIL
13:  !  23:PICK CL FAIL
14:  !arg3:Part Data ID to set a
15:  !     status (omissible)
16:  CALL IMSETSTAT(AR[1],AR[2],AR[3])
```

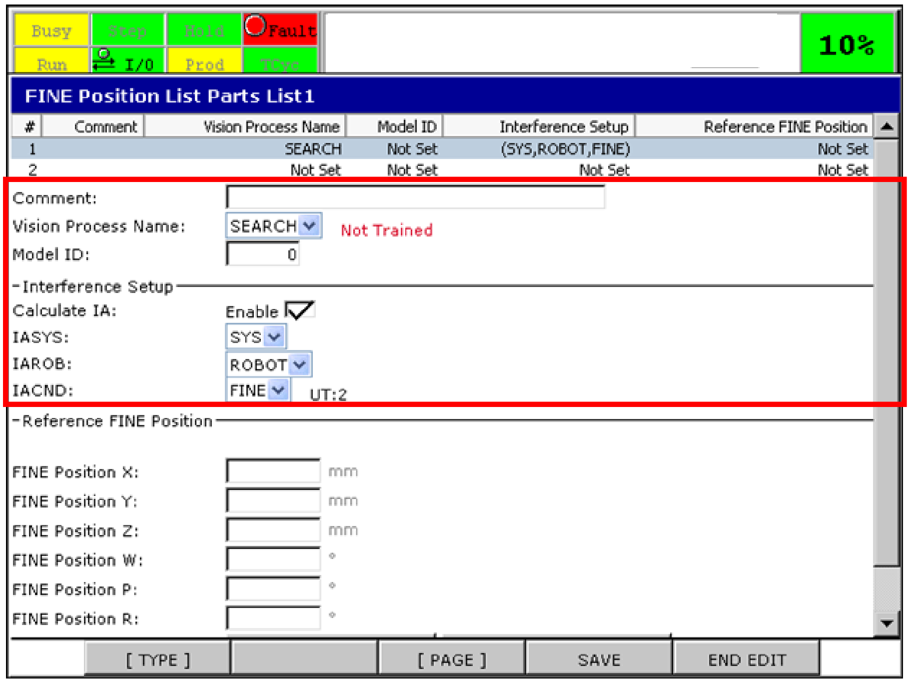
9.3.6 Calculate a FINE Position

To calculate a FINE position, the following operations and settings are required.

- Set up the parameters for calculating a FINW position
- Set up the reference FINE position
- Call the BINPICK_GETFINEPOS in a TP program

9.3.6.1 Set up the parameters for calculating a FINE position

Select [FINE Position List] from the sub menus displayed by pressing F3 PAGE and set data required for getting a FINE position and a reference FINE position.



Comment

When multiple FINE positions are set, set a comment for a FINE position to be set. Up to 50 characters can be input.

Vision Process Name

Select the name of a vision process to be used to get offset data. The BIPICK_GETFINEPOS.TP checks the FINE vision process name or SEARCH vision process name stored in the part data. If it is different from the vision process name set in the Parts List Manager, an alarm is issued. When no process name is selected, the program does not check any vision process name.

Model ID

Set the model ID the vision process selected in [Vision Process Name] is to output. The BINPICK_GETFINEPOS checks the FINE model ID or SEARCH model ID stored in the part data. If it is different from the model ID set in the Parts List Manager, an alarm is issued. When a value of 0 is set, the program does not check any model ID.

Calculate IA

Use this check box to select whether to calculate interference avoidance positions when a FINE position is obtained. When this box is checked, the drop-down boxes for selecting interference avoidance data that are located to the right of [IASYS], [IAROB], and [IACND] are enabled. Interference avoidance positions are calculated using the selected interference avoidance data.

IASYS

Select an interference setup (system) data you want to use for calculating interference avoidance positions when a FINE position is obtained.

IAROB

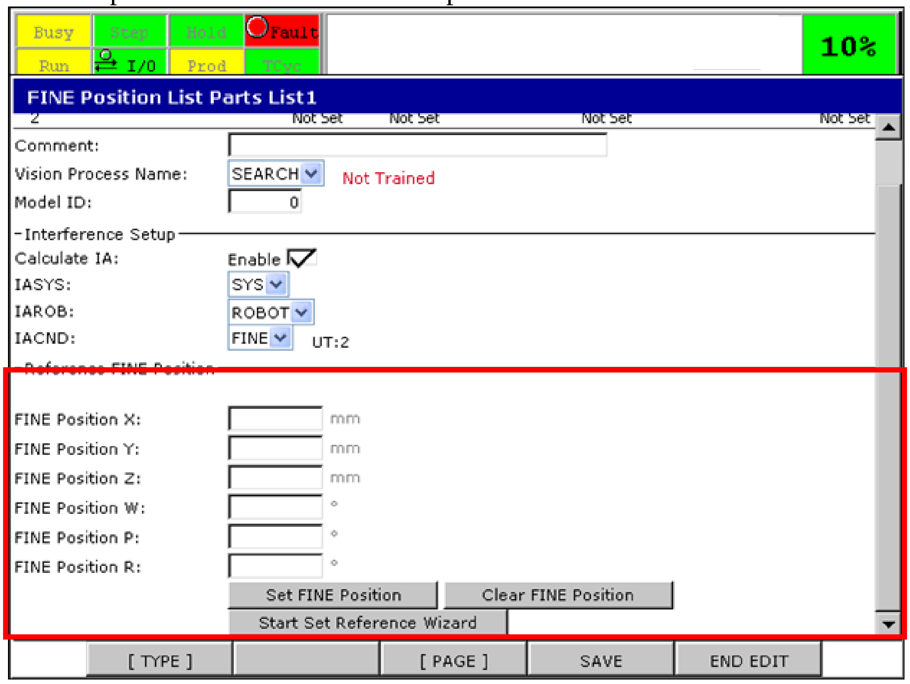
Select an interference setup (robot) data you want to use for calculating interference avoidance positions when a FINE position is obtained.

IACND

Select an interference setup (condition) data you want to use for calculating interference avoidance positions when a FINE position is obtained.

9.3.6.2 Set up the reference FINE position

Set the reference FINE position to calculate a FINE position.



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

The reference FINE position is displayed. When no reference FINE position is set, you cannot change it. If you want to fine-tune a reference FINE position setup, change the value in the corresponding text box.

Set FINE Position

Click the [Set FINE Position] button to set the current robot position and posture as the reference FINE position.

Clear FINE Position

Clears the reference FINE position setups.

Start Set Reference Wizard

Click the [Start Set Reference Wizard] button to start the Set Reference Wizard to set a reference FINE position. For details of the Set Reference Wizard, see Section 7.3, "SET REFERENCE WIZARD".

9.3.6.3 Call the BINPICK_GETFINEPOS in a TP program

Call the BINPICK_GETFINEPOS in a TP program to calculate a FINE position.
The BINPICK_GETFINEPOS requires the following arguments.

Argument 1:
Specify the index number of the parts list.

Argument 2:
Specify the index number of the FINE position in the FINE POSITION LIST.

Argument 3:
Specify the index number of a register to output the status including whether the calculation of the FINE position is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: SUCCESS
11: Fail to calculate a FINE position

Argument 4:
Specify the index number of a position register to output the FINE position.

Argument 5:
Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the FINE position.

Argument 6:
Specify the part ID to obtain the FINE position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

The BINPICK_GETFINEPOS is the following macro program.

```
   1:  !Calculates a FINE Position.
   2:
   3:  !arg1:Parts List ID
   4:  !arg2:Index number of FINE POS in
   5:  !     FINE POSITION LIST
   6:  !arg3:Index number of R[] to set
   7:  !     IA status
   8:  !   0:SUCCESS
   9:  !  11:FAIL
  10:  !arg4:Index number of PR[] to set
  11:  !     FINE POS
  12:  !arg5:Index number of PR[] to set
  13:  !     IA offset value at FINE POS
  14:  !arg6:Part Data ID to obtain the
  15:  !     FINE POS (omissible)
  16:  CALL IMGETFINEPOS(AR[1],AR[2],AR[3],AR[4],AR[5],
AR[6])
```

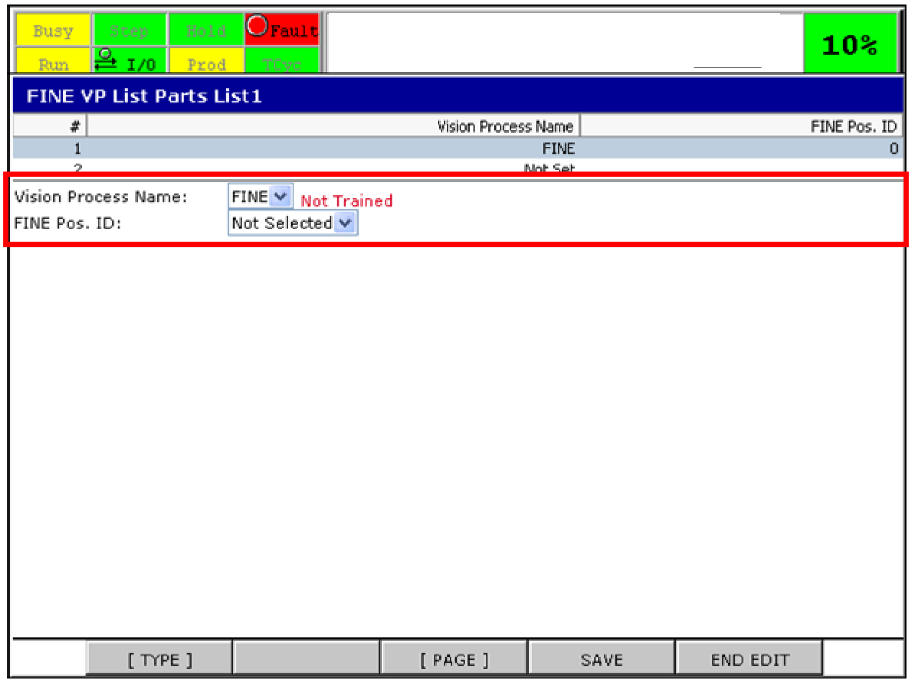
9.3.7 Execute a FINE Vision Process for a Popped Part Data

To execute a FINE vision process for a popped part data, the following operations and settings are required.

- Set up the parameters for executing a FINE vision process
- Call the BINPICK_FINE in a TP program

9.3.7.1 Set up the parameters for executing a FINE vision process

Select [FINE VP List] from the sub menus displayed by pressing F3 PAGE and set a vision process you want to execute as the FINE vision process.



Vision Process Name

Select a vision process you want to execute as the FINE vision process from the drop-down box.

FINE Pos. ID

Select the ID of a FINE position you want to use.

9.3.7.2 Call the BINPICK_FINE in a TP program

Call the BINPICK_FINE in a TP program to execute a FINE vision process.
The BINPICK_FINE requires the following arguments.

Argument 1:
Specify the index number of the parts list.

Argument 2:
Specify the index number of the FINE vision process in FINE VP LIST.

Argument 3:
Specify the index number of a register to output the status including whether the FINE vision proces is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: SUCCESS
1: FAIL

Argument 4:
Specify the index number of a register to output the Model ID of the FINE Vision Process result.

Argument 5:
Specify the Part Data ID to execute the FINE Vision Process operation. This argument can be omitted. If this argument is omitted, the FINE Vision Process operation is done to the popped Part Data.

The BINPICK_FINE is the following macro program.

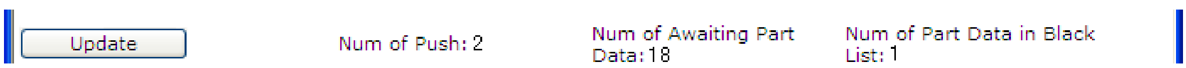
```
!Executes a FINE Vision Process.

!arg1:Parts List ID
!arg2:Index number of the FINE VP
!     in FINE VP LIST
!arg3:Index number of R[] to set
!     FINE Status
!   0:SUCCESS
!   1:FAIL
!arg4:Index number of R[] to set
!     Model ID of FINE VP result
!arg5:Part Data ID to set FINE
!     result (omissible)
CALL IMFINE(AR[1],AR[2],AR[3],AR[4],AR[5])
```

9.4 Part Data Monitor

Part data of parts list is displayed here.

Select [Part Data Monitor] from the sub menus displayed by pressing F3 PAGE and check parts list information and information of part data in the parts list.

Click the [Update] button in the setup screen. parts list information is displayed as follows.



Each item indicates the parts list information as listed below.

Num of Push
Number of times the part data is pushed in the parts list after power up of robot controller.

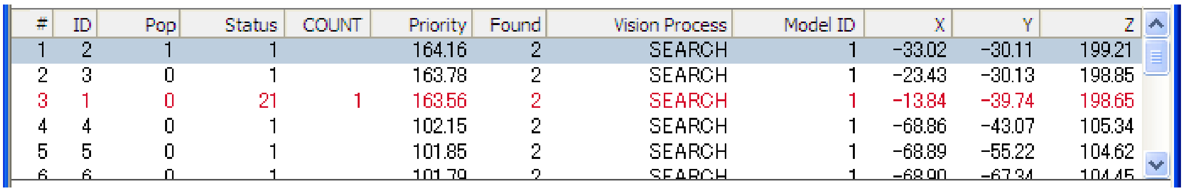
Num of Awaiting Part Data

Number of part data items in the parts list whose status is awaiting. When this value is 0, there are no parts that can be picked up.

Num of Part Data in Black List

Number of part data items in the blacklist in the parts list

Part data in the parts list is displayed in a list as follows.



#	ID	Pop	Status	COUNT	Priority	Found	Vision Process	Model ID	X	Y	Z
1	2	1	1		164.16	2	SEARCH	1	-33.02	-30.11	199.21
2	3	0	1		163.78	2	SEARCH	1	-23.43	-30.13	198.85
3	1	0	21	1	163.56	2	SEARCH	1	-13.84	-39.74	198.65
4	4	0	1		102.15	2	SEARCH	1	-68.86	-43.07	105.34
5	5	0	1		101.85	2	SEARCH	1	-68.89	-55.22	104.62
6	6	0	1		101.79	2	SEARCH	1	-68.90	-67.34	104.45

Each column indicates part data information as listed below.

#

Order in the parts data

ID

ID of the part data. This gets reset to zero after power up of the robot controller.

Pop

Whether the part data is popped. When the part data is popped, 1 is displayed. When it is not popped, 0 is displayed.

Status

Status of the part data. One of the following numbers indicating the status is displayed:

1: Awaiting
11: FINE FAIL
12: FINE IA FAIL
13: FINE CL FAIL
21: PICK FAIL
22: PICK IA FAIL
23: PICK CL FAIL

COUNT

Blacklist count when the part data is in the blacklist. When the part data is not in the blacklist, nothing is displayed.

Priority

Priority of the part data

Found

Number of pushes when the part is found by the SEARCH vision process and the part data corresponding to the found part is pushed to the parts list (Number of Pushes of Part Data). This data of the part data in the blacklist is updated when the part corresponding to the part data in the blacklist is found by the SEARCH vision process to the current total number of pushes. By comparing this data with the current total number of pushes, you can see whether this part data has been found recently.

Vision Process

Name of the vision process executed as the SEARCH vision process

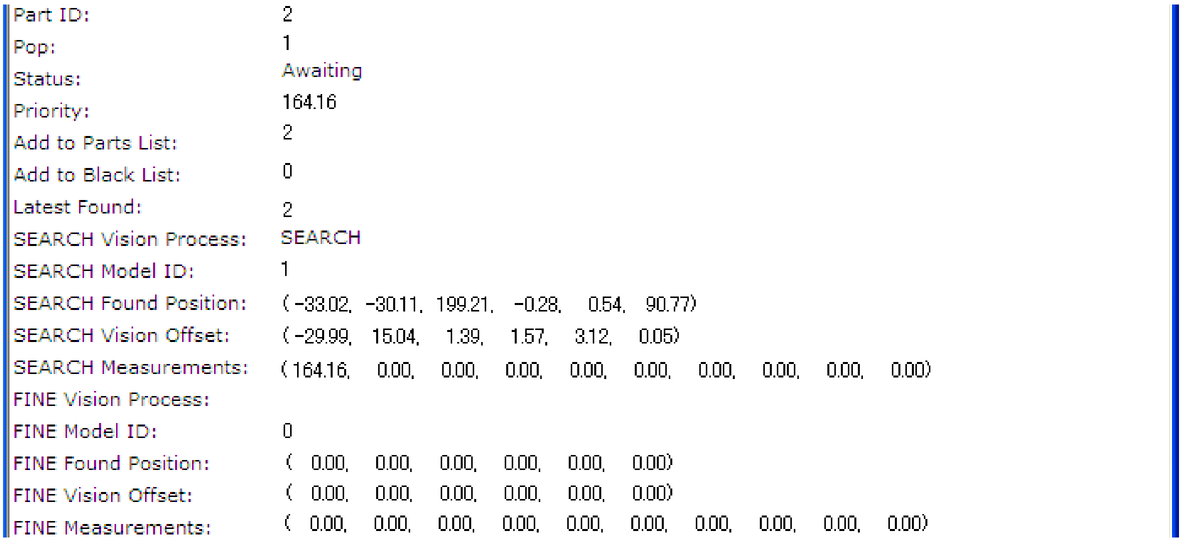
Model ID

Model ID of the found result of the vision process executed as the SEARCH vision process

XYZ

The found position of the part found by the vision process executed as the SEARCH vision process. The found position is the position of the part in the offset user frame.

If you select a line in the list, more detailed information of the part data in the selected line is displayed as shown below.



Each item indicates part data information as listed below. See Subsection 2.3.1, " Basic Rules of Parts List Manager" for more information on each item.

Part ID

ID of the part data

POP

Whether the part data is popped. When the part data is popped, 1 is displayed. When it is not popped, 0 is displayed.

Status

Status of the part data

Priority

Priority of the part data

Add to Parts List

Number of pushes when the part data is added to the parts list

Add to Black List

Number of pushes when the part data is added to the blacklist

Latest Found

Number of pushes when the part is found by the SEARCH vision process and the part data corresponding to the found part is pushed to the parts list (Number of Pushes of Part Data). This data of the part data in the blacklist is updated when the part corresponding to the part data in the blacklist is found by the

SEARCH vision process to the current total number of pushes. By comparing this data with the current total number of pushes, you can see whether this part data has been found recently.

SEARCH Vision Process

Name of the vision process executed as the SEARCH vision process

SEARCH Model ID

Model ID of the found result of the vision process executed as the SEARCH vision process

SEARCH Found Position

Position found by the vision process executed as the SEARCH vision process

SEARCH Vision Offset

Vision offset for the vision process executed as the SEARCH vision process

SEARCH Measurements

Measurement values obtained by the vision process executed as the SEARCH vision process

FINE Vision Process

Name of the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

FINE Model ID

Model ID of the found result of the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

FINE Found Position

Position found by the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

FINE Vision Offset

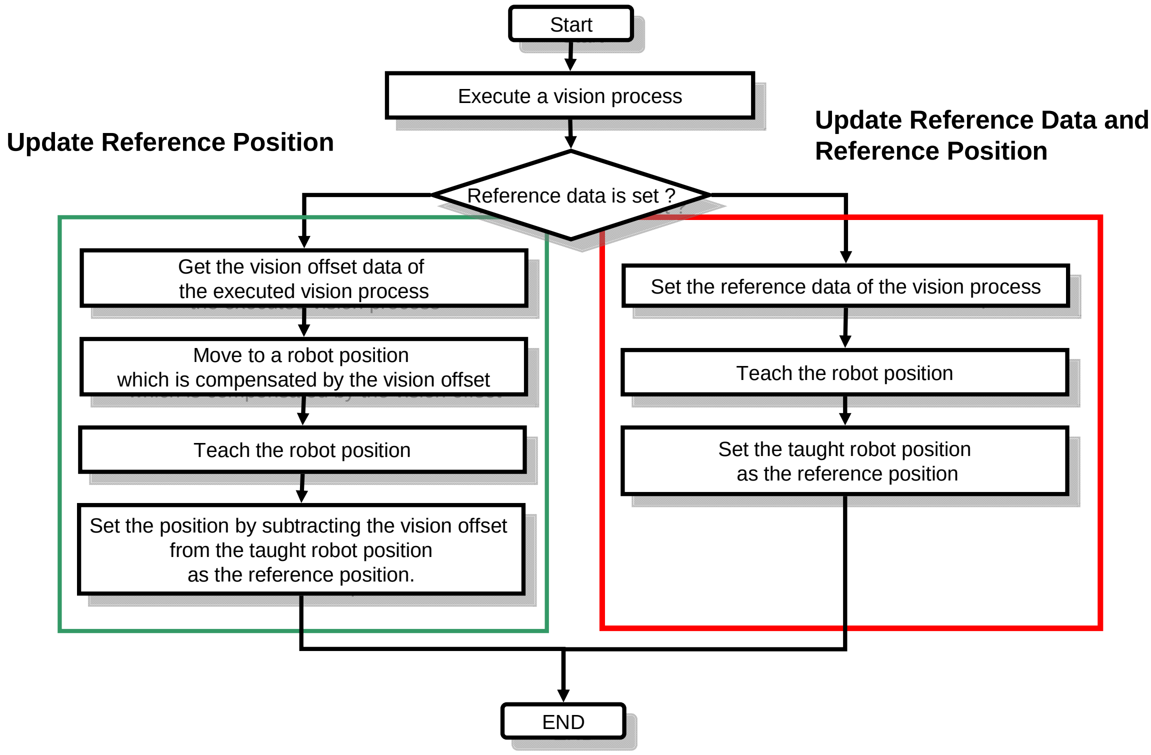
Vision offset for the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

FINE Measurements

Measurement values obtained by the vision process executed as the FINE vision process. This item is displayed in the Parts List Manager of [SEARCH + FINE] Type.

9.5 SET REFERENCE WIZARD

When you use the Parts List Manager, if you want to teach or reteach the reference position, use the Set Reference Wizard. To setup a reference position which is compensated with a vision offset, the steps described in the following figure must be required. The Set Reference Wizard displays the steps described in the following figure in the wizard form. By following the displayed step of the wizard, you can complete the teaching or reteaching of the reference position.



The use of the Set Reference Wizard enables you to teach the reference position easily without any errors even when the system has many reference PICK positions or reference FINE positions. The [Start Set Reference Wizard] button is displayed when [FINE Position List] or [PICK Position List] is selected from the sub menus displayed by pressing F3 PAGE, click this button to start the Wizard.

9.5.1 Basic Flow of Set Reference Wizard Operations

When you use the Set Reference Wizard, follow the steps shown in the figure below to set one reference position.

1. Execute the vision process selected in the [Vision Process Name] and get the vision offset data of the vision process[*1*2]

↓

2. Teach the reference position in the TP program whose name is “SET_POS.TP”.

*1 When the [Vision Process Name] is not set, a vision process is not executed. Then, an offset data is set to 0.0 in all the elements.

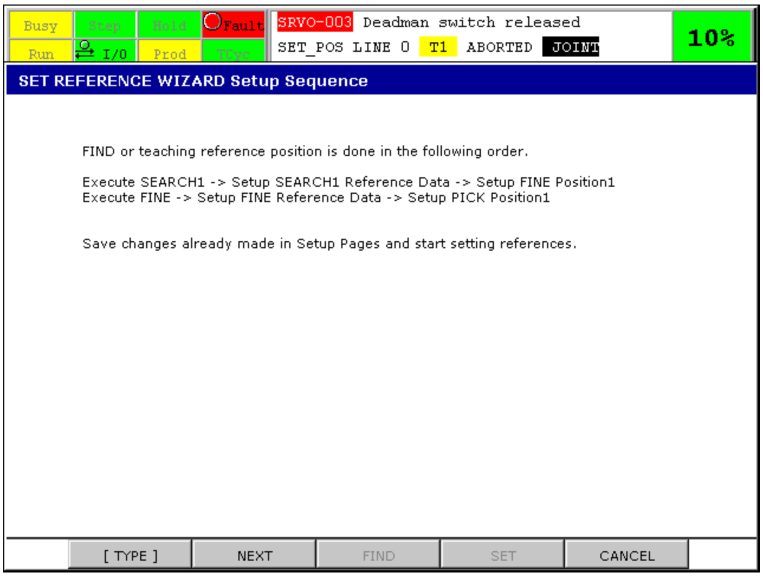
*2 When a vision process is executed, the found result can be as the reference data of the vision process. Then, an offset is set to 0.0 in all the elements.

The values obtained by subtracting the offset data obtained in step 1 from the position and posture taught to the TP program in step 2 are set to the Parts List Manager as the reference position.

If you want to get FINE positions using the 3D Laser Vision Sensor, basically perform the above series of processing twice because two positions, FINE position and PICK position, must be taught.

9.5.2 Details of Each Teaching Operation

After you start the Set Reference Wizard, the following screen appears, asking you to confirm the teaching order. After that, perform operations described in Subsection 7.3.1 for each reference position.



Perform operations according to the following three screens to set a reference position.

Vision Execution screen

The screen is to execute a vision process to get a vision result.

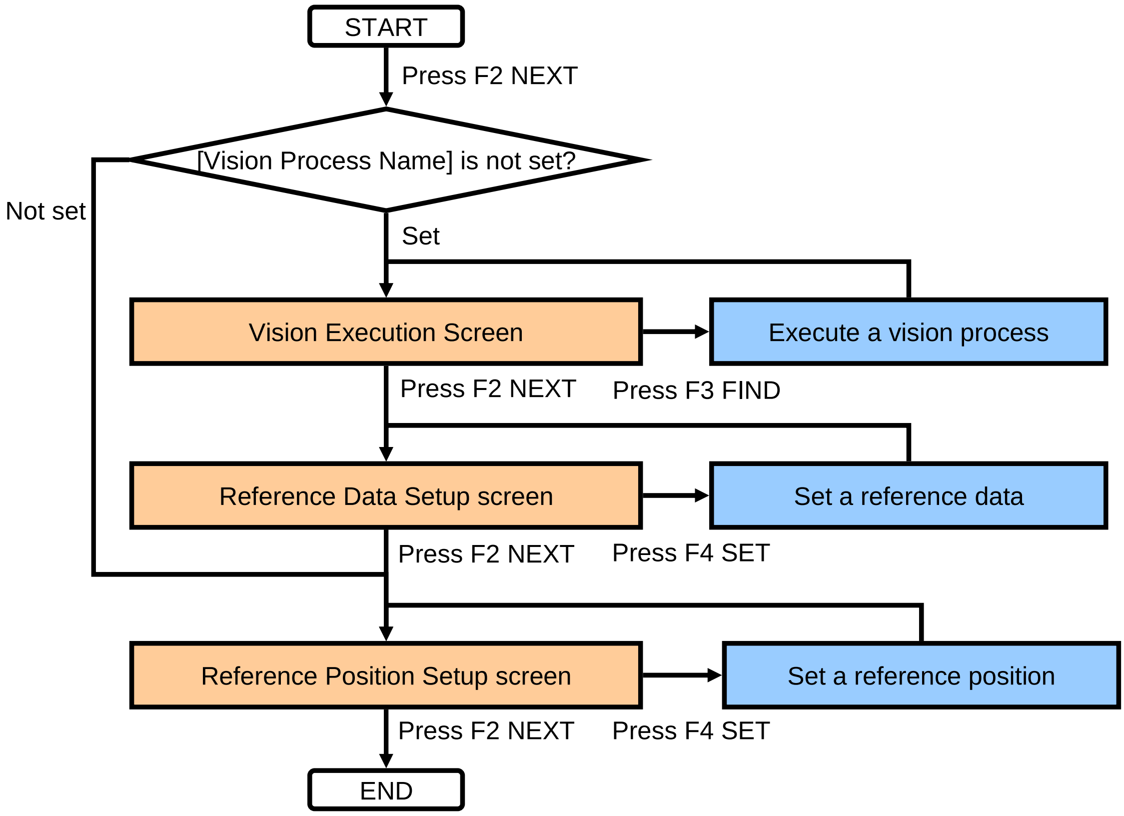
Reference Data Setup screen

The screen is to confirm that the found position of the found result executed in the Vision Execution screen is set as the reference data of its vision process.

Reference Position Setup screen

The screen is to confirm that the position taught to P[1] of the TP program is set as a reference position.

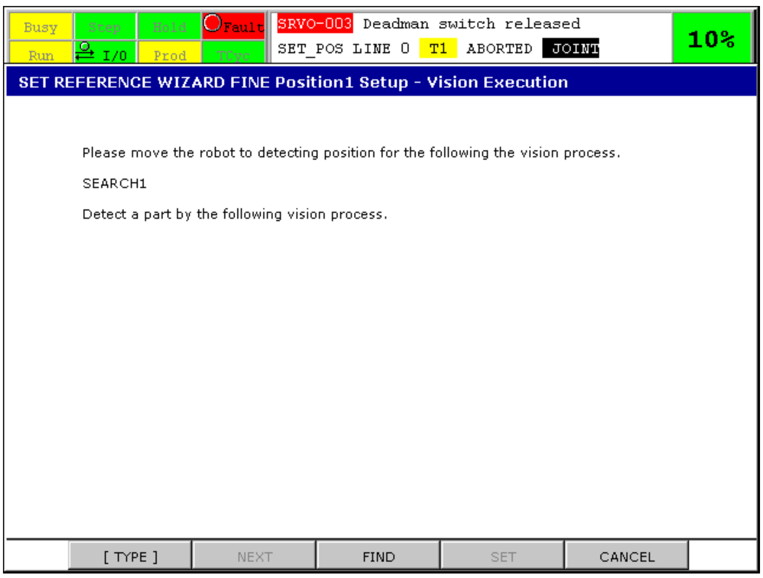
The following flow chart shows how and when each screen appears.



For details of operation corresponding to each screen, see the following subsections.

9.5.2.1 Vision execution screen

When a vision process is set to the [Vision Process Name], the Vision Execution screen is displayed as follows.



Each function key performs the following operations.

F1 [TYPE]

Bring you to another *i*RVision menu screen.

F2 NEXT
Move to the Reference Data Setup screen. At first, the function key is disabled. The function key is enabled after executing the vision process.

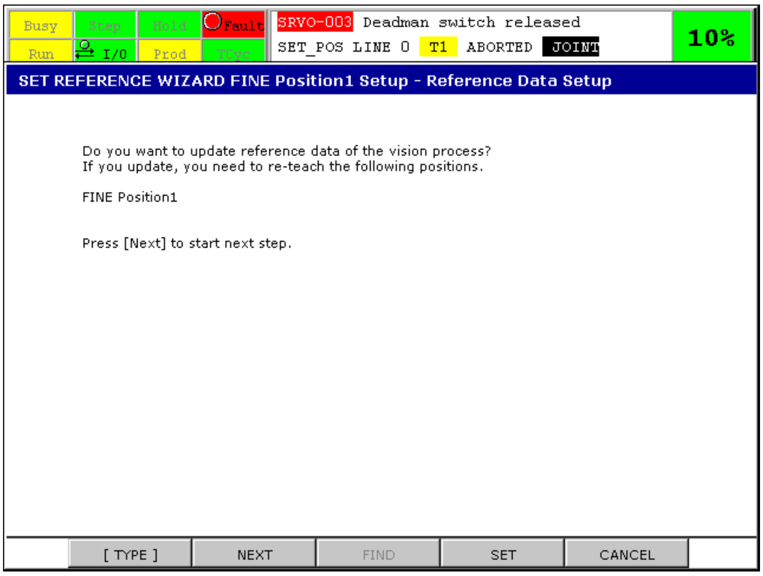
F3 FIND
Execute the vision process displayed in the screen. Please confirm that the found result of it is correct in the Vision Runtime.

Before executing the vision process, note the following points:
- When you are going to execute a SEARCH vision process and the fixed camera or the 3D Area Sensor is installed, move the robot so that it is not contained in the image, then press F3 FIND.
- When the Wizard for teaching the PICK position to which to apply an offset using a FINE vision process is running and you are going to execute the FINE vision process, please press F3 FIND after moving the robot to the FINE position,.

F5 CANCEL
Terminate the wizard.

9.5.2.2 Reference data setup screen

The screen is to confirm that the found position of the vision result in the Vision Execution screen is set as the reference data of it. Please set the reference data of the vision process when the vision process is not set any reference data or the reference data of it must be updated.



Each function key performs the following operations.

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

F2 NEXT
Move to the Reference Position Setup screen. When the reference data for the vision process has been set in the past, if you want to teach or re-teach the reference position, basically press F2 NEXT.

F4 SET
Set the found position of the found result executed in the Vision Execution screen is set as the reference data of its vision process.

When you use one vision process to compensate multiple robot taught positions (reference positions), if you update the reference data of the vision process, you must reteach all of the reference positions displayed in the message (reference positions compensated by the vision process). In the following cases, press F4 SET:

- No reference data is set for the vision process.
- It is necessary to modify a model found by pattern matching and update the reference data for the vision process.
- You want to update the reference data for the vision process.

F5 CANCEL

Terminate the wizard.

9.5.2.3 Reference position setup screen

After starting the wizard when any vision process is not set to the [Vision Process Name] or pressing F2 NEXT in the Reference Data Setup screen, the Reference Position Setup screen is displayed. At this time, TP program SET_POS.TP is generated for setting the reference position. When you press the EDIT key on the *i*Pendant, SET_POS.TP is displayed. (If a TP program named SET_POS.TP already exists, the contents of the program are overwritten. Be very careful when performing operation.) SET_POS.TP contains the following instructions:

```
1: UFRAME_NUM=1
2: UTOOL_NUM=1
3:L P[1] 100mm/sec FINE
```

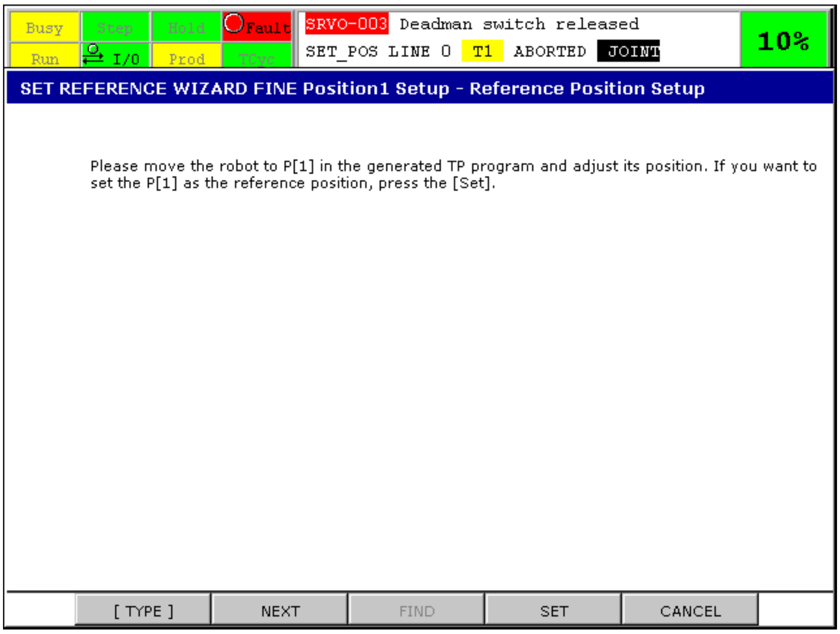
The following value is set to P[1]:

- When the reference position has been set:
  The position and posture obtained by applying the vision offset to the reference position and posture
- When no reference position is set:
  The found position found by the previously executed vision process

The following values are set for UFRAME_NUM and UTOOL_NUM:

- When interference data has been set:
  The user frame number and tool frame number selected in the interference data
- When no interference data is set and the reference position has been set:
  The user frame number and tool frame number used for the reference position already set
- When neither interference data nor reference position is set:
  The currently selected user frame number and tool frame

The Reference Position Setup screen is as follows.



Each function key performs the following operations.

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

F2 NEXT
Move to the next reference position setup screen. If there is no refreence position to be set, F2 COMPLETE is displayed in place of F2 NEXT.

F4 SET
Set the reference position. The position and posture obtained by subtracting the currently obtained vision offset from the position taught in P[1] in SET_POS.TP are set as the reference position in the Parts List Manager. Press F4 Set after moving the robot to an intended position and touching up P[1]. The position and posture taught in the past or the position found by the vision process are set in P[1] as described above. For this reason, you can execute the TP program, which reproduces P[1] and moves the robot near the part and easily reteach the reference position.

F5 CANCEL
Terminate the wizard.

9.6 KAREL PROGRAM

9.6.1 KAREL Programs of Parts List Manager

The Parts List Manager provides the following KAREL programs.

IMSEARCH.PC
Select a SEARCH vision process from the SEARCH VP LIST and execute the SEARCH vision process. And some Part Data created by SEARCH vision process result are added to the parts list. This program requires the following arguments.

Argument 1:
Specify the index number of the Parts List.
Argument 2:
Specify the index number of the SEARCH vision process in SEARCH VP LIST.
Argument 3:
Specify the index number of measurement array. The specified measurement value is set as the priority of Part Data when a Part Data is added to the Parts List.
Argument 4:
Specify the index number of a register to output the status of whether the SEARCH vision process is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: Some Part Data are added to the specified Parts List.
1: No Part Data is added to the specified Parts List.

IMPOP.PC

Pop a part data from the specified Parts List. This program requires the following arguments.

Argument 1:
Specify the index number of the Parts List.
Argument 2:
Specify the index number of a register to output the status of whether the pop operation is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: SUCCESS
1: FAIL
Argument 3:
Specify the index number of a register to output the Model ID of the popped Part Data. This value is used for identifying the type of the SEARCH Vision Process result.
Argument 4:
Specify the index number of a register to output the ID of the popped part data. This argument can be omitted.

IMGETFINEPOS.PC

Calculate a FINE position from an offset value by a SEARCH vision process and a reference FINE position. This program requires the following arguments.

Argument 1:
Specify the index number of the Parts List.
Argument 2:
Specify the index number of the FINE position in FINE POSITION LIST.
Argument 3:
Specify the index number of a register to output the status of whether the operation of obtaining the FINE position is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
0: SUCCESS
11: FAIL
Argument 4:
Specify the index number of a position register to output the FINE position.
Argument 5:
Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function.
Argument 6:
Specify the part ID to obtain the FINE position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

IMFINE.PC

Select a FINE vision process from the FINE VP LIST and execute the FINE vision process. A found result is set to a popped Part Data or a Part Data specified by Part Data ID. This program requires the following arguments.

Argument 1:
  Specify the index number of the Parts List.
Argument 2:
  Specify the index number of the FINE vision process in the FINE VP LIST.
Argument 3:
  Specify the index number of a register to output the status of whether the FINE vision process is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
  0: SUCCESS
  1: FAIL
Argument 4:
  Specify the index number of a register to output the Model ID of the FINE Vision Process result.
Argument 5:
  Specify the Part Data ID to execute the FINE Vision Process operation. This argument can be omitted. If this argument is omitted, the FINE Vision Process operation is done to the popped Part Data.

IMGETPICKPOS.PC

Calculate a PICK position from an offset value by a FINE vision process or a SEARCH vision process and a reference PICK position. This program requires the following arguments.

Argument 1:
  Specify the index number of the Parts List.
Argument 2:
  Specify the index number of the PICK position in the PICK POSITION LIST.
Argument 3:
  Specify the index number of a register to output the status including whether the operation of obtaining the PICK position is successful. In the register to store the error number, one of the values shown below will be set depending on the error that occurs:
  0: SUCCESS
  12: Fail to calculate a position to pick up a part
  13: Fail to calculate a position to approach a part
Argument 4:
  Specify the index number of a position register to output the PICK position.
Argument 5:
  Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the PICK position.
Argument 6:
  Specify the index number of a position register to output an APPROACH position.
Argument 7:
  Specify the index number of a position register to output the tool offset value calculated by the Interference Avoidance function. The outputted tool offset value is applied for the APPROACH position.
Argument 8:
  Specify the part ID to obtain the PICK position. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

IMSETSTAT.PC

Set a status to a popped Part Data. By executing the KAREL program, a specified process set in the Parts List Manager is done. This program requires the following arguments.

Argument 1:
Specify the index number of the Parts List.

Argument 2:
Specify the status to be set to the popped Part Data. The following status can be set.
10: FINE SUCCESS
11: FINE FAIL
12: FINE IA FAIL
13: FINE CL FAIL
20: PICK SUCCESS
21: PICK FAIL
22: PICK IA FAIL
23: PICK CL FAIL

Argument 3:
Specify the part ID to set a status. This argument can be omitted. If this argument is omitted, the operation is done to the latest popped part in the parts list.

9.6.2 KAREL Programs for Customizing the Parts List

The following KAREL programs are available for customizing the parts list.

IPCLR.PC

Clears the part data in a parts list. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.

IPCRT.PC

Obtains the found result from the specified vision process and creates part data. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.

Argument 2:
Specify the name of a vision process.

Argument 3:
Specify the measurement number (1 to 10) for which the measurement to be set as the priority of the created part data is set.

Argument 4:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in creating part data.
2: Failed in creating part data because there was no found result the vision process could output due to a position not found error.
999: Failed in creating part data due to an alarm other than a position not found error that occurred during find operation by the vision process.

This KAREL program only creates part data and does not push it in the parts list. To push part data to the parts list, after executing IPCRT.PC, execute IPPUSH.PC described below.

IPPUSH.PC

Pushes part data created by IPCRT.PC in a parts list. It is necessary to create part data using IPCRT.PC before executing IPPUSH.PC. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.
Argument 2:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in pushing part data in the parts list.
1: Failed in pushing parts data in the parts list because there was no part data that could be pushed.
999: Failed in pushing part data in the parts list due to an alarm other than the above (there was no part data that could be pushed).
Argument 3:
Specify the number of a register to which to output the part data ID assigned to the pushed part data.

IPDEL.PC

Deletes the specified part data from a parts list. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.
Argument 2:
Specify the ID of part data to be deleted from the parts list.
Argument 3:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in deleting part data.
1: Failed in deleting part data because part data having the specified ID was not found.
999: Failed in deleting part data due to an alarm other than the above (the target part data was not found).

IPPOP.PC

Places the specified part data in the popped state. This program requires the following arguments.
Argument 1:
Specify the number of a parts list.
Argument 2:
Specify the part data ID of part data to be popped.
Argument 3:
Specify a pop flag. Specify either of the following values:
1: Places part data in the popped state.
0: Places part data in the not popped state.
Argument 4:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in popping part data.
1: Failed in popping part data because part data having the specified ID was not found.
999: Failed in popping part data due to an alarm other than the above (the target part data was not found).

IPGTLSTPRM.PC

Outputs the value of a parameter such as the push count in a parts list to a register. This program requires the following arguments.

Argument 1:

Specify the number of a parts list.

Argument 2:

Specify the name of a parameter of which value you want to obtain. You can specify one of the following parameter names:

NUM_PUSH: Specify this name to obtain the push count.

NUM_POP: Specify this name to obtain the pop count.

UPDATE_PUSH: Specify this name to obtain the flag indicating whether to update the push count.

Argument 3:

Specify the number of a register to which to output the status of this KAREL program. Either of the following values is output as the status:

0: Succeeded in outputting the specified parameter to the register.

999: Failed in outputting the specified parameter to the register.

Argument 4:

Specify the number of a register to which to output the parameter value.

IPSTLSTPRM.PC

Sets the specified value for a parameter such as the push count in a parts list. This program requires the following arguments.

Argument 1:

Specify the number of a parts list.

Argument 2:

Specify the name of a parameter for which you want to set a value. You can specify one of the following parameter names:

NUM_PUSH: Specify this name to set a value for the push count.

NUM_POP: Specify this name to set a value for the pop count.

UPDATE_PUSH: Specify this name to set a value for the flag indicating whether to update the push count.

Argument 3:

Specify a value to be set for the parameter.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. Either of the following values is output as the status:

0: Succeeded in setting the specified value for the parameter.

999: Failed in setting the specified value for the parameter.

IPGTPRTPRM.PC

Outputs the value of a parameter of part data to a register, vision register, or character register. This program requires the following arguments.

Argument 1:

Specify the number of a parts list.

Argument 2:

Specify the ID of part data.

Argument 3:

Specify the name of a parameter of which value you want to obtain. You can specify one of the following parameter names:

LIFE_COUNT: Blacklist count

NUM_ADD: Push count when the part data is pushed in the parts list

NUM_BL: Push count when the part data is set in the blacklist

PRIORITY: Priority

NUM_LAST_FOUND: Push count when the same part as the part data is found

POP_STAT: Flag indicating whether the part data is popped
SCH_RSLT: SEARCH result
FINE_RSLT: FINE result
SCH_NAME: SEARCH vision process name
FINE_NAME: FINE vision process name

Argument 4:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in outputting the specified parameter to the register, vision register, or character register.
1: Failed in outputting the specified parameter to the register, vision register, or character register because part data having the specified ID was not found.
999: Failed in outputting the specified parameter to the register, vision register, or character register due to an alarm other than the above (the target part data was not found).

Argument 5:
Specify the number of a register, vision register, or character register to which to output the obtained parameter value.

To obtain the value of one of the following parameters, specify a register number:
STATUS: Status
LIFE_COUNT: Blacklist count
NUM_ADD: Push count when the part data is pushed in the parts list
NUM_BL: Push count when the part data is set in the blacklist
PRIORITY: Priority
NUM_LAST_FOUND: Push count when the same part as the part data is found
POP_STAT: Flag indicating whether the part data is popped

To obtain the value of either of the following parameters, specify a vision register number:
SCH_RSLT: SEARCH result
FINE_RSLT: FINE result

To obtain the value of either of the following parameters, specify a character register number:
SCH_NAME: SEARCH vision process name
FINE_NAME: FINE vision process name

IPSTPRTPRM.PC

Sets the specified value for a parameter of part data. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.

Argument 2:
Specify the ID of part data.

Argument 3:
Specify the name of a parameter for which you want to set a value. You can specify one of the following parameter names:
LIFE_COUNT: Blacklist count
NUM_ADD: Push count when the part data is pushed in the parts list
NUM_BL: Push count when the part data is set in the blacklist
PRIORITY: Priority
NUM_LAST_FOUND: Push count when the same part as the part data is found
POP_STAT: Flag indicating whether the part data is popped
FINE_RSLT: FINE result
SCH_NAME: SEARCH vision process name
FINE_NAME: FINE vision process name

Argument 4:

Specify the number of the register, vision register, or character register containing the value to be set for the parameter

To set the specified value for one of the following parameters, specify the number of the register containing the value:

STATUS: Status

LIFE_COUNT: Blacklist count

NUM_ADD: Push count when the part data is pushed in the parts list

NUM_BL: Push count when the part data is set in the blacklist

PRIORITY: Priority

NUM_LAST_FOUND: Push count when the same part as the part data is found

To set the specified value for either of the following parameters, specify the number of the vision register containing the value:

FINE_RSLT: FINE result

To set the specified value for either of the following parameters, specify the number of the character register containing the value:

SCH_NAME: SEARCH vision process name

FINE_NAME: FINE vision process name

Argument 5:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in setting the specified value for the parameter.

1: Failed in setting the specified value for the parameter because part data having the specified ID was not found.

999: Failed in setting the specified value for the parameter due to an alarm other than the above (the target part data was not found).

IPFNDPOS.PC

Searches a range from the specified position for part data and outputs the ID of the part data. This program requires the following arguments.

Argument 1:

Specify the number of a parts list.

Argument 2:

Specify the number of a position register containing position data. Part data is found when the distance (dist(pos, found_pos)) between this position (pos) and part data found position (found_pos) is within the range (dist_min ≤ dist(pos, part_pos) ≤ dist_max).

Argument 3:

Specify a direction whose value is to be used for calculating dist(pos, found_pos) above. Specify one of the following items:

X: Uses the X-direction element for calculating the distance.

Y: Uses the Y-direction element for calculating the distance.

Z: Uses the Z-direction element for calculating the distance.

XY: Uses the XY-direction element for calculating the distance.

XZ: Uses the XZ-direction element for calculating the distance.

YZ: Uses the YZ-direction element for calculating the distance.

XYZ: Uses the XYZ-direction element for calculating the distance.

Argument 4:

Specify dist_min above.

Argument 5:

Specify dist_max above.

Argument 6:

Specify part data to be output when multiple part data items satisfying dist_min ≤ dist(pos, part_pos) ≤ dist_max above are found. A value of 1 is specified for the index when the part data nearest dist_min is output. The value specified for the index is incremented each time part data is output in ascending order of closeness to dist_min.

Argument 7:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in searching for part data satisfying the relevant condition.

1: Failed in searching for part data because there was no part data satisfying the condition within the specified range.

999: Alarm other than the above

Argument 8:

Specify the number of a register to which to output the ID of the found part data.

Argument 9:

Specify the number of a register to which to output the distance between the output part data and position set in the position register specified for argument 2.

IPFNDPUSH.PC

Searches for part data whose push count when it is added to the parts list is within the specified range and outputs the ID of the part data. This program requires the following arguments.

Argument 1:

Specify the number of a parts list.

Argument 2:

Parameter for determining the part search range. The KAREL program searches for part data whose push count when it is added to the parts list is between the value specified for argument 2 and the value specified for argument 3.

Argument 3:

Parameter for determining the part search range. The KAREL program searches for part data whose push count when it is added to the parts list is between the value specified for argument 2 and the value specified for argument 3.

Argument 4:

Specify part data to be output when multiple part data items satisfying the condition specified for arguments 2 and 3 above are found. A value of 1 is specified for the index when the part data whose push count nearest to the push count specified for argument 2 is output. The value specified for the index is incremented each time part data is output in ascending order of closeness to the push count specified for argument 2.

Argument 5:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

0: Succeeded in searching for part data satisfying the relevant condition.

1: Failed in searching for part data because there was no part data satisfying the condition within the specified range.

999: Alarm other than the above

Argument 6:

Specify the number of a register to which to output the ID of the found part data.

Argument 7:

Specify the number of a register to which to output the push count when the output part data is added to the parts list.

IPFNDPRI.PC

Searches for part data with high priority and outputs the ID of the part data. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.
Argument 2:
Specify the priority order of part data to be output. A value of 1 is specified for the index when the part data with the highest priority in the parts list is output. The value specified for the index is incremented each time part data is output in descending order of priority.
Argument 3:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in searching for part data satisfying the relevant condition.
1: Failed in searching for part data because there was no part data within the specified range.
999: Alarm other than the above
Argument 4:
Specify the number of a register to which to output the ID of the found part data.
Argument 5:
Specify the number of a register to which to output the priority of the output part data.

IPFNDVP.PC

Searches for part data whose SEARCH vision process name is the specified vision process name and outputs the ID of the part data. This program requires the following arguments.

Argument 1:
Specify the number of a parts list.
Argument 2:
Specify a vision process name for searching for part data.
Argument 3:
Specify the priority order of part data to be output when there are multiple part data items with the vision process name specified for argument 2. A value of 1 is specified for the index when the following part data is output. The SEARCH vision process in the parts list containing the part data is the vision process name specified for argument 2 and the part data has the highest priority. The value specified for the index is incremented each time part data is output in descending order of priority.
Argument 4:
Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:
0: Succeeded in searching for part data satisfying the relevant condition.
1: Failed in searching for part data because there was no part data within the specified range.
999: Alarm other than the above
Argument 5:
Specify the number of a register to which to output the ID of the found part data.

IPCLRARPOS.PC

Use this KAREL program only when using the Search Area Restriction Tool. This KAREL program initializes the list of positions set as the search area provided for each parts list (search area list). This program requires the following arguments.

Argument 1:
Specify the number of a parts list. When a value of 0 is specified, the KAREL program initializes the search area lists for all parts lists.

IPSETARPOS.PC

Use this KAREL program only when using the Search Area Restriction Tool. This KAREL program sets the found position of the specified part data or position stored in a position register to the search area list. This program requires the following arguments.

Argument 1:

Specify a type of position to be set. You can specify one of the following values:

1: Sets the found position of picked part data.
2: Sets the found position of part data added to the blacklist.
3: Sets the position stored in the specified position register.

Argument 2:

When specifying 1 or 2 for argument 1, specify the number of the register containing the ID of picked part data or part data set in the blacklist. When specifying 3 for argument 1, specify the number of the position register containing a position you want to set for the search area.

Argument 3:

Specify a search area list in which to set the obtained position. Each parts list has a search area list. So, specify the number of a parts list.

Argument 4:

Specify the number of a register to which to output the status of this KAREL program. One of the following values is output as the status:

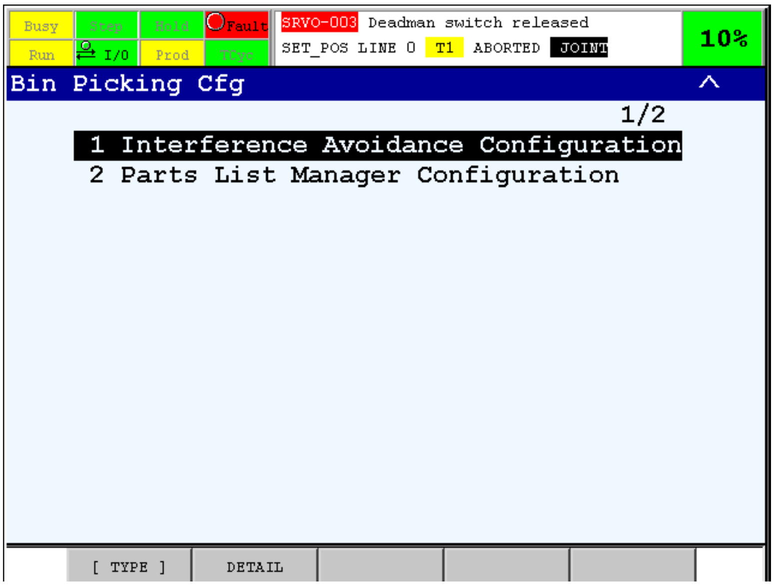
0: Succeeded in setting the specified position as the search area.
1: Failed in setting the specified position as the search area.

Argument 5:

When specifying 3 for argument 1 to use a position register for search area restriction, specify the user frame number of the coordinate system indicating the position stored in the position register. When specifying 1 or 2 for argument 1, do not enter argument 5.

10 BIN PICKING CONFIG

The bin picking setup function is used to set up the configuration of interference avoidance function and Parts List Manager. If you press MENU on the *i*Pendant and select [8 Bin Picking Cfg] from [8 iRVision], the following screen appears.



Interference Avoidance Configuration

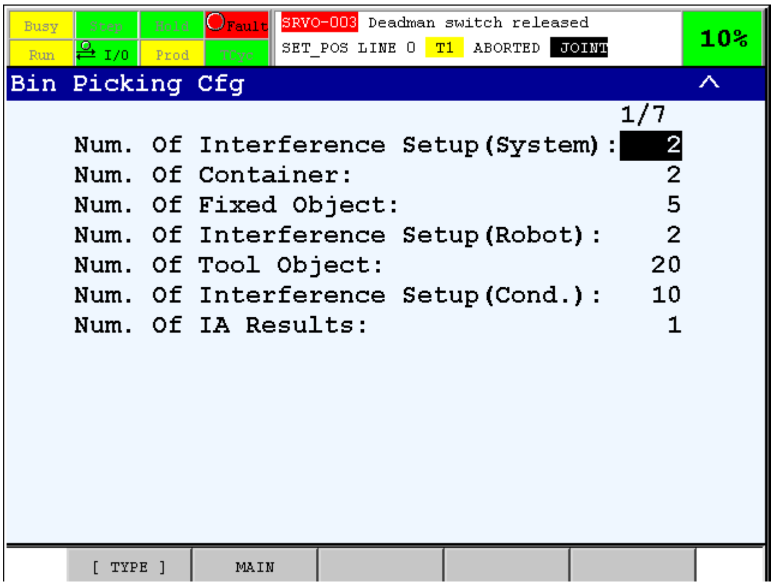
Place the cursor on [Interference Avoidance Configuration] and press the F2 DETAIL. The Interference Avoidance Configuration screen appears.

Parts List Manager Configuration

Place the cursor on [Parts List Manager Configuration] and press the F2 DETAIL. The Parts List Manager Configuration screen appears.

10.1 INTERFERENCE AVOIDANCE CONFIGURATION

If you select Interference Avoidance Configuration from the bin picking configuration main screen, the following screen appears. This screen allows you to change the maximum number of interference avoidance data sets that can be created. Changes to these parameters are applied by cycling power on the robot controller.



Num. of Interference Setup(System)

The maximum number of interference avoidance data sets (system data) can be changed.

Num. of Container

The maximum number of container objects to be set in interference avoidance data (system data) can be changed.

Num. of Fixed Object

The maximum number of fixed objects to be set in interference avoidance data (system data) can be changed. Note that this represents the total number of fixed objects to be created for all system data, not the maximum number of fixed objects to be created for a single system data set.

Num. Of Interference Setup(Robot)

The maximum number of interference avoidance data sets (robot data) can be changed.

Num. Of Tool Object

The maximum number of tool objects to be set in interference avoidance data (robot data) can be changed. Note that this represents the total number of tool objects to be created for all robot data, not the maximum number of tool objects to be created for a single robot data set.

Num. Of Interference Setup(Cond.)

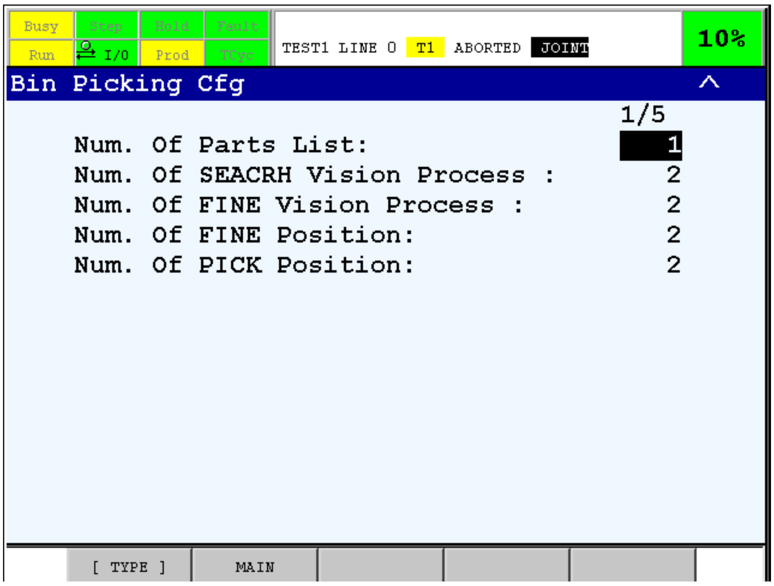
The maximum number of interference avoidance data sets (avoidance condition data) can be changed.

Num. Of IA Results

The maximum number of results to be output after interference avoidance calculation can be changed. If you change the maximum number to have multiple interference avoidance results output, the interference avoidance position does not need to be recalculated at the time of FINE vision process or part picking. The processing may take slightly longer, however, because multiple interference avoidance results are calculated every time.

10.2 PARTS LIST MANAGER CONFIGURATION

If you select Parts List Manager Configuration from the bin picking configuration main screen, the following screen appears. This screen allows you to change the maximum number of parts list manager data sets that can be created. Changes to these parameters are applied by cycling power on the robot controller.



Num. Of Parts List
The number of parts lists can be changed.

Num. Of SEARCH Vision Process
The number of processes that the Parts List Manager can set for a search vision list can be changed.

Num. Of FINE Vision Process
The number of processes that the Parts List Manager can set for a fine vision list can be changed.

Num. Of FINE Position
The number of positions that the Parts List Manager can set for a fine vision list can be changed.

Num. Of PICK Position
The number of positions that the Parts List Manager can set for a pick position list can be changed.

11 CUSTOMIZATION

11.1 HOW TO CUSTOMIZE WHEN THE CONTAINER POSITION MOVES

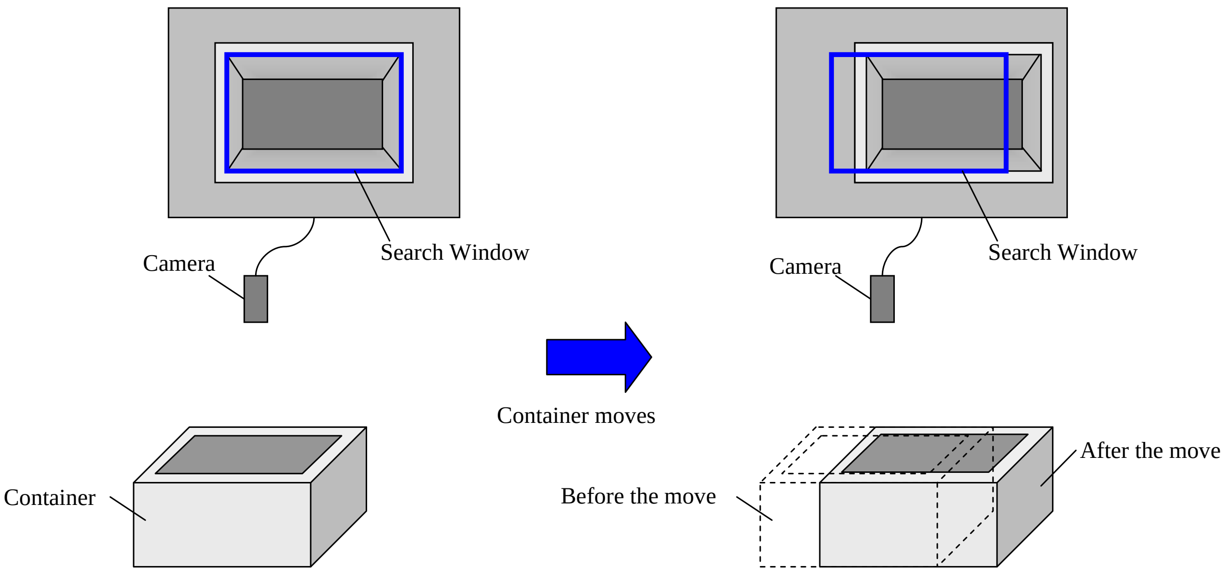
In a bin picking system, the container position may change every time the container is replaced. In such a case, the following problems may arise:

The interference avoidance function misjudges frequently.

The container object that is set in the interference avoidance system data remembers the position and size of the container based on the positions of three points on the reference user frame set in the system data. For this reason, if the container position changes, the remembered container object position does not match the actual position of the container, thus making the interference avoidance function prone to mistakenly detect interference when there is actually no interference or vice versa.

The search window is not set correctly.

In the SEARCH vision process, the search window for a part is usually set along the inner wall of the container in which the part is present. However, if the container position moves, the search window is not set correctly along the inner wall of the container, potentially making it impossible to detect the part. (See the figure below.)



In the cases described above, use the function that automatically moves the container object and search window. This function moves them internally using the detection result of the vision process that detects the container position.

First, create and set up the vision process that detects the container position.

Creating and Setting up the Container Detection Vision Process

On the Vision Setup page, create and set up the vision process that detects the container position. When the optical axis of the fixed camera installed in the upper part of the container is almost perpendicular to the horizontal plane of the container, as in the bin picking system with a 3D Laser Vision Sensor, it is recommended to create a "2-D Single-View Vision Process" using this camera. When the optical axis of the fixed camera installed in the upper part of the container is inclined with respect to the horizontal plane of the container, as in the bin picking system with 3D Area Sensor, and this camera is used for container detection, it is recommended to use the "2-D Multi-View Vision Process". For information about teaching the "2-D Single-View Vision Process" and "2-D Multi-View Vision Process", refer to Chapter 6 "VISION PROCESSES" in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

Changing TP Programs

This section describes how to change the TP programs described in Section 4.1 "BIN PICKING SYSTEM WITH 3D AREA SENSOR " to TP programs that use the container detection result for bin picking. You also can change the TP program of other bin picking system in the same procedure.

First, in addition to the registers used in the TP programs described in Subsection 4.1.10 "Creating TP program", the following registers are used:

R[15]	Maximum number of retries allowed for container detection
R[16]	Number of retries made for container detection

Also, the following vision register is newly used:

VR[1]	Vision register that stores the container detection result

BIN_FIND_CONTAINER.TP

Add a TP program that detects the container. If the attempt to get the offset data fails, continue to retry until the value set in Register [15] is reached. If the number of retries exceeds the value set in Register [15], a user alarm is output. In the TP program shown below, the name of the vision process that detects the container is CNTROFS.

```
 ! Move to snapping position
J P[2] 100% FINE

 R[15]=5
 R[16]=0

 LBL[10]
 ! Check retry times
 IF R[16]>R[15],JMP LBL[99]

 ! Run CONTAINER OFFSET process
 VISION RUN_FIND 'CNTROFS'
 VISION GET_OFFSET 'CNTROFS' VR[1] JMP LBL[91]

 END

 ! Retry CONTAINER OFFSET process
 LBL[91]
 R[16]=R[16]+1
 JMP LBL[10]

 ! ALARM
 LBL[99]
 UALM[2]
 END
```

Move to a position to snap an image

Set maximum number of times to retry.

Set 0 to the number of times retry .

Terminate the cycle if the number of times of retry exceed the maximum number of times.

Run the vision process for CONTAINER OFFSET.

Retry CONTAINER OFFSET process if it fails.

BIN_PICKING.TP

In BIN_PICKING.TP described in Subsection 4.1.9 "Creating TP Program ", change the part shown in bold below.

```
 1:  UTOOL_NUM=1
 2:  UTOOL_NUM=1
 3:  CALL BINPICK_CLEAR (1)
 4:
 5:  CALL BIN_FIND_CONTAINER
 6:
 7:  ! SEARCH
 8:  LBL[1]
 9:L P[1] 2000mm/sec FINE
10:  CALL BINPICK_SEARCH(1,1,10)
11:  IF R[10]<>0,JMP LBL[99]
12:
13:  ! POP
14:  LBL[2]
15:  CALL BINPICK_POP(1,11,12)
16:  IF R[11]<>0,JMP LBL[1]
```

Add the instruction for calling the program for CONTAINER OFFSET

11.1.1 Moving the Container Object in the Interference Setup Data According to the Amount of Container Travel

Setting Up the Interference Avoidance System Data

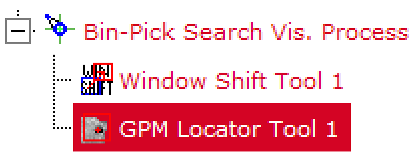
In the interference avoidance system data setup screen, enter the index number of the vision register described earlier that stores the result of the container detection vision process in the [VR] for [Container offset].

In the tree view of the interference avoidance system data setup screen, select the child object that moves together with the container and check the [Shift Object Pos.] checkbox for that object.

11.1.2 Shifting the Search Window According to the Amount of Container Travel (Bin-Pick Search Vis. Process)

Adding and Teaching the Window Shift Tool

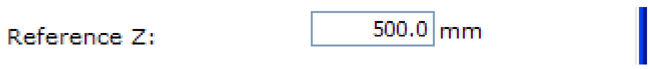
Add the Window Shift Tool so that the tree view of "Bin-Pick Search Vis. Process" has the following structure:



From the [Mode] selection box in the setup page of the Window Shift Tool, select [Other VP Result].

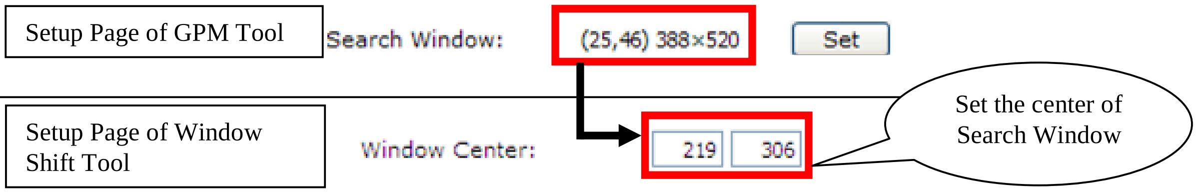
In the [Other VP Result] text box of the setup page of the Window Shift Tool, set the index number of the vision register that stores the result of the container detection vision process.

In [Reference Z] of the setup page of the Window Shift Tool, set the same value that is set in [Part Z Height] for the container detection vision process.



After executing the container detection vision process from the TP program, get the vision offset and store the result in the vision register. Then, in the setup page of the GPM Locator Tool for the Bin-Pick Search Vis. Process, teach the model and set the search window.

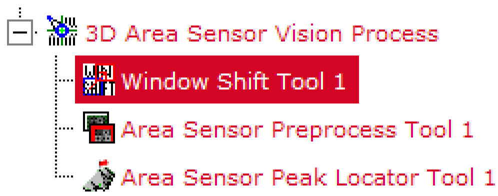
In the [Window Center] text box of the setup page of the Window Shift Tool, set the center position of the search window of the GPM Locator Tool used to detect a part inside the container.



11.1.3 Shifting the Search Window According to the Amount of Container Travel (3D Area Sensor Vision Process)

Adding and Teaching the Window Shift Tool

Add the Window Shift Tool so that the tree view of "3D Area Sensor Vision Process" has the following structure:



From the [Mode] selection box in the setup page of the Window Shift Tool, select [Other VP Result].

In the [VR], set the index number of the vision register that stores the result of the container detection vision process mentioned above.

When using the GPM Locator Tool for the 3D Area Sensor Vision Process, set [Reference Z] and [Window Center] as well. For details about the setting method, see Subsection 11.1.2, [Shifting the Search Window According to the Amount of Container Travel (Bin-Pick Search Vis. Process)].

Teaching the Area Sensor Preprocess Tool

After executing the container detection vision process from the TP program, get the vision offset and store the result in the vision register. Then, teach the container shape in the setup page of the Area Sensor Preprocess Tool. For details about the setting method, refer to Chapter 7 "COMMAND TOOLS" in the "R-30*i*B/R-30*i*B Mate CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference)".

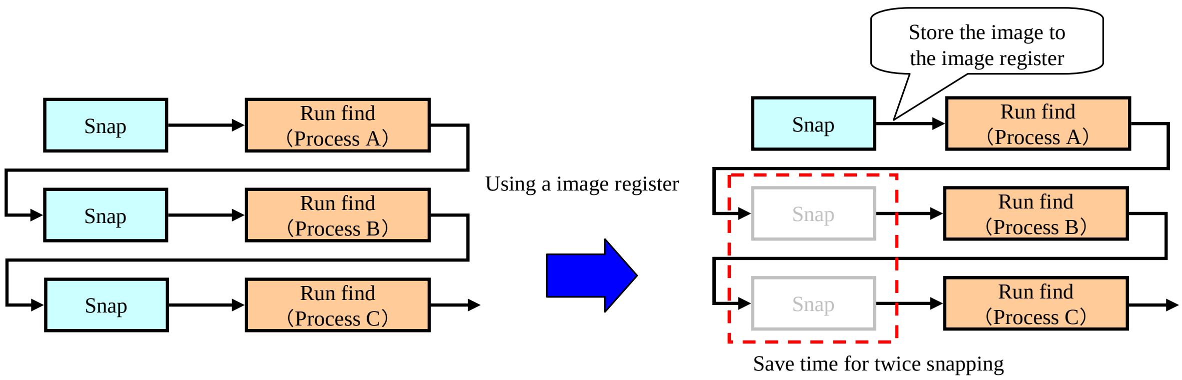
11.2 HOW TO CUSTOMIZE TO REDUCE PROCESSING TIME FOR SEARCH

This section describes how to reduce the processing time for SEARCH.

11.2.1 Using an Image Register

An image register is an area in memory assigned to temporarily store a snapped image. By saving the data necessary for detection, such as the snapped image and the robot position at the time of snapping to the image register, snapping and detection can be performed independently.

In a TP program where multiple SEARCH vision processes are set and the vision processes are switched until the part is detected, as shown on the left side of the following figure, an image is snapped each time a vision process is executed, regardless of whether the status of the part has changed, thus making the time it takes to snap images longer than necessary. To resolve this problem, the image snapped before the first vision process is executed is saved in the image register and the subsequent vision processes use this image stored in the image register. This eliminates the need to snap an image for each vision process, leading to a shorter SEARCH time.



The method to achieve customization for a bin picking system using an image register is described below.

Creating an Image Register

Set the number of necessary image registers in the system variable $VISION_CFG.$NUM_IMREGS. The default value is 0. Also, set the size of the image register in the system variable $VISION_CFG.$IMREG_SIZE. The default value is 300. Depending on the camera or sensor in use, set the value as follows:

- Black-and-white digital camera
  320 x 240 ⇒ 75
  640 x 480 ⇒ 300
  1024 x 768 ⇒ 768
  1280 x 1024 ⇒ 1280
  1280 x 480 ⇒ 600
  640 x 960 ⇒ 600
- Analog camera ⇒ 300
- 3D Laser Vision Sensor ⇒ 1500

After changing the values of the system variables $VISION_CFG.$NUM_IMREGS and $VISION_CFG.$IMREG_SIZE, cycle power on the controller re-create the image registers.

Setting up the Parts List Manager

Open the Parts List Manager setup page, and select [SEARCH VP List] from the drop-down box for changing the setup page. In the list view, select the program to be executed using the image register, and set the index number of the created image register in [Img. Reg].

Changing the TP Program

This section describes how to change the TP program described in Section 4.2 "BIN PICKING SYSTEM WITH 2D CAMERA" to a TP program that uses an image register for SEARCH. In BIN_PICKING.TP, change the parts shown in bold below.

First, in addition to the registers used in the TP programs described in Subsection 4.2.10 "Creating TP program", the following registers are used:

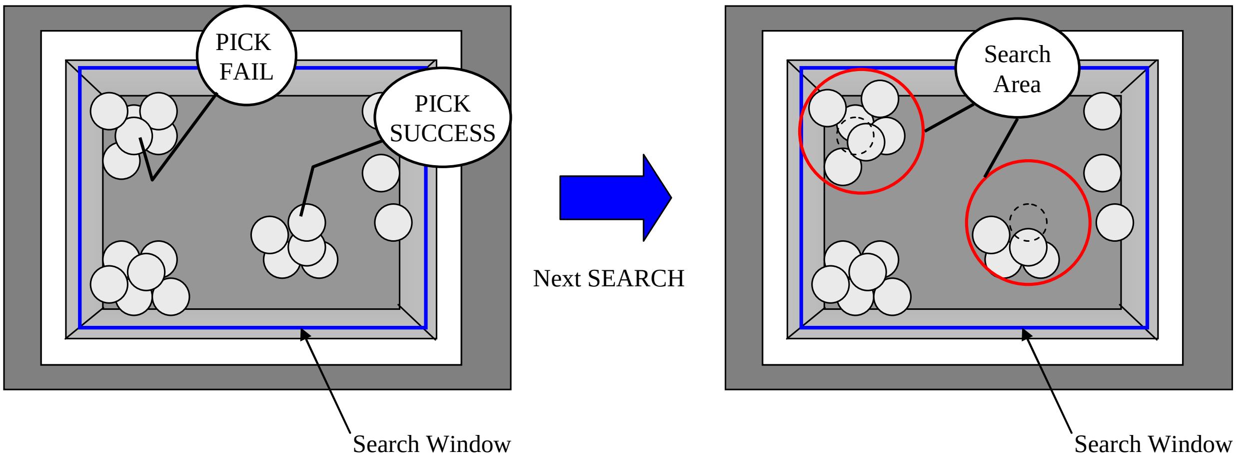
R[5]	SEARCH list ID of the Parts List Manager

```
 1: UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  CALL BINPICK_CLEAR(1)
 4:
 5:  ! SEARCH
 6:  LBL[1]
 7:L P[1] 2000mm/sec FINE
 8:  CALL IRVSNAP('SEARCH1', 1)
 9:  R[5]=1
10:  LBL[10]
11:  CALL BINPICK_SEARCH(1,R[5],10)
12:  IF R[10]<>0,JMP LBL[11]
13:  JMP LBL[2]
14:
15:  LBL[11]
16:  SELECT R[5]=1,JMP LBL[12]
17:         =2,JMP LBL[13]
18:       ELSE,JMP LBL[99]
19:
20:  LBL[12]
21:  R[5]=2
22:  JMP LBL[10]
23:
24:  LBL[13]
25:  R[5]=3
26:  JMP LBL[10]
27:
28:  ! POP
29:  LBL[2]
30:  CALL BINPICK_POP(1,11,12)
31:  IF R[11]<>0,JMP LBL[1]
32:
```

- Line 8: Add the instruction to snap an image and store it in the image register.
- Line 9: Add the instruction to set the ID number of SEARCH vision process which runs in the first.
- Line 11: Change to specify the ID number of the SEARCH vision process by R[5].
- Line 16: Switch the vision program if SEARCH fails.
- Line 21: Add the instruction to select the vision process which is listed in the next in the SEARCH List if no parts are found.
- Line 25: Add the instruction to select the vision process which is listed in the next in the SEARCH List if no parts are found.

11.2.2 Search Area Restriction Tool

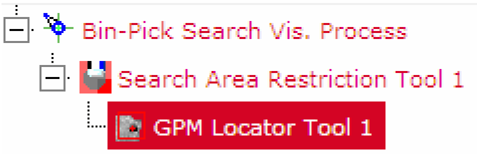
In a bin picking system, the search window for a SEARCH vision process is almost always set so that it encloses the entire container of parts. However, when the next SEARCH is conducted after a part is picked, as shown in the following figure, a change in the part pile status is limited in many cases to the area surrounding the part that has been picked or failed to be picked.



In such a case, set additional search areas (bold line circles in the above figure) limited to around the positions where the part pile status has changed inside the preset search window surrounding the entire container. By searching for a part within these limited search areas, the SEARCH vision process time can be reduced. *i*RVision provides the Search Area Restriction Tool that features this function. This section describes how to set up the Search Area Restriction Tool. Note that the Search Area Restriction Tool can be used only when the Bin-Pick Search Vis. Process is used as the SEARCH vision process.

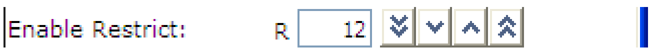
Setting up the Search Area Restriction Tool

Create the Search Area Restriction Tool as a child tool of the Bin-Pick Search Vis. Process. In addition, create the Locator Tool as a child tool of the Search Area Restriction Tool.

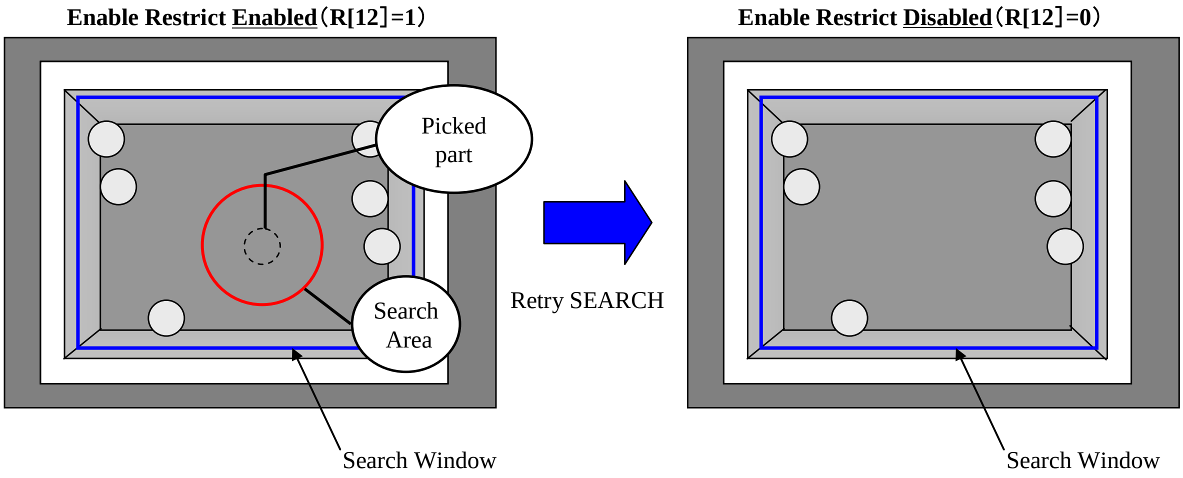


The GPM Locator Tool is a child of the Search Area Restriction Tool. Set the status of the GPM Locator Tool to Trained.

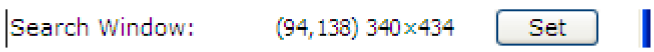
In [Enable Restrict], specify the index number of the register to be used to toggle between enabling and disabling the search area restriction function. Here, set Register [12] to toggle between enabling and disabling the search area restriction function, as appropriate for the sample TP programs described later.



Here is an explanation of when the search area restriction function should be enabled and disabled. When a search area is set only around the position where the part pile status has changed, as shown in the following figure, the system may not detect any part because there is no part inside the limited search area. In that case, disable the search area restriction function and execute the search again. This allows the system to search the preset search window surrounding the entire container for parts, preventing frequent system stoppages. When the system cannot detect any part inside the limited search area, as described above, disable the search area restriction function. Then, after the system becomes able to detect a part, enable the search area restriction function again.



In [Search Window], press the [Set] button to set the search window surrounding the entire container.



In [Part List ID], select the parts list ID from which to get the position where the part pile status has changed. Here, select Parts List 1, as appropriate for the sample TP programs described later.

In [Diam. Of Sch. Area], set the number of pixels representing the size of the search area to be set in the position where the part pile status has changed.

Changing TP Programs

This section describes how to change the TP programs described in Section 4.2 "BIN PICKING SYSTEM WITH 2D CAMERA" to TP programs that use the Search Area Restriction Tool for SEARCH.

First, in addition to the registers used in the sample TP programs described in Subsection "4.2.10 Creating TP Program", the following registers are used:

Table of Registers to Be Used Newly

R[15]	Register to toggle between enabling and disabling the Search Area Restriction Tool. The set value indicates one of the following statuses: 0: Disable the Search Area Restriction Tool 1: Enable the Search Area Restriction Tool
R[16]	Status of IPSETARPOS. One of the following values is set: 0: Succeeded in setting the specified position as the search area 1: Failed to set the specified position as the search area

Change BIN_PICKING.TP as shown below.

```
 1:  UFRAME_NUM=1
 2:  UTOOL_NUM=1
 3:  CALL BINPICK_CLEAR (1)
 4:  CALL IPCLRARPOS(1)
 5:  R[15]=0
 6:
 7:  ! SEARCH
 8:  LBL[1]
 9:L P[1] 2000mm/sec FINE
10:  CALL BINPICK_SEARCH(1,1,10)
11:  IF R[10]<>0,JMP LBL[10]
12:  CALL IPCLRARPOS(1)
13:  JMP LBL[2]
14:
15:  LBL[10]
16:  IF R[15]=0,JMP LBL[99]
17:  CALL IPCLRARPOS(1)
18:  R[15]=0
19:  JMP LBL[1]
20:
21:  ! POP
22:  LBL[2]
23:  CALL BINPICK_POP(1,11,12)
24:  IF R[11]<>0,JMP LBL[1]
25:
26:  ! Get PICK position
27:  CALL BINPICK_GETPICKPOS(1,1,14,20,21,22)
28:  IF R[14]=0,JMP LBL[3]
29:
30:  CALL BINPICK_SETSTAT(1,22)
31:  JMP LBL[2]
32:
33:  ! PICK
34:  LBL[3]
35:L P[2] 2000mm/sec CNT100
36:L PR[22] 2000mm/sec CNT50
37:L PR[20] 500mm/sec FINE
38:  ! Insert program instructions to grasp the part.
39:  CALL IPSETARPOS(1,13,1,16)
40:  R[15]=1
41:  CALL BINPICK_SETSTAT(1,20)
42:
43:  ! PLACE
44:L P[3] 2000mm/sec ﾅﾒﾗｶ100
45:L P[4] 2000mm/sec FINE
46: ! Insert program instructions to place the part.
47:
48:  ! Continuous PICK
49:  JMP LBL[2]
50:
51:  ! END
52:  LBL[99]
53:J P[5] 100% FINE
```

- Line 4: Add the instruction to clear the Search Area List.
- Line 5: Add the instruction to set disabled to restriction for the first SEARCH.
- Line 12: If some parts are found, clear the Search Area List.
- Line 16: Terminate the process if SEARCH fails with restriction disabled.
- Line 18: Retry SEARCH with restriction disabled if it fails with restriction enabled.
- Line 39: Add the instruction to set the found position of the picked part as the Search Area.
- Line 40: Add the instruction to set enabled to restriction for the next SEARCH

11.3 HOW TO CUSTOMIZE TO EXECUTE THE SEARCH PROCESS IN THE BACKGOURND PROCESS

In the TP program described in Chapter 4 "BASIC SETUP PROCEDURE", the SEARCH process is executed after the robot moving the robot out of the camera's field of view and stopping. The TP program may cause waste of time by stopping the robot at each the SEARCH process. The cycle time can be reduced by executing the SEARCH process or calculating a PICK position while the robot places the picked part. The cycle time of the bin picking system with the 3D Area Sensor can be particularly reduced because the 3D Area Sensor takes much time to acquire a 3D map. Using examples of bin picking system described in Section 4.1 "BIN PICKING SYSTEM WITH 3D AREA SENSOR" and Section 4.4 "FIXED FRAME OFFSET SYSTEM WITH 3D AREA SENSOR", some sample programs that the process is executed in the background process are descried below.

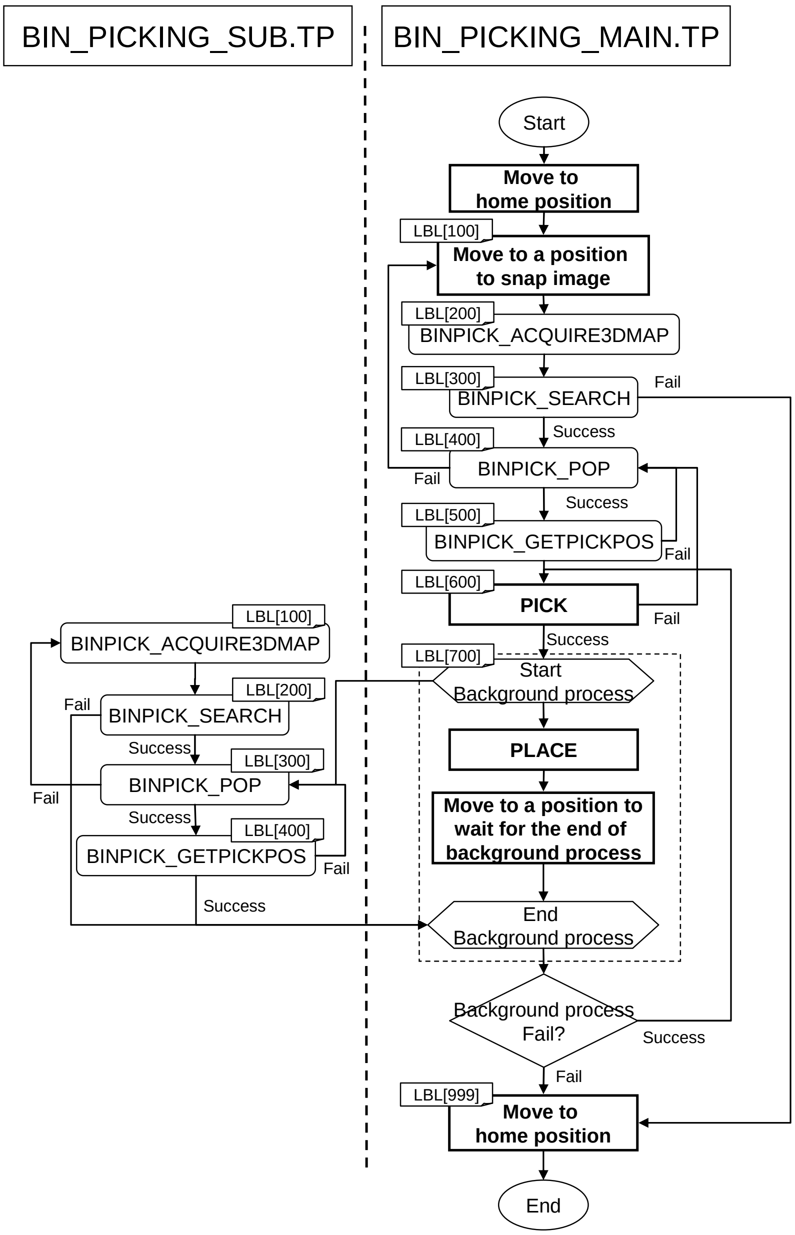
11.3.1 Bin Picking System with 3D Area Sensor

This subsection describes a sample program that the process is executed in the background process using the bin picking system described in Section 4.1 "BIN PICKING SYSTEM WITH 3D AREA SENSOR".

If there are multiple containers to pick up parts, please refer to Section 11.4 "HOW TO CUSTOMIZE BIN PICKING SYSTEM WITH MULTIPLE CONTAINERS".

Flow of the System

The flow chart of the system described below is as follows.



As can be seen from the figure above, there are the following two major TP programs, which are the main program (the BIN_PICKING_MAIN.TP in the figure above) and the sub program (the BIN_PICKING_SUB.TP in the figure above). The instructions that involve the robot motion are executed by the main program and the instructions that do not involve the robot motion are executed by the sub program. The sub program is called just before the robot placing the holding part and executes the following processes in the background while the robot places the holding part.

- POP
- Get PICK position
- Acquire 3D map
- SEARCH

The background process is only executed while the robot places the part it is holding because the main program waits for the end of the background process. But, the processes described the above are also executed by the main program before the first part is picked or when the robot fails to pick up a part.

The TP programs explained below use the following registers, position registers, tool frame, and user frame.

Table of Registers to Be Used

R[1]	The running status of the system. Values to be set represent the following states: 0: Normal 1: Cannot detect a part.
R[2]	The status that represents whether the robot holds a part. Values to be set represent the following states: 0: Does not hold a part. 1: Holds a part.
R[3]	The status of the background process. Values to be set represent the following states: 0: Not completed. 1: Completed.
R[4]	The status of SEARCH vision process
R[5]	The status of POP
R[6]	Model ID of the popped part data
R[7]	Status of the get PICK position process. One of the following values is set: 0: Success 12: Failed to get the interference avoidance position at the PICK position 13: Failed to get the interference avoidance position at the position to approach a part
R[8]	The flag indicating that the robot is within the camera’s field of view. 0: The robot is within the camera’s field of view. 1: The robot is out of the camera’s field of view.

Table of Position Register

PR[20]	Result of interference avoidance for the part pick position (avoidance position)
PR[21]	Result of interference avoidance for the part pick position (tool offset value)
PR[22]	Result of interference avoidance for the approach position (avoidance position)

Table of Tool Frame to Be Used

UTOOL[1]	TCP of the hand

Table of User Frame to Be Used

UFRAME[1]	Reference user frame

The Parts List Manager is set as follows.

The SEARCH vision process ID of the SEARCH VP List of the Parts List Manager to use: 1
The PICK position ID of the PICK Position List of the Parts List Manager to use: 1

BIN_PICKING_MAIN.TP

This is the main program for bin picking.

```
 ! Initialize data
 R[1]=0
 R[2]=0
 R[8]=0
 CALL BINPICK_CLEAR (1)

 ! Move to home position
 UFRAME_NUM=1
 UTOOL_NUM=1
J P[1] 100% FINE

 ! Move to snapping position
 LBL[100]
 UFRAME_NUM=1
 UTOOL_NUM=1
J P[11] 100% FINE
 R[8]=1

 ! ACQVAMAP
 LBL[200]
 CALL BINPICK_ACQUIRE3DMAP ('SENSOR')

 ! SEARCH
 LBL[300]
 CALL BINPICK_SEARCH(1,1,4)
 IF R[4]=0,JMP LBL[400]
 ! SEARCH Fail
 R[1]=1
 JMP LBL[999]

 ! POP
 LBL[400]
 CALL BINPICK_POP(1,5,6)
 IF R[5]=0,JMP LBL[500]
 ! POP Fail
 JMP LBL[100]

 ! GETPICKPOS
 LBL[500]
 CALL BINPICK_GETPICKPOS(1,1,7,20,21,22)
 IF R[7]=0,JMP LBL[600]
 ! GETPICKPOS Fail
 CALL BINPICK_SETSTAT(1,22)
 JMP LBL[400]

```

Initialize data.

Move to a home position

Move to a position to snap an image

The flag indicating that the robot is within the camera's field of view is set to 1.

Acquire a new 3D map.

Execute a SEARCH vision process.

Pop a part data from the Part list.

If any part data is not popped, move to a position to snap an image.

If the BINPICK_GETPICKPOS fails, pop a new part data.

```
46:  ! PICK
47:  LBL[600]
48:  UFRAME_NUM=1
49:  UTOOL_NUM=1
50:  R[8]=0
51:
52:L P[61] 500mm/sec CNT50
53:  ! Move to PICK position
54:L PR[22] 500mm/sec CNT50
55:L PR[20] 200mm/sec FINE
56:  ! Insert program instructions
57:  ! to grasp the part.
58:
59:L P[62] 300mm/sec FINE INC
60:  ! Insert program instructions to
61:  ! whether grasping succeeds or not
62:
63:  IF R[2]=1,JMP LBL[610]
64:  ! PICK Fail
65:  CALL BINPICK_SETSTAT(1,21)
66:  JMP LBL[400]
67:  ! PICK Success
68:  LBL[610]
69:  CALL BINPICK_SETSTAT(1,20)
70:L P[63] 500mm/sec CNT100
71:
72:  ! Start Background Calc and PLACE
73:  LBL[700]
74:  R[3]=0
75:  RUN BIN_PICKING_SUB
76:J P[71] 100% CNT100 TA    .T sec,
      CALL ROBOT_VIEWOUT
77:L P[72] 300mm/sec CNT100
78:L P[73] 300mm/sec FINE
79:  ! Insert program instructions to
80:  ! place the part
81:
82:L P[72] 300mm/sec CNT100
83:L P[71] 300mm/sec CNT100
84:  WAIT R[3]=1
85:  ! End Background Calc
86:
87:  IF R[1]=1,JMP LBL[999]
88:  JMP LBL[600]
89:
90:  LBL[999]
91:  UFRAME_NUM=1
92:  UTOOL_NUM=1
93:J P[1] 100% FINE
```

- (Line 50) The flag indicating that the robot is within the camera's field of view is set to 0.
- (Line 52) Move to a above position of the container.
- (Line 54) Move to a position to approach a part.
- (Line 56) Grasp the part.
- (Line 59) Move to a position to leave the container
- (Line 61) Check if the robot holds the parts.
- (Line 63) If the robot does not hold the part, pop a next part data.
- (Line 70) Move to a above position of the container.
- (Line 75) Start the background process to get a next PICK position.
- (Line 76) The flag indicating that the robot is within the camera's field of view is set to 1 after moving to a position that the robot is not within the camera's field of view.
- (Line 79) Place the picked part.
- (Line 84) Wait for the end of background process.

BIN_PICKING_SUB.TP

This is the sub program. The sub program is called just before the robot places the picked part. The following processes are executed in the background while the robot places the holding part.

- POP
- Get PICK position
- Acquire 3D map

- SEARCH

```
JMP LBL[300]

! ACQVAMAP
LBL[100]
WAIT R[8]=1
!  CALL BINPICK_ACQUIRE3DMAP('SENSOR')

! SEARCH
LBL[200]
CALL BINPICK_SEARCH(1,1,4)
IF R[4]=0,JMP LBL[300]
! SEARCH Fail
R[1]=1
R[3]=1
END

! POP
LBL[300]
CALL BINPICK_POP(1,5,6)
IF R[5]=0,JMP LBL[400]
! Pop Fail
JMP LBL[100]

! GETPICKPOS
LBL[400]
CALL BINPICK_GETPICKPOS(1,1,7,20,21,22)
IF R[7]=0,JMP LBL[410]
! GETPICKPOS Fail
CALL BINPICK_SETSTAT(1,22)
JMP LBL[300]
! GETPICKPOS Success
LBL[410]
R[3]=1
```

First, go to the process to pop a part data.

Execute a SEARCH vision process.

If the SEARCH vision process finds no parts, the register indicating the running status is set to 1 and the background process ends.

If any part data is not popped, move to a position to snap an image.

If the BINPICK_GETPICKPOS fails, pop a new part data.

If the BINPICK_GETPICKPOS succeeds, the background process ends.

ROBOT_VIEWOUT.TP

This program sets the flag indicating that the robot is within the camera’s field of view is set to 1. This program is called by the TA instruction just after the robot moving to out of the camera's field of view. To ensure that the robot is out of the camera’s field of view, the sub program waits for the process to acquire a 3D map while 0 is set to the R[8]. If there is any problem in the acquired 3D map, please adjust the time of the TA instructions or the robot position to call this program in the main program.

```
R[8]=1
```

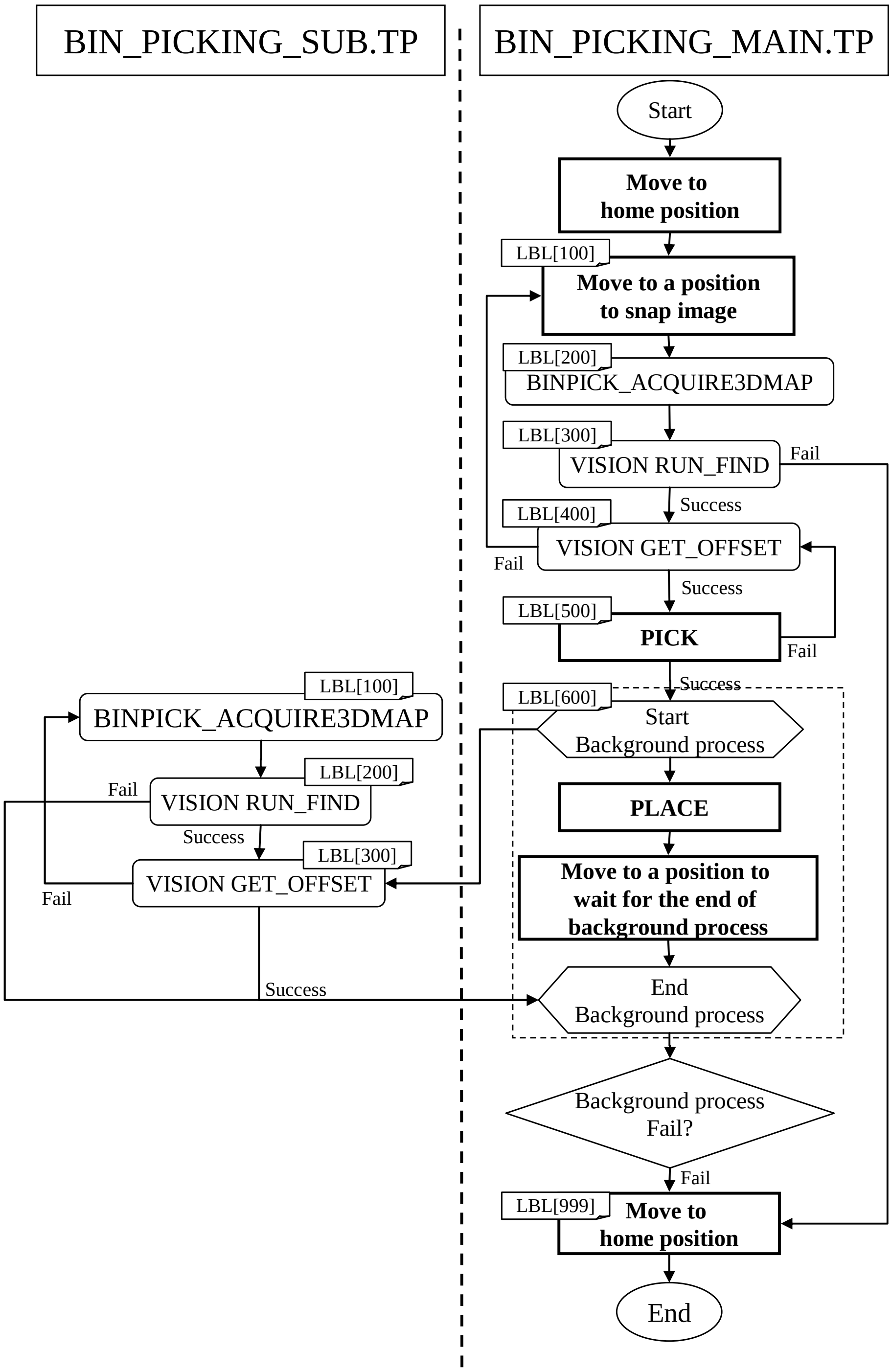
The flag indicating that the robot is within the camera's field of view is set to 1.

11.3.2 Fixed Frame Bin System with 3D Area Sensor

This subsection describes a sample program that the process is executed in the background process using the bin picking system described in Section 4.4 "FIXED FRAME SYSTEM WITH 3D AREA SENSOR".

Flow of the System

The flow chart of the system described below is as follows.



As shown in the figure above, there are two major TP programs, which are the main program (the BIN_PICKING_MAIN.TP) and the sub program (the BIN_PICKING_SUB.TP). The instructions that involve the robot motion are executed by the main program and the instructions that do not involve the robot motion are executed by the sub program. The sub program is run just before the robot places the part. The sub program executes the following processes in the background while the robot places the picked part.

- VISION GET_OFFSET
- Acquire 3D map
- VISION RUN_FIND

The background process is only executed while the robot places the picked part because the main program waits for the end of the background process. But, the processes described above are executed by the main program before the robot picks up the first part or when the robot fail to pick up a part.

The TP programs explained below use the following registers, position registers, tool frame, and user frame.

Table of Registers to Be Used

R[1]	Register that represents the status of the system. Setting a non-zero value causes the system to end. Values to be set represent the following states: 0: Normal 1: Cannot detect a part.
R[2]	Register that represents whether the hand holds a part. Values to be set represent the following states: 0: Does not hold a part. 1: Holds a part.
R[3]	Register that represents whether the sub program is completed. Values to be set represent the following states: 0: Not completed. 1: Completed.
R[4]	The number of result found by a SEARCH vision process
R[11]	The flag indicating that the robot is within the camera's field of view. 0: The robot is within the camera's field of view 1: The robot is out of the camera's field of view.

Table of Vision Register to Be Used

VR[1]	Register that stores the compensation data for SEARCH vision process

Table of Tool Frame to Be Used

UTOOL[1]	TCP of the hand

Table of User Frame to Be Used

UFRAME[1]	Reference user frame

MAIN_PROGRAM.TP

This is a main program.

```
 1:  ! Initialize data
 2:  R[1]=0
 3:  R[2]=0
 4:  R[11]=0
 5:
 6:  ! Move to home position
 7:  UFRAME_NUM=1
 8:  UTOOL_NUM=1
 9:J P[1] 100% FINE
10:
11:  ! Move to snapping position
12:  LBL[100]
13:  UFRAME_NUM=1
14:  UTOOL_NUM=1
15:J P[11] 100% FINE
16:  R[11]=1
17:
18:  ! ACQVAMAP
19:  LBL[200]
20:  CALL BINPICK_ACQUIRE3DMAP ('SENSOR')
```

- Initialize data. (line 1)
- Move to a home position (line 9)
- Move to a position to snap an image (line 15)
- The flag indicating that the robot is within the camera's field of view is set to 1. (line 16)
- Acquire a new 3D map. (line 20)

```

! SEARCH
LBL[300]
VISION RUN_FIND 'PROG'
VISION GET_NFOUND 'PROG' R[4]
IF R[4]>0,JMP LBL[400]
! SEARCH Fail
LBL[390]
R[1]=1
JMP LBL[999]

! Get Offset
LBL[400]
VISION GET_OFFSET 'PROG' VR[1] JMP LBL[100]

! PICK
LBL[500]
UFRAME_NUM=1
UTOOL_NUM=1
R[11]=0

L P[51] 500mm/sec CNT50
! Move to PICK position
L PR[52] 500mm/sec CNT50 VOFFSET, VR[1]
L PR[53] 200mm/sec FINE VOFFSET, VR[1]
! Insert program instructions
! to grasp

L P[54] 300mm/sec FINE INC
! Insert program instructions to
! whether grasping succeeds or no

IF R[2]=1,JMP LBL[610]
! PICK Fail
JMP LBL[400]
! PICK Success
LBL[610]
L P[55] 500mm/sec CNT100

! Start Background Calc and PLACE
LBL[600]
R[3]=0
RUN BIN_PICKING_SUB
J P[61] 100% CNT100 TA    .50sec,CALL ROBOT_VIEWOUT
L P[62] 300mm/sec CNT100
L P[63] 300mm/sec FINE
! Insert program instructions to
! place the part

L P[62] 300mm/sec CNT100
L P[61] 300mm/sec CNT100
WAIT R[3]=1
! End Background Calc

IF R[1]=1,JMP LBL[999]
JMP LBL[500]

LBL[999]
UFRAME_NUM=1
UTOOL_NUM=1
J P[1] 100% FINE
```

- Execute a SEARCH vision process. (VISION RUN_FIND 'PROG')
- If the SEARCH vision finds no parts, set the register indicating the running status is set to a error. (LBL[390])
- If the process to get the vision offset fails, execute the SEARCH vision process. (VISION GET_OFFSET … JMP LBL[100])
- The flag indicating that the robot is within the camera's field of view is set to 0. (R[11]=0)
- Move to a above position of the container. (L P[51])
- Move to a position to approach a part. (L PR[52])
- Grasp the part. (! Insert program instructions)
- Move to a position to leave the container (L P[54])
- Check if the robot holds the parts. (IF R[2]=1,JMP LBL[610])
- If the robot does not hold the part, get a next vision offset. (JMP LBL[400])
- Move to a above position of the container. (L P[55])
- Start the background process to get a next vision offset. (RUN BIN_PICKING_SUB)
- The flag indicating that the robot is within the camera's field of view is set to 1 after moving to a position that the robot is not within the camera's field of view. (CALL ROBOT_VIEWOUT)
- Place the picked part. (! Insert program instructions to)
- Wait for the end of background process. (WAIT R[3]=1)

BIN_PICKING_SUB.TP

This is a sub program. This program executes VISION GET_OFFSET in the background. If the VISION GET_OFFSET fails, this program executes VISION RUN_FIND. This program is called from MAIN_PROGRAM.TP.

```
JMP LBL[300]

! ACQVAMAP
LBL[100]
WAIT R[11]=1
CALL BINPICK_ACQUIRE3DMAP('SENSOR')

! SEARCH
LBL[200]
VISION RUN_FIND 'PROG'
VISION GET_NFOUND 'PROG' R[4]
IF R[4]>0,JMP LBL[300]
! SEARCH Fail
R[1]=1
JMP LBL[400]

! Get Offset
LBL[300]
VISION GET_OFFSET 'PROG' VR[1] JMP LBL[100]

! Background process finish
LBL[400]
R[3]=1
```

Acquire a new 3D map.

Execute a SEARCH vision process.

If the SEARCH vision finds no parts, set the register indicating the running status is set to a error.

If the process to get the vision offset fails, execute the SEARCH vision process.

ROBOT_VIEWOUT.TP

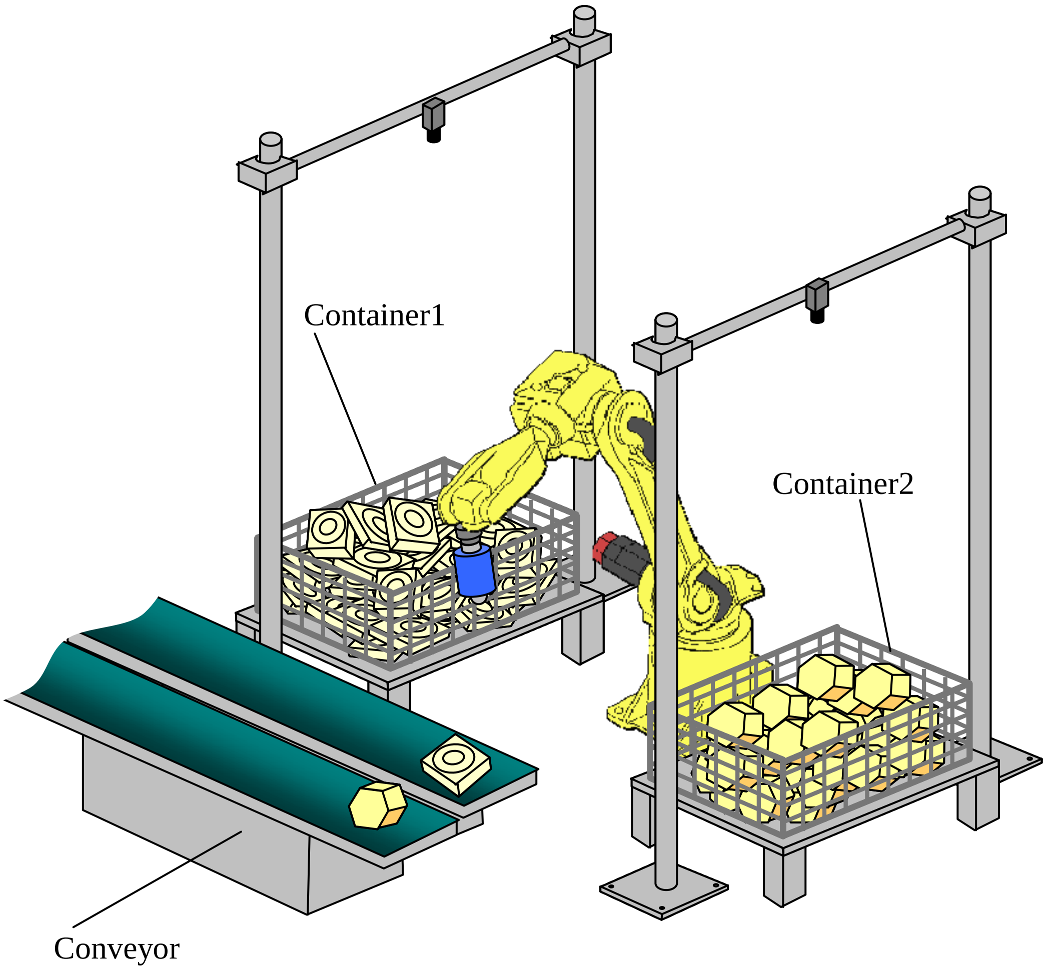
This program sets the flag indicating that the robot is within the camera's field of view is set to 1. This program is called by the TA instruction just after the robot moving to out of the camera's field of view. To ensure that the robot is out of the camera's field of view, the sub program waits for R[11] to be set to 1 before acquiring a 3D map. If there is any problem in the acquired 3D map, please adjust the time of the TA instructions or the robot position to call this program in the main program.

```
R[11]=1
```

The flag indicating that the robot is within the camera's field of view is set to 1.

11.4 HOW TO CUSTOMIZE BIN PICKING SYSTEM WITH MULTIPLE CONTAINERS

This section describes how to achieve customization for performing bin picking with multiple containers. The customization method described herein assumes a system that picks parts from two containers alternately as shown in the following figure.

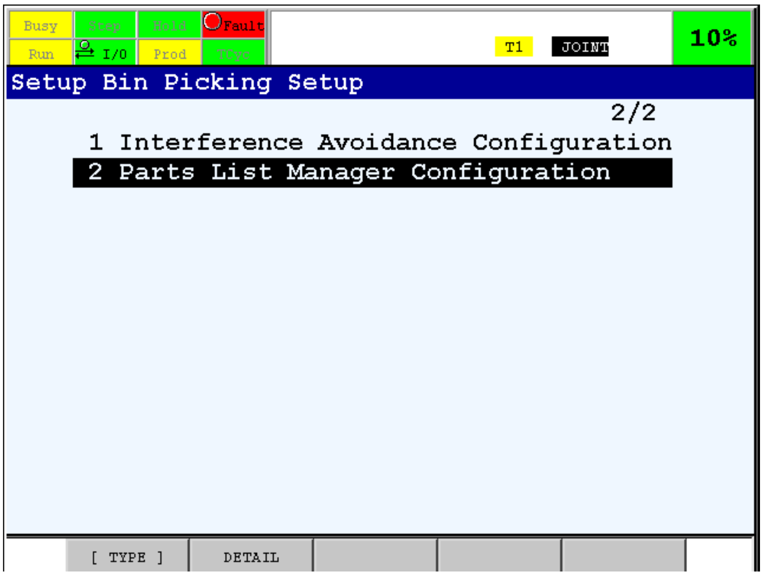


When performing bin picking with multiple containers, it is recommended to use a separate parts list for each container.

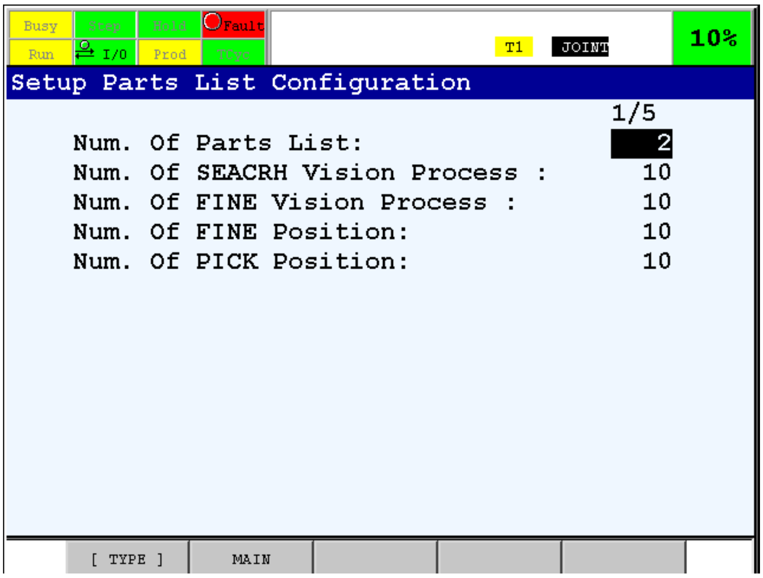
Changing the Number of Parts List

By default, the number of parts lists is 1. To change the number of parts lists, perform the procedure described below. Up to 20 parts lists can be created.

1 Press MENU on the *i*Pendant and select [8 Bin Picking Cfg] from [8 *i*RVsion].
2 Select [2 Parts List Manager Configuration] and press F2 Detail.



5 In [Num. Of Parts List], enter 2.



6 Cycle power on the controller.

This enables multiple parts lists to be used.

Setting up the Interference Avoidance Data

Create and set up the system data for container 2.

Setting up the 3D Area Sensor

Setting up the 3D Area Sensor installed in the upper part of container 2. The setup method is the same as for container 1.

Setting up the SEARCH Vision Process

Create and set up the SEARCH vision process so that the parts inside container 2 can be detected.

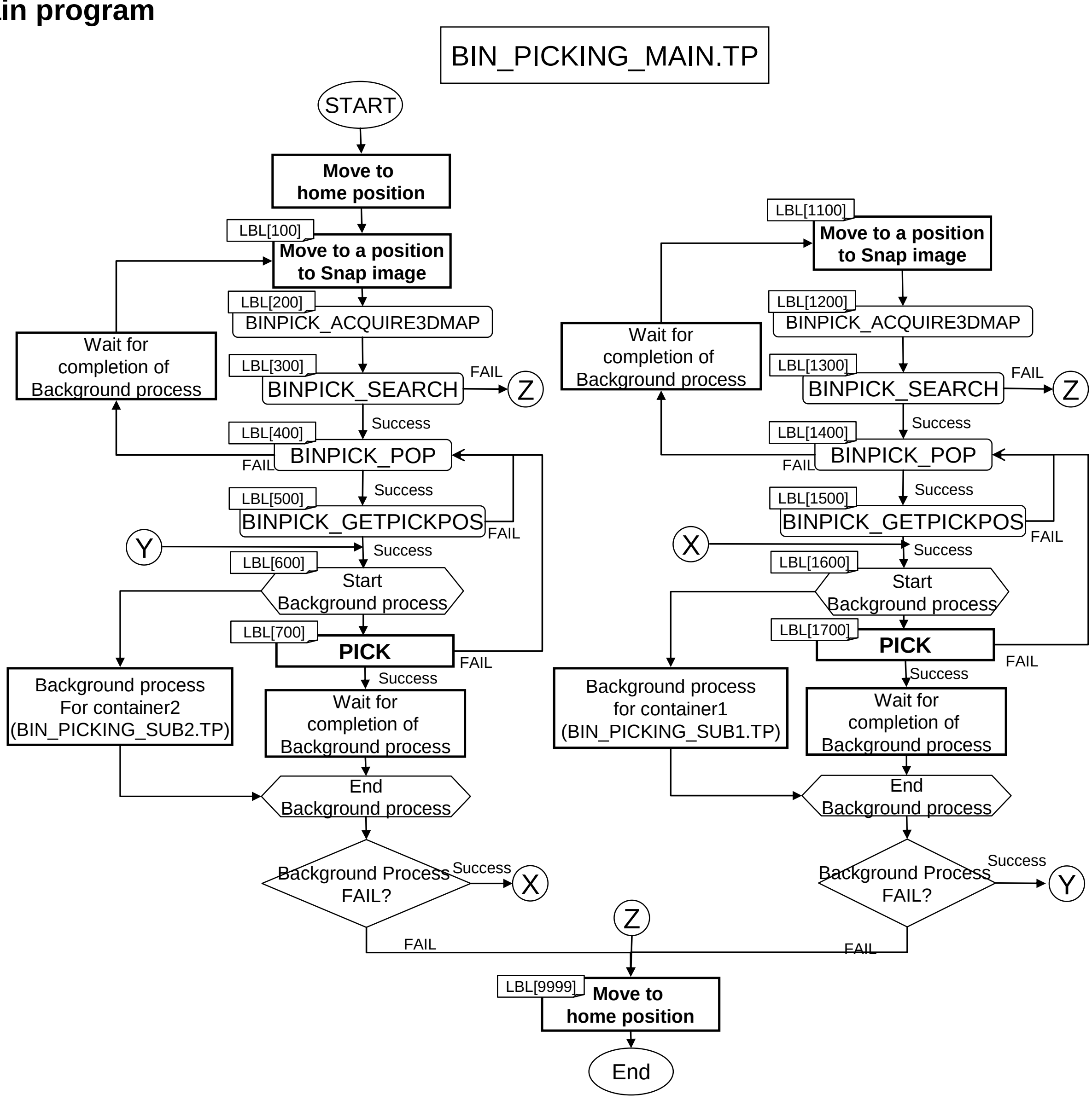
Setting up the Parts List Manager

Set up parts list 2 using the Parts List Manager. Add the created SEARCH vision process to the SEARCH list, and set the PICK position in the PICK position list. When setting the PICK position, select the same user frame number as that for parts list 1.

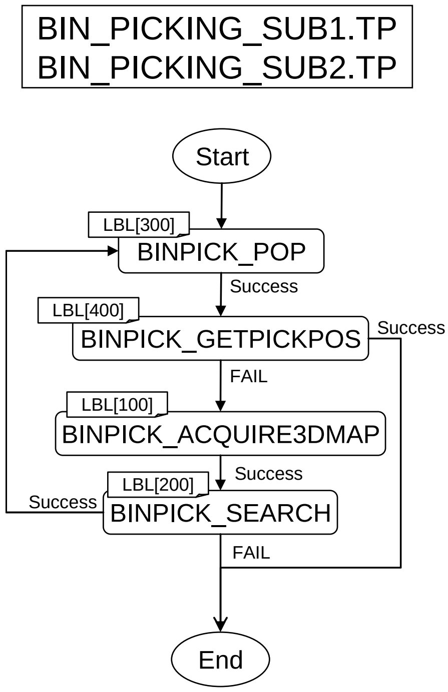
Creating TP Programs

The flow chart of the system described below is as follows.

Main program



Sub programs for background process



As can be seen from the figure above, there are the following three major TP programs.

- Main program (BIN_PICKING_MAIN.TP in the figure above)
- Sub program for the container1 (BIN_PICKING_SUB1.TP in the figure above)
- Sub program for the container2 (BIN_PICKING_SUB2.TP in the figure above)

The sub programs are called just before the robot picking a part.
For example, the BIN_PICKING_SUB2.TP executes the following processes in the background while the robot picks up a part from the container1.

- POP
- Get PICK position
- Acquire 3D map
- SEARCH

The main program waits for the completion of the sub program in the following two times.

- At the time when the placing the picked part is done
  After completion of the sub program, go to the process to pick up a part in the container different from the container that the robot picked up a part in the previous time.
- At the time when the robot fails to pick up a part
  After completion of the sub program, go to the process to pick up another part in the container that the robot fails to pick up a part in the previous time.

The TP programs explained below use the following registers, position registers, tool frame, and user frame.

Table of Registers to Be Used

R[1]	The running status of the system. Values to be set represent the following states: 0: Normal 1: Cannot detect a part.
R[2]	The status that represents whether the robot holds a part. Values to be set represent the following states: 0: Does not hold a part. 1: Holds a part.

R[3]	The status of the background process. Values to be set represent the following states: 0: Not completed. 1: Completed.
R[4]	The status of SEARCH vision process for parts list 1
R[5]	The status of POP for parts list 1
R[6]	Model ID of the popped part data from parts list 1
R[7]	Status of the get PICK position process for parts list1. One of the following values is set: 0: Success 12: Failed to get the interference avoidance position at the PICK position 13: Failed to get the interference avoidance position at the position to approach a part
R[8]	The flag indicating that a PICK position calculated by the BIN_PICKING_SUB1 exists. 0: Not Exist 1: Exist
R[104]	The status of SEARCH vision process for parts list 2
R[105]	The status of POP for parts list 2
R[106]	Model ID of the popped part data from parts list 2
R[107]	Status of the get PICK position process for parts list 2. One of the following values is set: 0: Success 12: Failed to get the interference avoidance position at the PICK position 13: Failed to get the interference avoidance position at the position to approach a part
R[108]	The flag indicating that a PICK position calculated by the BIN_PICKING_SUB2 exists. 0: Not Exist 1: Exist

Table of Position Register

PR[20]	Parts list 1: Result of interference avoidance for the part pick position (avoidance position)
PR[21]	Parts list 1: Result of interference avoidance for the part pick position (tool offset value)
PR[22]	Parts list 1: Result of interference avoidance for the approach position (avoidance position)
PR[120]	Parts list 2: Result of interference avoidance for the part pick position (avoidance position)
PR[121]	Parts list 2: Result of interference avoidance for the part pick position (tool offset value)
PR[122]	Parts list 2: Result of interference avoidance for the approach position (avoidance position)

Table of Tool Frame to Be Used

UTOOL[1]	TCP of the hand

Table of User Frame to Be Used

UFRAME[1]	Reference user frame

The Parts List Manager is set as follows.

The SEARCH vision process ID of the SEARCH VP List of the Parts List Manager to use: 1

The PICK position ID of the PICK Position List of the Parts List Manager to use: 1

BIN_PICKING_MAIN.TP

This is the main program for bin picking.

```
 1:  !Initialize data
 2:  R [1]=0
 3:  R[2]=0
 4:  R[3]=1
 5:  R[8]=0
 6:  ﾚｼﾞ[108]=0
 7:  CALL BINPICK_CLEAR(1)
 8:  CALL BINPICK_CLEAR(2)
 9:
10:  ! Move to home position
11:  UFRAME_NUM=1
12:  UTOOL_NUM=1
13:J P[1] 100% FINE
14:
15:  !**********************
16:  !CONTAINER1 PICK
17:  !**********************
18:
19:  ! Move to snapping position
20:  LBL[100]
21:  UFRAME_NUM=1
22:  UTOOL_NUM=1
23:J P[101] 100% FINE
24:  WAIT R[3]=1
25:
26:  LBL[200]
27:  CALL BINPICK_ACQUIRE3DMAP('SENSOR1')
28:
29:  LBL[300]
30:  CALL BINPICK_SEARCH(1,1,4)
31:  IF R[4]=0,JMP LBL[400]
32:  !SEARCH FAIL
33:  R[1]=1
34:  JMP LBL[9999]
35:
36:  LBL[400]
37:  CALL BINPICK_POP(1,5,6)
38:  IF R[5]=0,JMP LBL[500]
39:  !POP FAIL
40:  JMP LBL[100]
41:
42:  LBL[500]
43:  CALL BINPICK_GETPICKPOS(1,1,7,20,21,22)
44:  IF R[7]=0,JMP LBL[600]
45:  !GETPICKPOS FAIL
46:  CALL BINPICK_SETSTAT(1,22)
47:  JMP LBL[400]
48:
49:  !PICK and Start Background proc
50:  LBL[600]
51:  R[3]=0
52:  RUN BIN_PICKING_SUB2
53:
54:  UFRAME_NUM=1
55:  UTOOL_NUM=1
56:  R[8]=0
57:L P[601] 1500mm/sec CNT50
58:L PR[22] 500mm/sec CNT50
59:L PR[20] 200mm/sec FINE
60:  !Insert program instructions to
61:  !grasp
62:L P[602] 300mm/sec FINE INC
63:  !Insert program instructions to
64:  !whether grasping succeeds or no
65:  IF R[2]=1,JMP LBL[610]
```

- Initialize data. (line 1)
- Move to a home position. (line 13)
- Move to a position to snap an image. (line 23)
- Acquire a new 3D map. (line 27)
- Execute a SEARCH vision process. (line 30)
- Pop a part data from the parts list. (line 37)
- If any part data is not popped, move to a position to snap an image. (line 40)
- If the BINPICK_GETPICKPOS fails, pop a new part data. (line 46)
- Start the background process for the container2. (line 52)
- The register indicating that a PICK position calculated by the background process exists set to 0(Not Exist). (line 56)
- Move to a above position of container1. (line 57)
- Move to a position to pick up a part. (line 59)
- Grasp the part. (line 60)
- Move to a position to leave the container. (line 62)

```
 66:  !PICK FAIL
 67:  CALL BINPICK_SETSTAT(1,21)
 68:  JMP LBL[400]
 69:  !PICK SUCCESS
 70:  LBL[610]
 71:  CALL BINPICK_SETSTAT(1,20)
 72:L P[601] 1500mm/sec CNT50
 73:
 74:  !PLACE
 75:  LBL[700]
 76:L P[701] 300mm/sec CNT100
 77:L P[702] 300mm/sec FINE
 78:  !Insert program instructions to
 79:  !place the part
 80:L P[701] 300mm/sec CNT100
 81:  !Wait for completion of
 82:  !Background proc
 83:  WAIT R[3]=1
 84:
 85:  IF R[1]=1,JMP LBL[9999]
 86:  !Go to container2 pick
 87:  JMP LBL[1600]
 88:
 89:  !***********************
 90:  !CONTAINER2 PICK
 91:  !***********************
 92:
 93:  ! Move to snapping position
 94:  LBL[1100]
 95:  UFRAME_NUM=1
 96:  UTOOL_NUM=1
 97:J P[1101] 100% FINE
 98:  WAIT R[3]=1
 99:
100:  LBL[1200]
101:  CALL BINPICK_ACQUIRE3DMAP('SENSOR2')
102:
103:  LBL[1300]
104:  CALL BINPICK_SEARCH(2,1,104)
105:  IF R[104]=0,JMP LBL[1400]
106:  !SEARCH FAIL
107:  R[1]=1
108:  JMP LBL[9999]
109:
110:  LBL[1400]
111:  CALL BINPICK_POP(2,105,106)
112:  IF R[105]=0,JMP LBL[1500]
113:  !POP FAIL
114:  JMP LBL[1100]
115:
116:  LBL[1500]
117:  CALL BINPICK_GETPICKPOS(2,1,107,120,121,122)
118:  IF R[107]=0,JMP LBL[1600]
119:  !GETPICKPOS FAIL
120:  CALL BINPICK_SETSTAT(1,22)
121:  JMP LBL[1400]
122:
123:  !PICK and Start Background proc
124:  LBL[1600]
125:  R[3]=0
126:  RUN BIN_PICKING_SUB1
127:
128:  UFRAME_NUM=1
129:  UTOOL_NUM=1
130:  R[108]=0
```

Check if the robot holds the parts

If the robot does not hold the part, pop a next part data.

Place the picked part.

Wait for the completion of background process for the container2.

If the background process succeeds, pick up the part in the container2.

Move to a position to snap an image.

Acquire a new 3D map.

Execute a SEARCH vision process.

Pop a part data from the parts list.

If any part data is not popped, move to a position to snap an image.

If the BINPICK_GETPICKPOS fails, pop a new part data.

Start the background process for the container1.

The register indicating that a PICK position calculated by the background process exists set to 0(Not Exist).

Move to a above position of container2.

```
131:L P[1601] 1500mm/sec CNT50
132:L PR[122] 500mm/sec CNT50
133:L PR[120] 200mm/sec FINE
134:  !Insert program instructions to
135:  !grasp
136:L P[1602] 300mm/sec FINE INC
137:  !Insert program instructions to
138:  !whether grasping succeeds or no
139:  IF R[2]=1,JMP LBL[610]
140:  !PICK FAIL
141:  CALL BINPICK_SETSTAT(2,21)
142:  JMP LBL[1400]
143:  !PICK SUCCESS
144:  LBL[1610]
145:  CALL BINPICK_SETSTAT(2,20)
146:L P[1601] 1500mm/sec CNT50
147:
148:  !PLACE
149:  LBL[1700]
150:L P[1701] 300mm/sec CNT100
151:L P[1702] 300mm/sec FINE
152:  !Insert program instructions to
153:  !place the part
154:L P[1701] 300mm/sec CNT100
155:  !Wait for completion of
156:  !Background proc
157:  WAIT R[3]=1
158:
159:  IF R[1]=1,JMP LBL[9999]
160:  !Go to container1 pick
161:  JMP LBL[600]
162:
163:  LBL[9999]
164:  UFRAME_NUM=1
165:  UTOOL_NUM=1
166:J P[1] 100% FINE
```

Move to a position to pick up a part. (→ line 133)

Grasp the part. (→ line 134)

Move to a position to leave the container. (→ line 136)

Check if the robot holds the parts (→ line 138)

Place the picked part. (→ line 152)

Wait for the completion of background process for the container1. (→ line 157)

If the background process succeeds, pick up the part in the container1. (→ line 161)

BIN_PICKING_SUB1.TP

This is the sub program. The sub programs are called just before the robot picking a part. The following processes are executed in the background while the robot places the holding part.

- POP
- Get PICK position
- Acquire 3D map

```
 1:  IF R[8]=1,JMP LBL[500]
 2:  JMP LBL[300]
 3:
 4:  LBL[100]
 5:  CALL BINPICK_ACQUIRE3DMAP('SENSOR1')
 6:
 7:  LBL[200]
 8:  CALL BINPICK_SEARCH(1,1,4)
 9:  IF R[4]=0,JMP LBL[300]
10:  !SEARCH FAIL
11:  R[1]=1
12:  R[3]=1
13:  END
14:
15:  LBL[300]
16:  CALL BINPICK_POP(1,5,6)
17:  IF R[5]=0,JMP LBL[400]
```

If the PICK position calculated by the previous execution of background process exists, the background process ends. (→ line 1)

Go to the process to pop a part data. (→ line 2)

Execute a SEARCH vision process. (→ line 8)

If the SEARCH vision process finds no parts, the register indicating the running status is set to 1 and the background process ends. (→ line 13)

```
18:  !POP FAIL
19:  JMP LBL[100]
20:
21:  LBL[400]
22:  CALL BINPICK_GETPICKPOS(1,1,7,20,21,22)
23:  IF R[7]=0,JMP LBL[410]
24:  !GETPICKPOS FAIL
25:  CALL BINPICK_SETSTAT(1,22)
26:  JMP LBL[300]
27:  LBL[410]
28:  R[8]=1
29:
30:  LBL[500]
31:  R[3]=1
```

If any part data is not popped, move to a position to snap an image.

If the BINPICK_GETPICKPOS fails, pop a new part data.

The register indicating that a PICK position calculated by the background process exists set to 1(Exist).

If the BINPICK_GETPICKPOS succeeds, the background process ends.

BIN_PICKING_SUB2.TP

This is the sub program. The sub programs are called just before the robot picking a part. The following processes are executed in the background while the robot places the holding part.

- POP
- Get PICK position
- Acquire 3D map

```
 1:  IF R[108]=1,JMP LBL[500]
 2:  JMP LBL[300]
 3:
 4:  LBL[100]
 5:  CALL BINPICK_ACQUIRE3DMAP('SENSOR2')
 6:
 7:  LBL[200]
 8:  CALL BINPICK_SEARCH(2,1,104)
 9:  IF R [104]=0,JMP LBL[300]
10:  !SEARCH FAIL
11:  R[1]=1
12:  R[3]=1
13:  END
14:
15:  LBL[300]
16:  CALL BINPICK_POP(2,105,106)
17:  IF R[105]=0,JMP LBL[400]
18:  !POP FAIL
19:  JMP LBL[100]
20:
21:  LBL[400]
22:  CALL BINPICK_GETPICKPOS(2,1,107,120,121,122)
23:  IF R[107]=0,JMP LBL[410]
24:  !GETPICKPOS FAIL
25:  CALL BINPICK_SETSTAT(2,22)
26:  JMP LBL[300]
27:  LBL[410]
28:  R[108]=1
29:
30:  LBL[500]
31:  R [3]=1
```

If the PICK position calculated by the previous execution of background process exists, the background process ends.

Go to the process to pop a part data.

Execute a SEARCH vision process.

If the SEARCH vision process finds no parts, the register indicating the running status is set to 1 and the background process ends.

If any part data is not popped, move to a position to snap an image.

If the BINPICK_GETPICKPOS fails, pop a new part data.

The register indicating that a PICK position calculated by the background process exists set to 1(Exist).

If the BINPICK_GETPICKPOS succeeds, the background process ends.

12 TROUBLESHOOTING

This chapter describes troubles that are likely to occur in the *i*RVision Bin Picking system and their remedies.

12.1 EXECUTING KAREL PROGRAMS OF INTERFERENCE AVOIDANCE OCCUR AN ALARM

The following alarms may occur when the KAREL Programs of Interference Avoidance is executed.

PR[X] is uninitialized

[Cause]
The possible causes are described below.

- The value of the position register in which the target position is set is uninitialized.
- The value of the position register in which the frame offset value is set is uninitialized.
- The value of the position register in which the tool offset value is set is uninitialized.

[Remedy]
Set a target position, offset value, or tool offset value in the specified position register.

Illegal PR [X] type

[Cause]
The possible causes are described below.

- The value of the position register in which the target position is set is in joint format.
- The value of the position register in which the offset value is set is in joint format.
- The value of the position register in which the tool offset value is set is in joint format.

[Remedy]
Change the format of the target position, frame offset, or tool offset position register to cartesian or matrix format.

Illegal offset type

[Cause]
A value other than V or O is set in the second argument of IACHECK.PC, IACALAVOID.PC, or IAAVDWALL.PC.

[Remedy]
Set V or O in the second argument.

CVIS-389 Invalid data is specified

[Cause]
The possible causes are described below.

- An untaught interference setup (system) is specified.
- An untaught interference setup (robot) is specified.
- An untaught interference setup (condition) is specified.
- An interference setup (condition) of an invalid mode is specified

[Remedy]
Check that the specified interference setup (system), interference setup (robot), or interference setup (condition) has been taught. Check whether an interference setup (condition) of an invalid mode is specified.

CVIS-397 Invalid name is specified

[Cause]

The possible causes are described below.

- A nonexistent or untaught interference setup (system) is specified.
- A nonexistent or untaught interference setup (robot) is specified.
- A nonexistent or untaught interference setup (condition) is specified.

[Remedy]

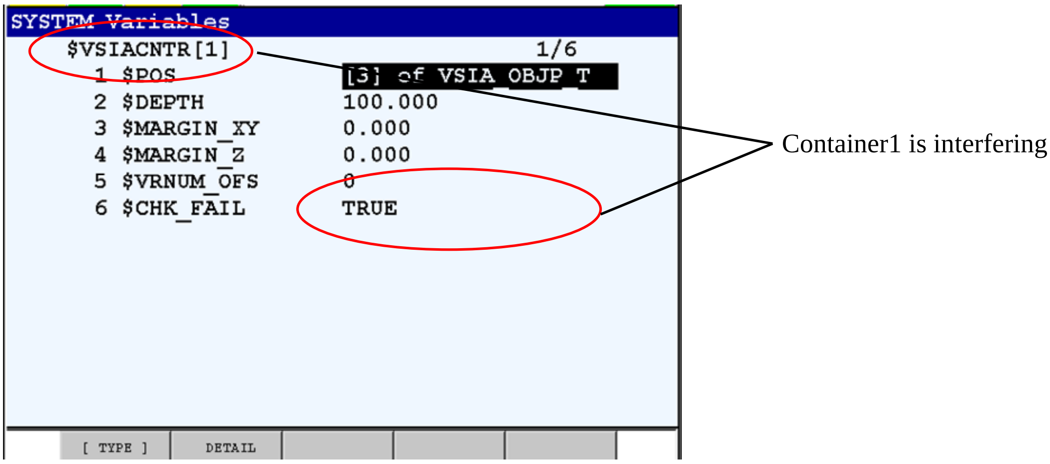
Check that the specified interference setup (system), interference setup (robot), or interference setup (condition) exists.

12.2 IDENTIFYING AN INTERFERING OBJECT

An interfering object detected by the interference avoidance function or Parts List Manager can be identified as follows.

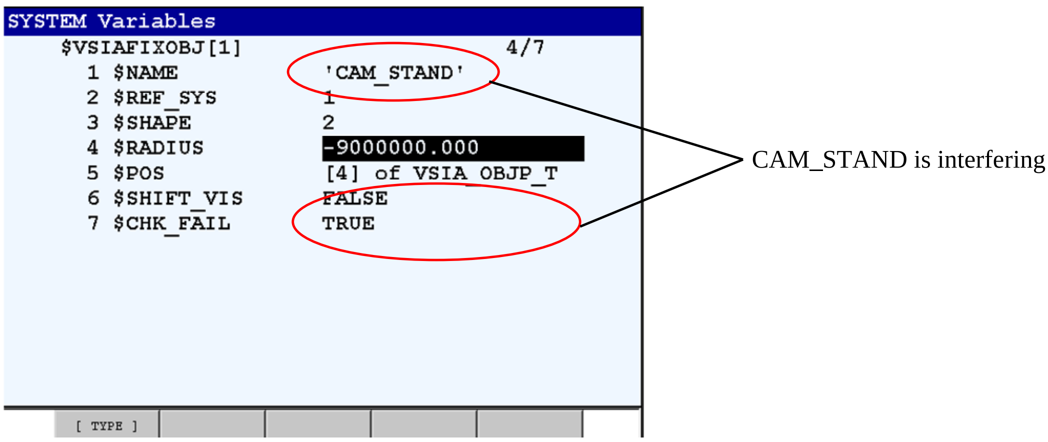
Identifying an interfering container

The container object for which $CHK_FAIL is TRUE in the system variable $VSIACNTR[] is interfering.



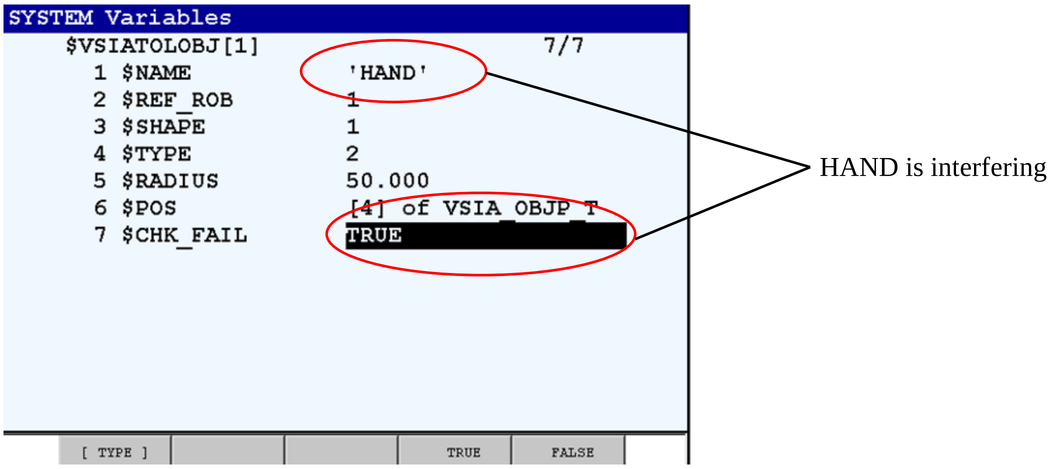
Identifying an interfering fixed object

The fixed object for which $CHK_FAIL is TRUE in the system variable $VSIAFIXOBJ[] is interfering.



Identifying an interfering tool object

The tool object for which $CHK_FAIL is TRUE in the system variable $VSIATOLOBJ[] is interfering.



12.3 THE ROBOT DOES NOT PROCEED TO PICK UP A PART EVEN THOUGH THE PART IS DETECTED

If the robot does not proceed to pick up a part even though the part is detected, only blacklist part data may remain in the parts list. Check this out using the Part Data Monitor of the Parts List Manager. If the parts list contains only blacklist part data, execute IPCLR.PC using a TP program to clear the parts list of its all data including the blacklist part data. Then, execute the TP program that performs bin picking.

12.4 THE ROBOT PROCEEDS TO PICK UP A PART WHERE NO PART IS PRESENT

If the robot proceeds to pick up a part where no part is present, the possible causes are as follows:

A part is detected mistakenly in the SEARCH or FINE vision process.

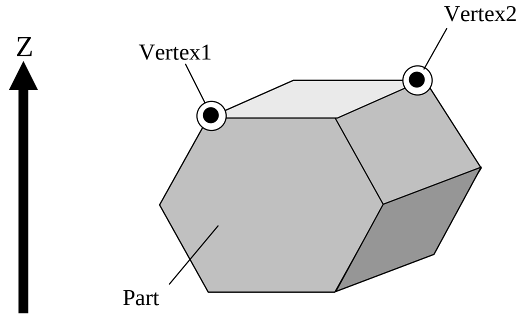
Using the monitor, check whether there is any part mistakenly detected during the execution of the SEARCH or FINE vision process near the position where the robot attempted to pick up a part. If there is any part mistakenly detected, adjust the vision process parameters to prevent such mistaken detection.

The calibration data is not correct.

If the robot proceeds to pick up a part where no part is present even though a part has been detected properly in the SEARCH or FINE vision process, the calibration data used in the SEARCH or FINE vision process may be incorrect. Touch up the found position of the vision process using the robot in order to check whether the found position is correct. If the position is not correct, perform calibration again.

The robot attempts to pick a part that has already been picked.

This phenomenon is prone to occur when the Area Sensor Peak Locator Tool is used. Since the Area Sensor Peak Locator Tool is intended to detect high positions in a 3D map, it may detect multiple vertexes in a single part, as shown in the following figure.



Pushing the vertexes detected in this way to the parts list results in multiple sets of part data existing for a single part. Consequently, when the part data having Vertex 2 as the detection result is popped up after a part is picked according to the part data having Vertex 1 as the detection result, the robot proceeds to pick up a part where no part is present, because the part has already been picked. To prevent this phenomenon, take the following steps:

- To prevent the robot from detecting more than one vertex for a single part, set a large value in [Search Range] for the Area Sensor Peak Locator Tool.
- To prevent the vertexes of the same part from being pushed to the parts list, set a large value in [Range] of [Duplication Check] in [Push Part Data Setup] of the Parts List Manager.
- To delete the data of the part that was near the successfully picked part and whose status is Awaiting, select [Delete] for [Process] and set a value equivalent to the size of the part in [Range] when setting the process for the part in [PICK SUCCESS] of [Status Setup List] of the Parts List Manager.

12.5 THE GRID FRAME SET DOES NOT OPERATE AS EXPECTED

If the Grid Frame Set does not operate as expected, first check the information provided here.

[CVIS-020 Big circles cannot be distinguished] is issued.

This alarm is posted when the four large black circles of the calibration grid could not be detected. Detection of large black circles failed because of an improper exposure time, or an object other than a grid point was detected. The Vision Runtime screen shows the image when a measurement failed. Check the image and adjust the snapping condition. When some of the large circles are not seen in the camera field of view, try the followings:

- Use a smaller grid pattern
- Use a lens with smaller focal length
- Lengthen the distance between the camera and the grid pattern so that the grid pattern is seen smaller in the image
- Rotate the camera or the grid pattern so that the X axis of the grid pattern does not point below in the image

[CVIS-015 Too few calibration points] is issued.

This alarm is posted when the number of grid points of the calibration grid detected during measurement is less than 4. Check whether the grid points are contained in the camera's visual field when the robot is placed at the measurement start position, whether the exposure time is proper, and whether the camera port number is correct. This alarm is posted also if a measurement is made when the camera is disabled for hardware trouble.

The program was terminated abnormally with an error.

If an error occurs, the program is terminated forcibly. Modify the setting to enable correct measurement then execute the program from the beginning.

12.6 THERE IS AN AREA THAT 3D POINTS CAN NOT BE ACQUIRED

If there is an area that 3D points are not acquired, adjust the condition of acquiring 3D map by referring to Subsection 7.4.4 "Adjusting the Condition of Acquiring 3D Map".

If the problem cannot solve by the adjustment described in Subsection 7.4.4 "Adjusting the Condition of Acquiring 3D Map", perform the procedures described in Subsection 7.4.2 "Adjusting the Focus of the Projector Unit" and 7.4.3 "Adjusting the Focus of the Camera Unit" again.

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REVISION RECORD

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